DHESI, Jagjit Kaur Jobal-
RELATIONSHIP OF BODY POSITIONS AND HEART RATE DURING CHAPATI-MAKING AT GROUND-LEVEL.

The Ohio State University, Ph.D., 1970
Home Economics

University Microfilms, A XEROX Company, Ann Arbor, Michigan
RELATIONSHIP OF BODY POSITIONS AND HEART RATE DURING CHAPATI-MAKING AT GROUND-LEVEL

DISSERTATION

Presented in Partial Fulfillment of the Requirement for the Degree Doctor of Philosophy in the Graduate School of The Ohio State University

By


The Ohio State University
1970

Approved by

Advisor
School of Home Economics
DEDICATION

To My husband, S. Sohan Singh Dhesi – The Source of Inspiration
ACKNOWLEDGMENT

The author wishes to express her appreciation and thanks to Dr. Francilla Maloch, Professor of Home Management and Household Equipment, for her sincere guidance, interest and cooperation which have made this study a success. Thanks are equally due to Dr. Ruth Deacon, Professor and Chairman of Management, Housing, and Equipment Division, who has shown a keen interest and cooperation throughout the entire graduate program.

Special thanks are due to Dr. D. Lois Gilmore, Professor and Associate Director of Home Economics; Dr. John L. Sitterley, Professor of Agricultural Economics; and Dr. Fern Hunt, Associate Professor of Home Management and Household Equipment, for their participation as members of the Graduate Committee.

Thanks are due to a special group Mr. H. T. E. Hertzberg, Research Physical Anthropologist, Aerospace Medical Research Laboratory, Wright-Patterson Air Force Base, Ohio; Dr. C. Richard Weaver, Statistician for the Ohio Agricultural Research and Development Center; Dr. Frank E. Poirier, Assistant Professor of Anthropology for their assistance in this study.

Thanks are due to the team workers of sister institutions - Dr. Mervin G. Smith, Assistant Dean and Coordi-
nator of International Affairs, The Ohio State University, Columbus; and Dr. D. Sundaresan, Dean Post-Graduate Studies, for their cooperation in making the graduate program a success.

Thanks are acknowledged to The Punjab Agricultural University, Ludhiana; The Government of India; and The United States Agency of International Development for providing the opportunity for graduate studies and financial assistance.

Thanks are due to Mrs. Doris Fulton, Assistant Professor of Home Management for helping in the Laboratory procedures; Cooperators who participated in this study, and friends for their interest and assistance in this study.

Last, but not the least, appreciation is extended to Teji and Sukhi for putting up with all kinds of circumstances.
VITA

July 10, 1932 ........ Born - Narangwal, Ludhiana, Punjab, India
1955 ................. B.A., Punjab University Chandigarh, Punjab, India
1957 ................. B.Ed., Same
1958-1961 ............ Teacher-incharge, Junior Basic Training Classes, Jullundur, Punjab, India.
1961-1963 ............ Research Assistant, University of California, Davis, California
1964 ................. M.A., Research Assistant, Washington State University, Pullman, Washington
1965 ................. M.A.T., Research Assistant, Same
1965-1966 ............ Statistician, Same
1966-1967 ............ Assistant Professor, Punjab Agricultural University, Ludhiana, Punjab, India
1968 ................. Acting Dean, Same
1968 ................. Selected Associate Professor, Same

FIELDS OF STUDY

Major Field: Home Management, Family Economics, and Household Equipment

Studies in Home Management. Professor Francille Maloch

Studies in Household Equipment. Associate Professor Dr. Fern Hunt, and Assistant Professor Miss Clarice Bloom
Studies in Family Economics. Professor Ruth Deacon

Studies in Agricultural Economics. Professor John L. Sitterley

Studies in Home Economics Education. Professor Julia I. Dalrymple, and Marie M. Dirks

Studies in Research Methods. Professor Donald Mathews
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEDICATION</td>
<td>ii</td>
</tr>
<tr>
<td>ACKNOWLEDGMENTS</td>
<td>iii</td>
</tr>
<tr>
<td>VITA</td>
<td>v</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>ix</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>x</td>
</tr>
<tr>
<td>I. INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>Energy Expenditures</td>
<td></td>
</tr>
<tr>
<td>Work Surface Heights</td>
<td></td>
</tr>
<tr>
<td>II. REVIEW OF LITERATURE</td>
<td>6</td>
</tr>
<tr>
<td>Posture</td>
<td></td>
</tr>
<tr>
<td>Anthropometrical Measurements</td>
<td></td>
</tr>
<tr>
<td>Angles of Body Bend</td>
<td></td>
</tr>
<tr>
<td>Heart Rate</td>
<td></td>
</tr>
<tr>
<td>III. OBJECTIVES AND HYPOTHESES</td>
<td>42</td>
</tr>
<tr>
<td>IV. METHODOLOGY</td>
<td>46</td>
</tr>
<tr>
<td>Sample</td>
<td></td>
</tr>
<tr>
<td>Laboratory Procedure</td>
<td></td>
</tr>
<tr>
<td>Screening Laboratory</td>
<td></td>
</tr>
<tr>
<td>Preliminary Laboratory</td>
<td></td>
</tr>
<tr>
<td>First Laboratory</td>
<td></td>
</tr>
<tr>
<td>Second Laboratory</td>
<td></td>
</tr>
<tr>
<td>Analysis of Data</td>
<td></td>
</tr>
<tr>
<td>V. ANALYSIS AND INTERPRETATION OF DATA</td>
<td>73</td>
</tr>
</tbody>
</table>

vii
Description of Subjects
Heart Rate
Angles of Body Bend
Relationship among Angles of Body Bend

VI. SUMMARY AND CONCLUSIONS .................. 100

APPENDIX
A ..................................................... 107
B ..................................................... 111
BIBLIOGRAPHY ..................................... 130
LIST OF TABLES

1. Techniques for Angles of Body Bend, Land Marks and Methods of Recording ................................. 21

2. Dimensions for the Arrangement of Kitchen Unit ................................................................. 49

3. Landmarks and Vertex as used for Various Angles of Body Bend ............................................. 68

4. Description of subjects .............................................................................................................. 76

5. Structural Dimensions of Subjects at the Standing, Sitting, and Squatting Positions ... 78

6. Least Squares Analysis of Variance for Heart Rate ................................................................. 82

7. Least Squares Means and Standard Errors of Heart Rate for Various Body Positions ........ 82

8. Regression Coefficients for Angles of Body Bend and Heart Rate ............................................ 85

9. Least Squares Analysis of Variance for Angle of Body Bend .................................................. 90

10. Least Squares Means and Standard Errors of Various Angles of Body Bend at Normal Sitting, Ball-making, Rolling, and Puffing Positions . 91

11. Correlation among Angles of Body Bend within the Various Body Positions ....................... 96

12. Blood Pressure, Resting Heart Rate and Cardiovascular Fitness Score ............................... 108

13. Scores of Cardiovascular Fitness Test for First and Second Laboratory ................................ 108

14. Scores of Psychological Attitudes for First and Second Laboratory ........................................ 109

15. Least Squares Means and Standard Error of Heart Rate ......................................................... 110
LIST OF FIGURES

I. Step Device for the Cardiovascular Fitness test ........................................... 54
II. Location of Landmarks ......................................................... 56
III. Various Steps of the Task of Chapati-making ................. 59
IV. Squatting Dimensions ....................................................... 64
V. Angles of Body Bend for Two Types of Normal Sitting Positions on the Low Stool .......... 65
VI. Angles of Body Bend at Three Body Positions while Sitting on Low Stool ................. 69
CHAPTER I
INTRODUCTION

Posture has been studied from the aspect of human anatomy, but very few studies have been made from the cultural point of view. A whole complex of factors— anatomical, physiological, psychological, cultural, environmental, technological— is involved in the evaluation of the many different postural habits. There are sex linked factors, such as clothing, pregnancy, nursing, and carrying a baby, which lead to differences in posture. Clothing and footwear affect the positions of sitting and standing. The amount of fat in strategic places may determine whether the position of squatting is comfortable.

Postural etiquette varies from culture to culture and over a period of time. Religious taboos or concepts of decency ban certain postures in a particular culture.

A cross-legged or "tailor fashion" sitting position is mostly used for prayer and also for performing holy ceremonies in the Sikh and Hindu religions whereas other sitting positions are culturally unacceptable during these occasions. There are eight to ten distinct variations of the cross-legged posture, some of which are
practically limited to people trained in these special forms such as Hindus and Buddhists (32). In the Mohammedan religion the acceptable sitting posture for prayer is to sit with lower legs bent under the body.

Hewes (32) reported that the deep squat position is very common in many parts of Asia, Africa, and Latin America. People use this position during work as well as during rest. The deep squat position of humans is very similar to that of the chimpanzee, and perhaps all people might squat if their cultures did not train them into other postures.

The various postures used for sitting in India also indicate the effect of costumes. Placing the feet flat on the floor with the knees bent up in front of the body is commonly used in Punjab. In other areas the freedom of movement available for legs in a sari or lengha allows the wide spread of legs during sitting.

There is need to explore the various cross-legged, squatting, kneeling and other postures which many people have found convenient for their daily work.

Research in home management in India has focused to a limited extent on the physical component of worker input.

**Energy Expenditures**

Koshy (43) conducted a study to investigate the various methods and equipment used in cleaning floors to
determine the types of equipment available to the people and also to find the amount of energy spent in cleaning floors. The energy expenditure in the cleaning of floors was greatest in washing and least in sweeping. The type of floor was an influencing factor in determining the energy expenditure; the tiled floors demanded the most energy.

Iyer (35) compared two different methods for performing four selected household tasks; cutting of a green plantain, grinding soaked rice, sweeping the floor, and rinsing napkins by the conventional and improved methods.

The conventional methods of cutting plantain, grinding rice, and rinsing a napkin consisted of squatting on the floor for the first two, and sitting with the knee bent for the third work. An improved method consisted of standing on the floor and working at counter height. Sweeping in the conventional and improved methods consisted of the use of the short and long handled brooms respectively.

The improved method for grinding soaked rice, sweeping the floor, and rinsing a napkin, consumed less oxygen as compared with the conventional method by 3.6, 11.6, and 13.8 percent.

Nirmala (50) studied the time and energy cost of
ironing a sari at different work heights. At the commercial ironing board the oxygen consumption was less than at the study table. At floor level, less oxygen was consumed per minute during sitting and ironing than during kneeling and ironing.

**Work Surface Heights**

Padma (52) conducted a study to determine preferred counter widths and heights for storing supplies and utensils. Two subjects participated in the study, and the tasks of making puries and chapatties were selected. In the preparation of chapatties, the 24 inch width was preferred. From the floor, heights of 33 inches and 28 inches were preferred for storing supplies and a height of 35 inches was preferred for storing utensils.

Bhwani (9) studied body reaches of 100 homemakers from Madhya Pradesh. The purpose was to develop guidelines for designing kitchen storage and also for designing working counters. The range for the maximum reach was from 65 to 75 inches, for maximum horizontal reach, 16 to 24 inches. The range for arm length of homemakers was less than that for maximum horizontal reach.

Dhand (17) conducted a study to find out the work heights and other measurements preferred by 50 homemakers for selected activities in the kitchen while standing to
work. The selected activities included stirring, chopping vegetables, rolling, kneading, mixing, and washing dishes. She reported three levels of counter heights: (1) 26 inches for stirring while using a stove and saucepan; (2) 31 inches for chopping vegetables, rolling, and kneading; and (3) 30 inches for mixing and washing the dishes.

One household task which is generally performed in the squatting position is chapati-making. Chapaties (flat unleavened bread) are the staple item of food in the Indian diet, particularly in Punjab. Preparation time may be 30 to 45 minutes at least three times a day. This task was selected for the study.

Two measures of cost to the body from the physical component of the worker input were selected for the study. These measures were—heart rate and angles of body bend. The procedures of time and motion and the calculation of energy cost have frequently been used in the past. Swartz (60) and Bratton (10) indicated limited value of energy expenditures as a measure but heart rate has been found to be a relatively sensitive indicator by researchers (18, 55, 61).
CHAPTER II

REVIEW OF LITERATURE

The importance of the human body for developing the design of equipment and arrangement of work areas has been considered by researchers in the disciplines of home economics (9, 23, 40, 41), and human engineering. The concern of these researchers have been that the machine should be adjusted to the body so that a man can work with maximum efficiency, comfort, and safety.

The literature has been reviewed with an emphasis on four factors. These factors are: posture, anthropometrical measurements, angles of body bend, and heart rate.

**Posture**

The definition of posture to which most of the authorities (11, 45) agree is that the body is in good balance when a perpendicular line passes through the following five landmarks: lobe of the ear, middle of the tip of the shoulder, middle of greater trochanter, just posterior of the patella and anterior to the outer malleolus. However, the
static vertical posture as defined above is more liable to produce feelings of fatigue than a dynamic posture. Hellebrandt studied the posture and its cost. He reported that the sense of fatigue associated with a motionless vertical posture could be due to cerebral anemia because it disappeared when the hydrostatic effect of gravity on blood circulation was opposed by peripheral pumping effect of postural movement (29:781).

Cooper and Glassow describe the physiological concept of normal posture as a condition in which the organs and systems of the body function efficiently. The energy requirement and blood pressure rise when a person assumes a rigid erect posture because of the muscular effort involved. Therefore, from the point of view of physiological efficiency the rigid, erect posture is not normal since the efficiency of metabolic and circulatory systems are reduced (16:114).

The statistical interpretation of normality is in terms of the frequency distribution of a population, and the normal posture would be that assumed by the majority. The statistically normal posture derived by frequency of occurrence of a posture would include the range of differences in sitting positions. These positions vary with occasions and time. The statistical normal posture, there-
fore cannot be a fixed value (16:114).

Normal posture is the one which varies with the circumstances. For concentrating on a stimulus, the normal posture will be erect. In conditions of distress, the normal posture would be a sagging of all body parts. In extreme fatigue, the normal posture would be that which conserves energy (16:115).

Metheny (46) stated that there is no single best posture for all individuals. The best posture for each person is that in which the body segments are balanced in the position of least strain and maximum support.

Body Positions

Squatting

Fahrni (20, 21) reported that any standing or sitting position is a strain on the back if it increases the lordotic curve of the spine and if the curved position is maintained for a period of time. The squatting position has the advantage over the standing or sitting position for keeping the lumbar spine flexed. The lordotic curve leads to the softening of posterior disc tissues as compared with the lateral or forward areas. The process continues to produce destructive changes in the posterior quadrant which loses its weight-bearing capacity and transfers the stresses to the remainder of the disc which gradually collapses.
The X-ray photographs of the lumbar spine of the Bhils of India did not show these symptoms of disc degeneration. The finding was mainly attributed to the frequent use of the squat position rather than the standing position.

Fahrni further reported that sitting on a cushion on the floor, with or without the back against the wall while hugging the knees is not only a good position for relaxation of the spine but also comfortable. Broer (12) indicated that keeping arms around the knees pulls the shoulders and rounds the upper back. Broer has also reported that if this squat position is maintained for a length of time, the pressure exerted on the blood vessels and nerves, particularly those running behind the knees cuts off circulation and nerve supply to the lower legs.

**Trunk Flexion**

Strait, Inman, and Ralstan (59) reported considerable low back strain involved in trunk flexion. The lumbosacral joint is a fixed fulcrum, and power from the spinal extensor muscle is necessary to counterbalance the weight of the head, arms, and trunk which is acting at the center of gravity in the thorax. The distance between the hip joint and the place where the weight is exerted increases even though weight does not change in magnitude. Therefore, power from the extensor muscle must increase, resulting in
dangerous compression of the lumbar invertebral disc. However, Portony and Morin (53) and Carlsoo (15) found that in full trunk flexion the sacrospinales is completely relaxed. The counteraction of gravity is probably taken over by the ligaments of the spinal column. The compressed abdominal and pelvic organs could be the other factors for offering passive resistance, which considerably reduces the load on the dorsal muscles.

Neck Flexion

Gray et al. (24) and Jones et al. (34) studied the "postural image" of comforts, correctness, and of height. The responses were quantified by measuring the angular relation of head to trunk and the change in electrical potential of the sternocleidomastoid and upper trapezius muscles. Jones et al. (34) found that the activity in the sternomastoid muscle differentiates the three postural responses. Its potential increases as the subject moved from most comfortable to best and from best to greatest sitting height. The postural activity of the trapezius followed a different and often opposite course from that of the sternomastoid. The difference between the posture of correctness and of height could not be distinguished by this muscle. When the subject moved from the best to most comfortable, the activity in the upper trapezius in-
creased significantly. The upper trapezius appeared to record the forward thrust of the head.

Gray et al. further reported a striking difference in the amount of postural change between male and female subjects. In the sitting postures, the mean of angle of head tilt had a range of 22.5 degrees for the males but only 6.5 for the females. This difference could be related to the fact that in many males "good posture" was a form of the exaggerated military posture, whereas comfort was conceived of as a slump. In the females, there appeared to be less of a dichotomy between "good posture" and comfort (24:254).

**Lower Leg Flexion**

Carlsoo (15) reported that those muscles of the lower leg which form the foot joint were very responsive to changes in body posture. Several of these including the tibialis anterior are located in osteofibrosis space which restricts the contraction of the muscle. As a consequence fatigue and pain may be 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.

Joseph (35) found that with a slight forward inclination of the lower leg, the activity in the calf muscles increased and on slight backward movement the activity in
the calf muscles decreased but it appeared suddenly in the tibialis anterior. As a result of the continuous activity in the lower legs with backward and forward movements, the problem of fatigue is more prevalent. People make adjustments, however, to avoid the continuous contraction of these muscles.

Pottier et al. studied the effects of sitting posture on the volume of the foot. The authors found that the feeling of heaviness in the legs and distension of the feet which appeared during prolonged sitting posture were due to an increase of the volume of the lower limbs. The compression of the backside of the thigh produced a greater increase of the foot volume. Three factors responsible for these increases were hydrostatic pressure, vasodilation, and disturbance of venous blood return (54:753).

**Anthropometrical Measurements**

Anthropologists (31) standardized anthropometric techniques, definitions, and terminology in a conference held in 1968. During the conference, the terminology of "static" versus "dynamic" body position was considered to be misleading and was changed to "structural" and "functional" respectively. The general definitions for defining structural positions are:
Heights

Heights are vertical distances, usually measured with an anthropometer from the floor as the subject stands (or sometime sits), or from a horizontal surface on which the person sits: e.g., sitting height, knee height (31:7).

Breadths

Breadths are horizontal, lateral or transverse dimensions, measured with the anthropometer or suitable caliper (31:7).

Lengths

Lengths are dimensions usually measured with the anthropometer or sliding caliper along the long axis of a body segment, usually implying no dissection (31:7).

Reaches

Reaches are dimensions along the long axis of the arm, often measured with a segment of the anthropometer, wall-to-measuring-block techniques can also be used. Reaches can be considered a special variety of lengths; they usually imply measurement in the horizontal plane in front of the subject, unless another direction is specifically mentioned in the title (31:7).
The conference was also concerned about the procedures of defining a position. The "instructive" type of definition was preferred over the "descriptive" type. The instructive type definition involves a full statement that indicates the subject's body position, the instrument used and the technique of measurement.

Stature

The method preferred in measuring the stature was that the subject stand erect but unstretched and free of the wall. This position of the subject was considered to be the most convenient for surveys in general, because it is the best approximation for the subject's stature seen by others. It requires minimal motivation of the subject (31:6).

Stature against wall:

Olivier defined stature as the subject standing at attention with hanging arms, heels together, and the back in contact with the backboard. The line joining the external auditory meatus and the lateral palpebral commissure lies horizontally which means that the subject is keeping his head straight; the stature is measured from the vertex to the floor (51:20).
Sitting Height

Hertzberg (31) presented the general definitions for defining structural positions as follows: the subject sits erect with the head in the Frankfort plane, and the feet resting on a surface adjusted so that the knees are bent at about right angles. When the anthropometer arm touched the scalp, the height from the sitting surface to the vertex of the head is measured (30:139).

Buttock-Knee Length

The subject sits erect with the feet on an adjusted surface so that the knees are bent at about right angles. The horizontal distance from the rearmost surface of the buttock to the front surface of the knee cap is measured by reducing the anthropometer to the size of a caliper (30:145).

Knee Height, Sitting

The subject sits erect with feet resting on an adjusted surface so that the knees are bent at about right angles. Using the anthropometer, the distance from the foot rest surface to the level of the musculature just above the knee is measured (30:143).
Measurements at Squatting

**Squatting Height**

Alexander and Clauser developed the procedure for measuring the squatting height of men. The subject squats down in a normal fashion with the insteps of his feet nine inches apart. The torso is maintained in an erect position while the subject supports himself with his right hand and with the head in the Frankfort plane. The vertical distance is then measured from the floor to the highest point on the head (2:9).

**Maximum Squatting Breadth**

Subject squats down in a normal fashion with the insteps of the feet 9 inches apart for males. The arms rest across the thighs in a comfortable position. The maximum horizontal distance across the knees and lower thighs is measured (2:9).

**Angles of Body Bend**

The techniques of measuring angles of body bend as well as the studies reporting the effect of working positions, household equipment, and available space on the body are given in this section.
Techniques of Measuring Angles of Body Bend

The techniques of measuring angles of body bend are classified as direct and indirect. The direct measurement is the one when the angle is read by placing the instrument on the body. For direct measurement the flexometer has been used for neck and back bend and an angle of bend apparatus to measure the angle of any anthropometric point from the greatest projection of the buttocks. For example, the angle measurements of the ankle and shoulder blade at the standing erect position and at the working position have been used.

Electromyography is also a direct technique which records the electric activity in various muscles.

Indirect

In the indirect technique the data are recorded from photographs.

Knowles (40) used profile motion pictures projected on polar coordinate paper to measure the angle of body bend of homemakers during ironing at an adjustable ironing board. The landmarks were placed at the forehead at the hairline, the fullest projection of the hip, the acromion and lateral malleolus. The angle was calculated by subtract-
ing angles at working position from the natural upright position.

Mize et al. (47) used Knowles method of measuring angle of body bend. The maximum reach for baking centers and the space in front of cabinets were studied. The subject was photographed from the side with landmarks on the temple, the extreme posterior bulge, and lateral malleolus.

Keiser (38) used Knowles's procedure to devise a technique for measuring angles of body bend as a basis for predicting energy expenditures. Measurement of the angles of body bend was the same as used by Knowles, but a different procedure for reading the angle was used. Keiser used the landmark at the fullest projection of the hip. The angle from the fullest projection of the hip to the hair line and from the fullest projection of the hip to the ankle were measured. The sum of the two angles equaled the angle of body bend after subtracting the normal angle of bend. In order to make comparisons of the effects of sitting and standing to work on the body motions of the worker, Bratton (10) developed a technique of measuring angle of arm lift. The angle of upper arm lift was formed by the underarm perpendicular line to the acromion, and a line from the acromion to the olecranon, the acromion mark was used as the vertex of the angle.
Grady (23) studied the effect of arrangements for use and storage of portable electrical appliances on the body motion of the worker by means of memo-motion techniques. The method of recording the angle of body bend was the same as used by Knowles. The landmarks were placed at ear lobe, acromion, greater trochanter, back of the patella, and front of the malleolus. The landmarks were used to find out the line of the body's center of gravity.

Wright (63) measured angles of neck bend, back bend and body slump for loading two types of dishwashers. Landmarks were used at temple, acromion, seventh cervical, sternal notch, trochanter, and lateral malleolus. The seventh cervical was used as vertex for measuring neck and slump bends while the greater trochanter was used for measuring back bend. The angles at the working position were derived by subtracting the same angles at normal standing posture from the measured angles.

Direct

Wright (63) measured the angle of back bend with the Leighton flexometer. A reading was made before loading each article in the dishwasher, and as the subject reached the deepest point during loading, the pointer was locked into position for the second flexometer reading. The sum of the reading was the total extent of back bend in loading.
that particular article.

Monroe et al. (48) studied bathroom space requirement by devising an angle-of-bend apparatus to measure the angle of any anthropometric point from the greatest projection of the buttocks. Angle measurements of the anthropometric points were made while the subject was standing erect and again while at work.

The electromyographic technique used by Joseph (35) measure the amplitude and duration of electric activity generated by muscles under strain. The action current is started from contracting muscle by means of electrodes. It is recorded by an oscillograph.

The techniques used for angles of body bend have been summarized in Table I.

Household Equipment and Available Space

Knowles (40, 41) studied the relationship of posture to fatigue in ironing. When women ironed at the standard height of ironing board, the angle of bend increased more than when they ironed at the preferred height. The fundamental factors for a comfortable working height were the arm, elbow height, abdominal and bust extension. The body height was an insignificant factor.

Bratton (10) analyzed the factors of cost to the body in standing or sitting to work under different pos-
### TABLE I

**TECHNIQUES FOR ANGLES OF BODY BEND, LAND MARKS, AND METHODS OF RECORDING**

<table>
<thead>
<tr>
<th>Type of Measurement</th>
<th>Landmarks on Subject</th>
<th>Angles of Bend</th>
<th>Method of Recording Data</th>
<th>Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indirect</td>
<td>Knowles, E.* (1944) (40)</td>
<td>1. Forehead at hairline</td>
<td>Angle of bend — formed by intersection of lines from forehead to hip and ankle as axis. Angle of bend while working — deviation from upright posture. Exterior angle — formed by lines from forehead to hip and ankle, with fullest projection of hips at axis.</td>
<td>16 mm motion pictures (8 frames per sec.) Angle of bend of image recorded every half sec. Subject photographed in profile.</td>
</tr>
<tr>
<td>Type of Measurement</td>
<td>Landmarks on Subject</td>
<td>Angles of Bend</td>
<td>Method of Recording Data</td>
<td>Sample Size</td>
</tr>
<tr>
<td>---------------------</td>
<td>----------------------</td>
<td>----------------</td>
<td>--------------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>Mize et al. (1956) (47)</td>
<td>1. Temple toward camera 2. Extreme posterior bulge 3. Ankle point toward camera</td>
<td>Same as Knowles</td>
<td>Motion pictures (1 frame 30 sec.) Single frame button hand operated.</td>
<td>1</td>
</tr>
<tr>
<td>Keiser, M.B. (1957) (58)</td>
<td>1. Fullest posterior protubrence below waist 2. Acromion 3. Medial and lateral malleolus</td>
<td>Angle of bend</td>
<td>16 mm motion pictures (8 frames per second). Used two synchronized cameras.</td>
<td>2</td>
</tr>
<tr>
<td>Type of Measurement</td>
<td>Landmarks on Subject</td>
<td>Angles of Bend</td>
<td>Method of Recording Data</td>
<td>Sample Size</td>
</tr>
<tr>
<td>---------------------</td>
<td>----------------------</td>
<td>----------------</td>
<td>--------------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>3. Hair line</td>
<td>Stooping angle formed by lines from fullest part of the hips, knee, and ankle. With knee as the axis. Motion of arms by addition of two angles: for upper arm by measurement of the angle formed by a line drawn perpendicular to the floor from the shoulder to the elbow; for the lower arm a line is drawn perpendicular to the floor from the shoulder and another from the shoulder to the arm and center of of the lower arm.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Ankle</td>
<td>Same as Keiser (1957)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Bratton, E.C. 1. Outermost point of lift—under arm 16 mm motion pictures (1 frame) N.A.
<table>
<thead>
<tr>
<th>Type of Measurement</th>
<th>Landmarks on Subject</th>
<th>Angles of Bend</th>
<th>Method of Recording Data</th>
<th>Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>acromion</td>
<td>1. Ear lobe</td>
<td>Angles of body and head bends and distances of lateral reaches were measured from the center of gravity line of the body, represented by a vertical line through the greater trochanter, vertical</td>
<td>16 mm motion pictures (1 frame per second). Subject photographed in profile.</td>
<td>4</td>
</tr>
<tr>
<td>2. Line from just beneath armpit to waistline, placed perpendicular to floor.</td>
<td>2. Acromion process</td>
<td>Angle of upper arm lift (under-arm perpendicular line to shoulder mark to elbow joint).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Protrusion of elbow joint on outside of arm.</td>
<td>3. Greater trochanter</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Front of malleolus at ankle</td>
<td>5. Front of malleolus at ankle</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Grady, E.R. (1965) (23)
<table>
<thead>
<tr>
<th>Type of Measurement</th>
<th>Landmarks on Subject</th>
<th>Angles of Bend</th>
<th>Method of Recording Data</th>
<th>Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>reaches from the floor using fixed equipment and body markings as guides.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electromyograph Joseph (1964) (35)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No angle measurements. Measure amplitude and duration of electric impulses generated by muscles in action.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Action current led off from contracting muscle by means of electrodes. Recorded by oscillograph.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monroe, M-M. 1. Ankle</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Randall, S.W. 2. Sacrum and H.D. 3. Shoulder blade</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bartlett. 4. Seventh cervical 5. Forehead 6. Chin</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>From the projection of buttocks to ankle sacrum, shoulder blade, seventh cervical, forehead and chin.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Angle of bend apparatus</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of Measurement</td>
<td>Landmarks on Subject</td>
<td>Angles of Bend</td>
<td>Method of Recording Data</td>
<td>Sample Size</td>
</tr>
<tr>
<td>---------------------</td>
<td>----------------------</td>
<td>----------------</td>
<td>--------------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>Direct and Indirect</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Sternal notch</td>
<td>a) angle of head tilt</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Lower palpebra for the Frankfort plane</td>
<td>b) angle of head thrust</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gray et al. (1965) (24)</td>
<td>Same as above</td>
<td>Same as above</td>
<td>Same as above</td>
<td>14</td>
</tr>
<tr>
<td>Wright, S.R. (1965) (63)</td>
<td>1. Temple</td>
<td>Angles of back bend: acromion, lateral malleolus, and trochanter; trochanter formed the axis.</td>
<td>Still pictures. Every tenth picture was measured for angles. The Leigh-ten flexometer for back bend.</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>2. Acromion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Greater trochanter</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Lateral malleolus</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Seventh cervical</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>temple, sternal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of Landmarks on Measurement</td>
<td>Subject</td>
<td>Angles of Bend</td>
<td>Method of Recording Data</td>
<td>Sample Size</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>---------</td>
<td>----------------</td>
<td>--------------------------</td>
<td>-------------</td>
</tr>
</tbody>
</table>

tural conditions. The finding was that the mean angle of arm lift was affected by the sitting or standing positions; the angle at sitting position was almost double that of standing to work.

Steidl (58) examined heights preferred by women for the separate electric oven. The height of the elbow revealed a more consistent relationship to the preferred oven height than any other body dimension.

Wright (63) measured the angles of body bend for loading front opening dishwashers. She found that the degree of neck bend was not significantly different for the two dishwashers. Relationships were found between angles of slump and loading the front opening dishwasher and also between back bends and loading the top opening dishwasher. Both neck bend and back bend were significantly affected by loading the upper or lower racks; neck bend was greater for the upper rack than for the lower rack, and back bend was greater for the lower rack than for the upper rack.

Grady (23) studied the effect of space arrangements for use and storage of portable appliances on the body motions of the worker. The appliances used were oven, fry pan and sauce pan. She concluded that for all these appliances storage below counter level was more favorable for body mechanics than was storage above counter.
Mize et al. (47) found that the use of storage space above counter height was more comfortable for the worker than was the space below counter height. However, this again depends upon the size of the appliance and other equipment being stored. Authors pointed that all of the bends to use the oven of the wood stove were greater than the comfortable angle of bend, and the bends required to reach containers for the refrigerator were also in the comfortable range of angles.

Heart Rate

A number of studies (13, 37) have been conducted to determine the physiological effects of muscular work of various intensities. When a position is changed from a "resting level" to a "working level" physiological response such as heart rate, blood pressure, cardiac output, pulmonary ventilation, oxygen consumption, carbon dioxide production, chemical composition of the blood and urine are modified by muscular activity.

Factors Influencing the Heart Rate

A large number of individual and environmental factors affect the heart rate. These individual and
environmental factors include:

<table>
<thead>
<tr>
<th>Individual</th>
<th>Environmental</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (13)</td>
<td>Anxiety (18, 27)</td>
</tr>
<tr>
<td>Sex (13)</td>
<td>Static and</td>
</tr>
<tr>
<td>Weight (1)</td>
<td>Dynamic Work (3, 4, 5, 6, 26, 36, 42, 49, 57, 62)</td>
</tr>
<tr>
<td>Physical Fitness (19)</td>
<td></td>
</tr>
<tr>
<td>Posture (37)</td>
<td></td>
</tr>
</tbody>
</table>

**Individual Factors**

**Age.** Physiological, not chronological, age influences the capacity for muscular work. Brouha (13) reported that after 25 to 30 years of age, maximum oxygen consumption decreases progressively, along with decreases in cardiovascular and respiratory capacity. It was further stated that although maximum performances of youth are not possible in later life, reactions to work depend more on the physical fitness of a person than on age.

**Sex.** Brouha (13) indicated that heart rate during and after muscular work was influenced by sex. He found that in some of his experiments involving light work on a bicycle ergometer, women's heart rates were higher than men's during work, although their recovery patterns were about the same. In both sexes, the maximum increase in heart rate with the increase in work load followed a
straight line, but the point of exhaustion was reached at a lower work load for women than for men.

**Weight.** Studies with respect to heart rate and weight show that although circulating blood volume and cardiac output are increased in obese subjects, the resting heart rate is normal or slightly slow. Adolph reported that "... much of the increase in cardiac output was expended in perfusing fatty tissue, perhaps to the disadvantage of resting muscle mass." (1:7)

**Physical Fitness.** Edholm (19) defined physical fitness as the relationship between the performance of the individual in a particular activity and the maximum capacity to produce. Simple physical fitness tests are made in which the heart rate is measured because of the close relationship between the amount of work and the heart rate for any individual. Furthermore, when work is stopped, the time taken for the rate to return to the resting level is also a valuable indication of the state of physical fitness. The greater the fitness the shorter the time for the heart to return to the resting rate.

One of the problems in measurement as cited by Brouha (13) is that physical measurement varies from hour to hour. Brouha summarized the relationship between
heart rate and fitness as follows:

For maximal work, the fit and unfit will reach their maximum heart rate, but the fit subject will be able to perform more work before he reaches that level than the unfit. This is because physical fitness depends to a great extent on the circulatory capacity that is closely related to pulse capacity. (13:183)

**Posture.** The effect of varying postures on the heart output has been studied. These studies indicated that heart putput is greatest in recumbency, less in sitting, and the least in standing position. Karpovich (37) indicated the main reason for this is the variation in the amount of returned blood to the heart. During sitting, the blood may pool in the lower legs and at the bottom of hips depending on the sitting position. During standing, the blood flows against gravity; therefore, less blood returns to the heart than during recumbency.

Asmussen et al. examined the influence of body position on the heart rate. The task consisted of extending the arms 15 times per minute against the elastic resistance provided by rubber tubing. The work was performed from the supine position and with the body tilted to a position of 60 degrees. The heart rate in the 60
degree position was higher than the supine both at rest and during the performance of task with arms. The authors stated that this difference is due to hydrostatic blood pooling (5:47).

Environmental Factors

Anxiety. Harleston et al. conducted a study to identify the physiological correlative evidence of test anxiety in a problem-solving situation. When low-anxious medium-anxious, and high-anxious subjects attempted to solve anagrams during the experiment, pulse and heart rates were recorded. The principal findings were that high-anxious subjects produced significantly large increases in heart rate with the onset of problem solving. It was tentatively concluded that the physiological correlative index was sensitive to both anxiety level and the task situation (27:551).

Dickerscheid (18) reported some fluctuations in the mother's heart rate when the child was present in the mother's physical environment. These fluctuations were statistically significant.

Dynamic and Static Work. Studies have been conducted to differentiate the effect of dynamic work from static work on blood circulation, and therefore, on
heart rate. However, it is very difficult to separate dynamic work from static work completely.

Sustained muscular contractions have the tendency to restrict venous blood flow and may contribute to unnecessary fatigue. Atzler gave as one of the general rules for use of the body in work: "...positively exclude static work because in muscles at static work blood circulation is reduced" (7:12).

Snorrason (57) emphasized that for appropriate work conditions "there must be avoidance of static work with the resulting circulatory disturbances, and cases of degeneration in muscles, ligaments, and joints." (57:12).

Muller (49) found that even light static work in the form of holding a weight reduced the blood circulation. Barcroft and Miller (8) reported that a continuous isometric contraction of muscles would slow the blood flow. However, it cannot be concluded that static work automatically leads to a reduction in venous return. White and Moore studied a group of subjects who extended and supported their legs in a horizontal position while sitting in a chair which was tilted slightly backward. They found that subjects subconsciously raise their mean intrathoracic pressure through a contraction of the
laryngeal passage and an increase in the respiratory action of the thorax which resulted in a large increase in the venous pressure. It was concluded that the skeletal muscle pumping action could not be the only factor for increasing venous return during exercise (62:647).

The heart rate is expected to be higher in static work than in dynamic work because of the comparatively small volume of blood circulating in the body. Hansen and Maggio found that the addition of static arm work to an ongoing dynamic leg work produced an increase in heart rate which was significantly larger for the observed energy expenditure rate increase than would have been expected from the relationship between heart rate and rate of energy expenditure for dynamic work (26:13).

Knox studied the effect of arm and leg work components on the heart rate in a combination of both dynamic and static work. The seated subjects stretched a spring to a load of 7.5 kilograms simultaneously with each arm. The dynamic work component of flexing and extending the arms and the static component were examined separately. The effect of two components on the heart appeared to be additive (42:41).
Hansen and Magio (26) also investigated the effect of combination of static and dynamic work. It was concluded that there was a large increase in the heart rate when the static component was added. The authors suggested that this could be due to nervous regulation of the heart rate initiated by an unknown stimulus.

Asmussen and Christensen studied the effect of peripheral blood distribution on the pulse rate during arm work. The task was hand cranking while sitting. The two conditions examined were: first with passive legs, and in the second the upper thighs were cuffed to arrest blood pooling in the legs. The ergometer was cranked at a series of equal loads under both conditions. The results indicated that the heart averaged about 10 beats per minute less when the legs were cuffed (5:48).

Asmussen and Hemmingsen made comparison between the heart rates during arm work and leg work. The subject walked on a treadmill for the leg work and drove a hand cranked tricycle on an inclined treadmill for the arm work. The authors suggested that the venous pump capacity of the arms was less than that of the legs (4:70).
The relationship between energy expenditure and the heart rate was studied by Asmussen (4) and Andrews (3). Asmussen et al. reported that at a given expenditure rate the heart rate is significantly higher in static arm work than in dynamic leg work (4:70). However, he did not make a comparison between the effects of arm work and a combination of arm and leg work.

Andrews (3) studied the relationship between the energy expenditure rate and the heart rate for the limb or limbs involved and kind of work, i.e., dynamic, static, or a combination of static and dynamic. He did not find a significant relationship between the energy expenditure and heart rate during the static arm work and the dynamic arm work.

Task. The effect of the task of ironing on the heart was studied by Dickerscheid (18) and Richardson (55). Dickerscheid found the task of ironing in a laboratory setting as the major source of variation in the mother's heart after accounting for the variations due to methodology, i.e., subject visit and order of conditions. Task level and interaction of child at task were statistically significant sources of variation in the mother's heart rate at 0.01 and 0.05 percent levels respectively (18:92). In contrast to the
study made by Dickerscheid, Richardson found no significant variation in heart rate which could be associated with the task of ironing (55:89).

**Work Surface Heights.** The relationships between heart rate and the various working heights were studied by Knowles (40) and Torney (61). Knowles studied posture as related to the height of the ironing board; she reported that while ironing at the preferred height, the heart rate was 28 to 30 per cent lower than that at the standard height. The percentage decrease appeared high; it represented an average rate of from 4 to 8 beats per minute more at the lower board height, which over a period of three hours represented considerably more heart action than at the higher board of preferred height.

Torney (61) studied heart rate as a measure of work cost of reaching selected shelf heights. She found that with a shelf at a shoulder height the work cost of lifting one pound decreased progressively until the point of normal downward reach. Work cost increased slightly at the next lower shelf but the lowest shelves were the most costly since the torso had to be lowered to reach them. The work cost for the shelves above the shoulders was also high.
SUMMARY

The standing position increases the lordotic curve of the backbone and puts pressure on the posterior quadrant of the vertebra which leads to disc degeneration. The squatting position relaxes this pressure; therefore, there are less chances of disc degeneration. The squatting position exerts pressure on the muscles at the back of the leg, and also on the nerves passing through these muscles; therefore, it interferes with the blood circulation and may lead to degeneration of muscles.

Head tilt activates the sternomastoid muscle while the upper trapezius muscle is active during the head thrust which is usually the comfortable position of the head.

Recognizing the limitations and comforts of the body, the researchers have applied the technique of angles of body bend for developing the design of work surface heights, storage facilities in the kitchen, and equipment. These studies have also contributed to the arrangement of equipment in the kitchens so that the comfortable body positions are managed during work.
The effect of individual as well as the environmental factors on heart rate is reviewed. The individual factors are age, sex, weight, physical fitness, and posture, while the environmental factors are anxiety, static and dynamic work, task and work surface heights.

Physiological age is more important than chronological age in affecting the heart rate. Women had slightly higher heart rate than men with the same amount of work. The circulating blood volume and cardiac output increased in obese subjects. The heart rate of a physically fit individual increases slowly with the increase in work.

Both static and dynamic work tend to lead to an increase in venous return. In dynamic work this is achieved primarily through the pumping action of the muscles and in static work, through an increase in intrathoracic pressure.

The heart rate has been shown to be higher for arm work than for leg work at a given energy expenditure rate. The difference appears to be due partially to hydrostatic effect, i.e., when arm work is performed in the normal sitting or standing position. There is some pooling of blood in the lower extremities due to gravity. Pooling of blood in the legs has the effect of reducing the volume of blood in circulation; hence, the heart rate
is increased.

The hydrostatic effect also contributes to the difference in heart rate between arm work and leg work. The legs possess a greater venous pumping capacity than the arms, which results in a larger stroke volume and lower heart rate for leg work at a given energy expenditure than for arm work.
CHAPTER III

OBJECTIVE AND HYPOTHESES

Objectives

The basic objective of this study was to investigate the physical cost of chapati-making through the physiological responses of subjects. The measures used for quantifying the physical cost were angles of body bend and heart rate.

Specific objectives were:
1. To devise a technique to take the anthropometrical measurements at the squatting position.
2. To devise a technique to measure head tilt and thrust, trunk, and upper back bends.
3. To collect the data for describing the subjects and their body positions while making chapaties.
4. To determine the factors which affect the heart rate.
5. To determine the relationship among angles of body bend.
6. To determine the factors which affect the angles of body bend.

42
7. To determine the relationship between heart rate and angles of body bend.

Assumptions

Certain assumptions were made to conduct the study:

1. Heart rate is a sensitive indicator of the physiological cost of work.
2. The degree of angles of body bend describe the position of the body.

Hypotheses

Heart rate

1. Body positions at various stages of the task do not account for variance in heart rate.
2. Heart rate does not differ between normal
sitting position and at various stages of the task.
   a. Ball-making
   b. Rolling
   c. Puffing

3. Angles of body bend do not account for variance in heart rate.
   a. Upper back
   b. Head tilt and thrust
   c. Armpit
   d. Elbow
   e. Trunk
   f. Knee
   g. Ankle

**Angles of Body Bend**


5. Angles of body bend do not differ between normal sitting position and at different stages of the task.
   a. Upper back
   b. Head tilt and thrust
   c. Armpit
   d. Elbow
   e. Trunk
Relationship among Angle of Body Bend

6. There are no relationships among angles of body bend.

   a. Upper back bend and other angles
   b. Head tilt bend and thrust and other angles
   c. Armpit bend and other angles
   d. Elbow bend and other angles
   e. Trunk bend and other angles
   f. Knee bend and other angles
   g. Ankle bend and other angles
This study was designed to study the effect of chapati-making on Indian women. The task of making chapatis was selected because of the long period of time required to sit in the same working position and frequency of its performance.

The kitchen unit with features similar to Indian kitchens was set in the laboratory. A three-inch high stool was placed against the wall. The equipment was imported from Rajasthan, India, and was arranged with the stool as the focal point, the stove to the right, rolling board in front, and dough plate in front but to the left side. Generally, the homemaker adjusts the distance of each piece of equipment from her sitting position to make the working position comfortable. In this study, the distance of each piece of equipment from the middle of the front side of the stool was based on the average figures derived from a related pilot study.\(^1\)

\(^1\)Dr. Francille Maloch measured the distance of equipment from the middle of the front edge of the stool for ten homemakers in a village of Rajasthan, India, in November, 1969. The average distance for each of equipment from the stool was calculated.
Heart rate and angles of body bend were used as measures of physiological response to the work. Telemetered samplings of heart rate were recorded, and two pictures were taken simultaneously at the selected steps of the task. The descriptive data were collected for cardiovascular fitness test, anthropometrical measurements, psychological attitudes, and demographic information.

Cardiovascular fitness test measured the capacity of an individual to perform work. Anthropometrical measurements were taken at the standing, sitting, and squatting positions to compare the structural dimensions between subjects. Attitudes toward task, equipment and supplies, bodily feelings, social and psychological environment, and the product were determined. The demographic background about the subject included place of residence, age, education, and experience of work at the ground level.

Sample

A list of all married women who are citizens of India and whose husbands were currently enrolled at Ohio State University was made. These families came from the Punjab and Rajasthan states of India. The status of residency of these women who participated
in this study was established on the basis of the employment of their husbands rather than on the basis of their place of birth.

The homemakers were contacted by telephone; the purpose of the study was explained to them, and they were asked about their experience with chapati-making at ground level in India. Those who had made chapatties at ground level were visited by the researcher. The laboratory procedure was explained briefly and photographs from previous studies were shown to acquaint them with the laboratory equipment. After the homemaker agreed to participate in the study, she was asked to complete (Form A, Appendix B). Information was sought on availability of transportation to the laboratory, appropriate clothes and shoes, health in general, the use of oral contraceptives, and the time for the menstrual period. It was made clear that the measurements were not diagnostic. A screening test was conducted in the laboratory to find out the heart pattern.

The criteria set for selecting the homemakers were being a healthy homemaker with a "normal heart pattern," having worked at ground level, being a full-time homemaker, and living with husband. Five subjects were selected for the study.
Laboratory Procedure

For conducting the study, the kitchen unit was arranged in the laboratory against a wall, which is a common procedure in India.

Arrangement of Kitchen Unit

The kitchen arrangement was standardized for making comparison of angles of body bend and heart rate among subjects. The following dimensions from the front middle point of the stool were used:

TABLE 2

DIMENSIONS FOR THE ARRANGEMENT OF KITCHEN UNIT

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Side</th>
<th>Distance (cms.)</th>
<th>Angle from front middle of stool (degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stove</td>
<td>Right</td>
<td>34.3</td>
<td>180</td>
</tr>
<tr>
<td>Rolling Board</td>
<td>Front</td>
<td>36.7</td>
<td>88</td>
</tr>
<tr>
<td>Dough Plate</td>
<td>Left</td>
<td>47.5</td>
<td>45</td>
</tr>
<tr>
<td>Plate for chapaties</td>
<td>Left</td>
<td>54.5</td>
<td>180</td>
</tr>
</tbody>
</table>

The distance between the middle point of the front edge of the stool and the scaled frame was 61 cms.
Laboratory Visits

Each of the subjects selected for this study visited the laboratory three times. The second and third visits were for the actual experiments. All the laboratories were held in the morning.

Four homemakers from India participated in a preliminary laboratory in order to standardize the laboratory procedure.

Screening Laboratory

The main purpose of this laboratory was to test the normality of heart beat pattern. The stimulation of the cardiac muscle is accompanied by electrical changes which spread throughout the heart and make it to contract. The main electrical waves are P - Q - R - S - T complex. If these waves are normal in amplitude, duration, and form, and also if there were no extra systoles, the heart pattern is considered normal (56). (Appendix B for definitions). The blood pressure was also recorded.

The height and weight were measured to see if a relatively homogeneous sample by body size could be selected from the women who had the normal heart beat pattern.

Resting Heart Rate. After recording the height, weight,
and blood pressure, the subject was acquainted with the telemetry equipment. Three electrodes were taped to the skin at three places: below the seventh cervical, at the sternal notch and armpit near the seventh rib. The electrodes were connected to the transmitter which was placed in the pocket of a belt which was fastened around the waist of the subject.

For recording the resting heart rate, the subject lay on a bed until a steady heart rhythm was reached. A heart rate was recorded for one minute.

Following the resting heart, the subject was given a test for fitness called the Ohio State University cardiovascular fitness test for women. The purpose of this test was to acquaint the homemakers with the test.

**Preliminary Laboratory**

The procedure outlined for the first and second laboratories was used in four preliminary laboratories with four homemakers from India. The purpose of this laboratory was to test the laboratory procedure, specifically, for the heart rate recordings and the still photographs for the measurement of angles of body bend.

On the basis of these four laboratories, the following improvements for the actual study were made: (1) the procedure of placing landmarks was changed to avoid slippage; (2) the dough recipe for the chapati was tested, and the weight of the ball of dough was standardized for
six balls weighing 50 grams each; (3) three steps of the task were selected—ball-making, rolling, and puffing and the decision was made to record data for the second, fourth, and sixth chapati; and (4) the sitting position was standardized.

First Laboratory

The subject was provided with panty hose and blouse to wear during the experiment. These clothes facilitated the location of anatomical points for attaching the landmarks on the body. This dress also helped in standardizing the effect of clothing for cardiovascular fitness test as well as for the weight of the subject.

Weight Measurement. The weight of the subject was taken with the provided clothes but without shoes. The scales were in pounds and ounces, and the weights were converted into kilograms.

The Ohio State University Cardiovascular Fitness Test for Women. The cardiovascular test for women was an adaptation of the Ohio State University cardiovascular fitness test which was designed for men by Kurucz (44). This test made it possible to measure the capacity of an individual to perform exercise, and it has implications for performance of household work. It was possible to compare different individuals with respect to the levels of fitness or capacity to perform work from the score
received from this test.

In adapting the test for women, Richardson had two changes made in the equipment used with men. The height of the step and of the hand bar were changed to adjust to the size of women, and also the cadence used for the test was decreased. The instructions for the physical fitness test were given to the subject before starting the test were the same as given by Richardson (55:99). For the description of the physical fitness test, and for the instructions to the subject see Appendix B.

The score of the fitness test was the number of the inning in which the subject's heart rate reached 150 beats per minute. The steps for the cardiovascular fitness test are shown in Figure I.

The average height of the sample for this study was about 10 cms. less than the average height of the sample studied by Richardson. Therefore, the height of the steps was reduced proportionately to the average height of the sample. The height used was 32.5 cms. and 42.6 cms.

**Landmarks.** Following the cardiovascular fitness test the landmarks were attached to the subject. The landmarks facilitate the measurement of the position by angles of body bend.

The white round landmarks were located at acromion,
Figure I--Step Device for the Cardiovascular Fitness Test
olecranon, ulnare, patella, lateral malleolus, and at the zygomatic bone between the tragion and lower border of the orbit (Figure II). A hole in the center of the round marks helped in locating the point at the center for accurately measuring the angle.

The seventh cervical vertebra and the sternal notch were marked with lightweight wooden rods attached to a cardboard base having a diameter of 3.8 cms. The rod was marked white at a distance of 2.5 cms. from the base to identify the landmark when the rod was partially obstructed.

The landmark at the greater trochanter was not marked for measuring the trunk bend because of a shift in landmark at the sitting position. Therefore, the point at which the hips touched the stool was used as a reference point for measuring the trunk bend.

For measuring the armpit bend, a straight tape in the middle of the armpit was attached. A systematic procedure was followed for attaching landmarks (Appendix B).

Photographing. In the kitchen unit, on the left side of the subject, a frame was placed which was marked horizontally as well as vertically at a distance of 10 cms. starting with the zero point at the bottom edge. The purpose of this frame was to keep a permanent record of the distances of each piece of equipment from the seated
Figure II.--Locations of Landmarks
position as well as of the dimensions of the subjects, through photographs. Ideally, the subject should sit underneath the frame during the performance of the task so that any proportional reduction in the size of the body as well as in the layout of the kitchen in the photographs, would have the same proportional reduction in the scale of the frame. Since the frame was just wide enough to cover the width of the kitchen unit, and since the subject sitting underneath might experience the feelings of confinement, the frame was placed on the left as near to the subject as possible. The camera was 363.9 cms. from the frame, and the subject was 262.8 cms. from the camera. Proportional reductions in the dimensions of the body, kitchen unit and the scale of the frame could be calculated for checking the accuracy of these measurements.

The distance from the subject and height of the tripod for the 35 mm. Agfaflex camera were kept the same for all subjects. The camera was focused at the middle of the body on the right side of the subject. "Tri-X-Pan" film was used with a shutter speed of 1/15 seconds. The photographs were coded according to laboratory number, subject number, and chapati number by placing a card on the frame before taking the photograph. Two photographs, simultaneous to the heart rate recording, were taken at
the selected steps of the task for each chapati. If the photographs at the step of ball-making was not missed because of its short duration, there were 20 photographs for each subject for each laboratory.

**Collection of Data during the Task.** The subject made six chapatis without interruption during the task; the buttocks were kept against the wall with both knees up. The chapatis were made at normal speed of each subject, and she was instructed not to be overly concerned about the quality of the product.

Heart rate was recorded for 15 seconds or less depending upon the duration of the step of the task. The recording were made at the normal sitting position before starting the task and the second, fourth, and sixth chapatis at the steps of ball making, rolling, and puffing (Figure III).

After the completion of the task, landmarks as well as the electrodes were removed from the body. Check lists regarding the attitudes of the subject toward the task, equipment and supplies, bodily feelings, social and psychological environment, and quality of the product were then completed by the subject. If the subject did not understand the English language, the questions were translated into Hindi language for her.

The attitude score consisted of the actual count of
Figure III—Various Steps of the Task of Chapati-making
all responses indicated by the subject. Each scale had a score ranging from five, indicating the most favorable, to one, indicating the least favorable. The maximum score possible for the total attitudes, attitudes toward the task, equipment and supplies, bodily feelings, social and psychological environment, and the product were 140, 5, 50, 35, 30, 20 respectively (Appendix B).

**Personal Data Sheet.** Upon completion of the attitude scale, the subject was asked to complete the personal data sheet which included information on the period of stay in the United States, place of residence in India, age, date of birth, education, number of years married, family size, work experience at the ground-level, and the frequency of making chapaties (Appendix B).

**Anthropometrical Measurements.** Following completion of personal data forms, the anthropometrical measurements of the subject were taken. Three measurements for every position were taken and an average measurement was calculated for that particular position was computed. Standardized procedures for measuring stature, maximum sitting position, and for other measurements at the erect sitting position were used. A standardized measurement for the squatting position was not available so a procedure was developed from the technique used for men by Alexander et al. (2), as well as consultations with re-
searchers.

Stretch Stature. The subject stood at attention with hanging arms, heels together, and the back in contact with the back board to which was fastened a standard height chart; occiput was in contact with the back board. The line joining the external auditory meatus and the lateral palpebral commissure lies horizontally which made sure that the subject was looking forward. The stature was measured from the vertex to the floor of the board (51:20).

Sitting Height. The subject sat erect; the head was in the Frankfort plane, and feet were resting on a surface adjusted so that the knees were bent at about right angles. With the anthropometer arm touching the scalp, the height from the sitting surface to the vertex of the head was measured (30:139).

Buttock-knee Length. Subject sat erect with feet on a surface adjusted so that the knees were bent at about right angles. The horizontal distance from the rearmost surface of the buttock to the front surface of the knee cap was measured by reducing the anthropometer to the size of the caliper (30:145).

Knee Height, Sitting. The subject sat erect with feet resting on the surface adjusted so that the knees were bent at about right angles. Using the anthropometer,
the distance from the foot rest surface to the level of
the musculature just above the right knee was measured
(30:143).

Arm Reach, Standing. The subject stood erect with
the feet together and the arms hanging straight; the
measurement was taken from the acromion of the right arm
to the third metacarpal of the closed fist of the right
hand.

Squatting Height. The subject sat on the floor
against the wall with the head in Frankfort plane. The
height was measured with the anthropometer from the right
side of the subject until the straight edge of the arm of
the anthropometer touched the vertex of the head.

Normal Squatting Breadth. This dimension was
measured at the maximum breadth from the left leg calf
muscles to the right leg calf muscles. The pointers of
the anthropometer touched the thighs, and the reading was
taken from the left to the right side.

Width between Feet. The width between feet was fixed
at 12.7 cms. on the basis of investigations made in the
practicing laboratory; however, when the subjects were
given the freedom to choose the width between feet to suit
their squatting position, the width varied from 2 cms. to
12.5 cms. The reason for this wide range could be the
shyness on the part of subjects, if this measurement had
been repeated a number of times this wide range of variation might have been reduced.

Width across Feet. The subject sat on the floor with a distance of 12.7 cms. between feet. The measurement was taken from the outside of the left tarsal to the right foot tarsal at the maximum width (Figure IV for squatting measurements).

Second Laboratory

The procedure of the first laboratory was repeated with the exception of the anthropometrical measurements and the administration of the personal data sheet.

Analysis of Data

Recording of Data

After the completion of both the laboratories, the electrocardiogram tapes were read for the number of cycles and time, in order to calculate the heart rate.

For the measurement of angles of body bend, 5 x 7 inch photographs were used. The body line as well as the landmarks were transferred from the photographs on the tracing paper in order to measure the angles.

The position of arms at the normal seated position on the low stool varied considerably among the subjects (Figure V). Therefore, the angles of body bend at the
Figure IV—Squatting Dimensions

Height

Squatting Breadth

Distance Across Feet

Figure IV—Squatting Dimensions
A. Normal Sitting

B. Normal Sitting

Figure V—Angles of Body Bend for Two Types of Normal Sitting Positions on the Low Stool

An - Ankle
K - Knee
T - Trunk
E - Elbow
B - Upper back
H - Head Tilt and Thrust
Ar - Armpit
normal seated were not subtracted from the working position. All angles were measured to the nearest 0.5 degree. It was not possible to locate the landmark at the sternal notch for ball-making and rolling. Therefore, this landmark was not used for measuring the neck bend. The procedure for measuring the angles was:

**Upper Back Bend**

A line parallel to the wall was drawn through the point where the back was tangent to the wall. The point of tangency was connected to the seventh cervical. The zero point of the protractor was placed at the point of tangency to measure the upper back bend.

**Head Tilt Bend**

A line was drawn joining the points between the tragion of the ear and the landmark at the zygomatic bone which was midway between the tragion and the lowest point of the orbit near the zygomatical foramen. The second line joined the points at seventh cervical and at the zygomatic bone. The angle was measured by placing the zero point of the protractor at the point on the zygomatic bone.

**Armpit Bend**

Lines were drawn joining the acromion and the olecranon, and the acromion and the point at the middle of the armpit. The angle was measured by placing the zero point of the protractor at the olecranon.
Elbow Bend

Lines were drawn joining the points between the acromion and the olecranon, and the olecranon and the ulnare. The angle of the elbow bend was measured by placing the zero point of the protractor at the olecranon.

Trunk Bend

A line was drawn joining the point at the patella of the knee and the point at which the hip touched the stool. The line parallel to the wall was the same as was used for measuring the upper back bend. The zero point of the protractor was placed at the intersection of these two lines to measure the trunk bend.

Knee Bend

Lines were drawn joining the points between lateral malleolus and patella of knee, the patella of knee and the point at which the hips touched the stool. The zero point of the protractor was placed at the patella to measure the angle of knee bend.

Ankle Bend

The line was drawn through points at lateral malleolus of ankle and patella to the floor. The second line tangent to the planter was drawn. The zero point of the protractor was placed at the intersection of these two lines to measure the angle of ankle bend.

The procedure for measuring the angles at ball-
making, rolling, and puffing is demonstrated in Figure VI.

A summary of measuring the various angles is given in Table 3.

**TABLE 3**

**LANDMARKS AND VERTEX AS USED FOR VARIOUS ANGLES OF BODY BEND**

<table>
<thead>
<tr>
<th>Angles</th>
<th>Landmarks</th>
<th>Vertex</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Upper back</td>
<td>Seventh cervical, tangency of the back with the wall.</td>
<td>Point of tangency with the wall.</td>
</tr>
<tr>
<td>2. Head Tilt</td>
<td>Seventh cervical, tragion, zygomatic bone</td>
<td>Zygomatic bone</td>
</tr>
<tr>
<td>3. Armpit</td>
<td>Acromion, line below the arm-pit, olecranon</td>
<td>Acromion</td>
</tr>
<tr>
<td>4. Elbow</td>
<td>Acromion, olecranon, ulnare</td>
<td>Olecranon</td>
</tr>
<tr>
<td>5. Trunk</td>
<td>Patella of the knee, point of tangency of hip</td>
<td>The extension of the line where upper back was tangent intersecting with the line from patella</td>
</tr>
<tr>
<td>6. Knee</td>
<td>Lateral malleolus, patella of the knee, and the point of tangency of hip</td>
<td>Patella</td>
</tr>
<tr>
<td>7. Ankle</td>
<td>Lateral malleolus, patella, the line of tangency of the sole of foot</td>
<td>Tangency at the sole of foot</td>
</tr>
</tbody>
</table>
Figure VI—Angles of Body Bend at Three Body Positions while Sitting on Low Stool
Statistical Procedure

Reliability of the Data

The landmarks which could slip to some extent were at the patella and lateral malleolus. The landmark at the patella was placed after dividing the distance between the lower and upper edge of patella by two. The slippage was checked after the task by measuring the distance between both the edges, and locating the central point for landmark as was done before the start of the task. No slippage was found.

The movement at the ankle joint was very slight. The slippage was checked by palpitating the lateral malleolus.

Two electrocardiographic tapes of heart rate recordings were selected randomly from each laboratory for checking. The counts of cycles and the time during which those cycles were recorded were checked. Where disagreement occurred the tapes were again read until the recorder and the person who was checking fully agreed.

The angles of body bend were checked in one of 20 photographs or one photograph for each subject from each laboratory. In the reading taken by using the landmarks at the zygomatic bone, acromion, olecranon and patella as the vertexes, there was a discrepancy of 1 to 2 degrees.
The measurements for upper back bend and trunk bend for which the tangency points for upper back and hip were to be established agreed to a discrepancy level of 2 to 4 degrees.

The averages and standard deviations for demographic variables, anthropometrical measurements, attitudes, and cardiovascular fitness test were also rechecked.

Methods of Analysis

The averages and standard deviations for demographic variables, anthropometrical measurements, attitudes and cardiovascular fitness test were calculated. Four methods were selected for statistical treatment of angles of body bend and heart rate data. These were: least squares analysis of variance (28), multiple correlation, simple correlation, and "t" to test the least significant difference of means (22).

The model used for the experiment to determine the effect of different positions and angles of body bend on the heart rate was:

\[ X_{ijkl} = u + L_i + S_j + P_k + A_e + E_{ijkl} \]

whereas \( X_{ijkl} \) is the total effect on heart rate of \( u \), the population; \( L_i \), the laboratory; \( S_j \), the subject; \( P_k \), the body positions; \( A_e \), the angle, and \( E_{ijkl} \) the random chance effect. The simple coefficient of correlation was calculated among angles of body bend within the
various body positions.

The multiple regression equation was:

\[ Y = a + b_1X_1 + b_2X_2 + b_3X_3 \ldots + b_nX_n \]

This regression equation indicates the relationship between heart rate and angles of body bend: upper back, head tilt and thrust, armpit, elbow, trunk, knee, and ankle bends. The regression coefficients give the change in heart rate due to each angle when the influence of other variables is removed.

The comparison between least squares mean of angles of body bend at the normal sitting position and the other three sitting positions was made. The significance of their difference was tested with the application of "t" test.

The comparison between least squares mean of heart rate at the normal sitting position and the other three sitting positions was made. The significance of their difference was tested through the application of "t" test.
CHAPTER V

ANALYSIS AND INTERPRETATION OF DATA

For the task of chapati-making, angles of body bend and heart rate were employed as measures of physical cost of the task to the worker. Descriptive data were collected on anthropometrical measurements, cardiovascular fitness test, attitudes, and demographic background of subjects.

The analysis and interpretation of the data were presented under four major categories which include descriptive information, factors affecting heart rate, the effect of body positions on angles of body bend, and relationship among angles of body bend.

The data were analysed using a least squares analysis of variance procedure (28). The analyses provided statistics concerning: (1) The effects of body positions on heart rate and angles of body bend, the effects were shown as means of heart rate and angles of body bend for various positions; (2) The effects of body positions and angles of body bend on heart rate, the effects of angles of body bend were expressed as
regression coefficients where the coefficients were the change in heart rate for a unit change of body bend; (3) Simple correlations among angles of body bend within the various body positions were computed with the effects of subject and laboratory absorbed. The simple correlation indicated the relationship between one angle with the other angles of body bend.

In interpreting the results of this study, three main limitations have been recognized. First, the laboratory activity was not a "natural" situation since the position of subjects and the place of each piece of equipment were fixed. Secondly, it was not possible to select the sample randomly. Thirdly, the size of the sample was small.

**Description of Subjects**

The descriptive information for subjects, who participated in this study is given in Table 4. Four subjects were born in Uttar Pradesh State and one was born in Rajasthan. Three of the four subjects, who were born in Uttar Pradesh migrated to Punjab and one of them, to Rajasthan. The Rajasthani subject
### TABLE 4

**DESCRIPTION OF SUBJECTS**

<table>
<thead>
<tr>
<th>Subject of Birth</th>
<th>Place of Residence</th>
<th>Age</th>
<th>Education</th>
<th>Married Stay in U.S.A.</th>
<th>Family Size</th>
<th>Experience of work at ground-level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uttar Pradesh</td>
<td>Punjab</td>
<td>24</td>
<td>8</td>
<td>6</td>
<td>12</td>
<td>2</td>
</tr>
<tr>
<td>Uttar Pradesh</td>
<td>Punjab</td>
<td>25</td>
<td>8</td>
<td>10</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Rajasthan</td>
<td>Rajasthan</td>
<td>33</td>
<td>7</td>
<td>13</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>Uttar Pradesh</td>
<td>Rajasthan</td>
<td>28</td>
<td>16</td>
<td>5</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>Uttar Pradesh</td>
<td>Punjab</td>
<td>24</td>
<td>14</td>
<td>5</td>
<td>12</td>
<td>3</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>26.80</td>
<td>10.60</td>
<td>7.80</td>
<td>9.00</td>
<td>3.60</td>
</tr>
<tr>
<td>S. D.</td>
<td></td>
<td>3.83</td>
<td>4.10</td>
<td>3.56</td>
<td>2.56</td>
<td>1.52</td>
</tr>
</tbody>
</table>
stayed in that state.

The age of the subjects varied from 24 years to 33 years with an average age of 26.8 years and a standard deviation of 3.8. Level of education varied from seven to 16 years of school completed. Length of marriage ranged from five to 13 years, and stay in the United States from six months to 12 months. The family size ranged from no child to four children. The standard deviations for demographic variables were relatively high, indicating a wide variability among the subjects.

The experience of work at ground-level ranged from one year to 11 years. These women made chapatis quite frequently in their home in India.

Anthropometrical Measurements

The anthropometrical measurements at the standing, sitting, and squatting positions were recorded because the variability in anthropometrical measurements could be related to angles of body and heart rate. However, this relationship was not statistically tested because of the small size of the
The averages and standard deviations for these measurements were calculated (Table 5). The standard deviations for the subjects varied more in weight, stature, arm length, and buttock-knee length than in sitting height, knee height, squatting height, and squatting breadth. Studies (9, 17) of anthropometrical measurements for body reaches have been conducted in India, but comparisons with the data from these studies are not made because the complete procedure used in measurements is not known.

Cardiovascular Fitness Test

The cardiovascular fitness test was developed to measure the capacity of a person to perform work, based on the reaction of heart rate to physical exertion. The scores of the cardiovascular fitness test during the first laboratory ranged from eight to 18 innings with one subject having the maximum possible score (Appendix A, Table 13). The average score for entire sample was 12 innings with a standard deviation of 3.9.

During the second laboratory, the range was the same as for the first laboratory; however, the physical fitness score was improved for all but one of these
<table>
<thead>
<tr>
<th>Subject</th>
<th>Standing</th>
<th>Sitting</th>
<th>Squatting</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Weight</td>
<td>Height</td>
<td>Knee-Height</td>
</tr>
<tr>
<td></td>
<td>Kilograms</td>
<td>Centimeters</td>
<td>Centimeters</td>
</tr>
<tr>
<td>1</td>
<td>37.40</td>
<td>149.00</td>
<td>54.40</td>
</tr>
<tr>
<td>2</td>
<td>46.40</td>
<td>151.80</td>
<td>58.30</td>
</tr>
<tr>
<td>3</td>
<td>51.90</td>
<td>155.30</td>
<td>61.20</td>
</tr>
<tr>
<td>4</td>
<td>42.80</td>
<td>146.50</td>
<td>57.70</td>
</tr>
<tr>
<td>5</td>
<td>53.00</td>
<td>159.60</td>
<td>63.20</td>
</tr>
<tr>
<td>Mean</td>
<td>46.30</td>
<td>152.40</td>
<td>59.00</td>
</tr>
<tr>
<td>S.D.</td>
<td>6.47</td>
<td>5.17</td>
<td>3.39</td>
</tr>
</tbody>
</table>
subjects. This change could be due to decrease in apprehension about the test as well as getting accustomed to the laboratory conditions. The average score on the second trial was 15.4 innings with a standard deviation of 4.3 (Appendix A, Table 13). The high average score indicated high cardiovascular fitness and therefore high capacity to perform work.

Attitudes

The subject's attitudes towards task, equipment and supplies, bodily feelings indicating pain or no pain, social and psychological environment, and the product were investigated.

The scores of attitudes were higher for the second laboratory than for the first laboratory (Appendix A, Table 14). The task of making chapaties was liked by all the subjects.

There were no complaints about feelings of body pain with the exception of one subject who had the lowest score in the sample. The average scores for attitudes for the first and second laboratory were similar but the standard deviation changed from 2.61 in the first laboratory to 0.17 for the second laboratory indicating that
variability in the bodily feeling as reported by subjects was less during the second laboratory than during the first laboratory.

The average score for social and psychological environment for both the laboratories was about the same but the range of scores was from 25 to 28 during the first laboratory and from 23 to 30 during the second laboratory. The standard deviation was 1.30 during the first laboratory and 3.24 for the second laboratory. The variability is partially due to the attitudes of those subjects for whom the laboratory was repeated because of defective film.

The average score for attitudes toward product was about the same for both the laboratories but the standard deviation was lower for the first than for the second laboratory. Again increase in variability could be due to the negative attitudes of those subjects for whom the laboratory was repeated.

Heart Rate

Hypothesis 1. Body positions at different stages of the task do not account for variance in heart rate.

The effects of body positions on heart rates were highly significant; \( F = 8.48, \text{ d.f.} = 3/117 \) even with the absorption of the effects of angles of body bend. When
the effects of angles of body bend were not absorbed, the
F value for body positions was higher, indicating that
some of the effects of body positions can be accounted for
by the differences in angles of body bend.

The least squares mean for heart rate was greater
for the first than for the second laboratory. It would
appear that the subjects were relaxed and better adjusted
to the laboratory conditions during the second laboratory
period. The effect of the laboratory was significant
\( F = 7.82, P < 0.01 \) (Table 6).

The least squares mean of the heart rate for
subjects ranged from 84.0 to 113.3 for all positions
(Appendix A, Table 15). The subjects accounted for
significant variation in heart rate \( F = 32.83, P< 0.01 \)
(Table 6).

The least squares mean for heart rate was higher
for body positions at normal sitting, ball-making, rolling,
and puffing (Table 7) than at recumbency (Appendix A,
Table 12). This finding agreed with the study by Asmussen
et al. (6) who reported that when the same amount of work
was performed from the supine position, and with a body
tilted, the average heart rate was higher at the tilted
body position than at the supine position.

Hypothesis 2a. Heart rate does not differ between the
normal sitting position and ball-making stage in the task.

The subjects were engaged in ball-making stage
TABLE 6
LEAST SQUARE ANALYSIS OF VARIANCE FOR HEART RATE

<table>
<thead>
<tr>
<th>Source of Variance</th>
<th>D.F.</th>
<th>Mean Squares</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laboratory</td>
<td>1</td>
<td>500.14</td>
<td>7.82***</td>
</tr>
<tr>
<td>Subject</td>
<td>4</td>
<td>2099.38</td>
<td>32.83***</td>
</tr>
<tr>
<td>Body positions</td>
<td>3</td>
<td>542.43</td>
<td>8.48***</td>
</tr>
<tr>
<td>Angles</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper back</td>
<td>1</td>
<td>85.99</td>
<td>1.34</td>
</tr>
<tr>
<td>Head tilt and thrust</td>
<td>1</td>
<td>187.14</td>
<td>2.93</td>
</tr>
<tr>
<td>Armpit</td>
<td>1</td>
<td>55.66</td>
<td>0.87</td>
</tr>
<tr>
<td>Elbow</td>
<td>1</td>
<td>21.12</td>
<td>0.33</td>
</tr>
<tr>
<td>Trunk</td>
<td>1</td>
<td>18.78</td>
<td>0.29</td>
</tr>
<tr>
<td>Knee</td>
<td>1</td>
<td>248.48</td>
<td>3.89**</td>
</tr>
<tr>
<td>Ankle</td>
<td>1</td>
<td>269.04</td>
<td>4.07</td>
</tr>
<tr>
<td>Remainder</td>
<td>117</td>
<td>65.95</td>
<td></td>
</tr>
</tbody>
</table>

*** P < 0.01  
** P < 0.05  
* P < 0.051  

TABLE 7
LEAST SQUARES MEANS AND STANDARD ERRORS OF HEART RATE FOR VARIOUS BODY POSITIONS

<table>
<thead>
<tr>
<th>Positions</th>
<th>Mean</th>
<th>S. E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal Sitting</td>
<td>86.3a</td>
<td>2.0</td>
</tr>
<tr>
<td>Ball-Making</td>
<td>103.0b</td>
<td>1.4</td>
</tr>
<tr>
<td>Rolling</td>
<td>103.7b</td>
<td>1.3</td>
</tr>
<tr>
<td>Puffing</td>
<td>96.5b</td>
<td>1.3</td>
</tr>
</tbody>
</table>

b Significantly different from a (t < 0.001).
for 6 to 7 seconds. Arm and hand movements are involved in ball-making. The mean of heart rate increased from normal sitting position from about 86 beats per minute to 104 beats per minute while ball-making. This difference in heart rate at the two positions was highly significant \((t < 0.001)\) (Table 7), indicating that although ball-making in the task of chapati-making is light work, it affects the heart rate considerably in this working position. The null hypothesis was rejected.

Hypothesis 2b. Heart rate does not differ between the normal sitting position and rolling stage in the task.

The duration of the step of rolling in the task of chapati-making was longer than that for ball-making and puffing. It involved movement of the arms and hands with the subject leaning forward. The movement of the hands was forward and backward on the rolling board. The mean for heart rate increased slightly from the ball-making step of the task, however, the difference in mean heart rate at rolling from the mean heart rate at normal sitting position was highly significant \((t < 0.001)\) (Table 7), meaning that even light work in this
position leads to significant increase in heart rate. The null hypothesis was rejected.

**Hypothesis 2c.** Heart rate does not differ between the normal sitting position and puffing stage in the task.

The puffing stage of the task was maintained from 10 to 13 seconds. During this position, the right arm was bent backward, putting pressure on the chapati, while the head was tilted to the right side. The trapezius muscle of the back and deltoideus muscle of the upper arm were in partial static contraction for most of the time. With the head held in tilted position, the left sternocleidomastoideus muscle would be stretched. The heart rate was about 97 beats per minute compared to 104 beats at rolling, and it was highly significantly different from the normal sitting position ($t < 0.001$), thus the null hypothesis was rejected.

**Hypothesis 3.** Angles of body bend do not account for variance in heart rate.

The effect of angles of body bend on heart rate was investigated by removing the effects of laboratories, subjects, and body positions through the least squares analysis of variance. Angles of body bend in this study included upper back bend, head tilt, and thrust, armpit, elbow, trunk, knee, and ankle angles.
Hypothesis 3a. The upper back bend does not account for variance in heart rate.

The $F$ value for heart rate for upper bend was not significant (Table 6). The null hypothesis was accepted.

The regression coefficient for upper back bend was $+0.194$ (Table 8), indicating that a 2 percent increase in upper back bend was associated with about 10 per cent increase in heart rate when the effect of other variables was removed. The compression of abdominal organs decreases the flow of blood between heart and these organs. The small amount of available blood leads to decrease in heart output increase in heart rate.

TABLE 8

<table>
<thead>
<tr>
<th>Angles</th>
<th>b</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper back</td>
<td>$+0.194$</td>
</tr>
<tr>
<td>Head tilt and Thrust</td>
<td>$+0.219$</td>
</tr>
<tr>
<td>Armpit</td>
<td>$-0.076$</td>
</tr>
<tr>
<td>Elbow</td>
<td>$+0.026$</td>
</tr>
<tr>
<td>Trunk</td>
<td>$+0.175$</td>
</tr>
<tr>
<td>Knee</td>
<td>$-0.639$</td>
</tr>
<tr>
<td>Ankle</td>
<td>$+0.413$</td>
</tr>
</tbody>
</table>

Hypothesis 3b. The head tilt and thrust bend does not account for variance in heart rate.
The head tilt and thrust bend was not a significant source of variation in heart rate (Table 6), thus the null hypothesis was accepted.

The regression coefficient for head tilt and thrust was +0.219 (Table 8), meaning that a 2 per cent change in head tilt and thrust was accompanied by a 10 per cent change in heart rate with the effects of body positions removed. The increase in head tilt and thrust bend would decrease the flow of blood toward the heart because of compression of blood vessels in the thorax.

Hypothesis 3c. The armpit bend does not account for variance in heart rate.

The F ratio for heart rate for armpit bend was not significant (Table 6). Therefore, the null hypothesis was accepted.

The regression coefficient for armpit bend was -0.076 (Table 8) which indicated that about 1 per cent increase in armpit bend led to a corresponding 10 per cent decrease in heart rate. The increase in angle of armpit bend would facilitate the flow of blood and decrease the heart rate.

Hypothesis 3d. The elbow bend does not account for variance in heart rate.

The elbow bend did not affect the heart rate significantly (Table 6). Therefore, the null hypothesis was accepted.
The regression coefficient for elbow bend was $+0.026$ (Table 8), meaning that after excluding the effects of body positions, about 0.3 per cent increase in elbow bend was associated with a corresponding increase of 10 per cent in heart rate.

Hypothesis 3e. Trunk bend does not account for variance in heart rate.

Trunk bend was not a significant source of variation in heart rate (Table 6). The null hypothesis that trunk bend does not account in heart rate was accepted.

The regression coefficient for trunk bend was $+0.175$ (Table 8), indicating that with an increase of 2 per cent in trunk bend there was a 10 per cent increase in heart rate when the effect of body positions removed. During the trunk bend, the pressure was on abdominal and pelvic organs. When the return of venous blood is slow, the heart output per stroke decreases, therefore, the heart rate increases. Barcroft (8) and Muller (49) reported that the continuous isometric contraction of muscles would slow the flow of blood.

Hypothesis 3f. Knee bend does not account for variance in heart rate

The F value for knee bend was significant at 0.051 per cent (Table 6). The null hypothesis was partially rejected.

The regression coefficient for knee bend was
-0.639 (Table 8), showing that after the effect of positions was absorbed, a 6 per cent increase in knee bend was associated with a corresponding 10 per cent decrease in heart rate. The increase in knee bend reduces the pressure on calf muscles of the lower legs as well as on the visceral organs. This position increased the returned blood which led to the increase in heart output, therefore, decrease in heart rate.

Hypothesis 3g. Ankle bend does not account for variance in heart rate.

The F value for heart rate for ankle bend was significant (P < 0.05) (Table 6). Thus the null hypothesis was rejected.

The regression coefficient for ankle bend was +0.413 (Table 8), meaning that a relative increase of 4 per cent in ankle bend led to a corresponding relative increase of 10 per cent in heart rate after the removal of the effects of body positions.

The increase in ankle bend, assuming that the positions of trunk and foot remain the same, would increase the pressure on calf muscles. When muscles are under pressure, comparatively less amount of blood is returned to the heart, and the heart output is decreased, therefore, the heart rate increased.
Angles of Body Bend

Hypothesis 4. Body positions at different stages of the task do not account for variance in head tilt, and thrust, upper back, armpit, elbow, trunk, knee, and ankle angles.

The effects of body positions at the various stages of the task were determined by least squares analysis of variance (absorbing laboratories and subjects). The angles of body bend include upper back, head tilt, and thrust, armpit, elbow, trunk, knee, and ankle. The body positions were highly significant in influencing all the angles of body bend with the exception of knee bend (Table 9).

Hypothesis 5a. Upper back bend does not differ between the normal sitting position and stages of the task.

The least squares mean for angle of upper back bend ranged from 35.3 degrees at the normal sitting position to 42.4 degrees for the rolling position. The angle of upper back bend was highly significantly different at the ball-making and rolling positions (t < 0.01) and (t < 0.001) respectively (Table 10). Thus the null hypothesis was rejected for ball-making and rolling positions, but was accepted for puffing position only.

Hypothesis 5b. The head tilt and thrust bend does not differ between normal sitting position and stages of the task.

The least squares means for the angle of head tilt and thrust bend ranged from about 34 degrees for
### TABLE 9
LEAST SQUARES ANALYSIS OF VARIANCE FOR ANGLES OF BODY BEND

<table>
<thead>
<tr>
<th>Source of Variance</th>
<th>Upper Back</th>
<th>Head Tilt and Thrust</th>
<th>Armpit</th>
<th>Elbow</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>D.F.</td>
<td>Mean Squares</td>
<td>F</td>
<td>Mean Squares</td>
</tr>
<tr>
<td>Laboratory</td>
<td>1</td>
<td>5.71</td>
<td>0.27</td>
<td>276.94</td>
</tr>
<tr>
<td>Subject</td>
<td>4</td>
<td>72.57</td>
<td>3.46***</td>
<td>390.03</td>
</tr>
<tr>
<td>Body Positions</td>
<td>3</td>
<td>253.58</td>
<td>12.08***</td>
<td>4251.27</td>
</tr>
<tr>
<td>Remainder</td>
<td>124</td>
<td>21.00</td>
<td></td>
<td>34.98</td>
</tr>
</tbody>
</table>

(Cont.)

<table>
<thead>
<tr>
<th>Source of Variance</th>
<th>Trunk</th>
<th>Knee</th>
<th>Ankle</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>D.F.</td>
<td>Mean Squares</td>
<td>F</td>
</tr>
<tr>
<td>Laboratory</td>
<td>1</td>
<td>0.02</td>
<td>0.00***</td>
</tr>
<tr>
<td>Subject</td>
<td>4</td>
<td>94.74</td>
<td>14.12***</td>
</tr>
<tr>
<td>Body Positions</td>
<td>3</td>
<td>48.27</td>
<td>7.19***</td>
</tr>
<tr>
<td>Remainder</td>
<td>124</td>
<td>6.71</td>
<td></td>
</tr>
</tbody>
</table>

***P < 0.01  **P < 0.05
## TABLE 10

**LEAST SQUARES MEANS AND STANDARD ERRORS OF VARIOUS ANGLES OF BODY BEND AT NORMAL, SITTING, BALL-MAKING, ROLLING, AND PUFFING POSITIONS**

<table>
<thead>
<tr>
<th>Positions</th>
<th>Upper Back Mean</th>
<th>S.E.</th>
<th>Head Tilt and Thrust Mean</th>
<th>S.E.</th>
<th>Armpit Mean</th>
<th>S.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal Sitting</td>
<td>35.3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.2</td>
<td>36.8&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.5</td>
<td>30.7&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.2</td>
</tr>
<tr>
<td>Ball-making</td>
<td>39.6&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.8</td>
<td>37.5</td>
<td>1.0</td>
<td>48.4&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.5</td>
</tr>
<tr>
<td>Rolling</td>
<td>42.4&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.7</td>
<td>33.7</td>
<td>1.0</td>
<td>61.0&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.4</td>
</tr>
<tr>
<td>Puffing</td>
<td>37.4&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.7</td>
<td>57.2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.9</td>
<td>19.3&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.4</td>
</tr>
</tbody>
</table>

(Cont.)

<table>
<thead>
<tr>
<th>Positions</th>
<th>Elbow Mean</th>
<th>S.E.</th>
<th>Trunk Mean</th>
<th>S.E.</th>
<th>Knee Mean</th>
<th>S.E.</th>
<th>Ankle Mean</th>
<th>S.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal Sitting</td>
<td>119.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.3</td>
<td>44.7&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.7</td>
<td>33.6&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.7</td>
<td>81.3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.1</td>
</tr>
<tr>
<td>Ball-making</td>
<td>87.2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.0</td>
<td>41.6&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.4</td>
<td>33.2</td>
<td>0.5</td>
<td>85.2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.7</td>
</tr>
<tr>
<td>Rolling</td>
<td>143.7&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.8</td>
<td>42.9&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.4</td>
<td>32.8</td>
<td>0.4</td>
<td>85.2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.7</td>
</tr>
<tr>
<td>Puffing</td>
<td>94.2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.7</td>
<td>41.5&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.4</td>
<td>34.2</td>
<td>0.4</td>
<td>85.8&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.7</td>
</tr>
</tbody>
</table>

<sup>a</sup>Significantly different from<sup>b</sup> (t < 0.001)
<sup>b</sup>Significantly different from<sup>a</sup> (t < 0.01)
the rolling position to about 57 degrees at the puffing position. The puffing position was highly significantly different from normal sitting position (Table 10). Thus the null hypothesis was rejected for puffing position only.

Gray et al. (24) and Jones et al. (34) determined the relationship between head bend, and trunk bend which brought the change in electric potential of sternocleidomastoid and upper trapezius muscles. During the head thrust, the activity was produced in the trapezius muscle which had an implication for the puffing position in this study. The puffing position also involved head tilt to the right side of the body, for which the production of electric activity in the left sternocleidomastoid muscle could be expected.

Hypothesis 5c. The armpit bend does not differ between the normal sitting position and stages of the task.

The least squares means for armpit bend ranged from about 19 degrees for puffing to about 61 degrees for rolling positions. The ascending order for the range for angle of armpit bend for four positions was puffing, normal sitting, ball-making, and rolling. The angle of armpit bend was highly significantly different from normal sitting position for ball-making, rolling, and puffing stages of the task (t < 0.001) (Table 10). There-
Hypothesis 5d. The elbow bend does not differ between normal sitting position and stages of the task. The least squares mean for elbow bend ranged from about 87 degrees for ball-making to about 144 degrees for rolling. The comparatively high standard error for the elbow bend could be due to the wide range of the elbow joint movement required by the various stages of the task. The position at the ball-making, rolling, and puffing were highly significantly different from normal sitting position for the angle of elbow bend \( t < 0.001 \) (Table 10). On the basis of these findings, the null hypothesis was rejected.

Hypothesis 5e. The trunk bend does not differ between the normal sitting position and stages of the task.

The least squares mean for trunk bend for positions ranged from 42 degrees to 45 degrees. Trunk bends for ball-making, and rolling were significantly different from the normal sitting position \( t < 0.01 \) (Table 10). The null hypothesis was partially rejected. Strait et al. (59) reported a considerable low back strain involved in trunk flexion. They emphasized that the power exerted from the spinal extensor muscle should be enough to counteract the weight of the arms, and trunk acting at the center of gravity in the thorax. The exertion of this power resulted in the compression of the lumber intervertebral discs.
However, Fahrni (20, 21) reported that standing posture of the Western world perpetuates the curve of the spine while the squatting position straightens the curve. The standing posture increases the fatigue by putting weight on the tissues of the vertebral column. The tissues soften from the continuous pressure which lead to disc degeneration. The disc degeneration was minimal in the Bhils of Madhya Pradesh who mostly use the squatting position.

Portony and Morin (53) and Carlsoo (15) found that in full trunk flexion the sacrospinales was completely relaxed. The counteraction of gravity was probably taken over by the ligaments of the spinal column. The compressed abdominal and pelvic organs might also offer possible resistance which probably reduced the load on the dorsal muscles.

Hypothesis 5f. The knee angle does not differ between normal sitting position and stages of the task.

The least squares means for knee bend for all positions was similar. The knee bend did not differ between the normal sitting position and of the other stages of the task (Table 10). Therefore, the null hypothesis was accepted.

Hypothesis 5g. The ankle bend does not differ between the normal sitting position and stages of the task.

The least squares means for ankle bend ranged from
81 degrees at the normal seated position to about 86 degrees at the puffing positions. The body positions at ball-making, rolling, and puffing were highly significantly different from normal sitting position ($t < 0.001$) (Table 10). The null hypothesis was rejected.

**Relationship among Angles of Body Bend**

**Hypothesis 6a.** There is no relationship between upper back bend and head tilt and thrust, armpit, elbow, trunk, knee, and ankle angles.

The coefficient of correlations of upper back with angles of elbow and trunk bends were significant at 0.05 and 0.01 levels respectively (Table 11), indicating that an increase in upper back bend was accompanied by an increase in elbow and trunk bends during this task. The correlation of upper back bend to the angles of head tilt and thrust, armpit, knee, and ankle was not significant (Table 11), therefore, the null hypothesis was partially accepted for these relationships, but rejected for the relationships between upper back bend and elbow and trunk bends.

**Hypothesis 6b.** There is no relationship between head tilt and thrust bend and upper back, armpit, elbow, trunk, knee, and ankle angles.

The angle of head tilt and thrust bend was negatively correlated to all the angles of body bend studied
TABLE 11

CORRELATION AMONG ANGLES OF BODY BEND WITHIN THE VARIOUS POSITIONS

<table>
<thead>
<tr>
<th>Angles</th>
<th>Upper back</th>
<th>Head tilt and thrust</th>
<th>Armpit</th>
<th>Elbow</th>
<th>Trunk</th>
<th>Knee</th>
<th>Ankle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper back</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Head Tilt and Thrust</td>
<td>-0.092</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Armpit</td>
<td>0.085</td>
<td>-0.061</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elbow</td>
<td>0.177**</td>
<td>-0.143</td>
<td>0.039</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trunk</td>
<td>0.260***</td>
<td>-0.020</td>
<td>0.059</td>
<td>-0.144</td>
<td>1.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knee</td>
<td>0.092</td>
<td>-0.158</td>
<td>0.125</td>
<td>0.046</td>
<td>0.384</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>Ankle</td>
<td>0.010</td>
<td>-0.282***</td>
<td>0.067</td>
<td>0.207**</td>
<td>0.007</td>
<td>0.501**</td>
<td>1.000</td>
</tr>
</tbody>
</table>

***P < 0.01
**P < 0.05
(Table 11), indicating that an increase in angle of head tilt and thrust bend was associated with the decrease in other angles of body bend. The coefficient of correlation for angle of head tilt and thrust bend was highly significant for ankle bend only (Table 11). The null hypothesis that there is no relationship between head tilt and thrust bend and ankle bend, was rejected, but the null hypothesis that there is no relationship between angle of head tilt and thrust bend and upper back, armpit, elbow, trunk, and knee bends was accepted.

Hypothesis 6c. There is no relationship between armpit bend and upper back, head tilt and thrust, elbow, trunk, knee, and ankle bends.

The relationship of angle of armpit bend to the other angles of body bend was not significant (Table 11), therefore, the null hypothesis was accepted.

Hypothesis 6d. There is no relationship between elbow bend and upper back, head tilt and thrust, armpit, trunk, knee, and ankle angles.

The coefficient of correlation for elbow bend to angle of ankle bend was significant at 5 per cent level and with upper back bend at the 1 per cent level (Table 11) meaning that the increase in elbow bend was related to the increase in upper back and ankle bends in positions for performing of this task at ground-level but not to the other angles of body bend. The null hypothesis that the angle of elbow bend was not related to upper back
and ankle bends was, therefore, rejected. On the other hand, the hypothesis that the elbow bend is not related to head tilt and thrust, armpit, trunk, and knee bends was supported.

Hypothesis 6e. There is no relationship between trunk bend and upper back, head tilt and thrust, armpit, elbow, knee, and ankle angles.

The coefficient of correlation between trunk bend and knee bend was highly significant as was the correlation between trunk bend and upper back bend (Table 11). This finding is relevant to the natural sitting position of the body. The coefficients of correlation between trunk bend and head tilt and thrust, armpit, elbow, and ankle bends were not significant; therefore, the null hypothesis that there is no relationship between trunk bend and other angles of body bend was accepted but for knee bend and upper back bend.

Hypothesis 6f. There is no relationship between knee bend and upper back, head tilt and thrust, armpit, elbow, trunk, and ankle angles.

The coefficients of correlation of knee bend with ankle and trunk bends were highly significant (P < 0.01) (Table 11), which meant that increase in knee bend was accompanied by an increase in trunk and ankle bends. This finding describes the natural relationships among these angles at the sitting position. The relationships
with the other angles of body bend were not significant, therefore, the hypothesis of no relationship between knee bend and trunk and ankle bends was rejected, but was accepted for head tilt and thrust, upper back, armpit, and elbow bends.

**Hypothesis 6g.** There is no relationship between ankle bend and upper back, head tilt and thrust, armpit, elbow, trunk, knee angles.

The coefficients of correlation between ankle bend, and knee, and head tilt and thrust, and elbow bends were highly significant ($P < 0.01$) (Table 11). The coefficients were negative for head tilt thrust bend, but positive for knee and elbow bend, meaning that increase in ankle bend was related to decrease in head tilt and thrust bend, but increase in knee and elbow bend.

The null hypothesis that there is no relationship between ankle bend and head tilt and thrust, knee, and elbow bends was rejected but was accepted for upper back, armpit, and trunk bends.
CHAPTER VI

SUMMARY AND CONCLUSIONS

The basic objective of this study was to investigate the physical cost of chapati-making through the responses of the subjects to the task. The measures employed for measuring the physical cost were angles of body bend and heart rate.

Five women from India participated in this study. All were healthy with a normal heart pattern, had experience of work at ground-level kitchen, and were full-time homemakers living with their husbands in Columbus.

The data were analysed using a least squares analysis of variance procedure. The analyses provided statistics concerning: (1) The effects of body positions on heart rate and angles of body bend, the effects were shown as means of heart rate and angles of body bend for various positions; (2) The effects of body positions and angles of body bend on heart rate, the effects of angles of body bend were expressed as regression coefficients where the coefficients were change in heart rate for a unit change of body bend; (3) Simple correlations among angles of body bend within the various body positions were computed with the effects of subject and laboratory absorbed. The simple correlations were calculated which indicated the relation—
ship between one angle with the other angles of body bend.

**Description of Subjects**

Four of the five subjects were born in Uttar Pradesh and one was born in Rajasthan. The subjects ranged in age from 24 to 33 years; in education, from seven to 16 years of school completed; in length of marriage, from five to 13 years; and the stay in U. S. A. ranged from six to 12 months. The experience of work at ground-level ranged from one to 11 years. Three of the five subjects used the same working position in India as was standardized for the task in the laboratory.

Anthropometrical measurements were taken at the standing, sitting, and squatting positions. The subjects varied more in weight, stature, arm length, and buttock-knee length than in sitting, knee, squatting heights, and squatting breadth.

The score on the cardiovascular fitness test during the second laboratory improved over that from the first laboratory for all subjects with the exception of one. The average score for the second laboratory was 15.4 innings with a S.D. of 4.5; the maximum score is 18 innings.

Attitudes of subjects were ascertained toward task, equipment and supplies, bodily feelings, social and psychological environment, and the product. The score for
attitudes were more positive during the second laboratory than in the first laboratory except for one subject.

**Heart Rate**

Body positions accounted for variation in heart rate highly significantly, therefore, the null hypothesis that the body positions do not account for variance in heart rate was rejected.

Heart rates were highly significantly different at ball-making, rolling, and puffing positions from the normal sitting position. The null hypothesis that the heart rate does not differ between the normal sitting position and the stages in the task of chapati-making was rejected.

The angles of knee and ankle bend were significant in affecting the heart rate. The null hypothesis that knee and ankle angles do not account for variance in heart rate was rejected but was accepted for upper back, head tilt and thrust, armpit, elbow, and trunk angles.

The regression coefficients for upper back, head tilt and thrust, and trunk bends indicated that a 10 per cent increase in heart rate was associated with about 2 per cent increase in angles of upper back, head tilt and thrust, and trunk bends.
The regression coefficients for heart rate and arm-pit and knee bends were negative, indicating that a relative increase in these angles would decrease the heart rate. The regression coefficient for ankle bend showed a 4 per cent increase in ankle bend resulted in a corresponding 10 per cent increase in heart rate.

**Angles of Body Bend**

The body positions affected the angles of body bend significantly with the exception of knee bend. The null hypothesis that body positions do not account for variance in upper back, head tilt and thrust, armpit, elbow, trunk, and ankle bend was rejected but was accepted for knee bend.

All the angles of body bend with the exception of head tilt and thrust, and knee bend differed at the ball making and rolling positions from the normal sitting position. The null hypothesis that upper back, armpit, elbow, trunk, and ankle bend do not differ at ball-making and rolling from the normal sitting position was rejected but was accepted for head tilt and thrust and knee bend at these positions.

At the puffing position of the task all the angles of body bend changed highly significantly from the normal
sitting position with the exception of upper back and knee bends. The null hypothesis that the head tilt and thrust, armpit, elbow, trunk, and ankle angle do not differ significantly from the normal sitting position was rejected but was accepted for upper back and knee angle.

Correlation among Angles of Body Bend

The relationship among angles of body bend described the body positions. The upper back bend was significantly related with elbow and trunk bends. The null hypothesis that upper back bend is not related with head tilt and thrust, armpit, knee, and ankle bend was accepted but was rejected for elbow and trunk bend.

Head tilt and thrust bend was negatively related with all the angles of body bend. This relationship was significant with ankle bend only. The null hypothesis that head tilt and thrust bend is not related with ankle bend was rejected but was accepted for the other angles of body bend.

The angle of armpit was not significantly related with all the angles of body bend, therefore, the null hypothesis that there is no relationship between armpit bend and the other angles of body bend was accepted.

Elbow bend was not significantly related with all
the angles of body bend with the exception of ankle bend and upper back bend. The null hypothesis that there is no relationship between elbow bend and ankle and upper back bend was rejected but was accepted for other angles of body bend.

Trunk bend was significantly related with knee and upper back bend. The null hypothesis that there is no relationship between trunk bend and knee and upper back bend was rejected but was accepted for other angles of body bend.

Knee angle was highly significantly related with ankle and trunk bends. The null hypothesis that there is no relationship between knee angle and trunk and ankle angle was rejected but was accepted for other angles of body bend.

The ankle angle was highly significantly related with knee, elbow, head tilt and thrust angle. The null hypothesis that there is no relationship between ankle angle and knee, elbow, head tilt and thrust angles was rejected but was accepted for other angles of body bend.

**Implications**

The general methodology used in this research has applicability for studying other tasks performed at
ground-level, also for studying work surface heights and storage spaces. Through this procedure, the heights of working surfaces and storage spaces can be established at which the angles of body bend and heart rate are minimum.

Improvement in working conditions in the home to enable minimum physiological cost to the body can increase the working capacity of the individual. These improvements could increase productivity of the worker, and therefore, long range implications are for the economic development of the country.

The significant increase in heart rate from the normal sitting to the ball-making, rolling, and puffing positions and the level of the heart rate imply a somewhat high cost of chapati-making. The physical cost of other tasks performed at similar body positions can be predicted by making comparisons with chapati-making.

**Suggestions for Further Research**

1. The study of chapati-making should be conducted in the home environment, although there will be problems in using telemetering equipment and in photographing.

2. The body positions used by women in their daily work should be studied in addition to further work with standardized body positions.

3. Other physically demanding tasks should be studied.
Appendix A
### TABLE 12

**BLOOD PRESSURE, RESTING HEART RATE AND CARDIOVASCULAR FITNESS SCORE**

<table>
<thead>
<tr>
<th>Subject Number</th>
<th>Blood Pressure</th>
<th>Resting Heart Rate</th>
<th>Innings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>36</td>
<td>73</td>
<td>12</td>
</tr>
<tr>
<td>2</td>
<td>N.A.</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td>3</td>
<td>48</td>
<td>67</td>
<td>15</td>
</tr>
<tr>
<td>4</td>
<td>52</td>
<td>78</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>50</td>
<td>68</td>
<td>9</td>
</tr>
</tbody>
</table>

### TABLE 13

**SCORES OF CARDIOVASCULAR FITNESS TEST FOR FIRST AND SECOND LABORATORY**

<table>
<thead>
<tr>
<th>Subject Number</th>
<th>Laboratory I</th>
<th>Laboratory II</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>13</td>
<td>18</td>
</tr>
<tr>
<td>2</td>
<td>12</td>
<td>15</td>
</tr>
<tr>
<td>3</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>5</td>
<td>9</td>
<td>18</td>
</tr>
<tr>
<td>$\bar{x}$</td>
<td>12.00</td>
<td>15.40</td>
</tr>
<tr>
<td>S. D.</td>
<td>3.94</td>
<td>4.34</td>
</tr>
<tr>
<td>Sub-Task</td>
<td>Equip.</td>
<td>Bodily</td>
</tr>
<tr>
<td>----------</td>
<td>--------</td>
<td>--------</td>
</tr>
<tr>
<td>Project and Peelings and</td>
<td>and</td>
<td>and</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
TABLE 15

LEAST SQUARES MEANS AND STANDARD ERRORS OF HEART RATE FOR LABORATORY I AND II BY SUBJECT AND POSITION

<table>
<thead>
<tr>
<th>Laboratory Number</th>
<th>No. of Observations</th>
<th>Means</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>62</td>
<td>99.9</td>
<td>1.1</td>
</tr>
<tr>
<td>2</td>
<td>71</td>
<td>95.7</td>
<td>1.1</td>
</tr>
<tr>
<td>Subjects</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>20</td>
<td>98.8</td>
<td>1.9</td>
</tr>
<tr>
<td>2</td>
<td>31</td>
<td>96.0</td>
<td>1.5</td>
</tr>
<tr>
<td>3</td>
<td>24</td>
<td>84.0</td>
<td>1.7</td>
</tr>
<tr>
<td>4</td>
<td>27</td>
<td>113.3</td>
<td>1.6</td>
</tr>
<tr>
<td>5</td>
<td>31</td>
<td>94.7</td>
<td>1.5</td>
</tr>
</tbody>
</table>
Appendix B
Definitions

The following definitions were used in this study:

Heart Rate

Electrocardiogram: A record of the heart muscle action potentials (EKG) (14).

Heart Rate: A measurement of heart beats per minute. It may be calculated from measurement over any period of time (14).

Normal P wave: P waves are normal in amplitude, duration and form. The impulse has arisen in the sinoatrial node as usual and has spread through both atria in a normal fashion; the atria have been contracting normally (56:16).

P - R Interval: The stimulus which was initiated in the sinoatrial node has spread throughout the atria, has reached the atrioventricular node, and has begun to spread down the interventricular septum. Therefore, the Q R S Complex begins (56:17).

Q R S Complex: The stimulus spreads through the atrioventricular node and the ventricular muscle is stimulated (56:17).

Normal Q R S Complex: Q R S complexes are normal in amplitude and duration, the stimulus has begun in the atrioventricular node, has spread through the interventricular conduction system normally, and the ventricular musculature has been stimulated in a normal fashion through normal pathways (56:19).

S - T Interval: The stimulus has spread throughout the ventricular musculature. During this period, the electrochemical changes which resulted in the Q R S complex are reversed; the recovery
takes place, and the ventricles can be stimulated again (56:20).

Angles of Body Bend

Landmarks:
A prominent point of the skeletal structure that can be located under the flesh by inspection or palpation (30).

Frankfort Plane:
The standard horizontal plane of orientation of the head, containing tragion and the lowest point of the orbit. This is closely approximated when the subject looks directly forward with his line of vision in the forward (30).

Structural Dimensions:
The dimensions of the body at the static position (29).

Cardiovascular Fitness Test

Inning:
Inning for physical fitness is defined as a 30 second work period followed by a 20 second rest period, and the work consists of stepping up and down on the bench to the cadence (55).

Phase:
Six innings in the cardiovascular fitness test constitute a phase (55).
Laboratory Procedure

Task: Making of Chapatis
Purpose: To measure the physiological cost of work.
Recording Method: Pictures and heart rate are taken simultaneously at the three steps of the task. The recording starts at the second chapati and ends at the sixth chapati by recording the alternate chapatis.

Screening Laboratory:
1. Take room barometric pressure _______Hgmm.
   Room temperature _______°C.
2. Take general measurements of the subject:
   a. Height _______cms
   b. Weight _______Kgs.
   c. Blood pressure while resting:
      Systolic _______Hgmm.
      Diastolic _______Hgmm.
3. Take heart rate while resting: _______beats/min.
4. Give instructions to the subject for cardiovascular fitness test.
5. Find out cardiovascular fitness test score: _______innings.

Preliminary Laboratory:
1. Weight of the subject _______Kgs.
2. Tape electrodes to the body for measuring heart rate.
3. Give instructions for the physical fitness test.

4. Find out physical fitness score: _________ innings.

5. Attach landmarks for locating the anatomical points.

6. Recording during the task:
   a) Subject sitting at normal sitting position, take heart rate recorded for 15 seconds and two photographs.
   b) Subject start making chapaties, take two photographs from the right side of the subject at the following steps: ball-making, flattening the ball, rolling, patting, and puffing the chapati; record heart rate simultaneously with the taking of pictures for 15 seconds or less if the duration of the step is less than 15 seconds.
   c) Take photographs and the heart rate simultaneously for the second, fourth, and sixth chapati.

7. Remove the landmarks and electrodes from the body; clean the skin with alcohol, soap, and then rub with cream.

8. Anthropometrical measurements:
   a) Structural measurements by standardized procedure:
      Maximum sitting height ________ cms.
      Knee height, sitting ________ cms.
      Buttock-knee length ________ cms.
      Arm reach, standing ________ cms.
b) Structural measurements at the squatting position

Squatting height __________ cms.
Squatting breadth __________ cms.
Width across feet __________ cms.

Laboratory I:

1. Repeat the procedure of the practicing laboratory from the first to the fifth step.

2. Recording during the task:
   
a) Subject sitting at normal sitting position; record heart rate for 15 seconds and take 2 pictures.

b) Before the subject starts making chapati, instruct her to sit with knees up, keep buttocks against the wall during the task; make one ball at a time.

c) Allow the subject to make one chapati without any recording to practice the standardized procedure.

d) Take two photographs and record heart rate for 15 seconds or less if the duration of the step was less than 15 seconds for the following steps: ball making, rolling, and puffing. Record at second, fourth and sixth chapati.

3. Repeat the procedure of the preliminary laboratory for the seventh and eighth step.

4. Ask the subject to complete the check list for psychological attitudes, and also her personal data sheet.
Laboratory II:

Repeat the procedure of Laboratory I exactly except for the anthropometrical measurements and the completion of the personal data sheet.
Procedure for Landmarks

1. Landmarks placed at the standing position of the subject:
   a) Subject stands erect but not stiff with head in the Frankfort plane. Mark seventh cervical and acromion by standing behind the subject.
   b) Mark right olecranon and ulnare by standing on the right side of the subject.
   c) Mark sternal notch and the tragion by standing in front of the subject.

2. Landmarks attached after the subject sits on the stool for making chapaties:
   a) Knee:
      Right edge: Mark on the front surface of knee, level the top edge of the patella by holding the bottom edge tightly to prevent patellar motion during procedure. Mark the level of the bottom edge of the patella on the front surface of the knee.
      Lower right edge: Mark the level of the bottom edge of the patella when the leg is relaxed and hold the top edge tightly to prevent patellar motion; mark with short horizontal line on the front surface of the knee.
      Central point: Locate the central point of the distance between the top and the bottom of the patella. Draw the line from the central point of the patella to the right edge of the knee and place the landmark.
   b) Mark lateral malleolus of the right foot.
c) Attach tape from the middle of the armpit to the end of the eighth rib.
Description of Physical Fitness Test

To standardize the test procedure, and to assure a uniform cadence, the cadence used for the fitness evaluation experiments was pre-recorded on a tape recorder. The tape contains 15 minutes of exact signals timed with an electric metronome.

The fitness test consists of 18 innings each of 50 seconds duration. The work consisted of stepping up and down on the bench to the cadence. (See Figure 1). Six innings constituted a phase, and there were three phases. Each phase was designated by a voice signal, "ready, one, two" then for the thirty seconds exercise the signal is "up, up, down, down" until the last inning in the phase which was noted as "up, up, down, stop." This was followed by a rest period of 20 seconds. Three work loads were included as follows:

1. Phase I consisted of six innings at a 20 step cadence per minute on the 32.5 cms. bench.
2. Phase II consisted of six innings at 24 step cadence per minute on the 32.5 cms. bench.
3. Phase III consisted of six innings at 24 step cadence per minute on the 42.6 cms. bench.
Instructions to the Subject for The Ohio State University Cardiovascular Fitness Test for Women

1. In this study, we need to know about your physical fitness, so we have developed this test to see how you endure physical activity: ADJUST BAR TO CHIN LEVEL. You need to step on this bench and back down to signals that we have recorded on a tape. You keep stepping up and back at a steady rate for 30 seconds then rest for 20 seconds. The thirty second exercise period and the 20 seconds rest period together make one inning. We want to know how many innings you can go before your heart rate reaches 150 beats per minute.

2. Our assistant will go through one inning while I give her the directions to show you how the test goes. The signals for your test are recorded on a tape, so that we could be sure that the rhythm is exactly the same for all of the women who take the test.

3. Notice that she grasps the bar with both hands. As the voice on the tape says, "Ready, one, two" she gets ready, then on the next signal "up, up, down, down," she will just follow the directions, keeping time with the words. The signal to end the inning is: "up, up, down, stop." You may use either foot to start and change during the test if you wish; it is usually easier to follow through on the same foot.

Notice, that she places her foot squarely upon the bench and straightens her back as she steps up.

GO THROUGH TEST DEMONSTRATION
Procedure and Recipe for Making Chapaties

Recipe:

3 cups of whole wheat flour
1¼ cup of water

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

Procedure:

Dough was weighed for each chapati to standardize the size of chapati.

1. Make balls by wrapping the dough in dry whole wheat flour.
2. Flatten the ball with hands
3. Roll the chapaties
4. Pat the chapaties
5. Roast the chapati on an iron plate and puff it
6. Remove the chapati when it is done
Instructions to the Subject for Task

1. Keep buttocks against the wall
2. Keep knees in the standing position during the task
3. Make chapatties at your normal speed
4. Make one ball at a time
5. Quality of the chapati is not the concern of this research project
6. Please do not talk during the task unless you want the flame of the stove to be adjusted and/or if there is some other emergency
Form A

Name _______________________ Time ____________

Transportation: Will you walk? Yes ___ No ___
Will you drive? Yes ___ No ___
If yes parking will be explained to you.

Clothes: Please avoid wearing synthetics.

Shoes: What type of shoes would you wear?
Do you have tennis shoes?

General Health

How do you rate your health in general?
   Excellent _____ Good _____ Fair _____
   Poor ______

Have you had any serious illness(es) within the last two years? Yes _______ No _______
If yes, what?

Are you on any medication at present?
   Yes _______ No _______

Are you taking oral contraceptives for birth control?
   Yes _______ No _______

Please do not make an appointment to come to the laboratory during the menstrual period.

Would you mind letting me know the approximate date of the beginning of your menstrual period? This would help me in planning the laboratory.

Date ______

I AM INTERESTED IN GETTING YOUR OWN OPINION; THEREFORE, PLEASE DO NOT DISCUSS THIS RESEARCH PROJECT WITH ANYONE, THANK YOU.
J. K. Dhesi
School of Home Economics
Ohio State University

Personal Data

1. Subject's Name ____________________________
2. How long have you stayed in this country? _______months
3. Place of residence in India ______________
4. Age ________yrs. Date of birth ________________
5. Last year of school or degree completed? ________year or degree
6. Number of years married ____________
7. Number of children in this country: _______ in India:
   Name of Children   Age   Sex   Grade in School
   _______________   ---   ---   _______________
   _______________   ---   ---   _______________
   _______________   ---   ---   _______________
   _______________   ---   ---   _______________
   _______________   ---   ---   _______________
8. How long have you worked at the ground level kitchen? ________yrs.
9. How frequently did you make chapaties in India after marriage?
   a) Most of the time __________
   b) Half of the time __________
   c) Once in a while __________
10. What was your usual position of making chapaties in India?
Questionnaire: Attitudes

I would like to know how did you feel about the task of making chapatis and the environment in the laboratory, and the factors which have contributed towards that feeling.

1. How did you feel about the task of making chapatis in the laboratory?

Liked very much _______ liked _______ disliked _______ disliked very much _______ don't know _______. Before you answer the factors which have contributed towards these feelings, I would like to give you an example to show you the method to answer this question.

Example

Task: Cleaning the house

If you feel that the task is described very closely by one end of the scale you should put your check mark as follows:

Clean _____ _____ _____ _____ _____ X Unclean

OR

Clean X _____ _____ _____ _____ _____ _____ Unclean

If you feel that task is fairly closely related to one or the other end of the scale but not extremely, you should
Put the check mark as follows:

Clean ______ ______ ______ X ______ Unclean

OR

Clean ______ X ______ ______ ______ Unclean

If both sides describe the task equally well or if the words do not apply at all, then you should place the check mark in the middle place:

Clean ______ ______ ______ X ______ ______ ______ Unclean

Important:
1. Be sure you check every set of words.
2. Never put more than one check mark on one set of words.

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

1. Quality of dough
   Good ______ ______ ______ ______ Poor

2. Height of stool
   Good ______ ______ ______ ______ Poor

3. Size of rolling pin
   Good ______ ______ ______ ______ Poor

4. Height of rolling board
   Good ______ ______ ______ ______ Poor

5. Height of stove
   Good ______ ______ ______ ______ Poor

6. Stove flame
   Good ______ ______ ______ ______ Poor
7. Distance of rolling board from you
   Good _______ _______ _______ _______ Poor
8. Distance of dough plate from you
   Good _______ _______ _______ _______ Poor
9. Distance of plate for chapaties from you
   Good _______ _______ _______ _______ Poor
10. Distance of stove from you
    Good _______ _______ _______ _______ Poor

How did you feel during the task?

11. Neck
    No Pain _______ _______ _______ _______ Pain
12. Back
    No Pain _______ _______ _______ _______ Pain
13. Upper legs
    No Pain _______ _______ _______ _______ Pain
14. Lower legs
    No Pain _______ _______ _______ _______ Pain
15. Feet
    No Pain _______ _______ _______ _______ Pain
16. Arms
    No Pain _______ _______ _______ _______ Pain
17. At patches
    No Pain _______ _______ _______ _______ Pain

How did you feel about the Social and Psychological environment in the laboratory?
18. Free ______ ______ ______ ______ ______ Entrapped
19. At ease ______ ______ ______ ______ ______ Uneasy
20. Interesting ______ ______ ______ ______ ______ Not interesting
21. Not tiring ______ ______ ______ ______ ______ Tiring
22. Have much skill ______ ______ ______ ______ ______ Lack skill
23. Satisfying task ______ ______ ______ ______ ______ Not satisfying

How did you feel about the chapatis you made today?
24. Round ______ ______ ______ ______ ______ Not round
25. Puffed ______ ______ ______ ______ ______ Not puffed
26. Smooth ______ ______ ______ ______ ______ Not smooth
27. White ______ ______ ______ ______ ______ Brown
BIBLIOGRAPHY


55. Richardson, Reta H. "Stimuli in Homemaking Activities Associated with Heart Rate Changes in Women from Two Socio-Economic Levels." Unpublished Doctoral Dissertation, Ohio State University, Columbus, 1969.


