ERGONOMIC ASSESSMENT OF PHYSIOLOGICAL COST OF SOME SELECTED HOUSEHOLD CHORES PERFORMED BY HOME MAKERS IN KADUNA METROPOLIS, NIGERIA

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DECLARATION

I declare that the work in this thesis titled "***Ergonomic Assessment of Physiological Cost of Some Selected Household Chores Performed By Home Makers in Kaduna Metropolis, Nigeria***" has been carried out by me in the Department of Home Economics, Ahmadu Bello University, Zaria. All information derived from literature has been duly acknowledged. No part of this thesis was presented for any higher degree at any other institution.

…… ……..

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CERTIFICATION

This thesis titled **"Ergonomic Assessment of Physiological Cost of Some Selected Household Chores Performed By Home Makers in Kaduna Metropolis, Nigeria"** by Halima Sidi BAMALLI, meets the regulations governing the award of Doctor of Philosophy degree (PhD) in Home Economics, Ahmadu Bello University, Zaria, and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This study is dedicated to my husband Alhaji Sidi Musa Bamalli and my children; Lukman, Imran, Zainab, Hannatu and Musa. You are my source of inspiration, support and encouragement.

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ABSTRACT

This study examined the ergonomic assessment of physiological cost of household work among women in Kaduna metropolis, Nigeria. It assessed the energy cost, heart rate, rate of perceived exertion and postural stress of cooking activities of kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam among women in Kaduna metropolis, Nigeria. The study had five specific objectives, five research questions and four null hypotheses. A 3 x 1 x 3 factorial experimental research design was employed for the study. The population of this study comprised of women residents in three (3) bedroom apartments of Government Secondary Schools within Kaduna Metropolis, Kaduna State, Nigeria. The simple random sampling was used to select sixteen (16) homemakers residing in three (3) bedroom apartments purposively selected among Government Secondary Schools within Kaduna metropolis, Nigeria. The Standiometre, Omron body Composition Monitor, Heart rate monitor, Flexi-curve, and Borg Scale were the instruments used to obtain relevant data. Three cooking activities were selected kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam. Descriptive statistics of mean, standard deviation, standard error, frequency and percentage were used to analyze the demographic characteristics, postural assessments and research questions. Repeated measures analysis of variance was used to test hypotheses 1 and 2 while one way analysis of variance was used to test hypotheses 3 and 4. The result revealed that Kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam led to high energy cost (expenditure) especially during and at the end of the cooking activities among women in Kaduna Metropolis, Nigeria ($p = 0.001$). The cooking activities increased the resting heart rate of women during and immediately after kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam in Kaduna Metropolis, Nigeria ($p = 0.012$). The rate of perceived exertion was maximum during

pounding yam but were moderate during stirring hard porridge (tuwon-shinkafa) and kneading dough among women in Kaduna Metropolis, Nigeria. ($p = 0.001$). Postural stress was significant at both upper curve and lower curve during pounding yam, stirring hard porridge (tuwon-shinkafa) and kneading dough among women in Kaduna metropolis, Nigeria ($P = 0.001$). The study concluded that the cooking activities and time spent during the performance of the activities had effect on the physiological and postural conditions of homemakers residing at the four (4) selected Government Secondary Schools within Kaduna metropolis, Nigeria. The researcher recommends among others that homemakers should make cooking activities of kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam a regular activity so that the body's physique becomes used to the activity.

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LIST OF ABBREVIATIONS

IEA	-	International Ergonomics Association
Kcal	-	Kilocaloris
Kg	-	Kilogram
Min	-	Minutes
Bpm	-	Beats per minute
BMI	-	Body Mass Index
VAS	-	Visual Analogue Scales
Kg/m^2	-	Kilogram per metre square
PF	-	Physical Fitness
BMR	-	Basal Metabolic Rate
REE	-	Resting Energy Expenditure
TEE	-	Total Energy Expenditure
SDA	-	Specific Dynamic Action of Food
PA	-	Physical Activity
EER	-	Estimated Energy Requirement
RPE	-	Rating of Perceived Exertion
M	-	Metre
Ft	-	Feet
”	-	Inches
SMK	-	Semi Modular Kitchen
MSD	-	Musculo-Skeletal Disorders
WHR	-	Working Heart Rate
HR	-	Heart Rate
MHR	-	Maximum Heart Rate
PPI	-	Pulse Deceleration Index
RHR	-	Recovery Heart Rate
NCC	-	Net Cardiac Cost
RCC	-	Relative Cardiac Cost
WBGT	-	Working Bulb Globe Temperature
SPSS	-	Statistical Package of Social Science
ANOVA	-	Analysis of Variance
CM	-	Centimeters

OPERATIONAL DEFINITION OF TERMS

Ergonomics: This refers to the interactions between the work of homemakers and the working environment (kitchen) for the purpose of reducing stress and fatigue during performing domestic chores.

Physiological Cost: This refers to the energy cost of activities performed by women during preparatory stage of cooking like pounding of yam, stirring of hard porridge (tuwon-shinkafa) and kneading of dough.

Cooking Activities: The selected cooking activities in this study are pounding of yam, kneading of dough and stirring of hard porridge (tuwon-shinkafa) all to be performed by the woman respondent.

Pounding: Is an activity of using energy to mash yam using mortar and pestle, repetitive action causes the yam to be mashed and further moulded.

Kneading: A manual activity of mixing of flour and other ingredients using knuckles of fingers to produce dough for pastries.

Stirring: A manual activity of turning food with the stirring rod to produce hard porridge (tuwon-shinkafa) in this particular study.

Heart Rate and Heart Rate Monitor: Heart rate refers to the heart beat of an individual per minute at a point in time and the heart rate monitor is a device that is use to determine the heart rate of home maker during household activities .

Body Composition Monitor: Medical device that precisely measures body composition parameters of body mass index, percentage, body fat, visceral fat and immediately interpret the results.

Household Tasks: Preparatory cooking activities performed by homemakers residing at staff quarters of Government Secondary School within Kaduna Metropolis, Nigeria.

Postural Stress: State of deviation in the human skeletal system while standing, sitting, bending or lying down.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Ergonomics has to do with designing systems, work methods, tools and equipment which enhance human capabilities. International Ergonomics Association (2010) opined that, ergonomics is the natural human tendencies to seek ways to make life easier, it is about paying attention to the dynamic interaction between person and environment, and the study of people in their work situations. Also, it is the knowledge about the interaction between people, the equipment they use, their enrolment and their tasking is applied to provide the optimum of condition in term of health, comfort and efficiency of work (International Ergonomics Association, 2010).

As a unique scientific discipline, ergonomics systematically applies the knowledge of human abilities and limitations to the design of a system with the goals of optimizing the interaction between people and other system elements to enhance safety, performance and satisfaction (Carayon, 2006). Human factors are relevant anywhere because people work with systems, whether they are social or technical in nature. The breath of the socio-technical systems include situations and circumstances where people interact with other systems, elements including artifacts; (for example, tools, machines, product, software); tasks; environments; teams; organizations; legal (for example, regulations and enforcement) and political (Carayon, 2006). Therefore ergonomics is concerned with the 'fit' between people, their technological tools and the environment. It takes account of the user's capabilities and limitations in seeking to ensure that tasks, equipment, information and environment suit each user (Brookhuis, 2005). Accordingly, Barkeley (2008) stressed that in the assessment of the 'fit' between a person and

the use of technology; the ergonomists consider the job (activity) being done and the demands on the user, the equipment used (its size, shape, and how appropriate it is for the task), and the information used (how it is presented, assessed, and changed). Ergonomics draws on many disciplines in its study of human and their environments which include anthropometry, biomechanics, mechanical engineering, industrial engineering, industrial design, kinesiology, Psychology and physiology (Berkeley, 2008).

According to the International Ergonomics Association (2010), physical ergonomics is concerned with human anatomical, and some of the anthropometric, physiological and biomechanical characteristics as they relate to physical activity. Cognitive ergonomics is concerned with mental processes such as perception, memory, reasoning and motor response, as they affect interactions among humans and other elements of a system. Such areas include mental work load, decision making, skilled performance, human computer interaction, human reliability and work stress. (IEA, 2010)

Ergonomics is employed to fulfill two goals of health and productivity. It is relevant in the design of such things as safe furniture and easy to-use interfaces to machines. Ergonomics in the workplace has to do largely with the safety of employees during long and short terms and that it can help reduce energy costs by improving safety (IEA, 2010).

Waugh & Grant (2001) define physiological cost of work as energy expended during an activity. Energy expenditure is the amount of fuel the body needs during specific work. The human body expends energy, which is the amount of energy needed to maintain basic physiological functions of the body organs in breathing, blood circulation, synthesis of compounds; the thermogeric effect of food-energy needed to process the food we eat to produce energy; and physical activities: energy is required to do work.

Energy expenditure depends on the type, duration and intensity of the activity as well as the body size and the fitness level of an individual (Bridger, 2008). The energy requirement for various activities is often referred to as energy "cost" of such activities. The information on the energy cost or physiological cost is obtained by a series of tests based on measurement of oxygen consumption with respect to the resting energy expenditure and read in term of kilocalories per kilogram body weight per minute (i.e. kcal/kg body weight/min) (Waugh & Grant, 2001). Jobs or working conditions presenting multiple risk factors will have a higher level of causing musculoskeletal problems. The levels of risks depend on the intensity, frequency and duration of the exposure to these conditions. Environmental work condition that affects risk includes intensity, frequency and duration of activities (Bridger, 2008)

Heart rate is the number of heart beats per unit of time, expressed as beats per minute (bpm). Tom (2010) and Pheasant (2010) reported that heart rate is used for measuring the physiological condition and oxygen consumption of women while performing various house-hold tasks. It is a better index of measurement, which has a linear relationship with energy expenditure. Postural condition refers to the state in which a person holds the body upright against gravity while standing, sitting, or lying down. Posture is the way the muscles and skeleton hold the body erect (Sandhu, 2003). Right Posture is essential in the maintenance of the natural curve of the body while wrong posture causes stress and fatigue. According to Roberts (2013) and Jeremy (2013) good posture is considered to be the natural and comfortable bearing of the body in normal healthy persons. This refers to the natural standing position of a person, a comfortable sitting position. Poor posture results from certain muscles tightening up or shortening while others lengthen and become weak which often occur as a result of one's daily activities.

Women are critical to the well being of any household. Aside from raising children, women routinely partake in most household activities, as preparing meals, dish washing, table setting, laundry, heavy lifting of objects, sweeping, vacuuming, defrosting refrigerator, ironing, scrubbing, lifting young children or heavy basket of wet clothes among others. The daily work schedule of women is very demanding, arduous, and are not only strenuous but repetitive also. The women are exposed to continuous non neutral postures, the non-neutral posture of the trunk frequently adopted by workers is risk for lower back pain (Suthar & Kaushit, 2011). This study therefore, sought to examine the physiological conditions of women while performing selected cooking activities in their kitchens in Kaduna metropolis, Nigeria.

1.2 Statement of the Problem

The home is a workplace for a woman; it is where she performs most of her domestic duties of washing, cooking, pounding food, lifting, sweeping and many others. A woman spends a major part of her time in the Kitchen (Verghese 1996). According to Lagomarsino (2004) a kitchen can make anybody's health and at the same time it can destroy anybody's health. By interpretation, while the kitchen activities can be seen as a means of physical activities that contribute to good health, it may also hinder the health of an individual if there is excessive weight gain and if the wrong posture or equipment is used. The researcher as a female has had personal interactions with some of whom are either overweight or obessed and therefore, suffer fatigue after the performance of household activities. Some of these women often complain of tiredness, fatigue, body aches and several other musculo-skeletal problems. This situation, the researcher of the present study feels,s may be the resultant effect of poor work habits, wrong postures and physical inactivity due to increasing sedentary nature of many forms of work, changing modes of transportation and increasing urbanization.

This may not be unconnected to the fact that women's work demands high degree of physical efforts due to the different types of activities, tools and equipment used and the manner in which the body segments are manipulated within the available space, and thus results in change in posture leading to increase in physiological cost of work. It may also result in permanent change in spine, in position of the joints, ligaments and muscles and in location of the organs of the body, thus enhancing the physiological cost of work and fatigue (Blum, 2009). The researcher of the present study wonders to what extent poor work habits and wrong postures relate to health, physical inactivity and physical stress of the women.

1.3 Objectives of the Study

The major objective of this study was to determine the physiological cost of work of women (body composition, energy cost, heart rate, rate of perceived exertion and postural stress) while performing cooking activities of kneading dough, stirring hard porridge and pounding yam among women in Kaduna metropolis, Nigeria.

The Specific Objectives of this study are to:

1. estimate the body composition of women (body fat (%), visceral fat, body mass index (BMI), and resting metabolic rate) used in of kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam among women in Kaduna metropolis, Nigeria
2. access the energy cost of cooking activities of kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam among women in Kaduna metropolis, Nigeria.
3. determine the heart rate of women as they perform cooking activities of kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam in Kaduna metropolis, Nigeria.

4. assess the rate of perceived exertion among women as they perform cooking activities of kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam in Kaduna metropolis, Nigeria.
5. evaluatethe postural stress of women as they perform cooking activities of kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam in Kaduna metropolis, Nigeria.

1.4 Research Questions

The following research questions were raised and used in this study.

1. what is the body composition of women (body fat, visceral fat, body mass index, and resting metabolic rate) used in kneading dough, stirring hard porridge (tuwon-shinkafa)and pounding yam among women in Kaduna Metropolis, Nigeria?
2. what is the energy cost of cooking activities of kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam among women in Kaduna Metropolis, Nigeria?
3. What is the heart rate of women in Kaduna metropolis with regards to cooking activities of kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam?
4. what is the rate of perceived exertion of cooking activities of kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam among women in Kaduna metropolis, Nigeria?
5. what is the postural stress of cooking activities of kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam among women in Kaduna metropolis, Nigeria?

1.5 Research Hypotheses:

The following null hypotheses were formulated and tested:

1. There is no significant difference in the effect of kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam on energy cost at three assessment levels among women in Kaduna metropolis, Nigeria.
2. There is no significant difference in the effect of kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam on heart rate at three assessment levels among women in Kaduna metropolis, Nigeria.
3. There is no significant difference in the effect of kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam on rate of perceived exertion among women in Kaduna metropolis, Nigeria.
4. There is no significant difference in the effect of kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam on postural stress among women in Kaduna metropolis, Nigeria.

1.6 Significance of the Study

The research specifically focuses on the physiological cost of household work among women with a view to improving the existing practices and enhancing the household activities. It will benefit women, building engineers, home economics curriculum developers, health professionals and many others. The result of this study will clarify understanding and create awareness among women and the general populace on proper ergonomics. It will clearly emphasize the need for the woman to reduce frequently encountered fatigue due to boredom which lead to stress and frustration, particularly at a time when the woman combines other jobs with household chores.

The result will also draw the attention of Building Engineers who design buildings specifically kitchens. The right surface for work in the home should be according to the anatomical measurement of age, sex and postural consideration of the user. Also the proper designing of

space for storage and the effective performance of routine activities should be of utmost consideration. The study benefit the health professionals by enabling all the stakeholders to reflect on the present health delivery and make a range of decisions necessary in the context of improving the quality of health among women.

The study will also provide inputs that will assist the Home Economics curriculum developers and guide the to make emphasis in the area of Ergonomics in Home Management courses. It will serve as a guiding document for self assessment on physiological cost of work in the home, food industries and other work places. Non-Governmental Organizations, Teachers, Students and other future researchers can make very good use of this document for future researches, and it will add to the body of existing knowledge.

1.7 Assumptions

The study was based on the assumptions that:

1. physical characteristics of women would influence their energy cost, heart rate, rate of perceived exertion and postures during cooking activities.
2. cooking activities of kneading dough, stirring hard porridge(tuwon-shinkafa) and pounding yam would lead to energy expenditure among women.
3. cooking activities of kneading dough, stirring hard porridge(tuwon-shinkafa) and pounding yam would affect the heart rate of women.
4. cooking activities of kneading dough, stirring hard porridge(tuwon-shinkafa) and pounding yam would affect the rate of perceived exertion of women.
5. cooking activities of kneading dough, stirring hard porridge(tuwon-shinkafa) and pounding yam would cause postural stress among women.

1.8 Scope and Delimitation of the study

The study was delimited to the ergonomic assessment of physiological cost of household work among women in Kaduna metropolis, Kaduna State, Nigeria. The study was delimited to women residing in four (4) Government Secondary Schools in Kaduna Metropolis each of the schools provides three (3) bedroom residential quarters for their staff. The schools are:

1. Queen Amina College Kaduna
2. Rimi College, Kaduna
3. Government College, Kaduna
4. Sardauna Memorial College Kaduna

The choice of Kaduna metropolis is based on the fact that the study is an experimental one and therefore needed to capture a large area. The study was also delimited to sixteen (16) women who were overweight and obesed and whose BMI was between 25.0 -30.0kg/m^2 and above. The study was further delimited to three (3) selected cooking activities of kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam. The choice of these three (3) cooking activities was made because there are numerous cooking activities and household tasks for which this study did not cover all.

The following instruments were used for this study; Standiometre for height and weight measurement; Omron Body Composition Monitor for the measurement of physical parameters; Heart Rate Monitor for the measurement of heart rate and energy expenditure; and Flexi-curve for the measurement of postural curves. All these instruments are delimited to this study to adequately measure the found.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 Introduction

The purpose of this study is to assess the physiological cost of household work among women in Kaduna State, Nigeria: To achieve this purpose, the theoretical framework guiding this study and related literature are reviewed in this chapter under the following sub-headings:

2.2 Theoretical framework

2.3 Concepts of household ergonomics

2.3.1 Broad Areas of Ergonomics

2.3.2 Basic Principles of Ergonomics

2.3.3 Importance of Ergonomics

2.4 Ergonomics cost of household work

2.4.1 Physiological cost of household work

2.4.2 Rating of perceived exertion of household tasks

2.4.3 Impact of household tasks on postural changes of women

2.4.4 Impact of household work on cooking

2.5 Household activities and kitchen designs

2.6 Review of Related Empirical studies

2.7 Summary

2.2 Theoretical Framework

"Activity theory is based on the idea that activity is primary, that doing proceeds thinking, that goals, images, cognitive models, intentions and abstract notions like "definition" and "determinants" grow out of people doing things" (Morf & Weber, 2000). Activity theory is based

upon the work of Vygotsky and his student Leont'ev from their studies of cultural – historical psychology in the 1920's (Verenikina, 2001).

Activity theory uses the whole work activity as the unit of analysis, where the activity is broken into the analytical components of subject, tool and object; where the subject is the person being studied, the object is the intended activity and the tool is the mediating device by which the action is executed (Bedny & Karwowski, 2006). Engestrom's modification of Vygostky's original theory provide for two additional units of analysis, which have an implicit effect on work activities.

Activity theory sees the integration of technology as tools which mediate social action. These tools, or artifacts, include instruments, signs, language, machines and computers. The relation between the individual and his or her environment is considered through the component of community. The relation between subject and community is mediated by rules and the relationship between object and community is mediated by the division of labour (Hettinga, 1998; Hashim & Jones, 2007).

Due to the fact that the tools which have been incorporated into the social system have been created and transformed by humans during the development of the activity itself, they will carry with them remnants of the cultural and historical evolution. Mediation through tools and technology is therefore not a neutral process, the tools will have an influence over the interaction between subject and the object. Leont'ev refers to this phenomenon as Ringstruktur, or "Ringstructure" a combination of three code terminating elements – subject, activity and object - where the subject is not primary and where the object completes the circle by influencing the subject.

Activity is presented as a system which comprises discrete hierarchically organized elements that are units of analysis. The content of these elements and the specifics of their interactions characterized structure of activity. A description of the structure of activity as a system is called the systemic-structural analysis and description of activity (Kyutti; 1996 Engestrom, 1999, Docortis, 2000;).

Systemic-structural analysis of activity employs distint methods that are categorized in terms of specific criteria. Activity as an object of study embodies multiple, distinct aspects enabling the systemic-structural approach to capture the multi-dimensionally of activity during task performance therefore multiple approaches must be employed to describe a single episode of activity (Kyutti, 1996).

The last decade witnessed the development of the systemic-structural theory of activity that is specifically tailored to the study of work (Bedny & Meister, 1999, Bedny, 2000; Bedny, Karwowsky & Bedny 2001; Bedny, Karwowsky & Kwon, 2001,).

Within the systemic-structural theory of activity, three different approaches are outlined:

a. The parametrical approach – which concentrate on the study of different parameters of activity such as cognitive analysis, error analysis and so forth.
b. The morphological approach in which mental and motor action concepts are the most ones and
c. The functional approach in which the major concepts are self regulation and function blocks, from the systemic-structural theory of activity perspective, task analysis focuses on the structure of activity during the task performance (Bedny, Karwowski & Kwon, 2001).

2.3 Concepts of Household Ergonomics

The term “ergonomics” has attracted various definitions from different scholars all of which are not far from one another. Chapanis (1991) gave his own definition as thus: Human factors ergonomics is a body of knowledge about human abilities, human limitations and other human characteristics that are relevant to design. Human factor engineering is the application of human factors information to the design of tools, machine systems, tasks, jobs and environments for safe, comfortable and effective human use.

The introduction of ergonomics in the English lexicon is widely attributed to British Psychologist, Hywel Murrel, at the 1949 meeting at the UK’s Admiralky, which led to the foundation of the ergonomicssociety. He used to encompass the studies in which he had been doing during and after World War II (Verenikina, 2001).

The term ergonomics from Greek meaning “work” and “natural laws” first entered the modern lexicon when Polish scientists, Wejciech Jastrzebow-ski, used the word in his 1857 article, the outline of ergonomics that is, science of work, based on the truths taken from the natural sciences (Olla & Kolade, 2009).

In its application, activity theory is a purposeful interaction of a subject with an object through the use of tools. The subject in this study refers to the married women who are saddled with domestic chores like cooking, laundry, house care. The object refers to those domestic activities performed by the women, which are cooking, laundry, and house care. While the tools are those utensils, devices or equipment used by the woman to make her work easier and less stressful. They are blender, gas cookers, microwave oven, mortar and pestle. Thus, ergonomics is the interactions between the subject, objects and tools.

The International Ergonomics Association (2010) developed the following definition and has been adopted by the Human Factors and Ergonomics Society. Ergonomics (or human factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies to theory, principles, data, and methods to design in order to optimize human well being and overall system performance. Ergonomists contributed to the design and evaluation of tasks, jobs, products, environments and systems in order to make them compatible with the needs, abilities and limitations of people. The Human Factors and Ergonomics Society also developed the following definitions; Human factors is concerned with the application of what we know about people, their abilities, characteristics and limitations to the design of equipment they use, environments in which they function and jobs they perform.

2.3.1 Broad Areas of Ergonomics

According to International Ergonomics Association (2010) ergonomcis can be split into three broad areas:

1. Physical ergonomics: It looks at how human anatomical, anthropometric, physiological and biochemical characteristics relate to physical activity. These include :

   Working postures**,** Manual handling**,** Repetitive movements, Musculoskeletal disorders Workplace layout and environments.
2. *Cognitive/Psychological ergonomics:* This area studies mental process e.g cognition, perception, memory, reasoning and emotion and how people interact with products, systems and environment. This includes:Mental workload**,** Decision making**,** Human computer interaction,Human reliability, Attitudes, Stress**,** Motivation**,** Pleasure, Cultural differences.

3. Organizational Ergonomics which is about optimizing the organizational structures, policies and processes of socio-technical systems. This includes:Communication, Work design Staff resource management,Work time patterns**,** Co-operative work, Quality management, Organizational culture.

To ensure that one's end-users' needs are kept in focus at all times, ergonomics should be an integral part of one's design development team. Constantly evaluating the ergonomics of anything, will help increase the likelihood that one's product or service will be a success.

2.3.2 Basic Principles of Ergonomics

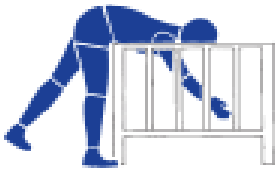
The field of physical ergonomics can be summarized in a series of principles. These principles can readily be applied at work, home or any other place, (as shown in Fig 2.1below).

According to Macleod (1990, 2008), Ergonomics is based on certain basic principles. These include the following:

1. Work in neutral postures – your posture provides a good starting point for evaluating the tasks that you do. The best positions in which to work are those that keep the body "neutral".
2. Reduces excessive force – Excessive force on one's joints can create a potential for fatigue and injury. In practical terms, the action item is for one to identify specific instances of excessive force and think of ways to make improvements.
3. Keep everything in easy reach – This principle deals with keeping things within easy reach. In many ways, this principle is redundant with posture, but it helps to evaluate task from this specific perspective.
4. Work proper heights – Working at the proper height is also a way to make things easier.

5. Reduce excessive motions – The individual is to think about the number of motions one makes throughout a day whether with one's fingers, wrists, arms or back.
6. Minimize fatigue and static load – Holding the same position for a period of time is known as static load. It creates fatigue and discomfort and can interfere with work.
7. Minimize pressure points – Another thing to watch out for is excessive pressure points, sometimes called "contact stress".
8. Provide Clearance – Having enough clearance is a concept that is easy to relate to.
9. Move, exercise and stretch – To be healthy, the human body needs to be exercised and stretched.
10. Maintain a comfortable environment – This principle is more or less a catch all, that can mean different things depending upon the nature of the type of operations that you do.

ERGONOMIC PRINCIPLE		DESCRIPTION
Joints must be in a neutral position		In the neutral position the muscles and ligaments, which span the joints, are stretched to the least possible extent
Keep work close to the body		If the work is too far from the body, the arms will be outstretched and the trunk bent over forwards

ERGONOMIC PRINCIPLE		DESCRIPTION
Avoid bending forward		The upper part of the body of an adult weighs about 40kg on average. The further the trunk is bent forwards, the harder it is for the muscles and ligaments of the back to maintain the upper body in balance
A twisted trunk strains the back		Twisted postures of the trunk cause undesirable stress to the spine
Alternate posture as well as movements		No posture or movement should be maintained for a long period of time. Prolonged postures and repetitive movements are tiring.
Avoid excessive reaches		It is necessary to limit the extent of forward and sideways reaches to avoid having to bend over or twist the trunk
Avoid carrying out tasks above shoulder level		The hands and elbows should be well below shoulder level when carrying out a task

Ergonomic Principle		Description
Limit the weight of a load that is lifted		There are guidance weight limits for both males and females detailed in Figure 2 of this document
Use mechanical aids		Many lifting accessories are available to help lift and move loads
Avoid carrying loads with one hand		When only one hand is used to carry a load, the body is subject to mechanical stress
Use transport accessories		There are a large number of accessories such as roller conveyors, conveyor belts, trolleys and mobile raising platforms, which eliminate or reduce manual handling.

Figure 2.1 Ergonomics Principles

Sources: Ergonomics in the Workplace: Health and Safety Authority (2005)

2.3.3 Importance of Ergonomics

Ergonomics is about ensuring a good fit between people and what they interact with. This could include the object they use or the environment they live in. Ergonomics should be considered in the design of every product, system or environment.

Ergonomist are often not given enough priority early in the design process, because of commercial or time pressures. But this is a false economy. Ignoring ergonomics can lead to designs which are likely to fail commercially as they do not fit the needs of the user.

Ergonomists are trained in analytical techniques to identify which user characteristics should be taken into account during design process. This is important when one considers how much individual vary in terms of: Body size, Body shape, Strength, Mobility, Sensory sensitivity, Mental ability, Experience, Training, Culture, Emotions.

When applied at the earliest stages of the design process, ergonomics method often identifies opportunities for innovations.

2.4 Ergonomic Cost of Household Work

Researchers have proved that any work station design or work environment that helps to perform the work with minimum energy and put minimum stress on cardio vascular system and muscular system is the best design of work (Varghese et al., 1995). So the kitchen workstation should be adequately designed and properly arranged in order to reduce the physical, physiological and temporal cost of the homemaker.

Ergonomics contributes to the designing and evaluation of tasks, jobs, products, environments and systems in order to make them compatible with the needs, abilities as well as limitations of the workers. (Bhatt, Sidhu, Sandhu & Bakhashi, 2011) . To obtain maximum efficiency in work with least cost to the body energy, there should be an ideal relationship between work, worker and work place (Steidl & Bratton 1968 in Bhatt et al., 2011). The home-maker is the predominant figure in the home and household work is an indispensable part of the home maker. She requires a lot of energy and time to complete work inside and outside the home with satisfaction and desired standards.

2.4.1 Physiological Cost of Household Work

Physical activity is typically defined as any bodily movement produced by skeletal muscles that results in energy expenditure above the basal level. Physical activity can be categorized in various ways, including type, intensity, and purpose or context. Physical activity is the broad and organizing concept around which more specific activities can be arranged.

Exercise and physical activity have been used synonymously in the past, but more recently, exercise has been used to denote a subcategory of physical activity. Exercise is "physical activity that is planned, structured, repetitive and purposive in the sense that improvement or maintenance of one or more components of physical fitness is the objective." (Casperson, Pourell & Christensen, 1985).

Physical fitness can be described as the ability to carry out daily tasks with vigor and alertness, without undue fatigue and with ample energy to enjoy leisure time pursuits and to meet unforeseen emergencies. Physical fitness includes cardio respiratory endurance, skeletal muscular endurance, strength, power, speed, flexibility, agility, balance, reaction time and body composition. It is a set of attributes that are either health or skill-related. The degree to which people have these attributes can be measured with specific tests (Dayan & Cohen, 2011). Just as the amount of physical activity can range from high to low, so can the level of physical fitness such as a person can be strong but lack flexibility.

Training for fitness objectives generally involves some combination of aerobic and anaerobic exercise which has been used to denote a subcategory of physical activity performed at an intensity that allows the metabolism of stored energy to occur through the use of oxygen. Examples of acrobic activities include the sedentary activities of daily life, as well as higher

intensity exercise such as walking and running where the heart rate is elevated and the activity is performed over a longer duration (three minutes or longer). In contrast, anaerobic exercise refers to movement performed at an intensity that required the metabolism of stored energy without oxygen. This type of activity includes intermittent, high-intensity exercise such as weight lifting, basketball and sprinting (Dayan & Cohen, 2011).

As an outcome measure for the benefit of physical activity, fitness has proved useful for understanding and comparing exercise and sport-related activities. However, researchers are reconsidering the findings of some studies that conclude low-intensity physical activity results in limited health benefits due to a lack of measurable fitness gains. Percent evidence suggests that health benefits can result even with no change in physical fitness. The traditional focus of measuring physical acitivity has been related to training intensity to meet performance and fitness objectives. Energy expenditure for this type of physical activity is typically measured in kilocalories. This techniques created measurement difficulties associated with assessing daily physical activity located in occupational tasks, household chores and incidental activity such as walking (Dayan & Cohen, 2011).

2.4.1.1 The General Benefits of Physical Activity for Health

Physical activity has long been acknowledged as an important part of a healthy lifestyle, and recent scientific evidence has linked regular physical activity to a wide range of physical and mental health benefits. Research has demonstrated protective effects of varying strength between physical activity and risk for several chronic diseases, including coronany heart disease, hypertension, non-insulin-dependant diabetes mellitus, osteoporosis and colon cancer. In fact, investigators suggest that 12% of the total number of annual deaths in the United States is attributable to a lack of regular physical activity (Wilmore & Knuttgen, 2003).

From a public health perspective, research has successfully argued that more benefit is achieved when the least active person take-up exercise than when moderately active persons increase their activity by a similar amount (Atwood, 2004; Mitchell, Cooperstein & Peterson, 2007). This recognition of the importance of physical activity for general health has been paralleled in the development of a new exercise prescription by the American College of Sports Medicine (ACSM) advocating that "every U.S adult should accumulate 30 minutes or more of moderate-intensity physical activity on most, preferably all, days of the week" (Carroll, 2007).

Although studies identified have identified a positive relationship between increased levels of physical activity and better mental health, less depression and lower levels of anxiety (Wang, Næss, Hoff, Albert, Pham, Richardson, & Helgerud, 2013), there is still a serious lack of hard evidence in the area of psychological well-being to support the equivalent relationship as has been established between exercise and physical health. At the same time, it has been speculated among health practitioners and the public that, in many cases, the psychosocial benefits of physical activity for mental health may actually outweigh the physical benefits.

2.4.1.2 Health Status

With respect to health, women have a greater life expectancy than men, but are also more likely to experience illness, violence and poverty. Women have been found to practice better health habits although "over a life they suffer more ill health and more frequent users of the health care systems". In general, women are poorer than men and make-up the vast majority of low-income single parents (Wilmore, Stanforth, Gangnon, Leon, Rao, Skinner & Bouchard, 1996). As well, they often carry a double workload, one in the paid work force and one in the home.

Women have a distinctive relationship with "health" in our society partly because of their reproductive capacities, but also because of their multiple roles. Women provide most unpaid

and informal health care services and play a key role in influencing the health behavior of others in their families (Carter, Banister, & Blaber, 2003). In modern societies, in the 19th century more and more women in industrialized countries stopped being homemakers and began to do jobs that men usually did. At this time, many factories were set up. First in England then in other European countries and United States. Many thousands of young women went to work in factories. The job of housewife is to take care of her husband and other members of the household and participate in the care of their homes. In relation to the professional health care system, women represent approximately 80% of all health care workers and tend to be stratified in the low-paying and low-status positions (Wang et al, 2013).

2.4.1.3 Energy Expenditure

Energy expenditure is the amount of fuel the body needs. The human body expends energy in the form of:

1. Resting Energy: amount of energy needed to maintain basic physiological functions of the body organs in breathing, blood circulation, synthesis of compounds etc.
2. The thermogenic effect of food energy needed to process the food we eat to produce energy.
3. Physical activities: energy required to do work (Bender & Bender 1997).

These three components make up our daily energy requirement. The amount of energy expended over a period of 24 hours or in carrying out a physical activity can be checked.

The unit of measuring energy is calorie. A calorie is defined as the amount of heat energy required to raise the temperature of 1ml of water at 15^0C by 1^0C. Food energy is measured in a fairly large scale, commonly known as the Kilocalories (Kcal). Energy is also measured in joule which measure energy in term of mechanical work. A joule is defined as the amount of energy

required to accelerate with a force of 1newton for a distance of 1metre. Thus 1 Kilocalorie = 4.184 kilojoules. (Bender & Bender, 1997, Brown, 2005).

Energy expenditure depends on the duration, the type of activity, the intensity of the activity, the body size and the fitness level. The energy requirement for various activities is often referred to as energy "cost" of activities. The information on the energy cost is obtained by a series of tests based on measurement of oxygen consumption with respect to the resting energy expenditure and read in terms of kilocalories per kilogram body weight per hour (i.e. Kcal / kg body weight / hour).

To estimate the energy cost of an activity that is not listed on table of energy cost for physical activities, the value for an activity per hour is listed and that it involves similar muscles and a seminar degree of exertion can be made. To do this:

1. Measure the body weight of the individual to perform the activity.
2. Check the value for the physical activity carried out on the table work respect to time spent.
3. Multiply the body weight by the energy expended per time.

2.4.1.4 Calculating Physical Fitness (Pf)

A key concept in testing physical fitness is that of a person's pulse rate, and in particular hour quickly this returns to normal after excessive exercise. It is important that pulse rate return to normal after strenuous exercise, otherwise the heart is put under continuous stress. There are 3 methods of calculating physical fitness as stated by Bender & Bender (1997).

Gallagher and Brouha Test: In these, the exercise steps into and off a bench (or step or engage in an exercise for instance) of height of 18 inches for boys and 16 inches for girls, or a rate of 30

steps per minute. The exercise continues for as long as possible up to four minutes. The pulse rate is taken at the following times after the exercise stops.

1 – 1½ minutes: 2 – 2½ mins, 3 – 3½ mins in each case the number of beats in the half minutes noted

P:1, P:2 and P:3

The fitness index is evaluated from Bender & Bender (1997):

$$\text{PF index} = \frac{50 \times T}{(P_1 + P_2\ P_3)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{ Equation I}$$

Where T = duration of the exercise in seconds and P_1, P:2 and P:3 are the measure pulse letouts in each ½ minutes.

Table 2.1: Index Grade

< 50	Very poor
50 – 60	Poor
60 – 70	Fair
70 – 80	Good
80 – 90	Excellent
> 90	Superb

Source: Bender & Bender (1997)

Body Mass Index (BMI)

It is an index used to measure the degree of adiposity. The quetelets index (Bender & Mayes, 2000)

$$\frac{\text{Weights (Kg)}}{\text{Heights } (M^2)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{ Equation II}$$

It is the most widely used height and weight index and is a validated measure of nutrition status. BMI accounts for different composition by defining the level of adiposity and relating to height thereby eliminating dependence on frame size. The BMI calculation requires weight and height

measurement and base on the result, it can indicate over nutrition or under nutrition. The WHO cut-offs' and description of BMI range in adult male and female are:

Table 2.2 BMI cut-offs for under and Over Nutrition in Adult

BMI Kg/M^2	**Description**
< 16	Severe underweight
16 – 16.9	Moderate underweight
17.0 – 18.4	Mild
< 18.5	Underweight
18.5 – 24.9	Normal weight
25.0 – 29.9	Overweight
> 30.0	Obesed
> 40.0	Mobidity obese

Sources: Bender & Mayes (2000)

A strong condition exists between total body fat and BMI, individual variation need to be recognized before the final arrangement. Difference in race, sex and age must be considered when evaluating the BMI. BMI tends to increase with age.

The percentage body fat weight considered "essential fat" is around 4% for man and 10% for women. American Dietetic Association recommended that men have 15 - 18% body fat, and woman 20 - 25% body fat Healthy man athletes may be as low as 15 – 20% body fat and female athletes could be as low as 10 - 20%.

Calculating the BMR of an individual. Basal Metabolic Rate (BMR) is the energy expenditure by the body when at rest but not asleep – under controlled conditions of thermal neutrality, measured at about 12hours after the last meal and depends on weight, age, and gender.

BMR is the number of calories per hour the body burns / day at rest. It is also refereed to as REE (Bender & Mayes, 2000).

A biometric study of BMR gives formular for calculating BMR as thus:

For men:

BMR =13.75 x weight(kg) + 5.003 x Height(cm) – 6.775 age + 665 ……. Equation III

For women:

9.563 x weight(kg) + 1.850 x height(cm) – 4.675 x age + 655.1……. Equation IV

BMI is expressed as kilocalories / Kilogram body weight / hour. BMR is ones energy expenditure without any contribution from exercise or digestion.

Factors which affect BMR are:

1. Body weight because there is a greater amount of active tissue in larger body.
2. Age: There is decrease in BMR with increasing age, even when body weight remains constant. This is due muscle tissue replacement by adipose tissue, which is metabolically much less active.
3. Sex: women have significantly lower BMR than men even when they are the same body weight because women's bodies have proportionately more adipose tissues than men.

Determining one's Energy Expenditure in Performing Some Activities

Energy cost for physical activities.

Total Energy Expenditure (TEE) is the total of basal energy expenditure, activity thermogenesis, and the thermic effect of food. The daily total energy expended by a person in 24 hours. It is given by TEE = BMR + SDA + PA. ……..……. Equation V

Where BMR = Basal Metabolic Rates

SDA = Specific dynamic action of foods.

PA = Physical activity

The total energy expenditure (TEE) depends on BMR, energy required for physical activity (PA) and energy cost for specific dynamic action of food (SDA).

Energy requirement increase with activity. Most useful way of expressing the energy cost of physical activities is on a multiple of BMR. Sedentary activities use only 1.1 – 1.2 x BMR. By contrast, vigorous exertion such as climbing stairs, cross-country, skiing, walking upstairs etc may use 6-8 x BMR. (Bender & Mayes, 2000).

2.4.1.5 Energy Balance

After provision of water, the body's first requirement is for metabolic fuels, fats, carbohydrates and amino acids from proteins (and ethamol). Food intake in excess of energy expenditure leads to obesity, while intake less than expenditure leads to emaciation and wasting, as in marasmus and kwashiorkor. Both obesity and severe under nutrition are associated with increase mortality. The body mass index, defined as weight in Kilograms divided by height in metres squared is commonly used as a way of expressing relative obesity to height. A desirable range is between 20 and 25 (Garrow, James & Ralph, 2000).

Energy requirements are estimated by measurement of energy expenditure. Energy expenditure can be determined directly by measuring heat output from the body but is normally estimated indirectly from the consumption of oxygen. There is an energy expenditure of 20kj/l of oxygen consumed regardless of whether the fuel being 2.57 Estimated Energy Requirement (EER) represents the average dietary energy intake that will maintain energy balance in a healthy person of a given gender, age, weight, height, and physical activity (PA) level. Balance is the key to the energy recommendation. (Garrow et al 2000).

Enough energy is needed to sustain a healthy and active life but too much energy can lead to obesity. Because any amount in excess of needs results in weight gain, there is no Tolerable upper intake level (UL) for energy.

To calculate your EER, first select the appropriate equation for your gender.

i. For men 19 years and older.

EER = 662 – 9.53 x age + PA x (15.91 x wt + 539.6 x Ht). ……. Equation VI

ii. For women 19 years and older:

EER = 354 – 6.L91 X Age + PA x (9.36 x wt + 726 x Ht). ……. Equation VII

Then insert your age in years, weight in kilograms, height in meters and physical activity factor as shown in the table below (Garrow, et al, 2000).

Physical Activity (PA) Factors for EER Equation

Men Women For an average weight person, adults equivalent to walking at 2-4 mph for the following distances.

Sedentary	1.0	1.0	only physical activity required for independent living.	
How active	1.11	1.12	1.5 to 3	Mi/day
Active	1.25	1.27	3 to 10	mi/day
Very active	1.48	1.4510 or more		mi/day

How to Estimate Energy Requirement

To estimate the energy requirements of an active 19 year old female who is 5 feet 5 inches tall and weighs / 51 unit135 pounds.

ERR= 354 – 6.91 x age + PA x (9.36 x wt ÷ 726 x ht) then, if necessary, convert pounds to kilograms (divide by 2.2) and inches to meters (divide by 39.37). ……. Equation VIII

135 1b ÷ 2.2 = 61.4 kg

65 in ÷ 39.37 =1.65m

Select the appropriate physical activity factor from the table above (1.27 for an active female). Then insert her age, physical activity factor, weight and height into the equation.

EER= 354-6.91 x 19 + 1.27 x (9.36 x 61.4 + 2726 x 1.65) ……. Equation IX

EER= 354-6.91 x 19 + 1.27 x (574.7 + 1197.9)

EER = 354-6.91 x 19 + 1.27 x 1772.6

EER= 354 – 6.91 X 19 + 1.27 x 1772.6

EER= 354 – 131 + 2251

EER = **2474**kcal/day

The estimated energy requirement for an active 19 year old female who is 5 feet 5 inches tall and weights 135 pounds is about 2474 kcal/day. (Garrow et al, 2000).

Metabolized is carbohydrate, fat or protein measurement of the ratio of the volume of carbon dioxide produced to volume of oxygen consumed (respiratory quotients RQ) is an indication of the mixture of metabolic fuel being oxidized. A more recent technique permits estimation of total energy expenditure over a period of 1 - 2weeks using dual isotopically labeled water. $^{2}H_{2}{}^{18}O$, ^{2}H is lost from the body only in water, while ^{18}O is lost in both water and carbon dioxide, the difference in the rate of loss of the two labels permits estimation of total carbon dioxide production and this oxygen consumption and energy expenditure, (Bender & Mayers, 2000).

The activity of dishwashing was carried out at two different heights viz, 79 and 84cm. The heart rate at rest was found to lie between 87-89 bpm. The working heart rate was minimum (105.42bpm) at 79cm with least energy expenditure (8.04kg/min) as compared to working

counter heights of 84cm (8.46kg/min). thus, it can be conducted that human energy expenditure during dishwashing as minimum at 79cm. (Bender & Mayers, 2000).

2.4.2 Rating of Perceived Exertion of Household Task

The Rating of Perceived Exertion (RPE) is a common method for determining exercise intensity levels. It is used in some research studies for that purpose, but may also be used in training programmes to describe the intensity of training sessions. The scale of perceived exertion is how hard you feel your body is working, and therefore is a subjective measurement. The commonly used scale is based on the research of Gunnan Borg, and is therefore also called the Borg scale. There are three versions of this scale (Borg, 1998).

i. Borg 6-20 - the original scale as developed by Borg, with the ratings between 6-20 which can correspond to 1/10 of the exercise heart rate.
ii. Borg CR10 – an updated combined category and ration scale by Borg with the ratings between o (nothing at all) and 10 (very very hard).
iii. Rob's RPE-5 Hand Scale – a new scale with some advantages over the other scales. For this RPE scale, the subject just holds up the fingers of their hand to indicate the intensity level from 1 to 5.

Borg (1998) describes the use of the RPE measurement. The RPE measurement should be taken while the subject is undertaking the exercise, not just after they have stopped. Prior to exercising, the subjects should be given instruction about how to use the RPE scales.

Carton & Rhodes (2012) examine human performance and perceived exertion during physical activity. This review considers the evidence of many investigators who have been researching the physiological basis as well as non-physiological basis for the ratings of perceived exertion.

During low levels of activity, physical perception in the working muscles appears to be the primary stimulus for effort perception. When work intensity exceeds the lactate household, incremental elevations in blood lactate component peripheral input from the micro-muscular mechanisms. Once a critical absolute ventilatory household is reached, central input also contributes to effort perception. In most instance, peripheral input predominates over central cues, although it has been shown that pronounced central cues may dominate the perception of effort, central (heart rate, VE, VO_2) or local (muscle and blood lactate, adenosine triphosphate, creative phosphokinase, glycogen) cues highlighted in these studies demonstrate both the complexity of effort perception, and the need for better understanding of the physiological components upon which it is based (Carton & Rhodes, 2012). Athletes have been shown to have a greater tendency to reduce perceptual ratings than their non-active counterparts. In view of these observations, it is apparent that a theoretical framework based upon physiological and psychological considerations may exist to support the concept of training-induced alterations in perceived exertion.

2.4.3 Impact of Household Task on Postural Changes of Women

The physical cost of the work of the home are to be thought of in terms of the effects on all the systems of the body that function during work. The maintenance of working position is sometimes the most fatiguing aspect of the job. Movements made during work performance may constitute beneficial exercise or they can subject parts of the body to stresses that are fatiguing or detrimental to general well being. The worker's body constitutes her most important item of household equipment. The entire body involved in the work is the focus in work study for the homemaker, the effect of a method of work on the entire body should be understood (Bridger, 1995).

2.4.3.1 Static Work

Static work may be defined as work done by means of static muscle contractions required to hold the body or any segment of it in a fixed position without contributing directly to the work performance (Bridger, 1995). Saha (1999) warned against static work in a listing of general rules for the body economy. The translation of one of the rules is "positively exclude static work… because in muscles at static work blood circulation is reduced." He further says that in order to have good work conditions, "…. there must be an avoidance of static work with the attendant circulatory disturbances, and cases of degeneration in muscles, ligaments and joints."

The harmful effects of static work on blood fluid circulation result basically from the maintained contraction as contrasted with the alternate contraction and relaxation of muscle. Muscular exercise augments cardiac output and so brings an increased flow of blood to the acting muscles. However, while the muscle is contracting, the blood vessels to that muscle are compressed and the blood supply to that muscle is reduced.

2.4.3.2 Fatigue from Static Work

The difference in feelings of fatigue after a period of active physical exercise compared to feelings after a period of working at a surface that is too low or too high may be due to the difference in the effect of dynamic and of static work. Maintaining the head in a position to see or raising the shoulders to position the hands above a work surface required a relatively steady contraction of muscles not directly involved in the work. Static work is as much or perhaps more likely to be associated with the light work of the present-day homemaker as with the more strenuous work of an earlier day.

Saha (1999) refer to a study in which fatigue from static work was found to be three to six times as great as from lifting; they do not mention the method of determining fatigue. But the ill

effects of static work are well known and the causes understood. The avoidance of static work for any part of the body is an important target for work improvement.

2.4.3.3 Erect Posture

The term "fatigue of standing" might more properly be called " fatigue of erect posture." Quiet standing and moving about on the feet while working are not, physiologically speaking the same. In housework there are relatively few cases of the quiet standing that is required of the subjects in physiological studies of standing. The erect posture has several physiological effects, some of which add up to feeling of fatigue, described the difference in energy expenditure for lying and standing or sitting and standing has nothing to do with the fatigue that is felt. It has been shown that it is erroneous to say that we save energy by sitting to work. Moreover, it is generally agreed that walking is less tiring than standing yet required greater energy expenditure.

The activity of muscles, which of course would show up in energy expenditure, is also not related to the fatigue of standing. According to Basmajian (1962:87 in Saha (1999) "The fatigue of standing is emphatically not due to muscle fatigue and, generally, the muscular activity in standing is slight or moderate.

The two physiological bases for the fatigue of erect posture are:

1. Effects on the circulation.
2. Pain arising from pressure on ligaments', joint capsules and tendons.

2.4.3.4 Body Mechanics

Mechanics is defined as the science of dealing with force and motion, then body mechanics is of course, a science dealing with body forces and motions. The term body mechanics in itself a

popularization of Kinesiology, "the scientific study of movements of the human body" is Kinesiology. Durall (1959:5) says in Saha (1999):

> "The teaching of fundamental movements of motor skills, and the improvement in performance of these skills rests squarely on the knowledge of human motion and how it is accomplished…. Understanding of the causes of fatigue and inefficiency is based upon many things of which kinesiology is oneand the principle of body movements are now being taught in many areas outside of education and medicine."

Body mechanics is of interest because of a desire to keep the homemakers' cost of work at a minimum. The physical cost of work can be too high in fatigue even for light work if the natural structure and functions of the body are disregarded during work performance. An untrained worker often will work against her body rather than let her body work for her. The physical cost of workman than be out of proportion to the amount of work accomplished in the technical sense of foot-pounds, in energy expended, or in the discomfort and sprain felt (Saha, 1999).

2.4.3.5 Mechanics of Movement

The laws of mechanics apply to moving the body and its segments just as they do to moving inanimate objects. Knowledge of the force of gravity of momentum and of leverage can contribute to the development of efficiency in body motions. Gravity is a force which is constantly acting upon the human body and one which the body is constantly combating except when in the prone position. Saha (1999) said, "The only way to profit from gravity is to keep on going downhill." How to maintain the upright posture economically during standing, sitting, walking, and running, climbing and lifting is a basic technique of work improvement. The

workers own body is not only her most important piece of equipment but also the greatest weight she normally transports and manipulates.

Walking, climbing stairs, lifting the arms, all involve the moving of weight through distance, constituting work in the technical sense. Lifting the body or parts of it may be a large share of the work in an activity, as for example, bending over to pick-up a paper scrap from the floor. The method of bending over is important for this activity because of the stress on intervertebral disc from the weight of the body not the weight of the object lifted. When this action is performed with the knee bend and with the back in good alignment, protection is maintained for intervertebral disc. The centre of gravity of the body in relation to the base of support is one of the keys to the economical handling of the body weight during work. The centre of gravity is an imaginary point at which the entire weight of the body may be thought to be concentrated, the centre of weight or mass. For women this point lies within the pelvic region at 55 percent of the standing height. The centre line of gravity shifts when we walk, run, or assume a sitting position. The line of gravity is a vertical line from the centre of gravity to the earth's surface. For the human body when standing, the base of support is in our two feet giving us a chance for variation in the breadth of support. When the feet are close together the base of support is narrow, when they are apart the base of support is broader (Saha, 1999).

Momentum is the force which the muscles must overcome when work is performed with sudden stops or sharp changes in direction. The housewife is constantly contending with Newton's first law, recognition of which is important to good body mechanics.

> **".** A body remains at rest or in uniform motion until acted upon by an unbalanced set of forces. This means that if a body is at rest, the forces acting on it must be completely balanced; the body is then said to be in equilibrium. If a body is moving it will continue

> to move at a uniform speed until some force causes it to stop moving or to change its rate or direction of motion… "(Williams and Lissner, 1962.2)

This is known as the law of inertia. The body in motion has momentum equal to the product of its weight times its velocity. Circular motions, when they are practical, avoid the unnecessary use of muscular force to overcome momentum, since speed is one component of momentum, slow circular motions require less muscular force than quick, jerky motions (Saha, 1999).

The leverage effects of the muscles on the bones are difficult to understand because of their complexity and the fact that they are hidden from sight. The arm is one example of a lever operated by muscles. It has been shown experimentally that the arm has its greatest strength when the forearm is perpendicular to the upper area with the right-angled bend at the elbow (Saha, 1999). The length of the lever arm of the biceps muscle on the radius bone of the forearm to the axis of rotation of the elbow joint, when "…the elbow is straight the lever arm of the biceps muscles is short. The lever arm increases as the elbow bends, is maximal at about 90 degrees of flexion, and again decreases beyond this point…" (Williams & Lissner, 1962:38 in Saha. 1999).

2.4.3.6 Good Working Posture

According to Carpenter (2000), working methods are important, stand correctly with feet apart and one slightly advanced. Use the strong muscles of the leg rather than the weaker ones of the back-bend at the knee. The trunk and arm muscles should be used for polishing, not just the hands. Arm movement should aid in chopping, rather than fingers. When picking up objects, use palms and finger bases instead of merely the tips.

When lifting, get set before taking the load, keep the weight close to the body, contract slowly and evenly and bend the knees slightly before lifting. To shift heavy objects, apply force to the centre of gravity of the load (Carpenter, 2000).

2.4.4 Impact of Household Work on Cooking

Everyday cooking in the home is still women's work. This should not be understood merely from the perspective of female subjugation (Furst, 1997). Food is an important expression of identity, and the giving of food seems to be closely related to feminity and the subjective experience of being a woman. According to Furst (1997) cooking may also be understood as an expression of "a rationality of the gift," which stems from a specific kind of work; production of use-values in the home. This rationality contrasts with "the rationality of the commodity," which sterns from production in the market. Women's present situation of double work points to an ambiguous position, as they are commuting between different realms of society. Cooking is however one of the housekeeping activities.

Housekeeping refers to the management of duties and chores involved in the running of a household, such as cleaning, cooking, home maintenance, shopping, laundry and bill pay. These tasks may be performed by any of the household member, or by other persons hired to perform these tasks. Housekeeping can be seen as an objective activity that can be done by either men or women, some people have argued that housekeeping is a site of historical oppression and gender division between traditionally gendered men and women (Kennedy, 2006).

According to Covert (2014), there's no biological explanation for why women and up doing more housework, it must stem from societal forces. Typical day, nearly half of them will do housework, but just 20 percent of men will do the same. And women put more time into

scrubbing the toilet or doing the laundry – three more hours each week than men. Men carve out three more hours of leisure time. Even mothers who work full-time will still put in a week and a half's worth more time on household task than their male partners each year. When the division of household labour falls along gender lines, where can we turn for explanation. There's a school of thought that women take on more of the childbearing work, moms spend twice the time on childcare each week than dads do – because they are biologically inclined to be caregivers. And its true that the female body is the one equipped to carry a pregnancy and breastfeed and that these experiences can create bonds, although there is also evidence that giving dads the time to be present during the earliest moments causes a bond that gets them more involved with their children later on. (Covert, 2014).

But there's no biological determinant for housework. No gender is physically predisposed to work to do the dishes or take out the trash. This drudgery is necessary – at least if you like eating off of dishes that don't have old food on them or living in a house that doesn't smell like the dump. But chores rarely bring the joy and fulfillment of parenting. At least one cause of the housework gap can be traced back to childhood chores. A variety of studies have found that girls are asked to do more work around the house than boys. One study found that girls did two more hours of chores a week while boys got twice as much time to play. This dynamic carries a lesson for both genders, girls learn that housework falls on their shoulders, and boys learn that girls will clean up after them (Covert, 2014).

According to Covert (2014), the gendered disparity does not end at time and effort, either. Girls may do more housework, but they don't get as much pay for it. Sixty-seven percent of boys allowances, but just 59 percent of girls do. The findings of the study showed that girls do two more hours of chores per week also found that boys are 15 percent more likely to get an

allowance for doing them. And when they do get paid for it, girls will get less. The lesson; boys are doing something special to be rewarded when they do a load of laundry or mow the lawn, while girls are doing something 'natural' that doesn't require renumeration. One study found that boys who grew up only with sisters are 13.5 percent more conservative in their views of women's roles compared to boys who grew up only with brothers. The researchers speculate that because their sisters are given the housework, those boys tend to assume domestic chores are women's work.

According to Covert, (2014), there's another school of thought, of course, that women just have higher cleanliness standards. "men are dirty pigs who don't care", the thinking goes. But this too is at heart a social construction that culture inculcates in both genders. Marketing messages illustrate the point: only about 2 percent of commercials featuring men show them cooking, cleaning or running after kids, while the majority of commercials featuring women are selling home products like cleaners or furniture.

The same study that produced these numbers found that men who view commercials with a male character in a non-traditional role are more likely to fovour domestic goals – but few are getting that exposure. Instead of assuming that women want cleaner homes, remember that they face higher expectations around cleanliness, a judgement that doesn't impact their male partners. As Jessica Grose has written, she "worried I would be judged for the beef jerky wrappers". Somewhere lodged within me was the message that it was my responsibility. Think back to the little girls being handled chores without pay: the cleanliness of the house is your responsibility, we tell them. By the time they are welcoming guests into their own houses, they've internalized the guilt for the dust bunnies in the corner. And any woman who wants to change this dynamic confronts another problem. What man has been called a nag? But when women as that their

husbands pitch in more, they run the risk of conjuring up this old label. A nag is just a person making a request that annoys the requestee. Women are told by parents, advertising agencies and a host of other societal forces that they are responsible for making the house clean, and when they push back, they are slapped with a pejorative. No wonder they spend so much more time tidying up. It might be more exhausting to try and have it any other way (Covert, 2014).

Men seen to be doing more cooking than they used to. In one survey of 900 men, nearly half said they go grocery shopping; 46 percent are responsible for cooking all of their household's food. Cooking is one of those tasks that comes with a satisfying reward at the end – a delicious meal. But man's embrace of the kitchen may also be thanks to cultural messages that gourment chefs are manly. Think Iron chef, Ace of cakes, Top chef, Hell's kitchen or rearly any other male-led food network show. Is there a way to make wiping a counter or a window mainly? Perhaps that holds the key to getting man to get off the sofa and vacuum under it.

Until then, however, housework will be the burden women bear that is perhaps the most obviously inexplicable; if there is any clear sign that society molds the way each gender views unpaid work, its household chores. There's just no good reason for why women are the ones required to take out the broom and the sponge (Covert, 2014).

2.5 Household Activities and Kitchen Designs

Child Care

i) Getting children ready for school and work

ii) Volunteering for school canteen and other jobs

iii) Bathing and dressing children

iv) Feeding babies

v) Wiping noses and bottoms

vi) Playing with children

vii) Comforting babies, children and partners.

viii) Driving the children to school and other activities

ix) Helping with homework

x) Supervising music practice

xi) Reading storybooks

xii) Stopping fights.

Cleaning, Decorating and Provision of Clothing

i) Cleaning the home

ii) Seasonal cleaning like washing curtains and beating carpets

iii) Cleaning out the garage

iv) Decorating (arranging the furniture and ornaments and choosing the colours of things).

v) Washing clothes

vi) Ironing clothes

vii) Mending clothes (and Sometimes making them)

viii) Shopping for new clothes and other family needs.

ix) Tends the garden

Foods Related Care

i) Planning meals

ii) Buying foods

iii) Preparing and cooking foods

iv) Serving foods

v) Washing up after meals.

Heath Care and Companionship

i) Doing first aid.

ii) Caring for sick people.

iii) Caring for pets.

iv) Listening to peoples stories of their day.

v) Giving advice.

vi) Entertaining guest.

vii) Remembering everybody's birthday.

viii) Fixing things that go wrong.

ix) Remembering what everyone else has forgotten.

x) Finding lost things.

xi) Putting people to bed.

xii) Kissing people goodnight.

Keeping up with Finances, Daily Household Items and Expenses

i) Paying monthly household bills in timely manner.

ii) Making sure all household issues are resolved regarding health/car insurance, cell phone bills, doctor appointment etc.

iii) Managing spending

iv) Any other secretarial duties that need to be done to help run a smooth partnership with the husband that is working to pay the bills.

2.5.1 Kitchen Work Triangle

The kitchen work triangle is a model that was developed in the 1940's to address the efficiency of the kitchen space between the major work centres; cooking (range), preparation (sink/dishwasher) and food storage (refrigerator). It was designed to maximize the efficiency of a one-cook kitchen that stemmed from Taylorist principles that has to do with time-motion studies from about the turn of the century.

The main workings functions in a home kitchen are carried out between the cook top, the sink and the refrigerator, as shown in fig 2.2 below.

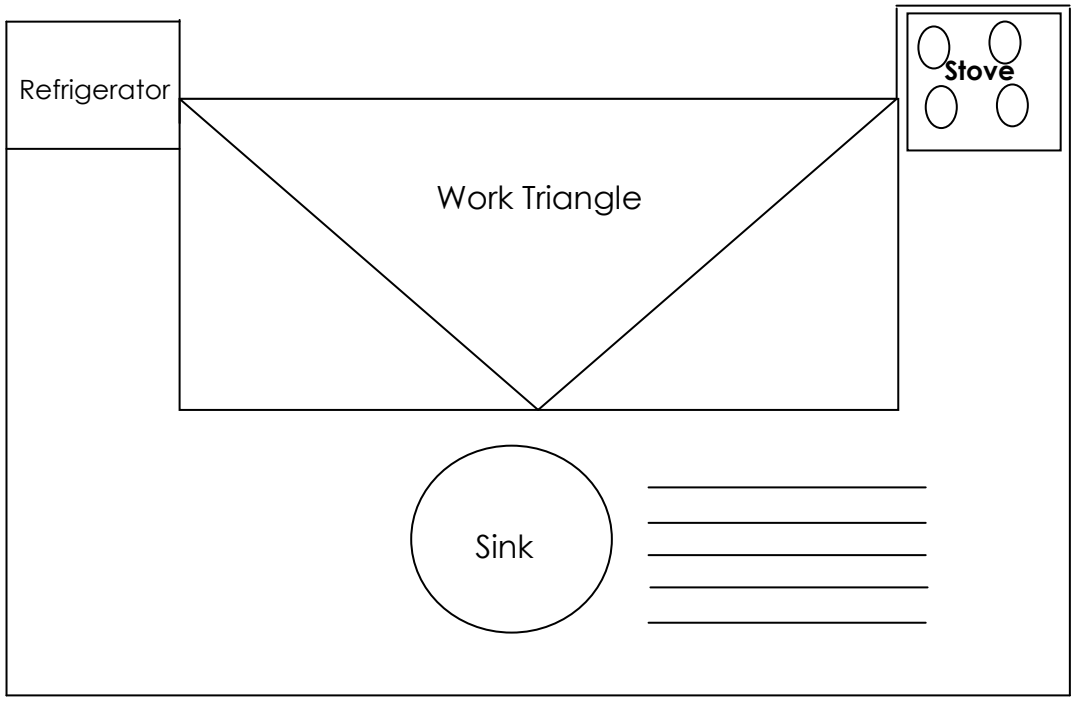


Fig. 2.2: Kitchen Triangle.

These three points and the imaginary lines between them, make up what kitchen experts call the "work triangle". The idea is that when these three elements are in close (but not too close) proximity to one other, the kitchen will run efficiently.

There are exceptions to this rule; in the single wall kitchens, it is geometrically impossible to achieve a true triangle but efficiency can still be achieved through the configuration of the three items, and how far apart they are.

2.5.2 Kitchen Design and Application

The kitchen work triangle principle is used by kitchen designers and architects when designing residential kitchens. The following principles are outlined by Kohler plumbing North America and National Kitchen and Bath Association (en. wilipedia.org/wiki/kitchen-work-triangle).

1. No leg of the triangle should be less than 4feet (1.2m) or more than 9 feet (2.7m).
2. The sum of all three sides of the triangle should be between 13feet (4.0m) and 26feet (7.9m).
3. Cabinets or other obstacles should not intersect any leg of the triangle by more than 12 inches (30cm).
4. If possible, there should be no major traffic flow through the triangle.
5. A full-height obstacle, such as a tall cabinet should not come between any two points of the triangles.
6. Besides the work triangle itself, there are several rules of thumb to consider when planning kitchen.
7. As measured between countertops and cabinets or appliances, work aisles should be no less than 42 inches (110cm) for one cook, or 48 inches (120cm) for multiple cooks.
8. A sink should have a clear counter area of at least 24 inches (61cm) on one side, and at least 18 inches (46cm) on the other side.

9. A refrigerator should have a clear counter area of at least 15 inches (38m) on the handle side; or the same on either side of a side-by-side refrigerator; or the same area on a counter no more than 48 inches (120cm) across from the refrigerator.
10. A store or cook-top should have a clear 15 inches (38cm) area on one side, and at least 12 inches (30cm) on the other side.
11. At least 36 inches (91cm) of food preparation area should be located next to the sink.
12. In a seating area where no traffic passes behind the diner, allow 32 inches (81cm) from the wall to the edge of the table or counter; if traffic passes behind the diner, allow 44 inches (110cm).

2.5.3 Kitchen Layouts

There are four main kitchen layouts 'L", "Galley", "U" and "G" (Peninsula), each accommodates a work triangle in its own way.

2.6 Review of Related Empirical Studies

Several studies have been conducted on various aspects of physiological cost of work by other researchers in various parts of the world, particularly, India. This section presents a review of empirical studies such as Agarwal & Sharma (2003) conducted a research on the ergonomic evaluation of postural stress among Asian women. The major objectives of the study were to determine the working conditions and postural stress experienced by these women. Descriptive cum experimental research design was used, and forty women workers were selected for the study. For descriptive data, structural interview schedule was used, flexi curve, step stool, and heart rate monitor were used as instruments for data collection. The study proved that there was significant difference in postural stress experienced by the women respondents.

Agarwal & Sharma (2003) study has similarity with the present study because both studies examined physiological conditions and postural stress of women. Also, both studies used flexi curve as an instrument for measuring postural stress, the studies only differ in their experimental design and geographical location. Agarwal & Sharma study used Asian women workers in food processing industries while the present study used women in their kitchens.

Sandhu (2003) conducted an experimental study on the efficiency of selected household tools / equipments and ergonomic principle in reducing energy costs of selected household work. The study adopted factorial research design, twenty four (24) female, having the same height, weight and age as well as body surface area were selected for the study. The subjects were asked to perform the given work first with the use of traditional tools / equipment then with the ergonomic household tool/equipment. The results of the study showed that sweeping and washing floors with adequate tools reduces human cost of doing work. Based on the findings, Sandhu concluded that ergonomic principles should be considered when selecting tools/ equipment for performing household work.

The study has similarities in the adoption of similar research design. They differ in the sense that the study focused on the efficiency of selected household tools for home clearing and ironing while the present study researched into the effects of energy cost, heart rate, rated perceived exertion and postural stress on the cooking activities of kneading dough, stirring rice moulds and pounding yam.

Kishtwaria, Rana, Awasthi & Lata (2004) conducted a study on the physiological workload of respondent engaged in plucking tea leaves and identified the major causes and consequence of physiological stress. Random sampling methods was adopted to select tea growers from two Tehsils of Kangra district of Himachal Predesh. A total of thirty women engaged in tea

plantation activity were selected in order to achieve the objective of the study. The results were recorded with the use of polar heart rate monitor, flexi-curve and weighting balance. Data were analysed using frequencies, percentages, means scores, relational statistics and regression analysis.

The finding revealed that the better the physical health, the lesser the stress of workload on the health of workers. The similarity of Kishtwaria et al., study with the present study was in the instrument used for collecting data, both studies used heart rate monitor and flexi-curve. They however, differ in the activities performed. Kishtwaria et al., study engaged in tea plantation activity, the subjects in the present study engaged in cooking activities. Kishtwaria et al., study also identified the cause and consequences of physiological stress which the present study does not.

Chauhan & Sharma (2006) conducted a study with the objective of determining the postural stress, heart rate and energy expenditure encountered by women. A descriptive cum experimental research design was used. The purposive random sampling design was used to sample forty women workers involved in construction work. The result of the study showed that angle of deviation was more in bending position and was maximum in older groups than other groups.

Chauhan & Sharma (2006) and the present study are to some extent similar, since all three objectives of Chauhan & Sharma's study form part of the objectives of this present study, there exist similarities in the instrument used. The two studies differ with women involved in construction work while the present study concentrated on the domestic chores of women. Furthermore, the geographical location differs. Nevertheless, the study will also be relevant in discussing the findings of this present study.

Oberoi, Harshipender & Gupta (2006) conducted a study on the assessment of muscular stress of rural women while performing different activities with traditional and improved tools. The objectives of the study was to: access the frequency of postural changes, compare angle of deviation, access the change in grip strength, and compare the change in muscular skeletal problems with the use of traditional as well as improved tools. 30 women samples were used for the experimental study. The result of the study showed that postures were reduced to a significant level without undue fatigue and frustration with the use of the improved tools.

Oberoi et al (2006) to some extent have similarities with the present study in assessing the postural stress of women while they differ in the activities used. Their study focused on farm activities while the present study focused on domestic activities of woman. The result of Oberoi's study will be pertinent in discussing the findings of the present study.

Yue, Woo, Sum, Kwok & Hui (2007) measured the energy expenditure of common household tasks in a Chinese population among thirty (30) younger adult and seventy-eight (78) old people at rest and during activities using indirect calorimeter. The findings revealed that energy expenditure was lower in subject aged or = 60 years compared with those 60 years. Yue et al., study and present study have similarities, both studies measured energy expenditure of common household activities. The difference is that Yue et al's study used indirect calorimeter while the present study used heart rate monitor to assess the energy expenditure germen.

Nagori & Lodha (2011) conducted a study on the physiological cost of home makers while using kitchen storage. The objectives they used for the study was to calculate;

(a) Homemaker's physiological cost of work while using kitchen storage furniture for cooking in Semi Modular Kitchen (SMK) and Non-Modular Kitchen (NMK) in terms of;

i. Work area triangle

ii. Body Mass Index (BMI)

iii. Rated Perceived Exertion (RPE)

(b) To find out the requirements of kitchen storage design on different working body postures and Musculoskeletal disorders, (MSD).

A sample of sixty households were used having 30 each for SMK and NMK storage designs. An interview schedule and anthropometric measurement were used. Body Mass Index and respondent Rated Perceived Exertion (RPE) were measured, Flexi-curve was used to record postural changes and body map was used to determine musculoskeletal disorders in women. Frequency, percentages and T-test were used to analyze the data. The result revealed that the changes in physiological conditions of the home makers were less among semi-modular kitchen respondents.

Nagori and Lodha (2011) study have similarities with the present study in terms of assessing rated perceived exertion, body postures, and instruments used in the two studies. The study differ in the fact that their study focused on physiological conditions of home makers while using kitchen storage furniture for cooking on the other hand the present study examine the physiological conditions of the home makers before, during and after the performance of some selected cooking activities in their various homes. The result of this study will equally be relevant in discussing the present study.

Bhatt, Sidhu, Sandhu & Bakhshi (2011) conducted a study on the assessment of physical stress parametres of female workers engaged in selected cooking activities. The objectives of the study was to obtain a maximum efficiency in work with least cost to the body energy. The study purposively selected sixteen respondents having similar physical and physiological parametres.

The study selected five activities which were cutting, kneading dough, rolling chapattis, grating and dishwashing. The results concluded that differences in the degree of resting and working posture adopted by the home makers for both thoracic and lumber regions were found to be significant.

Bhatt et al., (2011) study and this present study are to some extent similar in three objectives: heart rate, energy expenditure and postural stress. Equally the two studies are similar in the number of samples and instruments used (Heart rate monitor and flexi curve), but differ in their methods of selection. Bhatt's study covered five activities; cutting, kneading dough, rolling chapattis, grating and dish washing. While the present study intends to cover three cooking activities; kneading dough, stirring hard porridge and pounding yam. Data collected in the present study will be analyzed at 0.05 alpha level as against 0.01 alpha level used in Bhatt's study. The findings was relevant in the discussion of the present study.

Biswas, Samanta & Saha (2011) conducted a study on the cardiac strain of confectionery worker in relation to heart exposure during regular work shift. The objectives of the study was to assess the physiological strain of workers engaged in sweet making activities in terms of cardiac strain indices in relation to heart stress. 33 full-time workers from eastern India were compared for cardiac strain profile obtained during summer and winter during their regular work shift.

The materials and methods used include, working heart rate (WHR) was recorded continuously during work. The pulse deceleration index (PPI) was obtained from recovery heart rate (RHR). Net cardiac cost (NCC) and relative cardiac cost (RCC) were the main indices used to evaluate physical strain. Thermal stress was assessed from bulb globe temperature (WBGT). The study concluded that the physical workload is aggravated with various ergonomic stressors present in the work place.

Biswas et al (2011) study focused on confectionary workers which differ from the present study that focused on the domestic chores of women. The studies also differs in the sample size, geographical location and instruments. While similarities only exist in the objectives of assessing the heart rate of women. Biswas et al' should have incorporated other parameters in their study.

Gayatri, Deepa & Nidhi (2011) conducted a study on the cost of assessment of ergonomic risk. A practical approach in redesigning of workstation for hospitality industry. The study aimed at finding out occupational factors influencing their health status. Ergonomic cost of selected drudgery prone activities was calculated by measuring the physiological parameters of selected activities. Postural discomfort questionnaire based on Visual Analogue Scales (VAS) was used to measure subjective qualitative judgments of different staffs regarding postures and discomfort at various times throughout the day. The results showed that the average working heart rate was found maximum for laundering activities followed by kitchen and house-keeping activities. The study explored the physical stress and strain in the working postures of the workers working in the kitchen house-keeping and laundry in the hotel. The study revealed that the workers of different departments of the hotel were doing very heavy task with awkward postures and repetitive motion. Their physiological cost of work was very high as they had to spent more energy while doing the task.

Gayatri et al (2011) study was similar with the present study in measuring some physiological parameters in assessing the working postures of women in the kitchen, but differ with other work stations as housekeeping and laundry. Gayatri et al study was conducted in the hotel while the present study concentrated in the domestic kitchen at home. The result of Gayatri's study was also relevant in discussing the findings of this present study.

Bhattacharyya, Burna & Chakrabarti (2011) conducted a study on the Ergonomic Intervention to reduce Physiological Stress of Workers engaged in Tea Fields. The objective of the study was to relate the effective application of ergonomic principles to improve occupational health. A total of 180 workers were selected; who have the age range between 35-50 years. Data were collected with a well structured interview schedule. The study assessed work related stress and postural stress, which was determined in terms of Energy Expenditure, Rate of Perceived Exertion and Muscular Stress.

Bhattacharyya et al (2011) study focused on the ergonomic intervention to reduced physiological stress of workers in tea fields, while the present study focused on domestic activities of women in their kitchens. The study is similar in the assessment of some physiological parameters such as postural stress, energy expenditure and rated perceived exertion. The study differ in the selected activities and the instrument used in the study. The age range in Bhattacharyya et al's study is a draw-back, 35-50 years is almost above middle age. The result of this study was very much relevant in discussing findings of the present study.

The study conducted by Karki, Joshi, Dhingra & Sandhya (2012) on the physiological assessment of Nilgiri women involved in economic activities had the following objectives; to assess the physiological cost of work, to calculate rated perceived exertion and to assess the musculoskeletal risk associated while performing activities. A descriptive cum experimental research design was used. A sample of 30 women was selected by applying simple random sampling technique. The result showed that women were found to be significantly working in farm and non-farm activities and due to overexertion of work schedule; they were developing bio-mechanical stress and health hazards.

Karki et al (2012) study to some extent has similarities with the present study. The objectives of assessing the physiological cost of work and rated perceived exertion are similar. The research design and simple random sampling technique were all similar to the present study. But the studies differ in their sample size, and the type of activities the women were engaged in. The result of this study was also relevant in discussing findings of this present study.

Bhatt & Sidhu (2012) conducted a study on the Physiological Stress Assessment of Female Workers at Kitchen Work Station. The aim of the study was to expose the extent of the physiological stresses of female workers at kitchen work station while performing the various activities. A survey of 80 home makers and experiment on 16 respondents having similar physical and physiological parameters were used. Five activities in which the respondents faced maximum problems were selected and were standardized. The study revealed that fatigue during the selected five activities i.e cutting, grating, rolling, kneading, dish washing, was felt mainly at the wrist, fore arm, followed by discomfort in the shoulders, upper arm, lower back and neck.

Bhatt & Sidhu (2012) study have very close similarities with the present study in the area of the objectives and selection of 16 samples having similar physical and physiological parameters. Bhatt & Sidhu's study experimented on five studies while the present studies experimented on only three, out of which one activity of kneading dough was common in both studies. The results of Bhatt & Sidhu (2012) study was relevant in discussing findings of the present study.

Bhatt & Sharma (2014) conducted a study on the Physiological Aspects of Load Carriage Activity done by Food Grain Handling Workers in India. The objectives of the study was to evaluate the workers with respect to the workload, energy expenditure and musculoskeletal pain or discomfort resulting out of work practice. Representative samples of 40 rice mill workers engaged under food cooperation of India were taken for the study. Descriptive cum experimental

research design was used. The results showed that average peak heart rate of the rice mill workers suggested the workload as moderate to very heavy.

Bhatt & Sharma (2014) study focused on physiological aspects of load carriage activity done by food grain handling workers in India, while the present study focused on cooking activities amongst women in Kaduna state, Nigeria. The objectives of assessing heart rate and energy expenditure is similar to the present study but differ in assessing musculoskeletal pain or discomfort resulting out of work practice. The study differ in sample size and sampling technique. The results of Bhatt and Sharma's study was also relevant in discussing findings of this present study.

Joshi, Sharma & Rastogi (2014) conducted a study on the Ergonomic Assessment of Physiological Cost of Work of Construction Workers. The objectives of the study was to investigate the physiological cost of work in terms of mean heart rate, energy expenditure and mean blood pressure. Randomly selected 30 construction workers were assessed, and sampling design was experimental in nature. The activities were categorized and assessed as basic construction work, laser operations, gas cutting, power tools operations, installation and management and supervision work. Results regarding mean blood pressure and energy expenditure showed that, basic construction work (loading/unloading) was found to be most strenuous activity, however, safety management and supervision was least exhaustive one.

Joshi et al (2014) study focused on the assessment of women construction workers while the present study focused on domestic chores of women. Joshi's study and the present study are to some extent similar in the two objectives except that both differ in the number of samples. The research design and sampling techniques were however similar to the present study. The result of Joshi's study was also relevant in discussing findings of this present study.

Shitu (2016) conducted a study on the effect of work environment on physiological and postural conditions of home-makers residing in Colleges of Education, North Central Geo-Political Zone, Nigeria. The objectives of this study was to examine the effect of work environment and tools on physiological and postural conditions of home-makers. Six (6) randomly selected College of Education were used. Home-makers whose BMI was between 18.5-24.9 (normal weighting BMI categories) were used. The instruments used were heart rate monitor, flexi-curve, a digital blood pressure meter, a statue meter, bathroom scale and self designed structured recording sheets and score card. Household tasks used in this study were washing clothes, house cleaning, ironing and dish washing as well as tools used during house cleaning and physiological and postural condition of home-makers in their residential dwellings.

The results revealed that there are significant effect on heart rate energy expenditure posture, level of intensity of pain on work environment and tools used during house cleaning. Both studies have similarities to some extent. Shittu's study and the present study are similar in determining the physiological and postural condition in the use of heart rate monitor and flexi-curve. Shittu's study differ with the present study in the selection of household activities, population and sample, and the categories of house-makers (BMI category). Factorial design of 5x 4 x 3 was used while the present study used 3 x 1 x 3 factorial design. The study was relevant in discussing the findings of the present study.

Situ (2016) conducted as a study on the effect ergonomic principle of furniture designs and furnishings on family members' musculoskeletal conditions in Urban Area of Oyo State, Nigeria. A sample of 60 families was used, descriptive and simple regression analyses was used. The findings showed that ergonomic principles have significant effects on family members musculoskeletal conditions. Situ's study differ with the present study in many ways. The study

looks at musculoskeletal condition of family members while the presents study looked at the physiological conditions of women while performing household activities. The studies differ in the sample and instrument used.

2.7 Summary of Reviewed Literature

Summarily, this chapter has reviewed literature with respect to ergonomic assessment of physiological cost of household work among women. The review clarify the theoretical framework upon which the study is based. It emphasized the need for a goal directed or purposeful interaction of a subject with an object through the use of tools. The chapter further reviewed literature on the concepts of household ergonomics, broad areas, importance and basic principles upon which it is built. With respect to health, the physiological cost of household work was reviewed. The energy expenditure and different methods of calculating physical fiteness were reviewed. Literatures on the rating of perceived exertion of household work, impact of household work on postural stress of women, and impact of household work on women were all reviewed.

More importantly, a number of empirical studies related to ergonomic assessment of physiological cost of household work among women conducted widely were reviewed. Most of the empirical studies conducted focused on the farm, industries and construction companies outside Kaduna State, Nigeria. Worthy to note is the fact that all the empirical studies reviewed gave little or no specific attention to physiological cost and postural conditions during cooking activities such as; kneading dough, stirring hard porridge and pounding yam at three assessment levels in Kaduna metropolis, Nigeria. This study therefore serve to fill up the missing gap in the aspect of literature.

Furthermore, most of the studies reviewed used various instruments for measuring physical and physiological parameters. This study specifically used an instrument for measuring body physical composition (Omron Body Composition Monitor) to determine percentage body fat, visceral fat and resting metabolic rate among women, in Kaduna metropolis, Nigeria. Thereby filling up the missing gap in the existing literature.

CHAPTER THREE

RESEARCH METHODOLOGY

This chapter describes the design and procedures used for the study, under the following sub-headings:

3.1 Research Design

3.2 Population of the Study

3.3 Sample and Sampling Technique

3.4 Instrument for Data Collection

3.4.1 Validation of Instrument

3.4.2 Reliability of the Instrument

3.5 Procedure for Data Collection and

3.6 Procedure for Data Analysis.

3.1 Research Design

The research design used for this study was experimental factorial design. A 3 x 1 x 3 design shows the physiological costs of three cooking activities of Kneading dough, Stirring hard porridge (tuwon-shinkafa) and pounding yam were assessed at one working environment i.e. at each respondent's kitchen.

Each participant was assessed in all the variables before, during and after each activity. This design is shown in the paradigm below:

Table 3.1: 3 x 1 x 3 Factorial Design

Household Activities	Working Environment	Assessments
Kneading dough	Kitchen	Before
Stirring rice mould	Kitchen	During
Pounding yam	Kitchen	After

Paradigm of 3 x 1 x 3 Factorial Research Design.

3.2 Population of the Study

The population of this study comprised women residents in three (3) bedroom apartments of Government Secondary Schools within Kaduna Metropolis, Kaduna State, Nigeria (See Appendix v). There are thirty-three (33) three (3) bedroom apartments within the study area occupied by married couples as presented in table 3.2

Table 3.2 Population of the Study

SN	Government Secondary Schools	Number of women in 3-bedroom apartments
1	Queen Amina College, Kaduna	4
2	Rimi College, Kaduna	15
3	Government College, Kaduna	3
4	Sardauna Memorial College, Kaduna	11
	Total	**33**

Source: Field Work, (2017)

3.3 Sample and Sampling Technique

Purposive sampling technique was used to select four (4) Government Secondary Schools in Kaduna Metropolis with residential quarters (3-bedroom apartments). Details of the selected secondary schools are presented in table 3.3. The houses were chosen because of uniformity and homogeneity of their structure aimed at determining the suitability of the environment for household chores, and for the purpose of accuracy and easy reach of women. Nwogwu (2006) stated that purposive sampling technique could be used when specific elements that satisfy predetermined selected criteria are to be used. Simple random sampling was used to select sixteen (16) women who were overweight and obese, (whose body mass index (BMI) was between 25.0 and 30.0kg/m^2). This is in accordance with the suggestion of Denga (2002) and Shittu (2016) who stated that half the number of sample frame is ideal as sample size in experimental research.

Table 3.3 Selected Schools and Sample Size

SN	Government Secondary School	Number of women in 3-bedroom apartments	Sample Size	Percentage
1.	Queen Amina College, Kaduna	4	2	12.5
2.	Rimi College, Kaduna	15	7	43.75
3.	Government College, Kaduna	3	1	6.25
4.	Sardauna Memorial College, Kaduna	11	6	37.5
	Total	**33**	**16**	**100%**

Field work, 2017

3.4 Instrument for Data Collection

The following instruments were used for data collection:

1. Standiometre (ZT 120)
2. Omron Body Composition Monitor (HBF -511B-E/HBF-511 T-E)
3. Omron Heart Rate Monitor (HR – 210)
4. Isomers Flexible Curve (Isomers)
5. Borg Scale (Borg CR10 Scale, 2004)

1. Standiometre is a measuring scale that can measure both height and weight of an individual. It is used in this work to obtain the height and weight measurements of respondents.

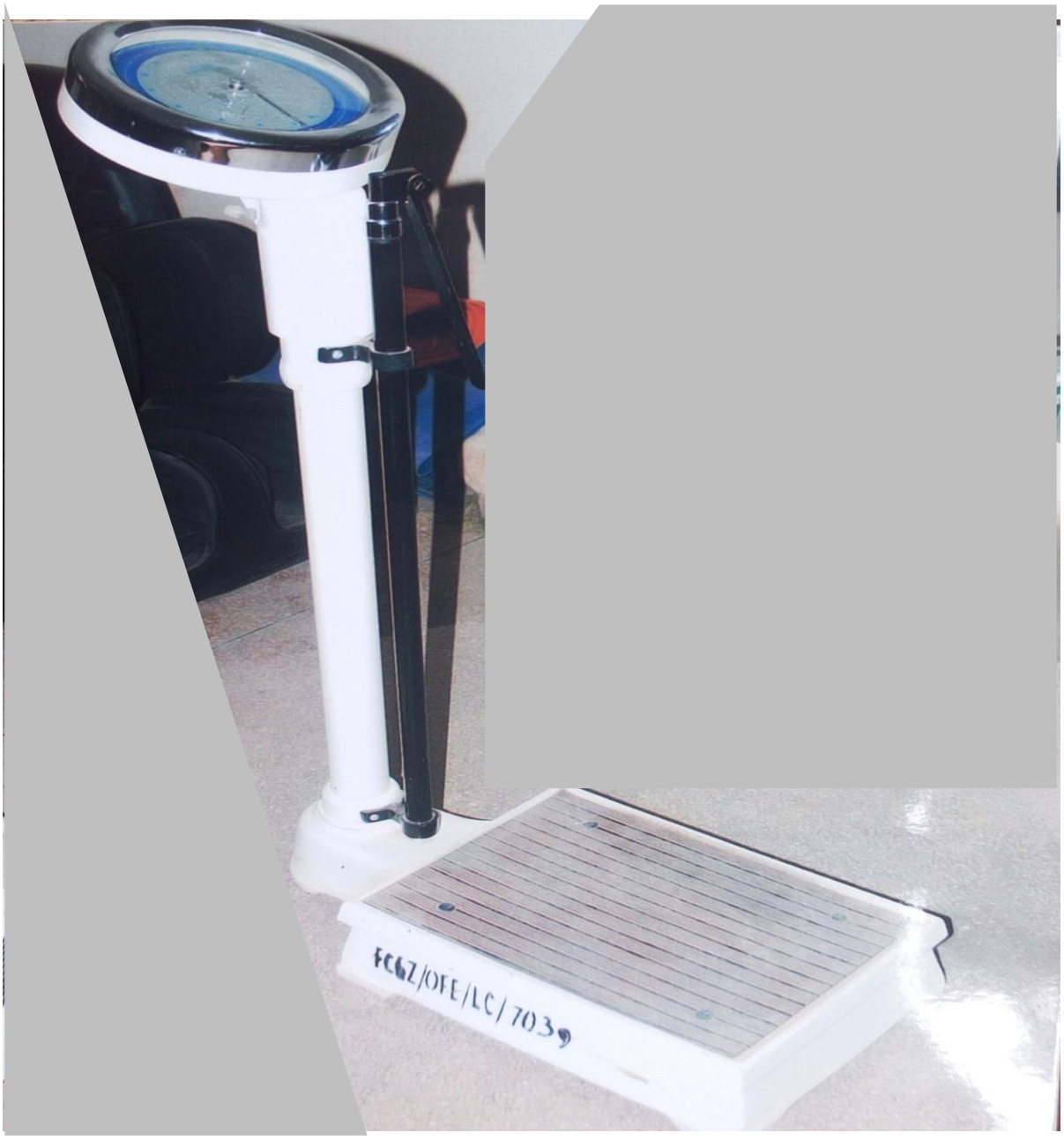


Plate 1: Standiometre
Model: ZT 120: Health Scale

2. Omron Body Composition Monitor is a medical device that can be able to precisely measure the following body composition parameters and immediately interpret the results:
    i) Body fat
    ii) Visceral Fat
    iii) Body Mass Index
    iv) Skeletal Muscle
    v) Calculate Resting Metabolic Rate.
    vi) Weight Measurement up to 150kg.

Omron Body Composition Monitor BF511 is clinically validated for measurement of individuals from the age of 6-80years. The unique Omron 8-sensor measurement technology uses both hands and feet to provide one of the most accurate methods of entire body composition measurements. The BF511 measures the body fat percentage by Bioelectrical Impedance (BI) method. Muscles and bones are body tissues with a high water content that conduct electricity easily. Body fat is tissue that has little electric conductivity. The BF511 sends an extremely weak electrical current of 50KHz and less than 500μA through the body to determine the amount of fat tissue. This weak electrical current is not felt while operating the BF511 machine. In order for the scale to determine body composition, it uses the electrical impendence, along with the height, weight, age and gender information to generate results based on Omron's data of body composition.

Omron body composition monitor was used before the onset of the cooking experiment. It is also a scale that has digital readings of some physical measurements. To take the measurement using the Omron Body Composition Monitor, the following steps were followed:

1. The power was turned on.
2. ‘00 kg’ showed on the display unit.
3. The personal profile number was selected.

a) The GUEST button was pressed while holding the display Unit.

b) The GUEST indication “G” appeared on the display.

c) The personal data (age, gender and height) was set.

4. Start measurement

a) Each participant steps on the main unit and the feet placed on the foot electrodes with the weight evenly distributed

b) When “START” appeared on the display, the arms were extended straight at a 90^0 angle to one’s body.

c) After the measurement was completed, the weight was displayed again and the client stepped off the unit.

5. The measurement results were checked by pressing the appropriate button to view the desired measurement results.

The Omron body composition monitor is presented in plate 2 below (see appendix vi)



Plate 2: Omron Body Composition Monitor

Model BF 511: Technology & Design: Japan

3. Omron Heart Rate Monitor

The Strapless Heart Rate Monitor Model HR-210 is a very practical sports and fitness aid, as it monitors the heart rate without requiring the individual to wear a heart rate transmitter. It is equipped with calorie measurement along with a real-time clock, stopwatch, backlight and keypad lock functions.

The HR210 is used to achieve maximum health benefits from workout programs. It is important to know the following:

i) Maximum heart rate (MHR)

ii) Upper heart rate limit

iii) Lower heart rate limit during our activity

MHR is expressed in beats per minute. To obtain MHR from an MHR test, the following formular can be used to get the estimate: 220 – age = MHR.

For example:

A 40 year old individual can train for basic health maintenance:

iv) His maximal heart rate limit = (220 – 40 years (age) x 78%)

v) His lower heart rate limit (220 – 40 (age) x 65%)

To take the measurement of heart rate the following steps were followed:

1. A wrist watch was worn and finger tips (preferably index finger and middle finger) placed on both metallic plates to enter Heart Rate mode. A beep tone was heard, "HR" banner was displayed and ♥ (a diagram of a heart) flashed to indicate the watch was detecting heart rate reading. It took between 6-10 seconds to detect a heart rate reading.
2. Fingers were removed and readings were taken.
3. To exit heart rate mode, fingers were removed for 3 seconds or press any key.

To take calories reading:

Take a heart rate reading while the stop watch was running in order to view the calories turned. Refer to "Heart Rate Measurement". The calories reading shown in stopwatch mode represented an average of the calories lost during the time elapsed. The more frequent you provide a heart rate reading the more accurate the calories calculation. Omron Heart Rate Monitor is presented in plate 3 (see appendix viii, x, xii).



Plate 3: Omron Heart Rate Monitor

Model HR – 210: Omron Healthcare, inc. China

4. Isomers Flexible Curve

The flexible curve is a tape measure with graduation on both sides in inches and centimeters. It comes in sizes 30/45/50/60/80cms. The size use for this study was size 60cms/24 inches (see appendix vii, xi, xi).

Flexible curve was used to take the postural analysis of the lumbo-sacral region during the performance of the activity. The angle of bend of the back during the performance of the activity was measured and compared with the normal bend of the back and the angle of deviation was determined by subtracting the normal angle of bend from the angle of bend during the bending posture (Oberoi et al, 2006).



Plate 4: Isomers Flexible Curve. (Tape Measure)

Isomers: China

3.4.1 Validation of Instrument

The issue of validation relates to whether the data collected using the instruments were really measuring what they were supposed to measure. The instruments used in this study were digital and standardized instruments which were validated by the manufacturers, they include

stadiometer, Omron body composition monitor, Omron heart rate monitor and Flexible curve. The most obvious type of validity evidence was based on test reliability.

Pilot Study: The aim of the pilot study was to pre-test the instrument for appropriateness and clarity for the study and to identify logical problems which might occur using the proposed method. According to Ary et al (2002), the pilot study provides an opportunity to assess the appropriateness and practicality of the research instrument and methodology and it permits a preliminary testing of the hypotheses. It may give some indications of its tenability and suggest whether further adjustment is needed.

The pilot study was then conducted at Anchau and Zaria. The choice of Anchau and Zaria was basically due to the fact that they both share the same characteristics with the area of study. Three (3) respondents were used for the experiments. The pilot study was conducted three (3) times. The first two were not accepted by the supervisor, the third study was accepted. Also at each instance, the activity was changed, so the experiment had to be repeated. Anchau was approved at the initial stage while Zaria was later approved as after the pilot study as it was easrlier proposed as the study area. Also the researcher had all the records of the respondent's physical assessment.

3.4.2 Reliability of the Instrument

The result of the pilot study was to establish the reliability of the data collected from the instruments that was used for this study. The data collected was analysed using Statistical Package of Social Science (SPSS) Version 17. The Cronbach's Alpha was used to establish the reliability coefficient and internal consistency index of the instruments, perhaps the most widely used reliability coefficient (Field, 2005). The result of the pilot study revealed that for energy

cost, the reliability index of Cronbach's alpha of 0.819 was obtained. For heart rate, 0.930, for rate of perceived exertion 0.956 and for postural stress, 0.758 were obtained.

3.5 Procedure for Data Collection

A letter of introduction from the Department of Vocational and Technical Education was obtained, introducing the researcher in order to obtain permission of authorities to administer the experiments in the study area (See Appendix I). The letter was taken to the principal of each of the government secondary schools within Kaduna metropolis. The purpose of the study was explained in the letter as well as every safety precautionary measures. Two briefed research assistants along with the researcher conducted the experiments in phases explained below.

Phase I - The experimental activities were conducted in the respondent's home. A prio-visit was made to each of the respondents' home. The researcher explained every experimental procedure to the participant. All expenses for the materials were provided by the researcher. Each woman respondent performed the three activities: kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam. 16 women respondents who had BMI 25-30 and above were involved in carrying out the activities in Kaduna metropolis, Nigeria.

Phase II - The reading for physical characteristics was taken using the Standiometre for height and weight, the Omron Body Composition Monitor was used for Body Mass Index (BMI), Body fat, Visceral fat and Resting Metabolic rate. All this was done within 15 minutes with each participant (See Appendix II) normal angle of the back was taken with flexi-curve.

Phase III – The three activities selected in the preparatory stage of cooking: kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam were conducted and a resting period of 30 minutes was given between each activity (See Appendices II, III & IV).

Activity I – Activity of kneading dough was performed by each respondent within fifteen minutes. The readings for energy expenditure, heart rate were taken before, during and after cooking activities for each participant using the Omron heart rate monitor. The angle of bend of the back during the performance of activity was measured and compared with the normal angle of the back using a flexi-curve. The rate of perceived exertion was taken using the Borg scale (See Appendices VII & VIII).

Activity II – Stirring hard porridge (tuwon-shinkafa) within 15 minutes was performed by each of the respondents within fifteen minutes. The readings for energy expenditure, heart rate were taken before, during and after the cooking activities for each participant using the heart rate monitor. The angle of bend of the back during the performance of activity was measured and compared with the normal angle of the back using a flexi-curve. The rate of perceived exertion was taken using the Borg scale (See Appendices IX & X).

Activity III – Pounding yam was performed by each of the respondents within fifteen minutes. The readings for energy expenditure, heart rate was taken before, during and after the cooking activities for each participant using the heart rate monitor. The angle of bend of the back during the performance of the activity was measured and compared with the normal angle of the back using a flexi-curve. The rate of perceived exertion was taken using the Borg scale (See Appendices XI & XII).

3.6 Procedure for Data Analyses

The Statistical Package for Social Science (SPSS) Version 17 was used for data analyses. Descriptive statistical tools of means, standard deviation and standard error were employed to describe the demographic characteristics, body composition and the research questions. Data of estimated Kneading of dough, Stirring of hard porridge (tuwon-shinkafa) and pounding of yam

was analysed using `Repeated Measures Analysis of Variance (ANOVA) because of the 3 x 1 x 3 levels of experimental conditions and used for hypotheses 1 and 2, while one way analysis of variance was used to test hypotheses 3 and 4. Postural analysis for the angle of deviation was determined by subtracting the normal angle from the angle of bend during the postures in different activities. The hypotheses raised to guide this study were tested at an alpha level of 0.05. Where statistical significance occured, Scheffe post hoc test was conducted to determine where the difference lied. Where the F value was greater than the critical value at 0.05 level of significance, the null hypothesis was rejected and when the F value was less, the null hypothesis was retained.

CHAPTER FOUR

DATA PRESENTATION AND ANALYSIS

This chapter presents the statistical analysis of the data collected from the experiment on the ergonomic assessment of physiological cost of household work among women in Kaduna metropolis, Nigeria. The data collected was analyzed and discussed according to the research questions and hypotheses raised for the study.

4.1 Analysis of Demographic Characteristics of particiants

4.2 Answers to Research Questions

4.3 Testing of Null Hypotheses

4.4 Discussion

4.1 Analysis of Demographic Characteristics of Participants

Table 4.1: Distribution of Participants by Age, Height and Weight

Variables	Min	Max	Mean	SD	Std Error
Age (year)	25	35	30.00	3.077	0.77
Height (cm)	160	168	163.44	2.476	0.62
Weight (kg)	65	94	85.10	9.368	2.34

Table 4.1 shows the means, standard deviation (SD) and Standard Error (SE) of demographic characteristics of the participants used for the study. The data showed that the mean age, height, weight of the participants were 30.00 ± 3.077 years, 163.44 ± 2.476 cm, 85.10 ± 9.368 kg.

4.2 Answers to Research Questions

Research Question One

What is the body composition of women (body fat, visceral fat, body mass index and resting metabolic rate) used in kneading dough, stiring hard porridge (tuwon-shinkafa) and pounding yam among women in Kaduna Metropolis, Nigeria.

A total of 16 women representing 16 households in Kaduna metropolis were used for this study. The body composition of the participants is presented in table 4.2.

Table 4.2: Means, Standard deviation (SD) and Standard Error (SE) of the body composition of the Participants

Variables	**Min**	**Max**	**Mean**	**SD**	**Std Error**
BMI (Kg/ m^2)	25	36	31.89	4.072	1.02
%Body fat	33	48	43.01	5.731	1.43
Visceral fat	5	11	8.13	1.966	0.50
Resting metabolic rate (kcal)	1173	1691	1541.88	141.788	35.45

BMI= Body Mass Index

Table 4.2 shows the means, standard deviation (SD) and Standard Error (SE) of body composition of the participants used for this study. The data show that the mean body in mass index (BMI), %body fat, visceral fat and resting metabolic rate of the participants were 31.89 ± 4.072 kg/m^2, 43.01 ± 5.73190, 8.13 ± 1.996, 1541.88 ± 141.788 kcal. The result of the body composition showed that the participants were overweight and obese.

Research Questions Two

What is the energy cost of cooking activities of kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam among women in Kaduna metropolis, Nigeria?

The energy cost was calculated in calorie utilization before, during and after in the analyses of the three cooking activities of kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam. The descriptive statistics of the energy cost of the participants during the performance of the selected cooking activities are computed and presented in table 4.3.

Table 4.3 Mean and Standard Deviation Showing the Effect of period of Cooking Activities on Energy cost of women in Kaduna Metropolis, Nigeria

Activities	Energy cost	N	**Means**	SD	SE
Kneading of dough	Before		00	00	00
	During	16	31.44	12.570	3.142
	After		60.31	24.668	6.167
Stirring hard porridge (tuwon-shinkafa)	Before	16	00	00	00
	During		23.62	22.888	5.722
	After		51.50	28.951	7.238
Pounding yam	Before	16	00	00	00
	During		27.50	22.760	5.690
	After		54.38	31.724	7.931

Table 4.3 shows the energy cost during kneading dough was nil at the onset (before), the energy cost progressed during the activity with mean and standard deviation of 31.44 ± 12.570. After the activity the mean and standard deviation progressed to 60.31 + 24.668. The energy expended

during the stirring of hard porridge (tuwon-shinkafa) was nil at the onset (before) but progressed during the activity with mean and standard deviation of 23.62 ± 22.888. After the activity the mean and standard deviation progressed to 51.50 ± 28.951. The energy expended during the activity of pounding yam was nil at the onset (before) but progressed during the activity with mean and standard deviation of 27.50 ± 22.760. After the activity the mean and standard deviation further progressed to 54.38±31.724. It was observed that the energy expended during the kneading dough was high during and after the activity, then closely followed by the pounding activity and lastly lower at the stirring activity all during and after the activities. From this observation, therefore, it can be deduced that cooking activities and the time have effect on energy cost.

Research Question Three:

What is the heart rate of women in Kaduna metropolis with regard to cooking activities of kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam?

The differences in heart rate before, during and after the performance of three selected cooking activities was calculated. The means and standard deviation on the effects of these three activities on the woman's heart rate during the performance of the activities were computed and presented in table 4.4.

Table 4.4: Mean and Standard Deviation Showing the Effects of period of cooking activities on Heart Rate among Women in Kaduna Metropolis, Nigeria

Activities	Heart Rate	N	Means	SD	SE
Kneading of dough	Before		87.06	23.319	5.830
	During	16	118.44	19.517	4.879
	After		123.06	15.652	3.913
Stirring hard porridge	Before	16	93.75	12.272	3.068
	During		95.69	24.955	6.239
	After		114.50	9.338	2.335
Pounding yam	Before	16	97.44	10.126	2.531
	During		114.81	16.001	4.000
	After		118.62	19.131	4.783

The results in table 4.4 indicate that the heart rate when kneading dough at the onset (before) had a mean and standard deviation of 87.06± 23.319. The heart rate progressed during the activity with mean and standard deviation of 118.44±19.517. After the activity the mean and standard deviation further progressed to 123.06 ± 15.652. The effect on heart rate when performing stirring hard porridge (tuwon-shinkafa), showed a mean and standard deviation at the onset (before) 93.75 ± 12.272. The heart rate progressed during the activity with mean and standard deviation 95.69 ± 24.955. After the activity the mean heart rate and standard deviation was 114.50 ± 9.338. From these observations, it can be deduced that all the three cooking activities have effects on the heart rate of women. Also, each activity progresses from a lower value (before) to moderate (during) and higher values (after).

Research Question Four:

What is the rate of perceived exertion of cooking activities of kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam among women in Kaduna metropolis, Nigeria?

The effects and level of intensity of work experienced during the performance of selected cooking activities were based on 12 point numerical scale (Borg Scale, 1998). For activities that exert pains, the score should be equal to or above 4.0 while a score lower than 4.0 should be for no pain. The frequency and percentage of the feeling of exertion experienced by participants during the performance of selected cooking activities are presented in table 4.5, 4.6, 4.7.

Table 4.5: Percentage of Rate of Perceived Exertion of Kneading Activity among Participants

Response	**Frequency**	**Percentage**
Very light	1	6.2
Fairly light	3	18.8
Moderate	6	37.5
Somewhat Hard	5	31.2
Hard	1	6.2
Total	16	100.0

Table 4.5 shows the rate of perceived exertion among participants while kneading dough. The highest with moderate exertion rate of 6(37.5%), then somewhat hard with 5 (31.2%). Fairly light were 3(18.8%) while very light and hard had 1(6.2%) respectively.

It was observed that participants recorded lower percentage rate of perceived exertion during kneading activity with a total of 10(62.5%).

Table 4.6: Percentages of Rate of Perceived Exertion of Stirring Activity among participants

Response	Frequency	Percentage
Very light	1	6.2
Fairly light	5	31.2
Moderate	4	25.0
Somewhat Hard	5	31.2
Hard	1	6.2
Total	16	100.0

Table 4.6 Shows the percentages of rate of perceived exertion among participants while stirring hard porridge (tuwon-shinkafa). The highest with moderate exertion was 4(25.0%) then somewhat hard and fairly light with 5(31.2%) respectively. Very light and Hard were 1(6.2%) respectively. It was equally observed that women recorded lower percentage rate of perceived exertion during stirring hard porridge (tuwon-shinkafa) with a total value of 10(62.5%).

Table 4.7: Percentage of Rate of Perceived Exertion of Pounding Activity among Participants.

Response	Frequency	Percentage
Very, very light	1	6.2
Fairly light	1	6.2
Hard	12	75.0
Very hard	2	12.5
Total	16	100.0

Table 4.7 shows the rate of perceived exertion among participants while pounding yam. The highest (hard) was 12(75.0%) followed by very hard with frequency of 2 (12.5%). The response of very, very light and fairly light were 1(6.2%) respectively. It was observed that during pounding activity, participants had high percentage of rated perceived exertion because the total frequency was 14(87.5%).

Research Question Five:

What is the postural stress of cooking activities of kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam among woman in Kaduna metropolis, Nigeria?

The posture used during the performance of the activities was taken and subjected to postural analysis. The angle of deviation was obtained by subtracting the normal angle of bend during the postures in the three different activities. The mean and standard deviation of the postural analysis are presented in table 4.8.

Table 4.8: Postural Stress among Different Activities Experienced by the participants

Posture	Activities	N	Means	SD	SE	D (^{0})
Upper curve	Pounding		249.75	10.605	2.651	32.94
	Kneading	16	236.56	1.263	.316	19.75
	Stirring		225.62	1.996	.499	8.81
Lower curve	Pounding	16	233.50	1.506	.376	24.19
	Kneading		225.56	1.094	.273	16.25
	Stirring		216.50	2.066	.516	7.19

Table 4.8 shows the postural stress of different activities experienced by the participants. statistical comparison of angle of spinal cord at upper back (normal curve) before the activity was significantly different (216.81± 26.790) from all other activities (pounding yam, kneading dough and stirring hard porridge (tuwon-shinkafa). Analysis of critical difference among various activities indicated that angle of spinal cord during pounding yam (249.75 ± 10.605) was significantly higher in comparison to kneading dough (236.56 ± 1.263) and stirring hard porridge (tuwon-shinkafa) (225.62 ± 1.996). The angle of spinal cord during kneading dough (236.56 ± 1.263) was significantly higher as compared to stirring hard porridge (tuwon-shinkafa) (225.62 ± 1.996).

Further statistical comparison of angle of spinal cord at lower back (normal curve) before the activity was significantly different (209.31 ± 1.702) from all other activities (pounding yam, kneading dough and stirring hard porridge (tuwon-shinkafa). Analysis of critical difference among various activities indicates that angle of spinal cord during pounding yam (233.50 ± 1.506) was significantly higher as compared to kneading dough (225.56 ± 1.094) and stirring hard porridge (tuwon-shinkafa) (216.50 ± 2.066). The angle of spinal cord during kneading dough (225.56 ± 1.094) was significantly higher than stirring hard porridge (tuwon-shinkafa).

Mean deviation in angle of spinal cord for different activities for both upper and lower back are as follows: For performing the activity of pounding yam the mean deviations both for upper back and lower back were 33.94 and 24.19 respectively. It was found that when kneading dough, the mean deviation were 19.75 and16.25 respectively. For carrying out the activity of stirring hard porridge (tuwon-shinkafa) the mean deviation for upper back and lower back were 8.81 and 7.19 respectively. It was observed that the mean and standard deviation of the angle of spinal cord

was higher in the activity of pounding yam then followed by kneading dough, while stirring hard porridge (tuwon-shinkafa) had the least mean and standard deviation. This however implies that postural stress is higher in the activities of pounding yam than kneading dough and the least was stirring hard porridge (tuwon-shinkafa).

4.3 Testing of Hypotheses

Hypothesis One:

There is no significant difference in the effect of kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam on energy cost at three assessment levels among women in Kaduna metropolis, Nigeria.

Repeated measures of analyses of variance was used for testing this hypothesis because of the multiple levels of the independent variables of kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam.

The cooking activities performed were tested at three assessment levels (before, during and after). The summary of the repeated measures of ANOVA is presented in table 4.9.

Table 4.9: Repeated Measures of Analysis of Variance (ANOVA) on the effects of selected cooking activities at three levels of assessment on energy cost among women

Source	SS	DF	MS	F	P
Corrected Model	74784.347[a]	8	9348.043	23.032	.000
Intercept	110002.778	1	110002.778	271.027	.000
Activities	745.722	2	372.861	.919	.402
Time	73649.764	2	36824.882	90.730	.000
group * time	388.861	4	97.215	.240	.916
Error	54792.875	135	405.873		
Total	239580.000	144			
Corrected Total	129577.222	143			

a. R Squared = .577 (Adjusted R Squared = .552)

Table 4.9 shows the summary of repeated measure ANOVA on the effects of kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam on energy cost among women in kaduna metropolis.

The results of the analysis show that time spent during these cooking activities led to high energy cost (P=0.001). With this observation, the null hypothesis which states that there is no significant difference in the effect of kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam on energy cost at three assessment levels among women in Kaduna metropolis, Nigeria was rejected.

In order to determine where the significant difference of selected cooking activities and three levels of assessment on the energy cost of household work among women, post hoc procedure using Scheffe test was conducted. The results are summarized on table 4.10.

Table 4.10: Post hoc procedure using Scheffe Test on effect of selected cooking activities at three assessment levels on Energy cost of women in Kaduna Metropolis, Nigeria

Activities	(I) Period	(J) Period	Mean Difference (I-J)	Std. Error	Sig.
Kneading dough	Before	During	-31.438*	5.651	.000
		After	-60.312*	5.651	.000
	During	Before	31.438*	5.651	.000
		After	-28.875*	5.651	.000
	After	Before	60.312*	5.651	.000
		During	28.875*	5.651	.000
Stirring hard Porridge (tuwon-shinkafa)	Before	During	-23.625*	7.533	.012
		After	-51.500*	7.533	.000
	During	Before	23.625*	7.533	.012
		After	-27.875*	7.533	.003
	After	Before	51.500*	7.533	.000
		During	27.875*	7.533	.003
Pounding yam	Before	During	-27.500*	7.970	.005
		After	-54.375*	7.970	.000
	During	Before	27.500*	7.970	.005
		After	-26.875*	7.970	.006
	After	Before	54.375*	7.970	.000
		During	26.875*	7.970	.006

*. The mean difference is significant at the 0.05 level.

Table 4.10 shows the post hoc test of significant difference between energy cost was as a result of the time spent in cooking activities.

Hypothesis Two:

There is no significant difference in the effect of kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam on heart rate at three assessment levels among women in Kaduna Metropolis, Nigeria.

This hypothesis was tested with the mean heart rate of the participants, presented in table 4.11. The repeated measures of analysis of variance was used for testing this hypothesis because of the multiple levels of the independent variables of kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam. The cooking activities were tested at three assessment levels (before, during and after). The summary of the repeated measures of analysis of variance is presented in table 4.11.

Table 4.11: Repeated measures of analysis of variance on the effect of three selected cooking activities at three assessment levels on Heart Rate among Women in Kaduna Metropolis, Nigeria

Source	SS	Df	MS	F	Sig.
Corrected Model	22939.375[a]	8	2867.422	9.368	.000
Intercept	1649940.250	1	1649940.250	5.390E3	.000
Activities	2377.542	2	1188.771	3.884	.023
Time	16686.292	2	8343.146	27.257	.000
Activities* time	3875.542	4	968.885	3.165	.016
Error	41322.375	135	306.092		
Total	1714202.000	144			
Corrected Total	64261.750	143			

a. R Squared = .357 (Adjusted R Squared = .319)

Table 4.11 shows the summary of repeated measures of ANOVA on the effect of kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam on heart rate among women in Kaduna metropolis, Nigeria. The results show that the duration of the different cooking activities had significant effects on heart rate of women in Kaduna metropolis ($p=0.016$). Therefore, the null hypothesis which states that there is no significant difference in the effect of kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam on heart rate at three assessment levels among women in Kaduna Metropolis, Nigeria was rejected.

In order to determine where the significant effects of cooking activities and time lay on heart rate of the participants, post hoc procedure using Scheffe test was conducted, the results are summarized on table 4.12.

Table 4.12: Post hoc Procedure using Scheffe test on Effect of Selected cooking activities at three assessment levels on heart rate among women in Kaduna Metropolis, Nigeria

Activities	(I) Period	(J) Period	Mean Difference (I-J)	Std. Error	Sig.
Kneading dough	Before	During	-31.375*	6.981	.000
		After	-36.000*	6.981	.000
	During	Before	31.375*	6.981	.000
		After	-4.625	6.981	.804
	After	Before	36.000*	6.981	.000
		During	4.625	6.981	.804
Stirring hard porridge (tuwon-shinkafa)	Before	During	-1.938	5.988	.949
		After	-20.750*	5.988	.005
	During	Before	1.938	5.988	.949
		After	-18.812*	5.988	.012
	After	Before	20.750*	5.988	.005
		During	18.812*	5.988	.012
Pounding yam	Before	During	-17.375*	5.494	.011
		After	-21.188*	5.494	.002
	During	Before	17.375*	5.494	.011
		After	-3.812	5.494	.787
	After	Before	21.188*	5.494	.002
		During	3.812	5.494	.787

*. The mean difference is significant at the 0.05 level.

Table 4.12 shows the post hoc test of significant difference between heart rate as a result of the time spent in cooking activities. As observed, the heart rate before the cooking activities is significantly different from the heart rate during the cooking activities, likewise after cooking activities ($p<0.01$). Thus, the heart rate before, during and after cooking are all significantly different from each other.

Hypothesis Three:

There is no significant difference in the effects of kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam on rate of perceived exertion among women in Kaduna metropolis, Nigeria.

The effect of the rate of perceived exertion on the performance of selected cooking activities was tested with the aid of one way analysis of variance (ANOVA) for each of the respective activity.

Table 4.13: One-Way Analysis of variance on the effect of selected cooking activities on rate of perceived exertion among women in Kaduna Metropolis, Nigeria

	SS	Df	MS	F	Sig.
Between Groups	26.167	2	13.083	8.722	.001
Within Groups	67.500	45	1.500		
Total	93.667	47			

$F(2, 47) = 3.15$ $P = > 0.05$

Table 4.13 shows the results of ANOVA $F(2, 47) = 3.15$ $P = > 0.05$. An observation of this analysis reveals that the selected cooking activities were perceived to cause exertion on the participants used in this study ($P < 0.05$). Therefore, the null hypothesis which states that there is no significant effect of the rate of perceived exertion of kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam among women in Kaduna metropolis, Nigeria was rejected.

In order to determine the significant difference among the selected cooking activities and its effect on the rate of perceived exertion on the participants, post hoc procedure using Scheffe test was conducted. The results are summarized on table 4.14.

Table 4.14: Post hoc Procedure using Scheffe test on Effect of Selected Cooking Activities on the Rate of Perceived Exertion among women in Kaduna Metropolis, Nigeria

(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.
Kneading	Stirring	.125	.433	.959
	pounding	-1.500*	.433	.005
Stirring	kneading	-.125	.433	.959
	pounding	-1.625*	.433	.002
Pounding	kneading	1.500*	.433	.005
	Stirring	1.625*	.433	.002

*. The mean difference is significant at the 0.05 level.

The multiple comparison presented in table 4.14 shows that there is no significant difference between the exertion rate on kneading dough and stirring hard porridge (tuwon-shinkafa) ($p>0.05$). However, there is significant difference between the rate of perceived exertion of kneading dough and pounding yam ($p<0.05$). Also, the result shows that, the rate of perceived exertion of pounding yam is significantly different from the rate of perceived exertion of kneading dough and stirring hard porridge (tuwon-shinkafa). Thus, the effect of perceived exertion on selected cooking activities among participants differed significantly from each other ($P < 0.05$).

Hypothesis Four:

There is no significant difference in the effect of kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam on postural stress among women in Kaduna metropolis, Nigeria.

One way analysis of variance was used for this hypothesis in order to test the significance of the variability obtained in the mean of postural stress during the performance of the activities. The summary of the analysis of variance model used for the test is presented in table 4.15.

Table 4.15: One Way Analysis of Variance on the effects of selected cooking activities on Postural Stress experienced by women in Kaduna Metropolis, Nigeria.

		SS	df	MS	F	Sig.
Upper curve	Between Groups	4669.625	2	2334.812	59.337	.000
	Within Groups	1770.688	45	39.349		
	Total	6440.312	47			
Lower curve	Between Groups	2315.375	2	1157.688	449.345	.000
	Within Groups	115.938	45	2.576		
	Total	2431.312	47			

F (2, 47) = 3.15 P = > 0.05

The results on table 4.15 reveal that the F-values obtained for postural stress experienced during the selected cooking activities (kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam) were 59.337 for upper curve and 449.345 for lower curve. The observed probability levels for the tests were all 0.000 ($P < 0.05$). This implies that the selected cooking activities had significant effect on postural curves among women in Kaduna Metropolis, Nigeria. Therefore, the null hypothesis which states that, there is no significant difference in the effect of postural stress of kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam among women in Kaduna metropolis, Nigeria was rejected.

To further determine the significant difference of the postural stress of selected cooking activities on the postures of the participants, the post procedure using multiple comparison was conducted and the results are shown in table 4.16.

Table 4.16: Post hoc procedure using Scheffe Test on the effect of selected cooking activities on Postural stress among women in Kaduna Metropolis, Nigeria

Dependent Variable	(I) Activities	(J) Activities	Mean Difference (I-J)	Std. Error	Sig.
Uper curve	Pounding	Kneading	13.188*	2.218	.000
		Stirring	24.125*	2.218	.000
	Kneading	Pounding	-13.188*	2.218	.000
		Stirring	10.938*	2.218	.000
	Stirring	Pounding	-24.125*	2.218	.000
		Kneading	-10.938*	2.218	.000
Lower curve	Pounding	Kneading	7.938*	.567	.000
		Stirring	17.000*	.567	.000
	Kneading	Pounding	-7.938*	.567	.000
		Stirring	9.062*	.567	.000
	Stirring	Pounding	-17.000*	.567	.000
		Kneading	-9.062*	.567	.000

*. The mean difference is significant at the 0.05 level.

The results in table 4.16 show that postures differ as the participants performed the selected cooking activities; consequently, at both upper and lower curves, pounding yam had higher effects than kneading dough and stirring hard porridge (tuwon-shinkafa). Thus, the effect of selected cooking activities on postural stress (deviation) among women differed significantly from each other ($P < 0.05$).

4.4 Discussion

The study was specifically designed to investigate the physiological cost of household work among women in Kaduna Metropolis, Nigeria. In line with this, the data collected were used to analyse the five research questions using mean and standard deviation as presented in tables 4.2 - 4.8. The four null hypotheses raised in the study were tested. Hypotheses 1 and 2 were tested using repeated measures of Analysis of Variance (ANOVA) because of the multiple nature of .the independent variables while hypotheses 3 and 4 were tested using one way analysis of variance (ANOVA) at 0.05 level of significance. This section presents the discussion of findings of the study.

The result of this study on the effect of selected cooking activities of kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam had significant effect on energy cost. This means kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam led to high energy cost (expenditure) especially during and at the end of the cooking activities by women in Kaduna Metropolis, Nigeria.

The findings are in agreement with Gayatri, Deepa & Nidhu (2011) who posited that the workers of different departments of the hotel were doing heavy task thus their physiological cost of work was very high. The findings are also supported by Bhatt, Sidhu, Sandhu & Bakhshi (2011), Bhatt & Sidhu (2012) who stated that significant difference was found in the energy expended during the five selected household activities. Also, findings concure with the findings of the study conducted by Bhatt & Sharma (2014) which revealed that average energy expenditure values indicate workload as moderate to heavy. Also in the findings of Shittu (2016) it was revealed that less energy expended during the performance of household task and the less appropriate the work

surfaces are to the height of the homemakers, the more the energy expended during the performance of selected household work.

The findings of the study on the effects of selected cooking activities of kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam had significant effects on the heart rate of the women. This is based on the deductions that the cooking activities increases the resting heart rate of women during and immediately after kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam in Kaduna Metropolis, Nigeria. The findings are in agreement with Gayatri, Deepa and Nidhi (2011) who posited that the average working heart rate was maximum for laundering, kitchen, and housekeeping activities. This finding is supported by Bhatt & Sidhu (2012) who stated that percentage increase in heart rate was maximum for grating and minimum for rolling. The findings concurred with the findings of the study conducted by Bhatt and Sharma (2014) which revealed that average peak heart rate of the rice mill workers suggested the work load as moderate to very heavy. Shittu (2016) also supports the findings of the present study as he states that significant effect existed on the heart rate when inappropriate height and tools were used during the performance of household activities.

The findings of the study on the effects of selected cooking activities of kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam revealed significant effect on the rate of perceived exertion among women. This is based on the deductions that the rate of perceived exertion was maximum during pounding yam but moderate during stirring hard porridge (tuwon-shinkafa) and kneading dough among women in Kaduna metropolis, Nigeria. The findings of Nagori and Lodha (2011) revealed that semi modular Kitchen had low perceived exertion due to good layout of kitchen storage furniture design. While the findings of Karki, Joshi, Dhingra and

Sandhya (2012) also showed mean rating of perceived exertion in the range of 1 to 1.27. The findings of Bhatt & Sharma (2014) supported the present study that exertion proceeds from moderate to heavy during the performance of activities. The findings are equally supported by Shittu (2016) who stated that work surfaces used during the performance of selected household tasks have significant effect on the level of intensity of pains experienced by the home makers.

The result obtained from this study on the effect of cooking activities of kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam revealed significant effect on postural stress (deviation) at both upper curve and lower curve among women in Kaduna metropolis, Nigeria. This is because the cooking activities performed by the women reflect the postural changes on their physical bearing during work. The findings are in agreement with those of Agarwal & Sharma (2003) who stated that angle of spinal cord (postural stress) both for upper back and lower back during rest was 912.72 ± 3.40 degrees and 211.354 ± 3.54 degrees respectively. But as soon as the woman performed various activities like washing, peeling, cutting, cooking, packing angle of spinal cord become increased. It was found that angle of spinal cord (postural stress) for upper back was highest (262.70 ± 4.32^{o}) and lower back was also high (239.72 ± 4.51^{o}) during the performance of household activities. This finding is supported by those of Gayatri, Deepa & Nidhu (2011) and Bhatt & Sharma (2014) who revealed that awkward postures like bending and twisting of the trunk adopted by the workers were the causes of pain and discomfort resulting out of work practice. Furthermore, Shittu (2016) reported significant effect on posture of homemakers during the performance of selected household activities which reflect the postural change on the physical bearing during work.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS.

This chapter presents the summary, conclusion and contribution of the study to knowledge and recommendations for further study on the ergonomic assessment of the physiological cost of household work among women in Kaduna metropolis, Nigeria.

5.1 Summary

5.2 Conclusion

5.3 Contribution to Knowledge

5.4 Recommendations

5.5 Implication of Findings

5.6 Suggestions for Further Studies

5.1 Summary

This study was designed to investigate the ergonomic assessment of the physiological cost of household work among women in Kaduna Metropolis, Nigeria. In line with this, the study had five objectives, five research questions and four null hypotheses. Literature and empirical studies related to the variables of the study were reviewed in order to provide basis for better analysis and observations. Prominent among the empirical studies reviewed were those conducted by Nagori and Lodha (2011) Karki, Joshi, Dingra & Sandhy (2012), Bhatt & Sidhu (2012), Bhatt and Sharma (2014), Shittu (2016) on the ergonomic assessment of household work.

The study adopted the factorial experimental design which investigated the effects of different cooking activities on energy cost, heart rate, rate of perceived exertion and postural stress during the performance of cooking activities of kneading dough, stirring hard porridge (tuwon-shinkafa)

and pounding yam by women in Kaduna Metropolis, Nigeria. The population of this study comprised thirty three (33) women each residing at a three-bedroom staff quarters at four government secondary schools within Kaduna Metropolis, Nigeria. Sixteen (16) women were the sample size who were randomly selected amongst the four purposively selected secondary schools. Standiometre, Omron heart rate monitor, Omron body composition monitor, Flexi-curve and a Borg scale were used as the instrument for data collection.

Data for age, weight, height, BMI, % body fat, visceral fat, resting metabolic rate were taken by the researcher before the activity. The participants had mean age 30.00 years, mean height 163.44cm, mean weight 85.10kg, mean BMI 31.89klg/m^2, mean body fat 43.01 %, mean visceral fat 8.13 and mean resting metabolic rate 1541. 88kcal, were judged to meet the criteria for overweight and obese women required for the study. Studies of Dayan & Cohan, (2011) have shown that physical fitness as the cardio respiratory endurance, skeletal muscular endurance, strength power, speed, flexibility, agility, tolerance, reaction time and body composition is associated to the physical activity of an individual.

Data for energy cost and heart rate were taken before, during and after the three cooking activities of kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam, while the data for rate of perceived exertion and postural stress were all measured during the performance of activities. In line with this, the data collected were used to analyze the five research questions using mean and standard deviation as presented in tables 4.2 – 4.8. The four null hypotheses raised in the study were tested. Hypothesis 1 and 2 were tested using repeated measures of analysis of variance (ANOVA) because of the multiple nature of the independent

variables, while hypotheses 3 and 4 were tested using one way analysis of variance (ANOVA) at 0.05 level of significance.

5.2 Conclusion

Based on the findings of the study it can be inferred that the cooking activities of kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam and period spent during cooking activities have significant effect on the energy cost, heart rate, rate of perceived exertion and posture of the home makers who are residents of staff quarters of selected government secondary schools in Kaduna metropolis, Nigeria.

5.3 Contribution to Knowledge

From the results of the analyses, the following findings were made, which have contributed to the existing body of knowledge on ergonomic assessment of physiological cost of household chores among home makers in Kaduna Metropolis, Nigeria:

1. Kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam caused high energy cost expenditure especially during and at the end of the cooking activities among women in Kaduna Metropolis, Nigeria (P = 0.001).
2. The cooking activities increased the resting heart rate of women during and immediately after kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam in Kaduna Metropolis, Nigeria (P = 0.012).
3. The rate of perceived exertion was maximal during pounding but was moderate during stirring hard porridge (tuwon-shinkafa) and kneading dough among women in Kaduna Metropolis, Nigeria. (P = 0.001).

4. Postural stress was significant at both upper curve and lower curve during pounding yam, stirring hard porridge (tuwon-shinkafa) and kneading dough by women in Kaduna metropolis, Nigeria (P= 0.001).

The cooking activities of kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam had effects on energy cost due to high calorie utilization. The resting heart rate increased significantly in this study. The selected cooking activities were perceived to cause exertion on the women and postural stress (deviation) was maximum at both upper and lower curves. Thus, contributing to the existing body of knowledge.

5.4 Recommendations

Based on the findings of the study, the following are recommended.

1. The home makers should make the cooking activities of kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam a regular activity, so that the body physique becomes used to the activities and serve in burning excess fat in the body.
2. The home makers should work moderately when performing kneading dough, stirring hard porridge (tuwon-shinkafa) and pounding yam to reduce the amount of exertion experienced by the muscles of the body during work, and to improve cardio respiratory endurance, skeletal muscular endurance, strength power, speed, flexibility, agility and tolerance during work.
3. The home makers should adopt ergonomic principles during kneading dough, stirrings hard porridge (tuwon-shinkafa) and pounding yam. Also the equipment and tools used during the performance of these cooking activities should be of the anatomical size of the worker. The mortar and pestle, working table, cooking space should fit the worker.

4. Home economics association / extension services should enlighten the general public through workshops, seminars and conferences on proper work habits, proper work postures and proper work environment in line with principles of ergonomics.

5.5 Implication of Findings

The study on ergonomic assessment of the physiological cost of household work among women in Kaduna metropolis, Nigeria, shows negative health implication for women. Obesity is associated with many diseases which may results to the onset of diabetes, hypertension, heart diseases and many other complications.

Home economics curriculum developers should use the findings of this study to improve on the existing curriculum at different levels of the educational system. Home economics association/extension services should create awareness on human ergonomics through conferences, seminars, workshops and publication in journals and periodicals.

5.6 Suggestions for Further Studies

In view of the findings of this study, it is suggested that further studies should be considered in the following areas:

1. Ergonomic assessment of physiological cost of laundry activities among women
2. Ergonomic assessment of physiological cost of cumulative household work among women
3. A replication of this study in other parts of Nigeria will serve as comparison of findings of the study.

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Appendix I

DEPARTMENT OF VOCATIONAL & TECHNICAL EDUCATION
AHMADU BELLO UNIVERSITY, ZARIA, NIGERIA.
FACULTY OF EDUCATION

VICE CHANCELLOR: **Prof. Ibrahim Garba** (B.Sc., M.Sc. (A.B.U.); Ph.D. (London) D.I.C.)
HEAD OF DEPARTMENT: **Professor A. A. Udoh** (B.Ed. (Hons) Nsukka; M. Ed. & Ph.D. Bus Edu. [A.B.U.])

Telephone: 069-51755, 50692

Your Ref: _____

Our Ref: Ph.D/Educ/10033/2007-2008

Date: 26th August, 2015

Letter of Introduction

HALIMA SIDI BAMALLI – PH.D/EDUC/10033/2007-2008

This is to certify that the above mentioned name is a Postgraduate student (Ph.D Home Economics) in the Department of Vocational and Technical Education, Ahmadu Bello University, Zaria carrying out a research topic: ***Ergonomic Assessment of Women Physiological Cost of work While Performing Household Activities in Kaduna State, Nigeria.***

Please, kindly give her every assistance she may require.

DEPT. OF VOC. & TECH. EDUC. HEAD DEPT DATE A.B.U. ZARIA

Professor A.A. Udoh
HEAD OF DEPARTMENT

Appendix II

Candidate's Number:	
Age	-
Height	-
Weight	-
BMI	-
Body Fat	-
Resting metabolism	-
Visceral Fat	-

Activities

1. Kneading

Heart Rate:		Energy expenditure (cal)	
Before	-	Before	-
During	-	During	-
After	-	After	-

2. Stirring

Heart Rate:		Calories:	
Before	-	Before	-
During	-	During	-
After	-	Ending	-

3. Pounding

Before	-	Before	-
During	-	During	-
After	-	After	-

Appendix III

Rating of Perceived Exertion Scale

Instruction:

Do not concern yourself with any one factor such as leg pain or shortness of breath, but try to focus on your total feeling of exertion. Look at the rating scale while you are performing the activities. Choose the number that best describes your level of exertion Try to evaluate your feeding of exertion as honestly as possible. It is your own feeling of effort and exertion, not how it compares to other people's scores.

RPE Scale

o-	Nothing at All
0.5-	Very, Very Light
1-	Very Light
2-	Fairly Light
3-	Moderate
4-	Somewhat Hard
5-	Hard
6-	
7-	Very hard
8-	
9-	
10-	Very Very hard (Maximally)

Borg (1998) Borg's Rating of Perceived Exertion and Pain Scales.

Appendix IV

Postural Stress

Angle of normal curve	-
Angle of bend	-
Deviation	-

Appendix V



Plate 5: Front View of Three (3) bedroom residential quarters at Government Secondary Schools in Kaduna State, Nigeria



Plate 6: Back View of Three (3) bedroom residential quarters at Government Secondary Schools in Kaduna State, Nigeria

Appendix VI



Plate 7: Side View, Measuring Weight, BMI, % Body Fat, Visceral fat and Resting Metabolic rate of the home makers using Omron Body Composition Monitor



Plate 8: Front View, Measuring Weight, BMI, % Body Fat, Visceral fat and Resting Metabolic rate of the home makers using Omron Body Composition Monitor

Appendix VII



Plate 9: Home maker kneading dough, Measuring postural curves of the home makers using flexi-curve during kneading dough



Plate 10: Home maker kneading dough, Measuring postural curves of the home makers using flexi-curve during kneading dough

Appendix VIII



Plate 11: Home maker kneading dough, Measuring energy cost and heart rate of home maker using heart rate monitor during kneading dough



Plate 12: Home maker kneading dough, Measuring energy cost and heart rate of home maker using heart rate monitor during kneading dough

Appendix IX



Plate 13: Home maker stirring hard porridge (tuwon-shinkafa), Measuring postural curves of the home makers using flexi-curve during stirring hard porridge (tuwon-shinkafa)



Plate 14: Home maker stirring hard porridge (tuwon-shinkafa), Measuring postural curves of the home makers using flexi-curve during stirring H

Appendix X



Plate 15: Home maker stirring rice moulds, Measuring energy cost and heart rate of home makers using Heart Rate Monitor during stirring hard porridge (tuwon-shinkafa)



Plate 16: Home maker stirring rice moulds, Measuring energy cost and heart rate of home makers using Heart Rate Monitor during stirring hard porridge (tuwon-shinkafa)

Appendix XI



Plate 17: Home maker pounding yam, Measuring postural curves of the home makers using Flexi-curve during pounding yam



Plate 18: Home maker pounding yam, Measuring postural curves of the home makers using Flexi-curve during pounding yam

Appendix XII



Plate 19: Home maker pounding yam, Measuring energy cost and heart rate of home makers using Heart Rate Monitor during pounding yam



Plate 20: Home maker pounding yam, Measuring energy cost and heart rate of home sssmakers using Heart Rate Monitor during pounding yam