CHAPTER TWO

REVIEW OF LITERATURE

Argosy (2010) stated that the foundation of the dissertation begins with a review of theories, methodologies, and measurement considerations central to the research question. The review identifies gaps in the literature and how this research adds to the knowledge base. Whether the research question focuses on theory development, theory extension, or theory application determines the appropriateness of the sources used. For instance, the sources may include government documents, databases, books, professional journals, refereed academic publications, and dissertations that form the rationale for the current undertaking. The literature must be evaluated and interpreted, properly referenced and presented to build an argument for the importance of the research and the appropriateness of the methods used in the dissertation.

The Purpose of the review of literature is to examine and evaluate literature which is relevant to the development of living room interior design and ergonomic problem evaluation and to guide development of living room interior design in the residential buildings in Hodaidah city.

Currently, no known single reference study exists that provides established ergonomic investigation to the design of living room interior in residential buildings for the Hodaidah city zones. The following presents a background of ergonomic related to the interior design and living room space, furniture design and discusses existing design guidelines research.

The quality of housing can enhance or diminish the wellbeing of individual and families as that of the entire community. Hence, this is a major field where much improvement could be achieved by considering more fully the human
factors involved. Therefore, home ergonomics is becoming very important amongst home scientist, ergonomists, industrialists, builders and interior designers (Varghese, et. al. 1989).

The fundamental goal of ergonomic design is to adopt the work process, tools or equipment and the working environment to fit the needs, size and capabilities of the worker to enable the worker to work comfortably, safely and ultimately increase productivity (Boerding, 1997).

Chakrabarti (1997) also stated that, for design purposes, to fit an intended user from amongst the known population group, different percentile values of different human body dimensions should be considered for different design dimensions. Designing an article or a system with a single percentile value for all the relevant human dimensions would fail to satisfy all the other dimensional features of the design. He also suggested that a workstation should provide positive motivation for acceptance by the anticipated users. This may be through providing a simple, clean, convenient place to work, giving a personal feeling of comfort, privacy, attractiveness, reliability and safety, freedom from unwanted obstacles, and also providing common behavioral pattern of movement, encouraging interpersonal interactions and bringing out various hidden psychological feeling.

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The available review of literature on aspects relevant to present investigation was divided into various sub-heads and presented in the following sections:

1) Background information about Yemen.
2) Architecture and residence building in Yemen.
3) Architecture and residence building in Hodaidah.
4) Ergonomics.
5) Anthropometric.
6) Psychophysical Scales.
7) Objective Measurement Techniques of posture.
8) Understanding Concepts about Designing Interior Space.
9) Interior design Aesthetics Principle and Design.
10) Active Workspaces in the living room.
11) Living room space and furniture’s arrangements.
12) Conclusion on reviewed literature.

2.1 Background information about Yemen:

2.1.1 Historical Background:

In pre-Islamic times, the area that encompasses the present-day Republic of Yemen was called Arabia Felix—happy or prosperous Arabia—and was ruled by a number of indigenous dynasties in several different kingdoms. The most important cultural, social, and political event in Yemen’s history was the coming of Islam around A.D. 630. Following the conversion of the Persian governor, many of the sheikhs and their tribes converted to Islam, and Yemen was ruled as part of Arab caliphates.

2.1.2 Location:

Yemen is located in the Middle East at the southern tip of the Arabian Peninsula between Oman and Saudi Arabia. It is situated at the entrance to the Bab el Mандeb strait, which links the Red Sea to the Indian Ocean (via
CHAPTER TWO

the Gulf of Aden) and is one of the most active and strategic shipping lanes in the world (Library of Congress, 2008).

2.2 Architecture and residence building in Yemen.

2.2.1 The characteristics and attributes of Architecture in Yemen

(Al-Maashi .1998) pointed that the architecture in Yemen has developed over hundreds of years and is observed today as a unique architectural identity that has prevailed throughout the centuries. The geographic and political isolation of Yemen over those centuries gave the vermicular a possibility to flourish and develop. Being physically and socially distant from foreign or outside methods and materials during that time, Yemen was able to develop its own unique styles of architecture. Today, it is thought that there are at least
six distinctive styles of vermicular or traditional architecture in the country. These styles vary from the reed houses of the Tehama coast strip on the Red Sea to the stone houses of the Midlands, to the adobe towers of Shibam, to the brick and stone houses of Sana’a. The rich canvas of architectural patterns seems to reflect the geographical, environmental, and socio-cultural multiplicity of Yemen, as well as respond to the needs of its inhabitants. For example, the architectural designs and patterns in Sana’a vary significantly from those in Shibam, Hadhramout. Both, as the UNESCO’s (United Nations Educational, Scientific, and Cultural Organization) interest indicates, have acquired a cultural and historical significance that is too precious to give away.

- **Membership in the architectural composition:**

Property membership in architecture heritage of Yemen is the same property that have been formulated on the basis of all the cities heritage Arab and Islamic countries, where we see clearly in the architecture of Yemen through appearances Fine facades of architectural and urban looks so city like organism grows and extends in both directions, horizontal and vertical, a principle borrowed from nature organisms, and regulates the relationship between space and mass, and organic appear in the architectural composition through two components:

- **Building materials.**

We find that the subjects of traditional construction main brick burned or dried mud and stone which is commonly used in roles lower, while the brick burned is used in the upper floors, and this use masks philosophy construction gained their information innately by a human Yemen is «that the building, which is approaching center of gravity of Earth, shows it permanence and security and permanence, power and respect, and this explains the tendency to make the lower floors heavy, and built of stone, note that the stone is available in abundance in Yemen and multiple sources and types and colors according to regions where there is, and is characterized by these stones, including the following:
CHAPTER TWO

1. Is characterized by these stones in multiple colors up to five or more colors.
2. Tests that these stones refers to the enjoyment of several varying qualities in terms of resistance to compressive strength, as well as water absorption property.
3. Resists weathering stones and fit the atmosphere warm and cold.
4. Easy cutting and shaping during the construction process.

- **Openings.**

There are usually two types of openings in architecture heritage, one upper and one lower and use these slots as follows: bottom hole used for a view of the outside, as well as ventilation The upper is a circular shape is used for lighting and decorations, and a high incidence of decoration and inscriptions.

- **Stucco.**

Plaster material composed by burning limestone in special incinerators, and produced from the burning of white soft-touch material, and has a variety of uses such as wall coverings, ceilings and floors of the Interior, and any material of construction materials such as Stones or Bricks or mud, as used in both Sana'a and Zabid in the coating interfaces external decoration, also used in the work of shelves and decorations on the walls and ceilings of the rooms Stones or Bricks or mud, as used in both Sana’a and Zabid in the coating interfaces external decoration, also used in the work of shelves and decorations on the walls and ceilings of the rooms, and was also used in Aalghemriaat (See plate No.1) and taste of stained glass and produced for use a great legacy, and Aalghemriaat found in old buildings on a semi-circular form of a single piece of translucent alabaster stone from which light perforates and the stone is cut from quarries especially in the form of flakes, according to the request of the customer.
• Free formation of interfaces.

Architectural heritage of Yemen does not abide by the rules of the Academy in the formation and theories own beauty architecture or fine arts and this is what gave her advantage and nature of the afternoon, came buildings and urban communities work distinct, spontaneous and automatic from experience accumulated in humans Yemeni and taste for arts architecture, popular and clear formulation aesthetics of buildings Traditional through a number of simple elements are as follows.

• The building block.

Yemeni-residential buildings characterized in terms of the Parallel roofs size of the external walls of the building, and has a repositioning in terms of continuity with the neighboring buildings, and this arises continuity in the three modes are:

- Adhesion in a single interface.
- Adhesion and facets.
- Adhesion in three interfaces.

• Interfaces.

Interfaces are expressed in traditional Yemeni architecture through building materials and decorations that implement the interfaces as follows:

- Notable formations of brick or stone material.
- Fonts bond between the holes, vertically or horizontally. The facades of buildings are used in the field of expression for the formation of Yemeni architecture of the aesthetic elements used in the interfaces through the use of vertical and horizontal line, and therefore this is in fact the use of metaphor and matching shapes in nature.
CHAPTER TWO

➢ The harmony in the traditional architecture of Yemen.

This is achieved through the general consensus among the facades of buildings and processors Fine and means Manifesting building materials and elements to form and decoration common achieved factor harmony and character of the joint gatherings Urban all, where the big difference between the buildings of special groups and building the rest of society.

➢ The contrast in the traditional architecture of Yemen

Figure of window clearly shows the contrast of white through the development of which wraps a framework around the vents and prominent decorations and the dark color of the walls of mud or stone. This superficial contrast- the contrast in terms of size, it is formed by prominent blocs used with the title like Mashrabiyyah See Figure No (2)

Symmetry in the traditional architectural facades

Yemeni architecture heritage not know symmetry, it is due to the free nature design and construction, which are not subject to any rules of the Academy. So come architectural facades spontaneous, embodies the aesthetic concepts inherited its own architectural character.

Derek (1996) pointed that Yemen have combined there is an opportunity for the creation of a truly Yemeni architecture suited to present-day needs yet observing the rich Yemeni traditions. It is therefore to be deeply regretted that in a sense of falsely understood "progress", certain circles wanted to be "modern" at any price, and despising the outstanding features of traditional Yemeni culture, attempted to introduce reinforced concrete buildings.

Cement blocks houses are hot in summer and during the day, and cold in the winter and at night, because the walls and roofs are so much thinner than in traditional houses. They require (but do not always get it) expensive maintenance because they are not faced with materials that weather naturally.
Construction methods have used thick walls and roofs, an advantage in ensuring that the heat of the day is "stored", allowing restitution at night, thereby providing a stable indoor temperature without any need for heating and air-conditioning. But from the point of view of earthquake risk, these are the most dangerous structures.

Geology dictates the use of a variety of suitable building materials, stone, random or cut; fired clay bricks; unbaked earth blocks; mixed material such as burnt brick facing to interior earth blocks. The latest use of thin walls of cement and sand blocks, supported by a reinforced concrete frame, are a total failure, making for structures insensitive to climate and costly to maintain. This has become a standard solution in many places in tropical areas. Most designers ignore the use of traditional solutions, aiming to try again and again to "re-invent the wheel".

It seems they are afraid to be accused of "romanticism", yet such solutions do not solve the problem in a satisfactory manner. The climatic differences are reflected in traditional building design in the various regions. Some recent new buildings have been erected, ignoring the influence of climate, with unfortunate results. The future housing development in the port city of Yemen must consider the traditional architectural elements in design (Binhabet ,2007). Traditional solutions making for successful buildings are: in the uplands, high buildings with thick walls and large glazed windows that benefit from the winter sun.

Plate No: 1 there are decorative grilles above, with colored glass set in gypsum it is traditional Yemeni window in the upper floor of a house with colored glass set in gypsum it was called Qamariyah window (Binhabet ,2007). Below the openings have timber shutters, with glazed windows behind. Gypsum plaster is used externally to give extra

Plate No. 1: Qamariyah window
protection against the weather to the wall which is of burnt brick set in mud mortar. The ornate decorative gypsum screen is flanked by a high ventilation opening.

There is a canopy over the timber shutters below, which have small hinged openings to allow a view or some ventilation when the main shutters are closed. The window is in a wall of burnt brick in the upper floor of a house in Sana’a; the coastal lowland windows have no glass, being fitted with timber grilles and shutters - the "mashrabiyyah" Plate No.(2), permitting a cooling breeze to enter the building in such humid conditions. The coast is typified by the old “Turkish-type” high buildings, today being replaced by more modest houses of thatch and straw.

Rain is not a great problem; providing earth walls are kept dry, they stand for ever. It must be said that without people there would be no buildings. Their costume and their buildings vary, as is seen in the Yemen, between the cool uplands, the warm coast, and the interior deserts.

Case studies have been made, whereby climatic data plotted on bioclimatic charts give some indications. In the uplands Sana’a has comfortable conditions by day and cool nights; in the intermediate zone, Ta’izz, for
example, has comfortable conditions during half of the year, and with less
diurnal variation from day to night; the coastal lowlands bordering the Red
Sea, including Mocha, Hodaidah, Luhaya, demand the cooling effect of
breeze;

Zabid lies in the Maritime semi-desert with a different microclimate; Ma’rib and
Baraqish are typical of the semi-desert in the east. Similar zones can be
identified in the former South Yemen with climatic differences between the
ocean and those on the Red Sea.

The form of traditional buildings anywhere in the world is influenced by local
climate and geology In the Yemen there is good building stone, and clays
suitable for making burnt bricks, as well as sun-dried blocks, or used in the
form of rammed earth or adobe.

The clays are suitable as finishes for flat earth roofs. Alabaster is fired in kilns
producing gypsum used for architectural details, as well as for strengthening
the surfaces, and for the manufacture of decorative features.

Plate No.3: residence buildings built in concrete or cement blocks
There is, however, a shortage of indigenous building timbers.

These local materials over the centuries have become the raw material used by sophisticated and expert craftsmen. In the uplands the resulting massive construction of walls and roofs is an ideal solution towards the achievement of comfortable buildings, the thick walls possess the necessary heat resistance, whereby traditional buildings in the upland regions in particular do not require any space heating or air-conditioning.

The criteria to be applied are that the structures should respect traditional patterns and also the climate, and should allow public participation in construction so as to encourage self-reliance. At the long-term aim must be to improve traditional techniques together with the application of appropriate technology. Only in this way will the Yemeni tradition survive, and it must survive.

### 2.3 Architecture and residence building in Hodaidah.

Hodaidah, the main port and principal industrial city of Yemen had a total resident population of about 416136 inhabitants (Population, 2004). Verdier (1983) pointed that the Hodaidah city has two types of residence buildings, the first type of residence buildings built in concrete or cement blocks, with a definite "western" style of drab anonymity.

These residential buildings architecture does not incorporate any of the ornaments and related decorative characteristics found in the traditional Yemeni buildings and which exemplify attention and care. The process of convergence of the three types of urban patterns is very simple, though still has to be fully analyzed.
The second type are Turkish style residence buildings architectural influence of the Ottoman Empire and, indirectly, of other powers seeking regional domination. As a result, an Ottoman-inspired architecture flourished in the old urban core of Hodaidah, although many of the buildings whose architecture reflected the Turkish influence it is in the old city it named Alsoor (Al Mina District), what remain of the old Turkish style residence buildings are being destroyed. These houses were built in the once important ports of Hodaidah for merchants and administrative officers, particularly during the Turkish occupations. They are two to four storey structures, with an internal stair. The ground floor is generally utilized for stores and shops which may have their own entrance and be unconnected with the residential part. The floor above contains the main sitting room (majlis), often with the characteristic wood latticed balcony known as rawshan or, colloquially, taqa turki (Turkish window) together with one or more sleeping/sitting rooms. A second floor contains private rooms and a semi covered court (kharja) with the stair to the floor or
floors above. This stair is not necessarily the continuation of that from the ground floor and may be in wood and open to the sky. The uppermost floor characteristically has an isolated room preceded by a covered porch (darwa) and opening onto a roof terrace (also kharja), enclosed by plaster screens. Sleeping on this terrace is common.

Additional areas of the terrace may be precariously roofed with thatched material or, more recently, corrugated metal sheeting. Kitchen, water rooms (where water for domestic consumption is stored) and bathrooms are located on the upper floors. Ventilation is achieved by the perforated high parapets of the terraces, latticed window and balcony shutters and perforations above the doors. Those on the waterfront were destroyed to make room for major sewer lines.

A large cornice road has developed along the shore; and stores have taken the place of these residence buildings. Other buildings, within the city, have collapsed, mainly because of lack of maintenance. They are being gradually cleared up. Also, as the centre of economic activities and particularly trade activities became established firmly within the old city centre, some of these buildings were also torn down to provide additional rooms for storage facilities and for stores (Ismail and Samir, 1982).

2.4 Ergonomics.

The word ergonomic was derived from the Greek word, “ergon”, meaning work, and “nomos”, meaning law or usage. The literature suggests that the word “Ergonomics” was independently used in 1949 by a British Scientist, K.R.H. Murrell (Kroemer, 2003). It is the application of human factors data, including anthropometric data, to design better living conditions.

2.4.1 History of Ergonomics.

Our era provides us enormous changes and unforeseen advancements in technology, which lead to specific changes in economic and socio-cultural values. As a result of this shift, consumer’s need and expectations have
changed into a search for new experiences. Companies, in search of satisfying the new expectations of this era’s consumer, aspire to be innovative. To achieve this, they concentrate on the user as the main source of innovation and design their products taking into consideration ergonomic, user needs and functionality.

Historically, ergonomics can be seen to have arisen as a response to the need for rapid design of complex systems. As technology becomes more complex and work systems operate under increasingly severe constraints, good ergonomic design becomes increasingly important. Thus, “technology push” can be identified as one of the main factors influencing the direction and growth of the subject. The modern ergonomist has an important role to play as a source of scientific information about humans (a scarce commodity in many organizations), as a generator of knowledge about the human component of a work system, and as a member of a design team (Bridger 1995).

In Britain, the field of ergonomics was inaugurated after the Second World War (the name was invented by Murrell in 1949 despite objections that people would confuse it with economics). The emphasis was on equipment and workspace design and the relevant subjects were held to be anatomy, physiology, industrial medicine, design, architecture, and illumination engineering. In Europe, ergonomics was even more strongly grounded in biological sciences. In the United States, a similar discipline emerged (known as “human factors”), but its scientific roots were grounded in psychology (applied experimental psychology, engineering psychology, and human engineering).

Openshaw and Taylor (2006) pointed that the ergonomics is a science focused on the study of human fit, and decreased fatigue and discomfort through product design. Ergonomics applied to office furniture design requires that we take into consideration how the products we design fit the people that are using them. At work, at school, or at home, when products fit the user, the result can be more comfort, higher productivity, and less stress.
CHAPTER TWO

Ergonomics can be an integral part of design, manufacturing, and use. Knowing how the study of anthropometry, posture, repetitive motion, and workspace design affects the user is critical to a better understanding of ergonomics as they relate to end-user needs. This reference will explain some of the human factors that can be observed and should be applied to ergonomic product design (Pheasant, 2003).

2.4.2 Modern Ergonomics

Modern ergonomics contributes to the design and evaluation of work systems and products. Unlike in earlier times when an engineer designed a whole machine or product, design is a team effort nowadays. The ergonomist usually has an important role to play at the conceptual phase and in detailed design as well as in prototyping and the evaluation of existing products and facilities (Bridger 1995). Architectural design could benefit from ergonomics, as a complex system where there are various users of equipment, products and treatment / care environment are still often designed without giving sufficient consideration to the users who will perform their activities in it, leading to dysfunctional workplaces (Villeneuve, 2004). Some ergonomics methods can be used to provide key information (for example, user-needs analysis and task analysis) to designers of hospitals so that better decisions can be made in design (Hignett, 2006).

Ergonomics is about ensuring a good fit between people, the things they do, the objects they use and the environments in which they work, travel and play. Human factors (or human factors engineering) is an alternative term for ergonomics, and is more commonly used in the USA. Ergonomics needs to be considered in the design of virtually any product, system or environment. Failure to do so may lead to designs which do not fit the physical, psychological or sociological needs of the users, leading to ineffective, inefficient or unsafe designs, which are unlikely to be commercially successful. The human sciences of psychology, anatomy and physiology provide information about the abilities and limitations of people, and the wide differences that exist between individuals. People vary in many ways: body
size and shape, strength, mobility, sensory acuity, cognition, experience, training, culture, emotions, etc.

Ergonomists are trained in analytical techniques which enable the full extent of these user characteristics and individual differences to be considered when influencing the design process. Good designers are trained to consider the people who will use the products, systems and environments they design, but they also have many other factors to consider. All too often, commercial or time pressures mean that ergonomics principles are compromised or not given adequate priority until too late in the design process.

However, in recent years, crowded and competitive markets, raised consumer expectations, and new legislation have led to a more rigorous application of ergonomics. Fundamental themes of ergonomics, such as 'user-centered design', 'user friendly', 'inclusive design' and 'usability' have become buzzwords within the design industry. Far from being a constraint on creativity, ergonomics methods can be applied at the earliest stages of the design process, defining user needs and identifying opportunities for innovation. Some design consultancies employ qualified ergonomists and many other design groups work closely with specialist ergonomics consultancies.

During the past decade, research in ergonomics had led to heightened interest in the technology of work and furniture design based on biomechanics of the human body (Parcells, et. al., 1999). Most design projects involve multidisciplinary teams, including designers, engineers, marketing researchers, brand managers and, increasingly, ergonomists. Ergonomics is a broad subject area and is applied in many areas of industry, commerce and government. It can be considered fewer than three broad headings (Pheasant 1988):

- **Physical ergonomics:**
  It is concerned with human anatomical, anthropometric, physiological and biomechanical characteristics as they relate to physical activity. The relevant topics include controls and displays, working postures, manual handling, repetitive movements, work-related musculoskeletal disorders, workplace
layout, safety and health, lighting, and the thermal and acoustic environment. Bridger (1995) and Chou and Hsiao (2005) believed anthropometry is a research area in ergonomics dealing with the measurement of human body dimensions and certain physical characteristics. Anthropometric data can be used in ergonomics to specify the physical dimensions of workspaces, workstations, and equipment as well as applied to product design.

- **Psychological ergonomics:**
  It is concerned with mental processes, such as perception, cognition, memory, reasoning and emotion, as they affect interactions amongst people and with products, systems and environments. The relevant topics include mental workload, cognition, decision-making, skilled performance, human-computer interaction, human reliability, work stress, training, cultural differences, attitudes, pleasure and motivation.

- **Organizational ergonomics:**
  It is concerned with the optimization of sociotechnical systems, including their organizational structures, policies, and processes. The relevant topics include communication, staff resource management, work design, design of working times, teamwork, participatory design, community ergonomics, co-operative work, new work paradigms, organizational culture, virtual organizations and quality management.

Presently, the importance of safety and ergonomic in the design and manufacture of consumer products had grown significantly. The latest technology had increased the option to broaden the ergonomic and safety features of certain consumer products. However, it will also pose new risks which are more complicated to manage.

Therefore, it is important for the product designer and manufacturer to use anthropometric data and ergonomic knowledge in making decision during designing of machines, equipment, products and systems (Mattila, 1996).
2.5 Anthropometry.

The word "anthropometry" means measurement of the human body. It is derived from the Greek words "anthropos" ("man") and "metron" ("measure"). Anthropometric data are used in ergonomics to specify the physical dimensions of workspaces, equipment, furniture, and clothing so as to "fit the task to the man" and to ensure that physical mismatches between the dimensions of equipment and products and the corresponding user dimensions are avoided (Bridger 1995).

Anthropometry is "the study and measurement of human body dimensions" (Wickens, 244). Anthropometry may be simple to define; however it is very difficult to illustrate what the study entails and how it affects every day circumstances for humans of variability between and within populations, genders, and individuals (Trevor, 2010).

The human body dimensions vary a significant amount from one individual to the next by differences in shapes and sizes of various body parts. It is the responsibility of ergonomic engineers to design products and materials to adequately fit and properly accommodate the large variations in the human population. Anthropometry can be used to examine the different ways that engineers and scientists can measure the human body (Pheasent, 2006).

2.5.1 History of Anthropometry

Anthropometry and the data analysis of human measurements dates back to 1654 when a German physician, by the name of Johann Sigismund Elsholtz, published a thesis entitled Anthropometric. The thesis described anthropometric as the study of human measure. It gave a synopsis of human measurements and the proportions of the body. The book was made for artists, astrologers, and for the study of medicine. A tool to be used in human measurement was even designed in the paper, it was called an
anthropometric. The device was similar to tools used by artists to make human sculptures (Ulijaszek et al., 1998).

Although Esholtz’s first paper described anthropometry in 1654 it would be many years later before a study would take place collecting data and organizing it into a database. In 1861 an instructor at Amherst College in Boston Massachusetts began the first anthropometric data collection in the United States. Dr. Edward Hitchcock would record measurements of his students five separate times during their collegiate careers.

The measurements included: age, weight, height, finger reach, chest girth, lung capacity, and strength (Jenkins, 2005). These measurements were the basis of advice on health and exercise techniques that would be important to the students (Seaver, 1905). The study continued for around twenty-five years, at which time new techniques that were being discovered by other researchers came to the forefront. During these times many scientists around the world began forming groups and publishing anthropometric journals. This newly found research pushed authors to write books on the subject and some interesting research formed during the latter half of the 18th century (Hrdlicka, 1919).

As the research in anthropometry grew so did the industrial revolution that was taking place around the world. The industrial revolution began in the late 1700’s, but did not become a powerful worldwide entity until the 1880’s at which time the United States, Canada, Australia, Europe, Russia, and Japan had joined the new age (Stearns, 2007).

The revolution which began the mass production of goods required products that would accurately describe the customers. Before this time craftsman would design each product for its individual owner. As chairs, shoes, clothing, and many other products became manufactured by large industries, anthropometry found a place in the design aspect of production (Karwowski, 2006). This aspect of anthropometry pushed the field again into a new phase of history and into the 20th century.
The industries around the world flourished in parallel with the research into anthropometry. A large impetus came in the 1940’s and the dawning of World War II. The war pressed for more advances in soldier uniforms, equipment, and everyday items. A group of scientists and engineers who were working on this type of research into product development found that there were many practical applications to human factors engineering. In 1949 after the war, Dr. Hywell Murrell created a name for the research into “the study of human beings in their working environment” called ergonomics (Pheasant, 2006). The new discipline of ergonomics created a large need for anthropometric data. This need gave researchers the necessary fuel to begin large databases and the standardization of measurements.

A vast majority of the databases are constructed from military personnel. This is due in part to the cost and inadequate technologies that hinder private industries to make large and accurate civilian databases (Karwowski, 2006).

The majority of research that is conducted in the U.S. is comprised of military studies, but as technologies grow better scientists are able to find new ways to acquire and analyze civilian databases. In recent years technology has allowed scientists to record electronic databases and begin recording digital measurements which are more accurate than traditional methods.

The military’s database for anthropometric measurements is comprised of 40 surveys that were taken over 43 years beginning in 1945 and includes over 75,000 subjects (Adebisi, 2009). The data that is used in the research that was conducted for this paper comes from the American National Survey (ANSUR) which was recorded in 1988.

2.5.2 Anthropometric tools and anthropometric data

Anthropometry requires the use of many different measuring devices as well as techniques to acquire measurements of height, breadth, depth, distance, circumference, and curvature (Kroemer, 2001). The primary tools used by
engineers are: anthropometric with straight or curved branches, spreading calipers, and a sliding compass (Wickens, 2004). Measuring tapes can also be used to measure circumferences and curvatures.

Anthropometric data are used in design standards for new systems and in the evaluation of existing systems in which there is a human-equipment interface. The purpose of the data is to ensure that the worker is comfortable and efficient in performing work activities and in the use of the equipment.

The measurement of anthropometric data takes place with the individual test person who thus provides a random sample. In contrast, the future end customer is taken into account when the data are used for product creation and design. This transition takes place through statistical analysis of the body measurement data. (Karwowski, 2006).

2.5.3 Application of Anthropometry in design

According to Bridger (1995), clearly the natural variation of human populations has implications for the way almost all products and devices are designed. Some obvious examples are clothes, furniture, and automobiles. Anthropometric data can be used to optimize the dimensions of a diverse range of items—the length of toothbrush handles, the depth and diameter of screw tops on jars and bottles, the size of tools in tool kits supplied with automobiles, and almost all manual controls, such as those that are found on televisions, videocassette recorders, radios, etc. Body size and proportion vary greatly between different population and racial groups—a fact which designers must never lose sight of when designing for an international market. U.S. manufacturer hoping to export to Central and South America or Southeast Asia would need to consider in what ways product dimensions optimized for a large U.S. and probably male user group would suit Mexican or Vietnamese users, who belong to one of the smallest population groups in the world. It is usually impracticable and expensive to design products individually to suit the requirements of every user (although this is a recent development in the history of design). Most are mass-produced and designed
to fit a wide range of users—the custom tailor, dressmaker, and cobbler are perhaps the only remaining examples of truly user oriented designers in western industrial societies.

According to Fatih (2006) in the design of mass-produced items the task of the ergonomist is first to characterize the way a product is to be used and then to identify the issues which might affect usability—including the constraints which are imposed on the design by the anthropometry of the user population. From this, anthropometric dimensions appropriate to the design of the particular product can be specified. Second, the necessary data from the corresponding consumer/user group are obtained for use in dimensioning either the product itself or its range(s) of adjustability.

2.5.4 Types of Anthropometric Data

- **Structural Anthropometric Data**
These are measurements of the bodily dimensions of subjects in fixed (static) positions. Measurements are made from one clearly identifiable anatomical landmark to another or to a fixed point in space (e.g., the height of the knuckles above the floor, the height of the popliteal fossa, or back of the knee, above the floor, etc.). Some examples of the use of structural anthropometric data are to specify furniture dimensions and ranges of adjustment and to determine ranges of clothing sizes. Figure 4.3 shows structural variables which are known to be important in the design of vehicles, products, workspaces, and clothing. Figure 4.4 shows examples of vehicle dimensions which would require user anthropometry to be specified (Bridger 1995).
Figure No. 4: Some common structural anthropometric variables. (Source: Bridger 1995)

- **Functional Anthropometric Data.**

These data are collected to describe the movement of a body part with respect to a fixed reference point. For example, data are available concerning the maximum forward reach of standing subjects. The area swept out by the movement of the hand can be used to describe "workspace envelopes"—zones of easy or maximum reach around an operator. These zones can be used to optimize the layout of controls in panel design. The size and shape of the workspace envelope depends on the degree of bodily constraint imposed on the operator. The size of the workspace envelope increases with the number of unconstrained joints. For example, the area of reach of a seated operator is greater if the spine is unencumbered by a backrest and can flex, extend, and rotate.

Standing reach is also greater if the spine is unconstrained and greater still if there is adequate foot space to enable one or both feet to be moved. Somewhat counter intuitively, one way to increase a worker's functional hand reach is to provide more space for the feet (Bridger 1995). (Helander, 1995) pointed that in anthropometry human body dimensions are used to design artifacts.
The general principle is that the artifact must fit the size of the human body (Helander, 1995). Percentiles of body measures are commonly used to represent variability - from 5th percentile small size to 95th percentile large size. Several different body measures are used for design purposes, such as stature, sitting eye height, sitting elbow height, forward reach, lower leg length, and so forth. These measures are listed in anthropometric tables for populations, men/women. It would be too expensive to design; therefore the 5th to 95th range is commonly used for design to accommodate the greatest percentage of the user population. In this regard, there is no substitute for common sense, If a shelf can just as easily be placed an inch or two lower, without significantly impacting on other design or cost factors, thereby accommodating 98 or 99 percent of the user population obviously that is the correct design decision (Chiara, et. al., 1992). There are many anthropometric design guidelines and they are commonly used for design furniture like, chairs, sofa and workplace arrangements.

However Fatih, (2006). pointed in below given examples of some common anthropometric variables and how they are used in ergonomics.

- **Standing eye height**: Height above the ground of the eye of a person standing erect. Can be used as a maximum allowable dimension to locate visual displays for standing operators. The displays should not be higher than the standing eye height of a short operator so that short operators do not need to extend the neck to look at displays.

- **Standing shoulder height**: Height of the acromion above the ground. Used to estimate the height of the center of rotation of the arm above the ground and can help specify the maximum allowable height for controls so that short workers need not elevate the arms above shoulder height to operate a control.
• *Standing elbow height*: Height above the ground of the elbows of a person standing erect. Used to design the maximum allowable bench height for standing workers.

• *Standing knuckle height*: Height of the knuckles above the ground. Used to determine the minimum height of full grip for a standing operator. Operators with high standing knuckle heights should not have to stoop when grasping objects in the workplace.

• *Standing fingertip height*: Height of the tips of the fingers above the ground. Used, as above, to determine the lowest allowable position for controls such as switches.

• *Sitting height*: Distance from the seat to the crown of the head. Can be used to determine ceiling heights in vehicles to provide clearance for users with tall sitting heights.

• *Sitting elbow height*: Height of the elbows of a seated person above the chair. Used to determine armrest heights and work surface heights for seated operators.

• *Popliteal height*: Height of the popliteal fossa (back of the knee) above the ground. The 5th percentile popliteal height may be used to determine the maximum allowable height of nonadjustable seats. The 95th percentile popliteal height may be used to set the highest level of adjustment of height-adjustable seats.

• *Knee height and thigh depth*: Taken together, these variables specify the height above the floor of the upper thigh of a seated person. Can be used to determine the thigh clearance required under a table.

• *Buttock-popliteal length*: Distance from the buttocks to the back of the knee. Used to determine the maximum allowable seat depth so that seat depth does not exceed the buttock-popliteal length of the short users.

• *Shoulder width*: Widest distance across the shoulders. Used to determine the minimum width of narrow doorways, corridors, etc. to provide clearance for those with wide shoulders.

• *Hip breadth*: Widest distance across the hips. Used to determine the space requirements necessary for clearance and, for example, the minimum width of seats to allow clearance for those with wide hips.
• **Abdominal/chest depth**: Widest distance from a wall behind the person to the chest/abdomen in front. Used to determine the minimum clearance required in confined spaces.

• **Vertical reach (sitting and standing)**: Highest vertical reach. Used to determine maximum allowable height for overhead controls so that they are reachable by the shortest users.

• **Grip circumference**: Internal circumference of grip from the root of the fingers across the tip and to the palm when the person is grasping an object. Used to specify the maximum circumference of tool handles and other objects to be held in the palm of the hand. Handle circumferences should enable those with small hands to grasp the tool with slight overlap of the thumb and fingers.

• **Reach**: The dimensions of the reach envelope around an operator can be used to locate controls so that seated operators can operate them without having to lean forward away from the backrest or twisting the trunk and standing operators can operate them without forward, backward, or sideways inclination of the trunk. Arm movements should be kept in the normal work area to eliminate reach over 40 cm for repeated actions. (These data are also applicable to the design of all vehicle cockpits and cabs).

### 2.6 Psychophysical Scales

Workspaces should facilitate efficient, safe and comfortable work. However, “comfort” has both physical and emotional dimensions. Balogun et al. (1986) suggested that equipment should not only be physically undemanding, but that it should also be perceptually acceptable to the user. Given this, the present study included psychophysical ratings of discomfort and effort level. It is too often assumed that in testing of strength expression only the physical findings are of importance. However, biophysical and psychosocial components are of equal importance (Singleton et al., 1973). In the present study the psychophysical observations included the rating of perceived exertion (RPE).
2.6.1 Definitions of comfort and discomfort

Ergonomics is the study of the relationship between humans and machines including such matters as maximum efficiency, safety, comfort, and accuracy (Corsini, 2002). Though the term ‘comfort’ is commonly used, there is still substantial debate in the literature regarding its definition. Likewise, automobile seat comfort, as a science, still lacks a coherent, universally accepted definition.

Various authors have defined comfort in different ways which are described as given below:

- a) Comfort is “a construct of a subjectively-defined personal nature”.
- b) Comfort is “affected by factors of a various nature (physical, physiological, psychological)”.
- c) Comfort is “a reaction to the environment”.

(Bishu, et al., 1991; Helander and Zhang, 1997; Richards, 1980; Zhang et al., 1996), (Baber, 2002). Looze et al. (2003), Merriam-Webster Online Dictionary (2007) defines comfort as,

- a) “Contented well-being”.
- b) “A satisfying or enjoyable experience”.

Allen (1990) described it as a range of states from relief, well-being, and satisfaction to making life easier. The definition by Slater (1985) is “a pleasant state of physiological, psychological, and physical harmony between a human being and the environment”. Richards (1980) emphasized that comfort is a state involving a sense of well-being, in response to an environment or situation. Summers (2000,) divides comfort into an emotional aspect, “a feeling of being more calm, cheerful, or hopeful after you have been worried or unhappy”, and a physical aspect, “a feeling of being physically relaxed and satisfied, so that nothing is hurting you, making you feel too hot or cold etc”.

45  P.G. Department of Home Science
In summary, comfort is, as subjectively-defined is a multifaceted construct, a positive feeling in the form of relief, encouragement, enjoyment, well-being, satisfaction, and/or pleasantness that results from interactions with the environment.

It is assumed that as comfort increases, discomfort decreases. Likewise, it is assumed that when discomfort increases, comfort decreases. However according to research by Helander, Czaja, Drury, Cary, and Burri (1987), comfort and discomfort may actually be based on two sets of completely different criterion. Feelings of discomfort were associated with “pain, tiredness, soreness, and numbness,” which were a result of the physical dimensions of the chair (Helander & Zhang, 1997; Zhang, Helander, & Drury, 1996).

Comfort, on the other hand, was associated with feelings of well-being and the positive aesthetic impressions of the chair. Interestingly, buttock and limb pain do not affect comfort ratings of chairs. Lumbar pain is the most important factor for determining comfort while seated (Bishu et al., 1991; Page, Tortosa, Garcia, Moraga, & Verde, 1994; Vergara & Page, 2002).

Comfort is strongly associated with muscular strain rather than other issues such as intradiscal pressure or the imitation of the natural spine curve while standing (Vergara & Page, 2002). Furthermore, static muscular effort is the main cause of short term lumbar and dorsal pain (Vergara & Page, 2002).

This finding supports the impact of postural fixity, the buildup of lactic acid in the muscles due to static postures, on perceptions of comfort and its implications on chair design. In a study by Reinecke, Hazard, and Coleman (1994), they write, “The positive effect of small movements around a posture to reduce muscular strain has already been considered by chair manufacturers, who produce chairs with flexible backrests.” The use of flexible back materials, such as mesh, may also promote small movements around a posture. Attention to chair design may therefore reduce the occurrence of static muscular effort, resulting in increased overall comfort.
Westguard and Aaras (1984) studied that, while posture is important to the comfort of all people at work. A poor posture becomes a hazard to health and safety in two main situations: in tasks, which are static in nature and involve maintaining the posture for relatively long periods; and in tasks, which involve the exertion of force. In the first situation, the postural loads on muscles and joints can lead to muscular fatigue, pain, and in long term to cumulative physiological changes and injury.

Haslegrave (1994), Brantingham, ET. al. (1970) reported that the primary occupational symptoms and diseases related to prolonged constrained standing are pain, discomfort, fatigue, swelling of the lower extremities and foot, due to blood pooling and varicosities of the lower extremities.

**Comfort Measurement**

Comfort may be measured using a variety of subjective and objective methods. Subjective measures are the only way to examine true subject preferences and feelings about chair design (Vergara & Page, 2002).

The use of subjective measures is the most direct method to evaluate comfort, which is itself a “subjective state or feeling” (de Looze et al., 2003). Helander and Mukund (1991) discussed the drawbacks of subjective qualitative methods as applying only to the comparison of different models of chairs by the same group of subjects. Furthermore, subjective measures rely on the abilities of subjects to accurately identify and rate their own levels of comfort, which may or may not be accurate. Subjective evaluations of variables such as comfort, however, can be the ultimate criterion of some users in a purchasing situation.

As stated by Christiansen, “not anatomical or orthopedic aspects, body posture, task performance, but the users’ subjective evaluation of seat...
Comfort is the decisive criterion for the choice where to sit on or what chair to buy” (Christiansen, 1997; Shackel, Chidsey, & Shipley, 1969).

Comfort is measured in various ways in the literature. Subjective measures include the general comfort rating, body area [dis]comfort rating, chair feature checklist, method of adjustment, and personal comments (Christiansen, 1997). According to Christiansen (1997), however, no particular measurement method dominates. The overall reliability and validity of any comfort rating method varies greatly depending on the sample of subjects.

Subjective measures of comfort are often coupled with objective measures in research on comfort. Compared to subjective measures, objective measures are favored by most researchers because they can be quantified (Christiansen, 1997). Objective methods include posture analysis, electromyography, anthropometric fit assessment, pressure distribution, spinal load estimation, biomechanical analysis, physiological indicators, subject performance, and behavior analysis (Christiansen, 1997; de Looze et al., 2003).

**Discomfort**

Discomfort maps and rating charts have been used in numerous studies to identify the most affected area(s) of the body while the subject is completing a task. Marley and Fernandez (1995) combined the use of a body map with the identification of RPE for these specific ratings, thereby identifying localized the rating of perceived exertion during the observation of asymmetrical lifting.

In the present study a combination of both of the above mentioned studies were adapted and used to observe the discomfort the subjects were feeling during the completion of the specific task. The body map from Marley and Fernandez (1995) was combined with the rating scale of Schulze and Woods (1994). See figure (4) that illustrates the words of Marley and Fernandez (1995).
Charles,( 2001) pointed out that during the next testing session the study will be required to turn various valves at various testing velocities. While we will
be measuring strength and work output, and physiological parameters, we will also be objectively assessing psychological parameters. The first of these psychological parameters is the identification of an area on a chart of the hand and forearm which is causing you discomfort.

The study only need to identify one area, labelled 1 to 8, which is causing the most discomfort. Charles say the parameter involves is the identification of one area on the whole body, which is causing discomfort. The areas are broken up in various segments, which are the following: Hand, Wrist, Forearm, Upper arm, Shoulder, Whole body.

While identifying this one area you will be asked to suggest a rating on a scale of 1 to 10, 1 corresponding to discomfort being “just noticeable”, 5 “Moderate” and 10 corresponding to a rating of “intolerable”. Once again try to be as objective as possible and try not to over or underestimate the degree of discomfort. You will be asked for your rating and identification at the end of a control being tested in all three velocities for a specified position (Charles. 2001).

Discomfort has been widely used and generally accepted as a proxy or risk factor for musculoskeletal disorders, and discomfort measures have been commonly used to evaluate ergonomic interventions (Sauter et al., 2005). It is also known that discomfort relates to poor biomechanics and circulation, restlessness, and fatigue (Zhang et al., 1996).

Several definitions/meaning of discomfort are as follows:

a) “Mental or physical uneasiness” (Merriam-Webster, 2007).


c) “A generic and subjective sensation that arises when human and physiological homeostasis, psychological well-being, or both, are negatively affected” (Shen and Parsons, 1997).

d) “An absence of comfort or ease; uneasiness, hardship, or mild pain” (Discomfort, 2007).
e) “A feeling of slight pain or of being physically uncomfortable” (Summers, 2000).

f) “A feeling of embarrassment, shame, or slight worry” (Summers, 2000).

Additionally, feelings of discomfort increased with time during the workday (Helander & Zhang, 1997). The most common discomfort ratings of sedentary workers occur in the neck and lumbar portions of the body; only discomfort in these areas has been found to cause decreased general comfort ratings (Vergara & Page, 2002).

Visual discomfort and musculoskeletal discomfort, particularly in the neck and shoulders, are occupational health concerns for people who work with computers (Bergqvist and Knave (1994); Bergqvist et al, 1995; Hunting et al, 1981). In terms of ergonomics, comfort integrates a sense of wellbeing with health and safety; conversely, discomfort could be related to biomechanical factors involving muscular and skeletal systems (Zhang et al, 1996).

**Relationship between comfort and discomfort, their factors and models.**

Quite different viewpoints are also found in the literature regarding the relationship between comfort and discomfort, and indicating an overall lack of consensus:

- a) In common parlance, comfort may refer to both comfort and discomfort (Zhang et al., 1996, p. 377).
- b) Comfort and discomfort need to be treated as different and complementary entities” (Zhang et al., 1996, p. 377).
- c) Comfort is absence of discomfort (Branton, 1966; Hertzberg, 1972).
- d) Comfort does not necessarily entail a positive affect (Branton, 1966,).
- e) Comfort is one side of a continuum ranging from extreme comfort through a neutral state to extreme discomfort (Shackel et al., 1969).

As psychological constructs, similar to ‘fatigue’ or ‘effort’, comfort and discomfort more recently have been suggested to require treatment as
different and complementary entities in ergonomic evaluations and interventions (Sauter et al., 2005; Zhang et al., 1996). Zhang et al. (1996) found that sitting comfort and discomfort are orthogonal (Figure 1), not merely the opposite of each other, and therefore should be treated as independent entities. They observed that discomfort is related to biomechanics and fatigue factors, whereas comfort is related to a sense of well-being and aesthetics.

Similarly, Hancock et al. (2005) showed that discomfort relates to a lower-level need (prevention of pain), and comfort, as one of attributes inviting positive effect, relates to a higher-level need (promotion of pleasure). Paul et al. (1997) proposed the “nurturing and pampering paradigm”, and claimed that different strategies should be used for reducing discomfort (nurturing) and increasing comfort (pampering) in the workplace. Based on these authors’ views (Paul et al., 1997; Sauter et al., 2005; Zhang et al., 1996), it is a reasonable conclusion that these two different types of constructs should be investigated using two separate instruments.

Along with defining comfort and discomfort as two different entities, Zhang et al. (1996) identified two different factors for comfort, namely a sense of well-being and aesthetics. From a more macro view, it is known that there is a third type of comfort (i.e., psychosocial comfort, de Looze et al., 2003; Hsu and Wang, 2003). In the view of de Looze at el. (2003), psychosocial comfort is related to communication with other people, job satisfaction, and social support.

Hsu and Wang (2003) identified job dissatisfaction, intensified work load, monotonous work, low job control, low job clarity and low social support, as major contributing factors for psychosocial comfort, and found associations between physical/ergonomics variables and psychosocial factors, and their interactions with visual and musculoskeletal discomforts.

Similarly, Lu et al. (1996) found interactions between psychosocial factors and ergonomic workstation design factors, and argued that the psychosocial factors may contribute to physical discomfort. As such, the importance of
Psychosocial comfort should not be overlooked for a more comprehensive understanding of overall comfort perception, though this category is not considered in the present work.

Ideally, the optimal sitting experience will be a combination of maximal comfort with minimal discomfort (MCMD), where comfort (discomfort) is a combined entity of physical, emotional and psychosocial comforts (discomforts). Just seeing a seat without sitting can evoke a positive or negative feeling, which can affect the perception of comfort and discomfort during and after sitting (Eklund and Kiviloog, 2003; Helander, 2003). Therefore, emotional comfort and discomfort have a role in perception.

Similarly, a comfortable seat should be complemented by a comfortable posture if it is to ultimately provide the sitter a positive feeling while occupied. Hence, the concept of physical comfort is required to describe this situation (relaxed feeling) while sitting, distinguished from emotional comfort that does not necessarily require physical contact. In summary, it is argued that physical and emotional aspects of both comfort and discomfort are necessary to describe overall perception of comfort/discomfort (Table 2.1), and that interactions likely exist among the different types of comfort / discomfort (Figure 2.8).

<table>
<thead>
<tr>
<th>Physical</th>
<th>Emotional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formed during/after use</td>
<td>Formed before/during/after use</td>
</tr>
<tr>
<td>Physical contact required</td>
<td>Physical contact not required</td>
</tr>
<tr>
<td>Discomfort</td>
<td>Related to anti-aesthetics</td>
</tr>
<tr>
<td>A state of ill-being</td>
<td>Related to aesthetic</td>
</tr>
<tr>
<td>Related to poor biomechanics and circulation, restlessness, and fatigue</td>
<td>(unattractive, cheap, repellant)</td>
</tr>
<tr>
<td>Comfort</td>
<td>A state of well-being</td>
</tr>
<tr>
<td>Absence of physical discomfort (relaxed, refreshed)</td>
<td>Related to aesthetics</td>
</tr>
</tbody>
</table>

*Table No.1: Components of comfort and discomfort (Summers, 2000; Van Veelen et al., 2001; Zhang et al., 1996).*
Zhang et al.’s model (1996) considers only one type of discomfort (physical) and does not clearly divide comfort components. Given this, their model can describe only limited situations properly. With their model, for example, it is hard to describe the fact that even before sitting, there can be a negative feeling due to its design (e.g., unattractive color, cheap feeling, etc). Similarly, comfort can be evoked with and without the usage of the seat.

Hence, it is necessary to have the concept of emotional discomfort to address the former example, and a distinction between physical and emotional comforts to address the latter. Consequently, the concept of total comfort and discomfort emerges, where physical, emotional and psychosocial comforts are combined into total comfort, and physical, emotional and psychosocial discomforts into total discomfort. There should be a transition between comfort and discomfort within any type, where comfort and discomfort are both present (Figure No.7).
It is still not clear if, or to what extent, discomfort is dominant compared to comfort. Helander and Zhang (1997) found out that when discomfort was present, comfort became secondary, and observed that aesthetic design mattered with respect to comfort, but not to discomfort. Further, a full range of overall comfort ratings were found only when discomfort factor scores were low, and the range of comfort ratings was negatively associated with that of discomfort ratings. This indicates that, as the level of discomfort becomes more intensive, comfort factors tend to be unrecognized or become secondary.

Hence, discomfort would seem to be a dominant factor in overall comfort / discomfort perception. However, Helander and Zhang (1997) did not investigate this issue quantitatively (i.e., to what degree comfort was reduced due to the presence of discomfort, or how they affected each other), nor did they address possible effects of comfort on discomfort. Similarly, referring to Helander and Zhang (1997), de Looze et al. (2003)’s sitting comfort / discomfort model (Figure No. 7) has two unidirectional arrows in the middle from discomfort to comfort to indicate the dominance of discomfort. They expected that “for discomfort the relationships of objective measures with discomfort would be stronger than for comfort, as the link between discomfort (and) objective measures of physical exposure, dose or response is more direct” (de Looze et al., 2003,).
However, the validity and general applicability of this argument should be investigated further. Indeed, these authors mentioned that “the expectation that discomfort is more closely related to objective physical measures as compared to comfort cannot be verified”.

![Diagram of Sitting Comfort and Discomfort with Underlying Factors](image)

*Figure No.8: Theoretical model of sitting comfort and discomfort and its underlying factors at the human, seat and context level (adapted from de Looze et al., 2003). Reproduced with permission from Ergonomics.*

As an alternative, the dominance of discomfort or comfort in evaluation of, or experience from, a product can be determined according to the overall maturity level of a product family of concern that is likely to change with the stage of a product family life cycle (Figure No.7). For example, if a group of
products under consideration have a low level of quality on average and do not satisfy users' basic needs (prevention of pain, soreness, numbness, etc.), they can be evaluated more effectively with discomfort ratings.

On the other hand, if they meet these basic needs, they should be evaluated by comfort ratings, as the levels of discomfort will not differ much, and hence product quality will be difficult to distinguish in terms of discomfort. A decrease in comfort level from Stage III1 to Stage III2 and from Stage III2 to Stage IV can be partially explained by the temporal change in perceptions of comfort (Kolich and White, 2004).

Figure No.9: Proposed model of dominance of comfort and discomfort according to product life cycle - comfort/discomfort quality life cycle
2.6.3 Measuring living room sitting comfort and discomfort.

Precise quantification of ergonomic and interior design comfort / discomfort, a fundamental step for improving the living room interior design, requires that seating area and furniture geometries, esthetics designing postures and visual demands should be set close to space and furniture designing situations. Rebiffé (1969), indicated that ergonomic vehicle packaging, specifically harmonic layout of relevant parts, is more important for overall comfort than the seat itself. Anshel (2005) indicated that visual information in human-machine systems was so dominant that its deficiency could often result in awkward body postures.

Seat and furniture geometries and esthetics in designing postures, in turn is likely to influence interface pressure distributions, one of commonly used measure for seat comfort investigations. Besides ensuring realistic conditions, in terms of seat, posture, task, and environment, which are necessary (especially in a laboratory-based study) for their contextual effect on the human response as generally discussed by Annett (2002), short-term and long-term sitting comfort / discomfort need to be distinguished.

Sitting discomfort increases over time while sitting comfort tends to remain constant (Helander and Zhang, 1997). Some authors have suggested using long-term test durations for the assessment of seat discomfort. For example, Gyi and Porter (1999) indicated that at least two hours of testing was required to clearly assess discomfort, which seems mainly focused on measuring fatigue in seated postures.

Fatigue in sitting, however, could be simply due to “the passage of time” (Helander and Zhang, 1997), and not necessarily due to the seat design. Further, fatigue in vehicle has been shown to be affected by multiple other sources such as temperature, air quality, noise (Gameiro da Silva, 2002), seat cover ventilation (Hawkins, 1974; Reed et al., 1994; Temming, 1993), and circadian factors (Moore-Ede et al., 2003; Van Dongen and Dinges, 2000).
Measure of interface pressure does not effectively account for any of the above factors (temperature, air quality, noise, seat cover ventilation, and circadian factors), but rather accounts for the seat’s support and pressure distribution characteristics and postural changes. Therefore, in using pressure data for assessment of sitting comfort / discomfort, a method is required that can determine their levels within a relatively short period of time.

However, the result was only regarding statistically significant differences. Indeed, with a closer examination of the results, the authors found that there was time effect on comfort descriptors related to well-being and most discomfort descriptors, whereas no time effect was found in comfort descriptors related to seating area, seating furniture design (aesthetics).

Hence, comfort due to aesthetics seems relatively time-resistant, compared to other comfort and discomfort factors. Similarly, Kolsch et al. (2003) also included the time effect on discomfort in their comfort zone model, with comfort being defined as absence of discomfort. As noted, physical discomfort increases with time, and physical comfort also seems affected by time and/or by the presence of discomfort, especially when discomfort is substantial.

Contrary to the result of Helander et al. (1997), some researchers have found that emotional comfort is also time-dependant. For example, Eklund and Kiviloog (2003) observed that an initially attractive seat became more attractive over time, whereas an unattractive one became more unattractive over time.

However, no indication was provided whether these results were statistically significant. It thus appears that the relationship between instantaneous and long-term comfort ratings depends on how dominant aesthetic comfort and other comfort aspects are in the initial formation of total comfort, how strong the relevant stimuli are, and how long these comforts last as a result. Summarized in (Figure 10) are the potential stimuli and the formation order of comfort and discomfort, and their interactions?
In contrast to Zhang et al. (1996) and de Looze et al. (2003), a comfort effect on discomfort should be taken into account and vice versa.

Carter and Banister (1994) pointed out that there are several advantages and disadvantages associated with a seated posture. Sitting takes the weight off the legs, increases stability and reduces energy expenditure thereby alleviating fatigue and lowering the demand on circulation, but it also leads to slackening of the abdominal muscles and an unnatural kyphosis of the spine, which increases the pressure within the intervertebral discs (Figure No.11). They argued that sitting stresses the spine and the slackened muscles of the back.

Figure No.10: Relationship between components of comfort/discomfort (Gyouhyung Kyung 2008)

- Sitting comfort and discomfort.
Figure No.11: The natural curvature of the spine (A) while standing compared to (B) while seated. (Adapted from Grandjean, 1987)

Prolonged seated postures lead to discomfort due to the static load placed on the neck and back (Turville et al., 1998). Fenety et al. (2000) observed that when people first sit there is little seated movement, but as time progresses there tends to be an increase in “in-chair postural adjustments”.

Helander and Zhang (1997) considered the rise in both discomfort and seated movements with progressive time spent in a seated position, and suggested that people are inclined to continuously alter their posture in order to relieve the buildup of pressure and discomfort associated with prolonged sitting.

There appears to be a lack of consensus concerning the “ideal” of seated posture for sitting furniture and living room. Hochanadel (1995) recommended that the knees be at a slightly higher level than the hips in order to ensure that
the popliteal fossa clears the front edge of the chair thus minimizing the pressure on the posterior surface of the knee and thigh. On the other hand, Pheasant (1996) suggested that when seated there should be a 90° angle at the knee, but he does agree that if the seat height is too high the pressure on the posterior thigh may lead to a reduction in the circulation to the lower extremities, consequent swollen feet and a considerable amount of discomfort.

Harvey and Peper (1997) therefore recommended that the optimal chair height be determined by leg length and according to Carter and Banister (1994) it should range between 380 – 570mm above the ground.

Coleman et al. (1998) reported that low cost interventions can be implemented in order to overcome these height related problems, and suggested that in the case of a chair that is too high a footrest could be used so that feet are firmly supported and pressure on the legs reduced. A chair that is too low can simply be raised using a platform in order to retain the optimal seated working posture.

Sauter et al. (1991) suggested that an erect sitting posture with an elevated backrest was important for reducing the static loads imposed on the trunk. They did, however, point out that subjects adopted a stooped posture in order to relieve the static demands and associated discomfort of prolonged erect sitting.

Furthermore Carter and Banister (1994) stated that slumping forward places the ligaments and muscles in the lumbar region under a great deal of tension. Hochanadel (1995) found that a slightly reclined trunk posture of 100° – 110° reduces the intradiscal pressure of the spine as well as the electromyography activity in the back muscles, but as Burgess-Limerick et al. (2000) pointed out, if the trunk is reclined further than 110° there is an increase in tension of the anterior neck musculature due to the neck flexion required to maintain the same visual focal point.
Fujimaki and Mitsuya (2002) also recommended a reclining posture, but they did caution that this may affect the users’ ability to place their feet flat on the ground and thus suggested a footrest in order to prevent lower limb discomfort.

Several authors have stressed the importance of the use of a backrest (Aarås et al., 1997; Vergara and Page, 2000). It has been found that limited use of a backrest is associated with a high level of kyphosis in the lumbar spine with a large amount of in chair movement indicating discomfort.

It has also been noted that only backrests with a substantial amount of lumbar support bring about a reduction in discomfort in the lumbar region of the spine. The optimal height of the lumbar support has received considerable attention. In a study done by Coleman et al. (1998) they discovered that body mass index (BMI) was more closely associated with the height of the support than was stature.

They found that obese people (high BMI) tended to prefer a higher lumbar support compared to those with a lower BMI, and they therefore suggested that the height of the lumbar support should be adjustable from 150 – 250mm above the seat in order to suit each individual’s needs and preferences.

In terms of the backrest dimensions Grandjean (1987) recommended that only longer backrests (between 480 – 500mm) be used in the design of office chairs, as these are more effective in supporting the weight of the trunk and result in enhanced sitting comfort. Coleman et al. (1998) found that the depth of the backrest is seldom adjusted since the seat pan often provides a definite location for the buttocks and any deviation will increase the pressure on the ischial tuberosities.

According to Pheasant (1996) this chair dimension should however be adjusted according to the length of the upper leg of the user as this will allow all users to make full use of the backrest without placing pressure on the posterior surface of the knee.
Helander et al. (1995) emphasized the need for adjustability so that the anthropometric differences among users, what they are used to, and their personal preferences can be accommodated so that users can alter their postures when sitting for prolonged periods of time in order to reduce the strain and build up of discomfort experienced by them.

Similarly, sitting comfort needs to be divided into sitting comfort and discomfort as each is placed at a different stage of human needs (Hancock and Pepe, 2005), and comfort and discomfort are regarded as not merely opposing constructs (Zhang, et al., 1996).

Further, valid quantification of living room sitting comfort / discomfort requires that seats, sitting postures and visual demands be set close to actual sitting situations. (Gyouhyung , 2008) Short-term and long-term sitting comfort / discomfort need to be distinguished.

Sitting discomfort increases over time while sitting comfort tends to remain constant (Helander and Zhang, 1997) Increased discomfort seems largely associated with fatigue, which can result from one hour of seating (Uenishi et al., 2002). Gyi and Porter (1999) recommended at least two hours of testing to clearly assess discomfort (fatigue).

However, fatigue in seated postures has human contributing factors, and can actually result from other sources than the seat. Even when the seat is a major factor, other aspects, rather than the seat's function in providing support and distribution of body pressure, could be the major sources of any unpleasant feeling in sitting (e.g., aesthetics, micro-climate).

To promote musculoskeletal health, postural movement is essential. Several studies have shown that postural changes provide physiological benefits, such as relief of muscular fatigue (Dhingra et al., 2003; Jenny et al., 2001; Preuschen and Dupuis, 1969).
In order to describe humans' dynamic behaviors and the seat's supporting function, interface pressure is commonly used as an objective measure in the study of seat quality in terms of minimal discomfort, but evidence suggests that more careful consideration is needed for proper use given its limitations (e.g., creep, hysteresis) and potential confounders (e.g., a seat's sweat evaporation characteristic, noise, light, and air temperature).

Aside from such technical issues, the means by which pressure data are integrated into subjective responses remains unclear. Likewise, (Gyouhyung K., 2008) pointed that different weightings of interface pressure or feelings at local body parts may be used by individuals in determining global levels of comfort and discomfort.

The other aspects of the experimental seat were designed according to recommendations (Tougas and Nordin, 1987) that have been proposed for chairs: seat swivel, five-point base, height and tilt adjustability, and so forth. Seat evaluations have been mostly subjective (Bishu et al., 1991; Motavalli and Ahmad, 1993). Corlett (1995) has recommended the use of the chair feature check list, first proposed by Shackel et al. (1969) and later modified by Drury and Coury (1982), to obtain the mean and distribution effects of the various aspects of a seat.

A modified form of the chair feature check list was used to obtain the subjective responses for a given configuration of the seat. Features such as Cushioning, Stability, Personal Acceptability and Overall Discomfort were added to the Drury and Coury scale. The subjects had to rate eight aspects related to the seat using the five-point semantic differential scale. see figure (12).
Figure No.12: Chair feature check list (Adapted from Drury and Coury, 1982).

While all the local body parts, regardless of whether they make contact with a seat, affect whole body perceptions, each local body part and local interface pressure are expected to weigh differently in the decision process used to
obtain global perceptions. Therefore, it will be valuable to investigate whether some local body parts are more predominant in this process, and whether there is an ideal ratio in terms of pressure distribution among local surface areas of the seat (Gyouhyung, 2008).

Physiological changes occur with age, such as slower reaction times, loss of muscular strength and dexterity, increased susceptibility to fatigue (Warnes et al., 1993), and loss of joint flexibility (Haywood et al., 1991) and visual acuity (Eby and Kantowitz, 2006; Nicolle and Abascal, 2001).

Hence, older individuals might have different needs for living room interior design, as these physiological changes are likely to adversely affect seating experience and posture. Less is known, however, whether there are differences between age groups in the perceptions of comfort and discomfort of sitting experience. However, it remains unknown whether there are differences in effective subjective ratings of the improved seat-interface design for respective cultural groups and differences in relating local-to-global perceptions between cultural groups.

The perceptions of comfort sitting may also be significantly influenced by the anthropometric dimensions of the user, which determines the fit of the chair. While a small sized chair would be a bad fit for an individual with large dimensions, it would be appropriate for a person of small stature. Various issues may arise from inadequate person-chair fit, such as the compression of soft-body tissue that restricts blood supply.

Any instance of poor person-chair fit where the chair is too big or too small may result in such compression of the body Wright, In a study by Helander et al 1993), subjects of a smaller stature disliked large chairs because the seat pan was too long and the lumbar support was too high. Likewise, larger individuals disliked the small chairs for the opposite reasons (Helander et al., 1987; Helander & Zhang, 1997). The variations in perceptions of comfort across subjects could therefore be related to their anthropometric dimensions.
According to Pheasant (1986) the purpose of seating furniture is to provide stable body support in a posture that is comfortable over a period of time, physiologically satisfactory and is appropriate to the task or activity being considered. Chakrabarti (1997) also stated that one should consider appropriate anthropometrical requirements for sitting, for seat and work surface dimensions, legroom and clearances for getting in and out. The surrounding free movement space should also be present.

Therefore, home ergonomics is becoming very important amongst home scientist, ergonomists, industrialists, builders and interior designers (Varghese, et. al. 1989).

As stated by Chakrabarti and Nag (1996) the workstation must be in accordance with the human functions, such as:

1. Postural control and distribution of the body weight.
2. Visibility ranges for display and control areas.
3. Optimal positioning of the hand and foot controls.
4. User’s behavioral pattern in performing the tasks.

The fundamental goal of ergonomic design is to adopt the work process, tools or equipment and the working environment to fit the needs, size and capabilities of the worker to enable the worker to work comfortably, safely and ultimately increase productivity (Boerding, 1997).

Chakrabarti (1997) also stated that, for design purposes, to fit an intended user from amongst the known population group, different percentile values of different human body dimensions should be considered for different design dimensions. Designing an article or a system with a single percentile value for all the relevant human dimensions would fail to satisfy all the other dimensional features of the design. He also suggested that a workstation should provide positive motivation for acceptance by the anticipated users.

This may be through providing a simple, clean, convenient place to work, giving a personal feeling of comfort, privacy, attractiveness, reliability and
safety, freedom from unwanted obstacles, and also providing common behavioral pattern of movement, encouraging interpersonal interactions and bringing out various hidden psychological feeling. Corlett (1981).

Showed adoption of poor working postures in order to perform tasks, could lead to postural stress, fatigue and pain, which may in turn force the operator to stop work until the muscles recover. Westguard and Aaras (1984) studied that, while posture is important to the comfort of all people at work.

A poor posture becomes a hazard to health and safety in two main situations: in tasks, which are static in nature and involve maintaining the posture for relatively long periods; and in tasks, which involve the exertion of force. In the first situation, the postural loads on muscles and joints can lead to muscular fatigue, pain, and in long term to cumulative physiological changes and injury (Cited in Haslegrave, 1994).

According to Rio (1998) Rio, Rodrigo Pires Do. (1998). Ler- Ciencia* lei. Belo Horizonte: Health those inadequate postures, as the extreme ones and the static ones, take to general and/or specific overloads of the muscle-skeletal system, being one of the main factors in the origin of muscle- skeletal disturbances related to the work.

➢ **The Ergonomics of Back Discomfort**

The physical causes of back discomfort or cumulative back pain are believed to stem from the same kinds of ergonomic stresses, or risk factors that cause musculoskeletal disorders (MSDs) of the upper limbs.

➢ Sustained or prolonged postures. Holding a position for a long time reduces blood flow, depletes nutrients, and leads to a buildup of metabolic wastes.

➢ Awkward or non-neutral postures of the spine. Twisting, bending, or flattening the lower back can cause back pain by contributing to stretched, overworked muscles and ligaments. These postures can
also squeeze or even rupture the cartilaginous discs between vertebrae.

- Compression forces. Too much load on the discs through extra weight can also affect the discs.

- Localized contact stresses. Pressure on the back or lower legs can affect blood flow both at the site of pressure and in the legs and feet.

- Repetition without rest breaks. Repeated bending, twisting, or lifting can outpace the body’s ability to repair itself after exertions. Herman, (1992).

2.7.1 Biodynamic of Sitting.

In the relaxed sitting position, the head is held erect, balanced over the neck, with the head's center of gravity situated slightly anterior to the atlanto occipital joint. Body weight should be supported upon the ischial tuberosities and the adjacent soft tissues. The degree of the lumbar curve during the sitting posture depends upon sacral angulation which is governed by pelvic posture and the degree of mobility/fixation of the involved segments.
Figure No.13: Sitting posture essentially depends on the ischia. Left, it is far posterior, Right, it is well balanced over the ischial prominences.

The Figure (13) shows us, when the human sit on the tips of the ischial tuberosity (arrow on the left view), the pelvis (and lumbar spine) rock backwards, flattening and extending the lumbar curve. Over time, this position...
stretches out the connective tissue that stabilizes the posterior elements of the vertebra, due to plastic deformation forces.

However, if human "poke his butt" first, before he sit down, he end up sitting on the lower faces of the ischia, rather than the tips (see the arrow on the right), and that will rock his pelvis forwards, reinforcing the lumbar curvature, while also reducing the pressure within the lumbar discs. This is a great strategy for avoiding pelvic misalignment, disc derangement, and low back pain in general (Richard Schafer, 1974).

When a person sits, all these body parts interact in a chain of mechanical events with many short-term and long-term stresses. The act of sitting begins with a slightly forward lean (to keep the body balanced) and a bending of hips and knees. The sitter may grasp armrests to help hold the torso up while it's off-balance.

The backward tilting of the pelvis while sitting pulls the lower back into a straighter shape. Most of the shape change happens in the first three or four vertebrae above the pelvis, although six or seven vertebrae in all are involved. (Andersson, et. al, 1979).

In the process, the front edges of the vertebrae squeeze closer together while the back edges spread apart, putting great pressure on the front portions of the inter vertebral discs. The straightening of the lower back moves the spine a few centimeters away from the upper body’s balance center, or center of gravity. Where the torso was once nearly balanced over this inward curve of the spine, it is now markedly front-heavy in relationship to the straightened curve of the spine. To keep the torso from slumping forward, the lower back muscles on the outside of the spine contract strongly and steadily, (Klausen, 1965).

The discs, already stressed by being pinched at their front edges, are further compressed by the muscle contractions. Fluid seeps out slowly from the discs, flattening them slightly over the course of the day. Flattened discs make
the cartilage-cushioned vertebral facets bear more weight and may also put some pressure on the nerves emerging from between the vertebrae.

The lower back muscles are not the only ones at work. Because unsupported sitting is unstable, even a body that seems to be sitting still moves continually and imperceptibly, making tiny rocking movements over their chial tuberosities. (Branton, 1966 and Branton, 1969).

At the same time, the skin and muscles under the Ischia tuberosities are compressed. The large buttock muscles, the gluteus maxims, slide aside, leaving the Ischia tuberosities resting on a cushion of fat and skin. Blood flow and the filtering of nutrients and waste products to and from the disc cores are inhibited. Even well cushioned chairs create localized pressures capable of stopping blood flow. After a period of time in one position, the muscles in the lower back become fatigued. (Sjogaard, et. al., 1984, Miller and Stein, 1975), and the sitter tends to relax them in favor of letting the ligaments help hold the torso up right. (Lundervold, 1951).

If there is no postural support to keep the lower back and torso upright, the person tends to slump down and forward, causing an outward-curving shape in the lower back, stretching ligaments and further increasing compression of the discs. Simultaneously, the head comes forward, forcing the muscles at the back of the neck to work to keep the heading its original position. (Zacharkow, 1988).

Muscle tension at the back of the neck may increase as much as 50 percent when a person changes from an upright to a slumped sitting posture. If lumbar or pelvic support is available, the lower back muscles relax with less downward and forward slumping of the torso. The back rest can keep the lower back in a lordotic shape. Further, pelvic support can fill the space that exists between the lower back and the seatback. If the backrest is reclined, the discs also get some relief, sharing with the backrest the job of holding up the torso. A more balanced alignment shifts the primary weight-bearing role of
the upper torso to the skeletal structure, and as a result, muscles are far less stressed.

Overall, the act of sitting can place many stresses on the body. The most obvious ergonomic risk factors are the compressive forces experienced by the discs and the sustained static exertions maintained by the back muscles. This may explain why people who sit all day have about as much lower back pain as people who spend most of their time in a standing position. Agora, (1972). In fact, the more we sit, the higher our risk of herniated discs and other back troubles. Eklund, (1986).

2.7.2 Postural Variation:

Bhatnager et al, (1984) pointed that the Posture changes are generally believed to be signs of discomfort and have been observed to be more frequent in uncomfortable or poorly adjusted chairs. Some researchers attribute this to weight and hard surfaces creating uncomfortable high-pressure spots on the skin. Others believe it has to do with trying to achieve stable (low-energy) postures when muscle groups become tired, or simply shifting work from one set of muscles to another. Still other explanations have to do with boredom, temperature and humidity buildup, or even daily cycles of restlessness (Jurgen, 1980). But it’s misleading to use these findings to conclude that the absence of posture change means complete and long-term comfort. Prolonged, immobile sitting has many drawbacks (Griffing, 1960). Experts in the rehabilitation field emphasize the importance of frequent weight shifts (every 15 minutes or so) for the prevention of tissue breakdown due to impaired circulation (Olszewski and Engeset, 1980). Posture change stimulates the sponge-like compression and decompression that deliver nutrients to the disc cores and prevents (Adams and Hutton, 1983), some of the temporary disc shrinkage that normally occurs over the course of a day (Helander and Quance, 1990). Disc shrinkage may cause discomfort and affect how hard it is to lift things, it
also increases the possibility of pressure on major nerves or of overloading the facet joints between adjacent vertebrae. (Jensen and Bendix, 1992).

Uninterrupted sitting gradually stretches ligaments in the back, which stay stretched for about a half hour after getting up. Although we usually think of limber ligaments as healthy, during this recovery period the spine is slightly less stable and presumably more vulnerable to overextension. Finally, prolonged sitting can increase the risk of varicose veins, thrombosis, and pulmonary embolism in some people. So, unless it's driven by discomfort, fidgeting is good. Sitters should feel free to move around. (Rasch and Burke. 1978).

2.7.2.1 Types of Work Postures

The repertoire of the accomplished fidgeted includes several common sitting postures in addition to sitting upright: forward-tilted sitting, reclined sitting, cross-legged sitting, standing, and stable but unsupported postures. None of these postures are “correct”—each has its own advantages and disadvantages—but, in moderation, none is particularly harmful. The best way to sit is to change position frequently (Miller, 1992).

2.7.2.2 Forward-inclined Sitting

Miller (1992) pointed that some people like to sit on the front edge of their chairs or in forward-sloping seats, with their knees dropped a few inches. This has the positive effect of rotating the pelvis toward a more upright position, restoring some lordships to the lower back.

The tradeoff for this posture can be fatigue and pressure. If too much weight (more than about a third of body weight) is transferred to the feet, leg discomfort becomes pronounced. (Eklund, 1990). Sitting on the front edge of a seat can cause strong pressures under the thighs because so much of the body's weight is concentrated on the front rim of the seat. Chairs with forward-inclined seats can eliminate some of these drawbacks. Seating with a lower
pelvic support provides another alternative, allowing the sitter to comfortably sit back in the chair (Miller, 1992).

2.7.2.3 Reclined Sitting.

Reclining the back opens the angle between the trunk and thigh and aids circulation and the digestive process. By transferring upper body weight to a chair, the lower spine has less weight to support. This can be a significant effect, reducing forces on the lower back by as much as 20 percent.(Andersson,1974).

2.7.2.4 Crossing the Legs.

Crossing the knees or legs is a frequently observed posture that at first appears dysfunctional since it dramatically and uncomfortably increases pressure under one of the buttocks. Indeed, crossed-legged postures usually aren’t held for very long.(Dillon,1981) It’s believed that crossing the legs occurs in part to relieve pressure on one side of the buttocks. However, shifting from one buttock to the other provides temporary relief but accelerates rather than delays buttock fatigue (Dempsey, 1962). Crossing the legs may stabilize the body. Increased pressure under the buttocks increases friction and is advantageous when the sitter is sliding forward in a slippery seat or one with an inclined backrest (which also makes the buttocks tend to slide forward). Crossing the legs also keeps the knees together with minimal effort.

2.7.3 Dynamics of Sitting.

Sitting height should allow the hips, knees, and ankle joints to form an approximate right angle. The seat should deepen slightly to conform to the increasing thickness of the thigh as it meets the buttocks. The seat of the chair should be wide enough so that body weight can be distributed over a wide area and long enough to support the buttocks and lengths of the femurs. Bucket-type seats have a tendency to closely confine the body and restrict restless movements necessary to improve circulation.
Sofa most comfortable if it is inclined slightly backward and has arm rests at elbow height. The backrest of the chair should provide support at the hips, lumbar curve, and shoulders. The upper aspect of the lumbar curve should be supported by a slight convex curve in the back of the chair.

These factors contribute to relaxation of trunk muscles. However, the hollows and curves that make a desk chair comfortable are not desired in an adjustable chair because the hollows and curves no longer fit the body when the chair is tilted backward. If a head rest is provided, it should incline slightly forward so that the head and neck are supported in an upright position. If a leg rest is provided, it should be placed at nearly the height of the seat with a slight tilt forward to enhance venous blood and lymph drainage of the lower extremities (Richard Schafer, 1974).

Without proper design, sitting will require greater muscular force and control to maintain stability and equilibrium. This, in turn, results in greater fatigue and discomfort and is likely to lead to poor postural habits as well as neck or back complaints. (Chaffin, Anderson, 1991).

A sitting person usually moves his buttocks forward on the chair seat. In addition, the feet do not have proper contact with the floor surface (heels are off the floor) and body stability is weakened. On the other hand, if the seat surface is too low, the knee flexion angle becomes small, the user's weight is transferred to a small area, and there is a lack of pressure distribution over the posterior thighs (Zacharkow, 1988). When the seat is too deep, the front edge of the seat will press into the area just behind the knees, cutting off circulation to the legs and feet. To alleviate the discomfort, the person in the seat will slide forward but will lose proper lumbar and backrest support (Panero and Zeinik, 1979).

Too shallow a seat depth may cause the user to have the sensation of falling off the front of the chair as well as result in a lack of support of the lower thighs. A free area between the back of the lower limb and the seat pan is
useful to facilitate the suggested 80° flexion of the knees for rising out of the chair and for leg movements (Diffrient, et.al. 1974).

2.8 Understanding Concepts about Designing Interior Space.

When we design objects or interior space with objects within them, we create various experiences. Developing designs includes particular thinking and is a rational process that has at its heart both intuition and intention (Nelson & Stolterman; Mitchell, 1993). We live and experience how to design as a designer, and as a designer we must also understand the user’s lived experience. These experiences may be personal, social, real or imagined (Chris Jones in Mitchell, 1993; Nelson & Stolterman, 2003).

The design process applied to interior space problems, or designing interior space is about critical thinking and inquiry integrated within the pragmatic design elements (Friedman, 1997). However designing interior space also requires understanding what happens when the spatial experiences people have are grounded in real, lived experiences that are social and intangible, and that happen simultaneously with changing physical spatial conditions, such as lighting changing dynamically or time-space collapsing when we work at home or live at work through travel globally. These contemporary ways of living and working are both ‘lived’ experiences as phenomenological (White, 1998) and dynamic in that the physical space is a backdrop of changing activities that are not static (Ainley, 1998).

Spaces are designed after investigating multiple contexts including user needs, building contexts and user space requirements, researching and choosing appropriate materials, color and lighting, furnishings and materials and then combining it all aesthetically to create the interior space. Interior designers take a virtual idea and making it a living and active space.
2.8.1 Theories about space and the aesthetic nature of designed interior space

The meaning of aesthetics was separated into isolated categories at least from ancient Greece in philosophy. Greek aesthetics can be understood by elaborating Plato’s and Aristotle’s views about beauty; the former is romantic and the latter is intellectual (Warry, 1962). An aesthetic judgment test that established a "standard" in art production and ran the risk of diminishing creativity was the fear of critics of the consensus of opinion method of determining judgment standards. There seemed to be few acceptable alternatives to this methodology which was to be utilized once again in the current investigation (Gottschalk, 1971).

In beauty, Neo-Platonism theories place emphasis on its appearance, while Aristotelian theories focus on its harmony (Iannone, 2001). In Platonic doctrines, the “form” or “idea” is the essential concept (Saatkamp and Holzberger, 1988).

Forms mean eternal, imperceptible, and spiritual entities (Iannone, 2001). Plato’s metaphysical and intuitional point of view about “form” is applicable to beauty as well. Beauty is an immutable and timeless form (Saatkamp and Holzberger, 1988). Plato believed that beauty was associated with aesthetic forms which are innate in humans (Saatkamp and Holzberger, 1988). For instance, Plato said that form of a tree literally is a memory of the tree that we have already seen in heaven (Saatkamp and Holzberger, 1988). In other words, aesthetic forms are hidden structures of beauty.

In conclusion, it seems that aesthetics feeling is provoked in human by existed orders in an object as well as by associating a pleasant form (which can be innate or shaped through cultural practices) in the subject. Order, as Aristotle believed, is the aspect of aesthetics which is related to nature (Warry, 1962), and form is the aspect of aesthetics which is related to nurture. The former one is related to the properties of an object (here, the
appearances of designs), and the latter one is linked to the interpretation of a subject (here, the pleasant cultural symbols).

Interior space has long been documented theoretically in terms of ‘space’ as a physical entity grounded in attributes such as objects, walls and finishes, and other design elements such as lighting, form or color (Malnar & Vodvarka, 1992) This means that too often interior design and its processes are reduced to concepts of decoration, purely visual attributes, or static places where one designs an living room as living room, or selects finishes for static walls or plans layouts for work or play but not necessarily both.

In fact the opposite is true currently in professional practice, where in real life situations, interior spaces are complex places where designers work with environmental systems, volumes and dynamic changes in space and its activities and do so in a real time exchange with clients, users and other stakeholders (Vaikla-Poldma, 2003).

Documenting and understanding points of view, subjective responses and affective aspects of experiences in interior space are essential for good and thorough problem-situating and solving. Understanding these processes means developing knowledge through design research and theory, by looking at how design practices might improve on solving problems for better living. However Professional interior designers have tended to reject these inquiry modes, being more concerned with pragmatic aspects of building professional practices, ethical conduct and dealing with problem solving situations of a more pragmatic nature (Abercrombie, 1990; Malnar & Vodvarka, 1992; Hildebrandt, 2000).

There are some principles such as Unity, Balance, Variety, and Proportion that have been developed in the field of Fine Art under the name of “principle of design” or “principle of organization”. Principles of design (in Fine Art) are the result of some long-term empirical experiment and intuition, and they have been found effective in different places and times of humankind (Feldman, 1971). [Grieder, 1990] pointed that
the principles of rationalism in aesthetics were systematically presented by Aristotle. In the contemporary era, however, these rules have been developed in the field of Fine Art in the name of “principle of design” or “principle of organization”.

The followers of this school of thought believe that design grows from our basic need for meaningful order [Preble and Preble, 1994]. In other words, the way that we fulfill our need for order in our thinking is called design [Grieder, 1990]. Different principles have been defined by various authorities. For instance, Preble and Preble [1994] mentioned following seven key terms to represent aesthetics principles of design:

1) Unity and variety.
2) Balance (optical symmetry).
3) Emphasis and subordination.
4) Directional forces.
5) Contrast.
6) Repetition and rhythm.
7) Scale and proportion.

Grieder [1990] mentioned the following six items as major principles of design:

1. Unity.
2. Variety.
4. Rhythm.
5. Emphasis.
6. Proportion.

The principles that have been mentioned by almost all artists are:

1. Unity.
2. Balance.
3. Variety.
4. Proportion.
There is unity in a design, when it is understandable as a coherent unit and when the audience can distinguish it from the unrelated environment. Balance means that parts of the work should be felt in equilibrium to the viewer’s eye. We will enjoy things that are balanced and will not look long at things that are unstable. Variety means that design should have enough variability to maintain the viewer’s attention. Proportion means that the parts must be related according to a plan which the designer has intended (Grieder, 1990). Needless to say, that to successfully achieve a quality interior design, principles are important (Henton, 1968).

### 2.9 Interior design Aesthetics Principle and Design.

#### 2.9.1 Elements of interior design:

There are 6 basic elements used in all aspects of interior design and decorating. If you correctly incorporate all or most of these elements you will have created a beautiful and functional room.

1. Balance - "Balance is that quality in a room that gives a sense of equilibrium and repose (Allen, 1973)." There were several authors who suggested that balance was an interplay of weights in a room as perceived through the eye. Balance was evident, not only, within groups, but also, in the relationship between groupings and the architectural features of the space. The distribution of parts within the space was relatively even (Alexander, 1972, Faulkner and Faulkner, 1975).

2. Proportion - Proportion encompassed a pleasing relationship between the parts. This relationship included the proportion between individual pieces, as well as, the proportion between the pieces as a unit in relation to the whole interior space (Allen, 1973, Alexander, 1972, Faulkner and Faulkner, 1975, Sloan, 1967). The scale of individual pieces or groups of pieces within
an interior referred to the largeness or smallness of the piece in the particular interior space.

3. Harmony - The need for a unifying theme, a single motivating idea, which blended the elements of the component parts in an interior space explained harmony (Faulkner and Faulkner, 1975). Contrast without excess was the underlying principle of harmony or unity. A unified effect was also achieved by grouping related spaces (Allen, 1973, Alexander, 1972, Faulkner and Faulkner, 1975).

4. Emphasis - One element of design given dominance was Alexander's explanation of emphasis (Alexander, 1972). The center of interest in a room was created through use of color or value contrasts, directional lines, arrangement of objects or concentration of detail. Having given visual dominance to certain parts of a design while having subordinated others, an interesting diversion was achieved in an interior (Alexander, 1972, Faulkner and Faulkner, 1975).

5. Rhythm - The disciplined movement produced by regular recurrence of design elements was the definition for rhythm (Alexander, 1972). A flowing quality was implied that helped the eye to recognize the order of the spatial relationships. The simplest way to achieve rhythm was through some repetition of color, pattern, etc. causing the eye to move in a certain direction, was achieved by the use of a variety of lines and shapes (Alexander, 1972, Faulkner and Faulkner, 182). "Unity and Harmony are consequences of rhythmic repetition and progression (Faulkner and Faulkner, 1975)." As was mentioned earlier in this chapter, another factor must not be overlooked when judging quality interior spatial relationships. There was an agreement among various authors that the planning of rooms
was according to the particular function of the area. Rutt stated: Functional considerations are even more important than aesthetic considerations when furniture is being arranged. The first requisite for all rooms is comfort, but additional needs must also be met; for example, living-room arrangements must not handicap sociability (Henton, 1968).

6. Color The human eye can see more than 16 million colors. To simplify your paint choices look at your favorite piece of art, a rug or the upholstery fabric. Choose your colors based on that item using the “60-30-10 rule”. For example – your favorite painting contains blue, yellow and cream. You might then choose yellow walls (60%), a blue sofa (30%) and a cream accent cushion (10%).

The approach in this research was rationalistic. In this research, the principle of harmony, proportion and balance was incorporated to evaluate the aesthetic aspects of living room interior design, while two important aspects of balance, harmony, proportion of furniture design, space with furniture arrangements and living room area, were concentrated on.

2.9.2 Aesthetics aspect in design

A design should evolve from a simultaneous consideration of functional activities to which a room will be put and personal and aesthetic requirements (Shalini, 1994). In the ancient world, usefulness and beauty were one and alike. Engineering and aesthetic qualities were separated during and after the industrial revolution, when mass production was governed on aesthetic concerns (Lavie and Tractinsky, 2004 Petroski cited in Lavie and Tractinsky 2004) argued that in the early of 20th century, Loewy and Dreyfuss, two pioneers in industrial design, introduced aesthetic concerns of design, partly because of its capacity for the promotion of marketing.

Currently, Aesthetic aspects are becoming more and more important for consideration in the engineering design process [Lavie and Tractinsky, 2004;
Lin and Zhang, 2006; Liu, 2003; Yoshimura and Yangi, 2001 however, very few attempts have been involved with critical analysis of aesthetics in design.

Traditional studies about engineering design and human factors have mostly concentrated on ergonomic aspects of design and have paid less attention to the aesthetic aspects of design (Jordan, 1998; Liu, 2003). Although considering both functional and ergonomic features of a product are important in design, the users’ interests in and attraction to the product is another determinant for the success of a product. At this point, the “beauty aspect” of a product plays an important role. From the consumer’s viewpoint, the beauty value can make engineering products more readily satisfactory and can develop their commercial worthiness (Lavie, 2004).

2.10 Active Workspaces in the living room

Wendy, (2001) pointed that the Active Workspaces are places where people work with tangible tools and corporeal materials to produce end products. These spaces, tools and materials may be augmented with displays and speakers to inform and guide people’s work, actuators to help detect people’s actions and changes in the environment. Thus, the design of these Active Workspaces requires feats of engineering, yes, but also sound understandings of human needs and work processes, and a willingness to think of current technologies in new ways meet those needs. The real wizardry lies in integrating technologies, relevant information, applicable entertainment and people’s practices into a coherent design that adapts to people and responds to changes in the environment. This thesis argues for the creation of the next generation of such workspaces, which are made possible by the advent of dynamic new technologies. A study by Meesters, (2009) has demonstrated that the part of the house where the most activities are performed is the living room. Eight different activities, mentioned a total of 900 times, the living room is a multi-functional space (see Table No.2).

Living room and private outdoor space contain the largest number of different activities. However, the frequencies of the activities in the living room are considerably higher than those in the private outdoor space.
The living room can be regarded as a locus of activity in the dwelling. (Figure No.14) shows the main relations between activities and rooms in the dwelling. The activities that are connected to one room only are called isolates.

It affords leisure activities like relaxing and hobby. Especially relaxing, mainly consisting of watching TV and reading, is an important activity; almost 40 per cent of all activities mentioned for the living room fall under this category. The
living room is also where social activities take place: entertaining guests and being together with the nuclear family make up almost 20 per cent of all activities in the living room. For families with children, the living room is also a space where children can play. Quite a few people use their computer in the living room.

A small proportion also uses the living room to work at home. However, most people who work at home confine this to a study there is to some extent an overlap between the activities being at the computer and work at home. The activity relaxing makes up almost 40 per cent of all activities mentioned for the living room, it having a high frequency. The activity relaxing (e.g. watching TV or reading a book) is connected to many different meanings.

Meesters, (2009) has observed the living room is a place to relax and come to rest (represented by the value type hedonism). Besides that, people feel that watching TV or reading a book can make them forget about their daily work and let them learn new things through the meaning relaxation; the activity hobby is indirectly related to the same meanings as the activity relaxing. So we can say that the activities relaxing and hobby have similar meanings, represented by the value type’s hedonism, self-direction and stimulation.

We could even say that relaxing and performing a hobby are substitutes for one another; they fulfil similar needs. The activities entertaining guests and being together with the nuclear family lie close to one another in the network. Both activities have very similar meanings. Spending time together with family or friends affords social interaction and enjoying the good atmosphere. The activities eating, being together with the family and entertaining guests are all related. One might argue that eating is a social activity.

The meaning network shows that dinner time is the time of the day that people spend time together with family or friends. The activity being at the computer seems to have two dimensions. First, using the computer provides people with the possibility to work at home and provides them with access to information, represented by the value type self-direction. Second, by using the
computer people can stay in touch with friends and family, represented by the value type benevolence.

However the activity children playing; only through the meaning pleasure is it connected to the rest. The living room is a safe place for children to play and a place where they can learn (value type’s security and self-direction). These meanings are specific to the activity children playing. One can expect that only for families with young children will this branch exist of activities in the living room. Table 5.10 summaries the key features of the meaning structure for activities in the living room.

The connected to each other through the activities eating and being at the computer have an intermediate out-degree, they occupy an important position. These activities have meanings that represent both individual and collective interests. In other words, eating and being at the computer join two dimensions; the living room as a place to be on your own and the living room as a place to be together with others.

It is striking that the separate activities are connected to the active sharing of the main living room by family members emerges in the cases where room numbers are limited. In this case, the main living room can simultaneously be the sitting room or TV room of the house (Yildirim and Baskaya, 2006).

2.11 Living room space and furniture arrangements.
2.11.1 Living room space.

The various activities and elements of furniture usually associated with living spaces result in many levels of interface between the human body and the physical components of the space. Panero and Zeinik (1979) wrote in their book, “Human Dimension and Interior Space” about the relationship between the user and the chair or sofa. In this regard seat height must take into consideration popliteal height, while seat depth must be responsive to buttock-popliteal length.

Circulation around seating elements must accommodate maximum body breadth, while the location of a coffee table in relation to a chair should be responsive to human reach dimensions.
The height at which a painting is hung on a wall should be determined in relationship to eye height. The possibilities are almost endless and the drawings shown in figure no (15) explore only a few of the many design situations that require knowledge of human dimensions. The matrix above indicates some of the anthropometric measurements to take into consideration to ensure the proper levels of interface.

The variety of human activity that occurs within residential spaces, whether they are studio apartments, two-and three-bedroom cooperatives, or
CHAPTER TWO

suburban houses, is formidable. It is within this single environment that people sleep, dine, relax, meditate, entertain and are entertained, make love, do housework, read, cook, bathe, are conceived, and in some cases are born or die. It is also within these spaces that people spend at least half of their waking hours and are during the course of their lifetime.

The impressive number and diversity of functions that must take place within this single environment, the extended period of time that people spend within it, and their vulnerability to fatigue and accidents give the quality of their interface with that environment added significance.

Another factor that makes the quality of interface even more critical is the decrease in the size of residential spaces available on today’s market due to the increasing costs of both construction and land.

As a consequence of these external economic factors, it becomes necessary in many cases to maximize the utilization of existing spaces to the greatest degree possible. In some instances this involves innovative ways of perceiving both the problem and the design solution. For example, it may be necessary to explore the use of overhead space, to have a single portion of the space perform several functions, or to creatively recycle space for function.

The text and illustrations followed deal with human dimension and residential space in terms of the major functions that must be accommodated. Figure No. 17 and 18 here examine the relationship of female and male body dimensions to sofa seating, in order to determine how much space the seated body requires. The anthropometric measurements of major interest here are maximum body breadth and buttock-popliteal length.
Figure No. 16: Sofa seating Males

Figure No. 17: Sofa seating Female

Figure No. (16) Deals with male dimensions; based on 95th percentile data, the maximum body breadth dimension is 22.8 in, or 57.9 cm, with a nude subject.
Allowing for clothing and some body movement as well as change in posture and position, a minimum dimension of 28 in, or 71.1 cm, is suggested as a width allowance for a seated person. The overall dimension, therefore, includes the individual width allowances and the width of a sofa arm construction, which obviously can vary depending on personal design preferences.

A range of 3 to 6 in, or 7.6 to 15.2 cm, is suggested. Using the buttock popliteal length of the smaller person and adding a similar allowance of 6 to 9 in, or 15.2 to 22.9 cm, for backrest construction as well as a minimum zone in front of the sofa for foot movement, an overall depth dimension of 42 to 48 in, or 106.7 to 121.9 cm, is suggested.

The rationale for the dealing with female data is the same. The information should prove not only useful in providing a keener insight into the general relationship between body size and furniture but of specific value in establishing preliminary design assumptions for institutional seating in spaces designed exclusively for the use of males. In spaces where seating is to be used by both sexes, the larger dimensions should apply (Figure No. 17).

Figure No.18: Corner lounge chair seating male and female
Figure No. 19: Corner lounge seating with circulation

*Figure No.* (18) Examines the relationship of the female and male body dimensions to arm chair seating in order to determine the amount of space the seated body requires. The rationale is similar to that in dealing with sofa seating, outlined on the preceding page.

There is not intended to suggest a specific, layout for a conversational grouping, and therefore should not be taken literally. Nor is it suggested that special female and male seating be provided in the same living space. The *Figure No.* (19) Is essentially informative and its purpose is to suggest allowances for comfortable circulation relative to corner lounge seating situations. The anthropometrically key consideration is maximum body breadth data.
Since clearance involves the data related to the larger person rather than the smaller, center deal with the major clearances involves in lounge or conversational seating. The figure no. (22) Is based on a conversational grouping in which the clearance between the front of the seat and the edge of the table is limited between 16 and 18 in, or 40.6 and 45.7 cm. This clearance may require some degree of body contact or sidestepping for circulation and access. Anthropometrically, however, it does accommodate human reach, permitting the seated person access to the coffee table without rising.

The Figure No (21) also suggests a dimensional range for verbal conversation. The Figure No (22) illustrates a similar furniture arrangement.
that would permit circulation with full head on access. The clearance indicated, however, to permit such access would make it impossible for most people to reach the coffee table from a seated position. This could be extremely undesirable in terms of food, beverages, and cigarettes. Given the choice between full head-on-access and the accommodation of reach the authors opt for reach and recommend the smaller clearance.

The Figure No (22) suggests overall allowances for easy chair or reclining chair seating, including footrest. The buttock-leg length of the larger person is the most significant anthropometric measurement in establishing this clearance. It should also be noted that the height of the footrest is also a function of seat height. The footrest should be a few inches below the height of the seat.

The figure (23) illustrates the relationship of human dimension and accessibility to low and high storage or furniture usually associated with living spaces. The configuration of the furniture is not intended as a realistic...
illustration of any specific element, of furniture, but rather as a general representation of furniture types normally found in a living space. In situations where the user is not a known entity, either in terms of sex or body size, the body size data of the smaller person should govern.

In the event the user is known, dimensions more appropriate to that body size should be noted that for each sex two dimensions are shown on the drawing. In each case the lower figure is based on 5th percentile body size data and the larger on 95th percentile data.

2.11.2 Living room furniture arrangements.

Clive, (2001) pointed that the Furniture and Furnishings Apart from the interior space arrangements, the next major issue for interior designers is often the selection and placement of furniture and furnishing. In most interiors, furniture is a key lament in making the scheme and therefore has some significance in the planning process. In addition to the functional aspects; Furniture and furnishings often have important social and emotional purposes.

It is becoming increasingly apparent that clients assume functionality and reliability to be a ‘given’. Therefore successful design will meet other higher-level needs. The formula devised by the Frog design team ‘Form Follows Emotion’, recognizes that; Product design should always include something extra; no matter how elegant and functional a design, it will not win a place in our lives unless it can appeal at a deeper level, to our emotions... The emotional element can be present in any number of ways; it may appeal to our desire for enhanced nostalgia.

A study by Yildirim and Hidayetoglu,(2008) have demonstrated that even with different types of furniture and decoration, today, the living room is still the most important and cared-for space of a house, frequently also representing the socio-economic status of the family. Chiara, et. al., (1992), pointed out in the book titled,” Time-Saver Standards for Interior Design and Space Planning “ various size of living rooms and the furniture arrangements. He further expressed that the room within such spaces vary dramatically
CHAPTER TWO

depending on the size of the dwelling, the economic status and lifestyle of the user, and the relationship of the room to other areas of the dwelling. With regard to the luxury end of the scale, there are few limitations and no attempt has been made to identify the endless planning options possible. There are, however minimum requirements and basic planning considerations that are applicable whatever the size of the space.

2.11.2.1 Planning Considerations

Planning considerations should include adequate floor and wall space for furniture groupings, separations of traffic ways from centers of activity and case of access to furniture and windows. Circulation within the living room should be as direct as possible and yet not interfere with furniture placement; ideally, there should be no through traffic. If such traffic is necessary, it should be at one end, with the remaining portion of the room a “dead-end” space. During social activities, people tend to gather or congregate in relatively small groups. Desirable conversation distance is also relatively small, approximately 10 ft in diameter. When the living room is combined with the dining area, the dining area should be offset into an alcove or be clearly identified as an entity in itself.

2.11.2.2 Furniture Clearances

Figure No (24) show various groupings and related clearances. It shows that a space 12’6”x15’6” should be provided in order to accommodate seating for live around a 56-in-diameter cocktail table. The plan, sofa and cocktail table arrangement shown in Fig.6 requires a space at least 11’0” x 16’0”. It suggests that a space at least 12’9” x13’3” is required to accommodate a grouping to seat 6 or 7 persons, while it indicates that a corner arrangement for two requires a space at least 6’6” x 6’6”. When planning furniture arrangements, allowances for clearances should take into account the human dimension as well, as illustrated figure No (24) .It should be noted that these diagrams are not intended as models for complete living room layouts. They are intended only as guidelines to illustrate minimum clearances for preliminary planning purposes.

97
2.12 Conclusion on reviewed literature:

The functionality of furniture is based on its comfort, safety and usefulness. And this is relevant to the anthropometric characteristics of the user and the suitability of materials used in furniture design. Mandal (1982) noted the importance of furniture specifically designed for a human body proportions and recommended different sitting postures for different activities (Harper, et al., 2002). Living room furniture from manufacturers is typically not designed to accommodate the dimensions of the individual user. Including many developed countries as well, this problem is quite widespread in many places.
of the world. Instead, a one-size-fits-all philosophy has been adopted in the industry, because such furniture is less costly to manufacture and easier to sell at a lower price, and lessens inventory problems for manufacturers and in residences.

On the other hand, it is known that though manufacturing and inventory expenses are significant topics, there are besides expenses involved in products that do not reveal designs ground on appropriately selected anthropometric data and ergonomics. At the same time, not surprisingly, observations and measurements of body alignments indicate that furniture designed to accommodate the task and the individual's size is more acceptable to users than standardized styles.

It is observed that a beginning was done for fitting more of ergonomic necessities on design and products, done recently. This trend is improving by getting faster especially in European and Asian (Mandal, 1982). As for Yemen, it is known that, there are serious problems in this respect. This situation resulted from both lack of anthropometric data and living room design and furniture product problems. On the other hand, especially it is known that there are a lot of ergonomic problems in the residential building in Hodaidah city, Yemen and this could increase effectiveness and health problems. (Ozok, 1981; Kayis, 1986; Karakas, et al., 2004).

Therefore, the aim of the study was to meet the urgent need for anthropometric data from Hodaidah city population and to examine possible mismatch between the individual body dimensions of Hodaidah city population and the living room space and furniture they use.

In this study, designing an ergonomic space area is a challenging and complex task that must meet multiple requirements, and consider the interior design to harmonize human and living room space.

Within a living room space where vibration is generally present, the human dimension is required to accommodate human groups of individuals by firmly
supporting and physically fitting their preferred postures as well as allowing freedom to change postures.

Hence, to develop a more effective living room interior design, it seems necessary to investigate ergonomic and interior design-relationships between living room users' perceptions, behaviors, and relevant objective measures, and to integrate them into the redesign living room space area and furniture design.