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I am submitting herewith a dissertation written by Ann Vanderpoorten entitled "Use of Clothing and Perception of Thermal Comfort in the Home Environment." I have examined the final copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Home Economics.

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USE OF CLOTHING AND PERCEPTIONS OF THERMAL COMFORT IN THE HOME ENVIRONMENT

A Dissertation

Presented for the

Doctor of Philosophy

Degree

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Ann Vanderpoorten

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ABSTRACT

The study was designed to explore possible relationships among selected factors that may affect the perception of thermal comfort in the home environment. The use of clothing in maintaining thermal comfort was of primary interest. The conceptual framework for the study suggests that three broad categories of factors may affect an individual's perception of thermal comfort. These factors are environmental, psychological, and physiological.

A field survey exploring selected factors from each of these three categories was conducted through interviews and observations in homes. Two groups of 25 adults for a total of 50 participants living in 26 households were interviewed. An interview schedule and an instrument for recording observations were developed. In addition to factors established by other investigators as having an affect on the perception of thermal comfort, a number of exploratory items were included in the instruments.

A preliminary analysis of the two groups of participants was made to determine similarities and differences. The results of the statistical comparisons indicated that the data could be pooled reasonably for further analysis.

Because the primary objective of the study was to explore relationships, the data were analyzed by groups of variables. Two-way frequency tables were generated for gross comparisons. The chi-square test for probability of relationship and discriminant function analysis were applied to each grouping of variables.

Although the small size of the group studied and its restricted geographical location limit the applicability of the findings to other populations and locales, two broad conclusions were reached. The first was that many factors other than those which traditionally have been studied affect the perception of thermal comfort in the home environment. The second is that attitudes may affect both actions and perceptions related to thermal comfort.

Several statistically significant relationships were found between individual variables, such as the room temperature and the perception of thermal comfort, but only one group of variables appears to be useful as an indicator group. The physical characteristics of the occupants of a household can be used to predict the thermal conditions that will be maintained within the home.

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INTRODUCTION

Statement of the Problem

Historically, man has used clothing and draperies to achieve desired comfort in an enclosed space (Ryan, 1966). However, a typical person today is not usually aware of the difference textile products can make, if used efficiently, in reducing the use of energy while retaining the desired comfort level. This lack of knowledge can perhaps be partially attributed to the availability of cheap energy in the past few decades, the increased use of central heating, and trends toward the use of fewer textile products, especially drapes, in home interiors. However, lately the fossil fuels, particularly gas and oil, have shown signs of depletion. This in combination with political and environmental factors has caused the cost of energy to rise at an unprecedented rate.

Decreasing supplies and increasing costs have resulted in an intensified interest in more efficient energy use. Energy conservation through changes in the indoor climate to lower winter and higher summer temperatures, that may or may not be comfortable, is currently being urged by the federal goverment and numerous conservation organizations, as well as by utility companies themselves.

Approximately one-half of all the energy used in the United States is consumed by families (Paolucci, 1976). Of this amount about 40% of residential energy is used for space heating (Hogan, 1978). For this reason energy conservation effort is being aimed at reducing the amount of fuel used for space heating and cooling. The cooperation of many individuals and famil ites in this country will be needed if voluntary conservation programs are to have an appreciable impact on energy conservation.

People often have misconceptions about the relative savings possible when home temperatures are lowered in the winter. Generally, a reduction of one degree (Fahrenheit) in heating results in a savings of approximately 3%. Increasing the thermostat setting for cooling results in a savings of approximately 5% for each degree (Energy Conservation in the Home, 1977). However, because of increases in rates for fuels monthly bills may remain the same even when temperature settings are changed. In a previous study conducted by the present investigator (Vanderpoorten, unpublished study, 1977) some participants regarded the cost of additional clothing as more than offsetting the savings resulting from lowering the thermostat in winter. The expected wear-life of the clothing was not being considered by these people in their calculations of savings achieved.

The willingness of families to raise or lower home temperatures to conserve energy will depend in part on the adequacy of the information they receive about the true savings involved and in part of the ability of family members to maintain thermal comfort in altered environmental conditions. One of the difficulties of providing accurate and useful information to families about how to maintain thermal comfort is that the concept of thermal comfort is complex and little is understood about some of the subjective factors which affect feelings of comfort.

There are numerous studies reported in the literature that pertain to the thermal comfort of clothing; however, the majority of these studies have been concerned with extreme conditions of heat and cold or they have been carried out in a laboratory situation that has little resemblence to the environmental conditions and activity levels found within the home. Often these studies have attempted to isolate one or two of the variables that affect thermal comfort without consideration for the possible interactions that may occur with other, untested variables. This has led researchers to differ in their interpretation of the significance of various factors affecting thermal comfort (Bogaty, Hollies, Hintermaier, & Harris, 1953; Goldman, 1977; Hollies, 1976; Peplar, 1972). In addition, a review of the research indicates that there is little correlation between some of the laboratory assessments of fabrics and wear trials as they relate to thermal comfort (Andreen, Gibson, & Wetmore, 1953; Rohles, Hayter, & Berglund, 1977).

More recent studies (Fanger & Langkilde, 1975; Hollies, Custer, Morin, & Howard, 1979; McIntyre, 1975; Rohles, 1974; Rohles & Wells, 1977), particularly those conducted by members of the Amercian Society of Heating, Refrigerating and Air Conditioning Engineers, have considered the subjective responses of participants to various thermal conditions. The physical characteristics of people in relation to thermal comfort have also been investigated to some extent. These studies have been confined primarily to laboratory settings, however. Very recently the effects of color and texture in the environment, size of the room, and psychological factors have been suggested as having an effect on perception of thermal comfort.

More information is needed about the relative importance of the various factors affecting thermal comfort. Field studies that complement laboratory studies are needed in order to investigate simultaneously the multiple factors affecting the individual's perception of thermal comfort.

Purpose of the Study

The primary purpose of the study was to explore possible relationships among selected factors that may affect the perception of thermal comfort. The conceptual framework for the study states that three broad categories of factors affect an individual's perception of comfort (Figure 1). These categories are the near environment, physiological characteristics, and psychological factors. Certain factors in the environment have a pyschological impact on the individual, causing these two categories to overlap. Examples of factors are given for each category. The list of examples is neither complete nor is it exhaustive. In addition, the factors listed will have different levels of impact on the perception of thermal comfort and the impact will vary in different situations and at different times.

The following objectives were identified for the study: (1) to develop a tool for collecting information about the multiplicity of factors that affect perceptions of thermal comfort in the home environment, (2) to empirically evaluate the effects of selected factors on perceptions of thermal comfort, and (3) to develop guidelines for improving thermal comfort in cool indoor temperatures through clothing selection.

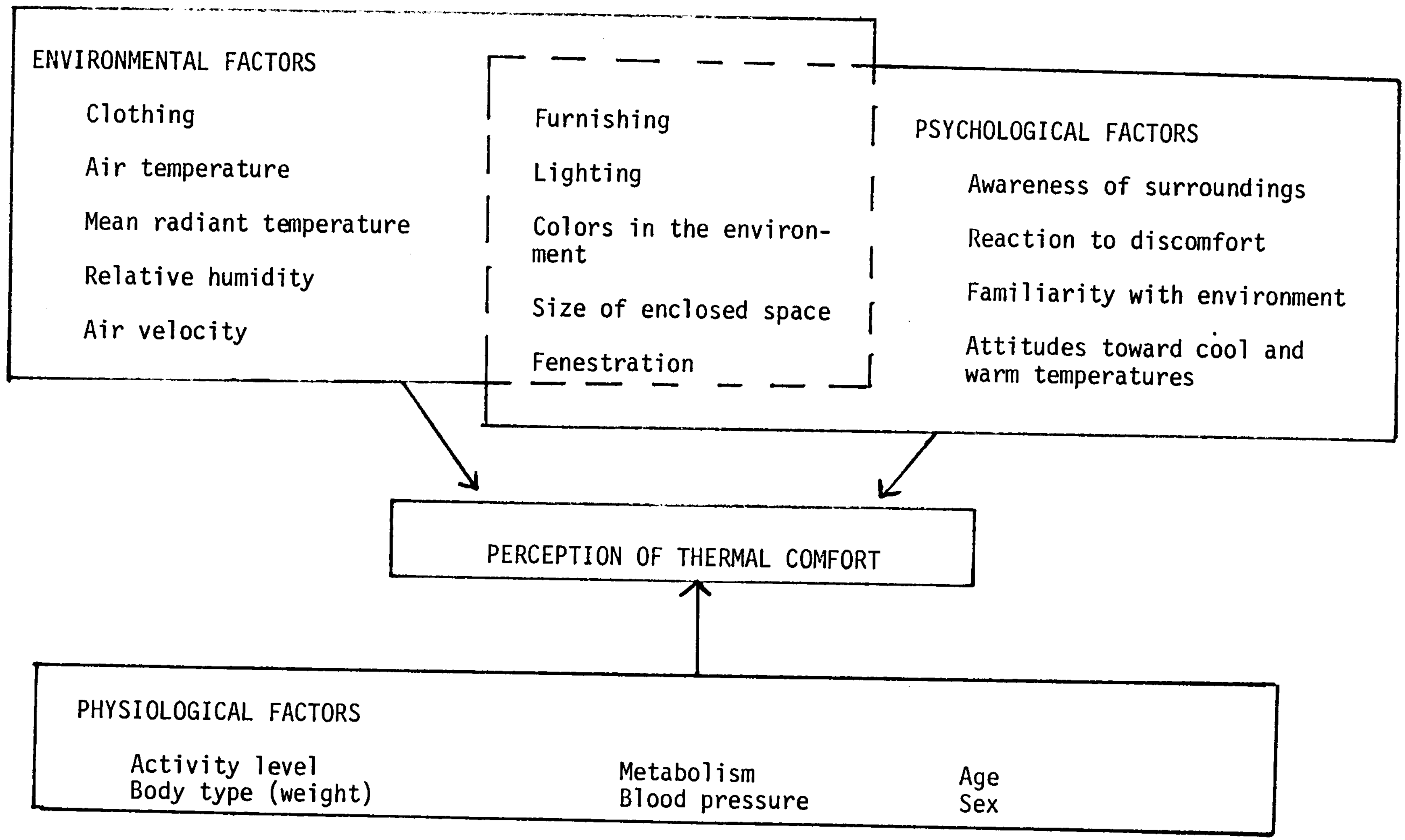

FIGURE 1. Categories of Factors Affecting the Perception of Thermal Comfort

Hypotheses

The hypotheses listed below were formulated to test the study. Because of the exploratory nature of the study a set of questions was developed from each hypotheses for use in analyzing and interpreting the data. An attempt was made to answer each question before testing the hypotheses as entities. This procedure was used because of the complexity of the hypotheses.

Hypothesis I. Perceptions of thermal comfort in the home are independent from personal physical characterisitcs, normal activity levels, the insulation value of ordinarily worn clothing, and selected environmental conditions within the home.

1. Is the perception of thermal comfort independent of physical characteristics of the person?

2. Is the perception of thermal comfort independent of the normal activity levels in the home?

3. Is perception of thermal comfort independent of selected environmental conditions within the home?

4. Is perception of thermal comfort independent of the estimated insulation value of ordinarily worn clothing?

Hypothesis II. The insulation provided by the choice of clothing worn in homes is independent from existing thermal conditions, personal physical characteristics, ordinary activity levels, and perceptions of thermal comfort held by family members.

1. Is the insulation value of clothing ordinarily worn independent of the physical characteristics of the wearer?

2. Is the insulation value of clothing ordinarily worn independent of selected thermal comfort conditions within the home?

3. Is the insulation value of clothing ordinarily worn independent of ordinary activity levels within the home?

4. Is the insulation value of clothing ordinarily worn independent of the perception of thermal comfort?

Hypothesis III. Thermal comfort conditions existing in homes are independent from personal physical characteristics and the perceptions of thermal comfort held by family members.

1. Are selected thermal comfort conditions in the home independent of the physical characteristics of the occupants?

2. Are selected thermal comfort conditions in the home independent of the perceptions of thermal comfort held by the occupants?

Definitions and Abbreviations of Terms

Specific terms used throughout the study are defined below.

1. Thermal comfort. The American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) definition given in Standard 55-66 is used: "that condition of mind which expresses satisfaction with the thermal environment" (Fanger, 1972, p. 13).

2. Dry bulb temperature (dbt). Also described as air temperature; the measurement of warmth or coolness by means of an ordinary mercury thermometer or the dry bulb of a sling psychrometer.

3. Mean radiant temperature (mrt). Heat exchange by radiation between a solid body and its surroundings. For this study the mean radiant temperature and the dry bulb temperature were assumed to be the same.

4. Relative humidity (rh). "The amount of water vapor in the air expressed as a percentage of the maximum amount that the air could hold at a given temperature" (Random House Dictionary, 1966). Relative humidity was determined by the use of a sling psychrometer and standard psychometric charts.

5. Air velocity (v). The rate of air movement relative to the individual in the environment. ASHRAE Standard 55-66 specified an ideal velocity as being 10 to 45 feet per minute (0.05 to 0.23 meters per second). The mean of the standard was assumed to exist in all homes used in this study.

6. Ambient atmosphere. The prevailing conditions of air temperature, relative humidity, and air movement that exist in a specific environment and surround the individuals in that environment.

7. Clo value. The clo is a measure of the insulative value of clothing. One clo is the amount of insulation necessary to maintain comfort in a normally ventilated room with air movements less than 10 feet per minute, at a temperature of 70° F (21° C) and a relative humidity of less than 50% while the subject is resting in a sitting position (Le Blanc, 1975; Meier, 1956). In physical terms one clo is 0.18 $Cm^2hr/KgCal$.

8. Perception of thermal comfort. The subjective assessment of thermal sensation; the conscious experience resulting from exposure to the thermal environment.

9. Activity level. An estimate of energy transfer from the body surface to the atmosphere as a result of various activities. The energy units are expressed watts per square meter of body surface (W/m^2). Estimates of activity levels used in this study were adapted from Fanger (1972).

10. Age category. Age was catergorized into seven groups for the study: 19-24, 25-34, 35-44, 45-54, 55-65, 65-74, and 75 and older. Participants in the study classified themselves into the appropriate age category.

11. Body type or weight category. Four categories were used for body type: underweight (slender), average, heavy, and obese. Participants were assigned to categories by the investigator without the knowledge of the participant.

12. Blood pressure category. The divisions in blood pressure were high, normal, and low. Participants classified themselves according to their personal knowledge. Participants who had no knowledge of their blood pressure level were classified as normal.

13. Body temperature category. The categories for body temperature were high, normal, and low. Participants were assigned to categories according to their personal knowledge of their body temperatures. Participants who had no knowledge of their body temperatures were placed in the normal category.

14. Group I. Used to designate study participants who were selected at random from the Knoxville, Tennessee and surrounding area telephone directory.

15. Group II. Used to designate study participants who were selected from among active, on-campus graduate students in the College of Home Economics at The University of Tennessee, Knoxville.

16. C. Used to designate temperatures reported in degrees centigrade.

17. F. Used to designate temperatures reported in degrees Fahrenheit.

18. Effective temperature (ET*). A single index that combines the wet bulb and dry bulb temperatures with barometric pressure and air velocity, specifically "the dry bulb temperature at the intersection of its loci with a 50% relative humidity curve found in an ASHRAE psychrometric chart" (Gagge, Stolwijk, & Nishi, 1971).

CHAPTER II

REVIEW OF LITERATURE

Thermal Comfort

Thermal comfort is defined by the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) Standard 55-66 as "that condition of mind which expresses satisfaction with the thermal environment" (Fanger, 1972, p. 13). ASHRAE Standard 55-66 specifies a dry bulb temperature of 75F (23.9C) and a relative humidity of 40% as its central recommendation when the mean radiant temperature equals air temperature (Peplar, 1972, p. 97).

The comfort zone described by ASHRAE in its complete description of thermal comfort conditions was established by asking for subjective reactions to the environment at different conditions. Revisions have been made periodically since the publication of the first thermal comfort chart as a result of further research findings (Nevins, Rohles, Springer, & Feyerherm, 1966). A study by Sprague and McNall (1970) supported the ASHRAE specifications for thermal comfort in general, although the results showed that some fluctuation from the specified standards was acceptable to the subjects participating in the study.

A study by Rohles and Nevins (1971) determined that the widest range of temperatures at which subjects reported being comfortable is from 62° F to 98 F (16.7° C to 37.7° C), depending on the relative humidity. The distribution of votes was normal, thus most of the subjects were comfortable at temperatures between 78° F and 82° F (25.6° C and 27.8° C).

Thermal comfort is also defined as the absense of sensation of discomfort due to heat or cold. This negative approach indicates a lack of understanding of the conditions for positive thermal comfort (Wyon, 1973). This may result in part from the multitude of variables affecting thermal comfort and interactions among the environmental, physiological, and psychological factors.

The state of an individual's thermoregulatory system and his thermal sensations are related. When environmental variables, such as temperature and clothing, and activity level change the thermoregulatory system adjusts to maintain the internal body temperatures needed for survival (Azer & Hsu, 1977). Therefore, although sensations of thermal comfort and discomfort are subjective, they function to inform the body of the thermal nature of the environment. The sense of temperature is designed primarily to help the individual avoid the discomfort of excessive heat and cold. When near-equilibrium exists between the individual and the environment there is no conscious realization of temperture (Bartley, 1958; Nevins, Gonzalez, Nishi, & Gagge, 1975).

Individuals are capable of maintaining a heat balance in widely varying conditions. However, the comfort zone is relatively narrow. Within the comfort zone internal heat balance is maintained by vasomotor action while under more extreme conditions the balance is achieved by sweating or shivering (Madsen, 1976). In a steady-state environment the range of thermal comfort and neutral temperature sensation is in the range of physiological thermal neutrality. When the conditions change from comfortable to uncomfortable physiological response and reported comfort levels change at approximately the same rate. However, when conditions change from uncomfortable to comfortable a sense of thermal comfort is reported before the physiological changes take place. Thus thermal discomfort acts as both a motivating force and an anticipatory response to action that will obtain thermal neutrality (Gagge, Stolwijk & Hardy, 1967).

A study by Gagge, Stolwijk and Saltin (1969) indicated that during steady exercize temperature sensations ranging from cool to hot were primarily related to skin and ambient air temperature rather than to metabolic rate and deep body temperature.

In a 1976 study McIntyre and Gonzalez found that, in general, there is no seasonal difference in preferred temperatures in resting subjects but that exercizing subjects preferred different temperatures during different seasons.

Gonzalez and Nishi (1976) investigated the effect of cool environment on thermal sensation and clothing selection. They were particularily interested in whether or not subjects would select adequate clothing to maintain thermal comfort when given the choice and in the effect of local cold discomfort in different body areas. They found that the subjects did not select clothing adequate to maintain thermal comfort although clothing was added when thermal conditions were lowered. In addition, the study showed that cold discomfort of the legs resulted in an assessment of the temperature as unacceptable even when the reported whole-body sensation was still neutral. Females were found to be more sensitive to cold discomfort than males, with young females reporting cold discomfort earlier than older females.

Factors in the ambient atmosphere that have the greatest effect on thermal comfort are air temperature, vapor pressure, air velocity, and mean radiant temperature (Fanger, 1972; Fourt & Hollies, 1970; Goldman, 1977; Yaglou, 1949). Two other variables are equally important to thermal comfort: activity level and thermal resistance of clothing (Fanger, 1972). In addition, the factors which influence comfort are psychological as well as physioligical (Hardy, Ballou, & Wetmore, 1953).

Gagge, Stolwijk, and Hardy (1967) define comfort by stating,

> "Comfort" is a recognizable state of feeling, but possesses no identifiable sense organ like the basic five senses. . . . Man's sense of comfort applies to the entire environment, including all the psychological and physioligical factors which affect him throughout his life.

The results of research on thermal comfort are not in agreement as to the ease or accuracy with which predictions of thermal comfort can be made from encironmental measurements such as air temperature and insulation. Wyndham (1969) reported that the many cultural factors which affect metabolic rate and body temperature reactions and man's psychological adjustment to thermal conditions make it difficult to determine a narrow range of comfort conditions that will apply equally to all people. The results of a study of heat stress conducted by Blockley (1969) support this view. Blockley found that within a few weeks his study subjects became acclimatized to the environmental conditions through changes in physiological response.

While studying the effect of changes in temperature and humidity on thermal sensations Nevins, Gonzalez, Nishi, and Gagge (1975) found significant differences amoung individual subjects' sensitivity to thermal sensations and humidity level.

In a study conducted in environmentally controlled rooms, identical in temperature, humidity, air speed, and other controllable variables but different in decor, subjects reported feeling more comfortable thermally in the room with attractive decor and less comfortable thermally in the sparsely furnished and neutrally furnished rooms (Psychology Today Newspaper Enterprise Association, 1980).

Supporting the view that accurate predictions can be made is a study by Rohles, Hayter, and Milliken (1975). Thermal sensation was predicted accurately from the effective temperature, an index that combines the wet bulb and dry bulb temperatures with barometric pressure and air velocity. They also demonstracted that individuals in thermal conditions that vary from neutrality feel colder than comfortable more quickly than they feel warmer than comfortable.

Studies of thermal comfort through the years show a marked increase in indoor temperatures in developed countries with a concommitant decrease in the clothing insulation used. Not only do higher temperatures have a detrimental effect on the performance of most activities they also result in fewer people feeling comfortable, even in optimum conditions. This occurs because the optimum temperature range becomes narrower at higher temperatures (Wyon, 1973).

Measurement of Thermal Comfort

One difficulty confronting every research effort in the field of thermal environment and comfort is the great number of variables influencing the responses of subjects. Many variables are difficult to control for and are often ignored. Also, the degree of influence of many variables is as yet unknown (Rohles, 1967).

The environmental conditions related to thermal comfort may be measured objectively or calculated from the objective measurement of related environmental conditions. However, the use of all the known parameters related to comfort does not fully describe comfort. In addition, the subjective assessment of comfort changes as people adapt to different conditions of environment, fiber, and fabric (Fuzek & Ammons, 1977; Lee, 1953).

The ASHRAE definition of thermal comfort refers to a "condition of mind" (Fanger, 1972). Garment comfort is defined as "a condition of mind which expresses satisfaction with a specific garment under a specific set of environmental conditions" (Wallenberger, Franz, Dullaghan, & Schrof, 1978). As Rohles (1971) points out, the important thing to notice is that both definitions related to the mind rather than to the body. For this reason, subjective evaluation of the feeling of thermal comfort is of primary importance to researchers. For example, Butler and Eicher (1978) found that perceptions, or subjective feelings, were more important to satisfaction with the environment than were the actual conditions of the environment.

In a study of the effects of air movement and temperature on thermal sensations Rohles, Woods, and Nevins (1974) found indications of the importance of the interaction of air motion and air temperature in thermal semsations. The level of sound associated with air movement affected the perception of thermal comfort.

Although the measurement of subjective judgement is complex it can be accomplished through the use of psychological scaling and perception analysis methods. Scales used for subjective measurement have been classified and found to provide a good basis for applying appropriate psychological laws (Hollies, 1977; Torgerson, 1958). Perception analysis is an extremely powerful tool for determining how the different features of clothing are appreciated by the wearer over the normal range of indoor and outdoor climate (Hollies, Custer, Morin, & Howard, 1979). The only way to determine a person's impression of the environment is to ask him (Rohles, 1978). The methods and techniques used to develop questions that will obtain the desired information are studied and refined almost continually.

Physical Properites of Textiles

Many consumers believe that natural fibers are comfortable and synthetics are somewhat uncomfortable. However, the effect of the fiber used in a fabric is modified greatly by the nature of the yarn, the fabric construction, the finishes applied, and the garment design. Often, one of these latter factors may be the greater cause of discomfort than the fiber (Kemp, 1971).

The findings of studies of the thermal properties and comfort of natural fibers versus synthetic fibers have not been in complete agreement with each other. Werden, Fahnestock, and Galbraith (1959) found no significant differences in comfort ratings for three sets of apparel, one each of cotton, nylon, and rayon/acetate.

The ratings were determined by a number of measurements, both objective and subjective in nature. Other researchers have found that fabrics of synthetic fibers are not rated as comfortable as natural fiber fabrics. This appears to be due to the combination of characteristics of synthetic fiber fabrics such as continuous filament yarns, lack of bulk, and lack of moisture absorption (Bogaty, Hollies, Hintermaier, & Harris, 1953). Thermal character and skin contact sensation are improved when yarn bulk and the randomness of fiber position are increased. Fabric constructions providing maximum cover for winter wear and maximum permeability for summer wear reduce or eliminate the undesirable thermal sensations associated with synthetics (Latta, 1977).

Certain characteristics of textile fibers, yarns, and fabrics are associated with thermal insulation properties. Bulky yarns and fabrics continaing air spaces which serve as insulation can contribute to reduced heat transfer. Thick, fluffy fabrics and those with rough or irregular surface textures may also tend to slow conductive or radiant heat flow. Smooth yarns and tightly woven fabrics with high thread counts are associated with low air permeability and will help prevent convective heat loss. Layering of fabrics also influences heat transfer.

In general, thicker fabrics that contain more air spaces are warmer regardless of fiber content. For example, raschel and circular knits are thicker than flat knits and are therefore warmer (Long Underwear, 1978). Thickness is the single more important factor in determining the thermal comfort characteristics of a textile fabric.

Thermal insulation is directly proportional to fabric thickness. The layers of air between fabrics also act as insulation and combine with the fabric so that the resulting thermal insulation value is greater than that of the fabric layers alone (Bogaty, Hollies, Hintermaier, & Harris, 1953; Fahmy & Slater, 1977; Rees, 1971). Other characteristics of textiles important to thermal comfort are the surface hairiness of the yarns and the fabric, the texture of the fabric, and the fabric porosity (Andreen, 1953; Andreen, Gibson, & Wetmore, 1953; Hardy, Ballou, & Wetmore, 1953; Hollies, 1976).

Many articles have appeared discussing the importance of moisture porosity and wickability in relation to comfort. Mehrtens and McAlister (1962) found that fabric wickability had no detectable influence on the subjective assessment of comfort when they tested a number of fabrics. However, other research has not supported this finding completely (Hollies, 1975; Hollies, Bogaty, Hintermaier, & Harris, 1953; Mecheels, 1971; Spencer-Smith, 1977; Woodcock, 1962). The absorption and release of water from the fabric plays an important role in the adjustment of body temperature to variations in atmospheric temperature and humidity. For undergarments, for example, a structure of low desity is desirable. Traditional fibers such as wool and cotton are capable of absorbing large amounts of water. Both fibers satisfy the basic requirements for comfort, as does viscose rayon (Treolar, 1977).

Transfer of moisture through clothing assemblies can be expressed in terms of the resistance of individual layers and between the outer surfaces and the surrounding atmosphere (Spencer-Smith, 1977).

The values of the resistance to water vapor transfer between the outer surface of clothing and the atmosphere vary with wind velocity in much the same way as the resistance to heat transfer by conduction and convection. In still air the value of the resistance to water vapor transfer between the outer surface of the clothing and the atmosphere is reduced due to convection.

In his investigation of moisture transfer through clothing Spencer-Smith (1977) noted several findings. The rate of water vapor transfer through different fabrics varies with the type of fiber and construction. One of the fabrics studied, linen, tends to have a higher rate of water vapor transfer than wool, cotton, polyester, and nylon. Although the effect has not been fully explained, it is thought to be related to the ease of wetting of the fabric. He also reported that the resistance through fabrics to water vapor is less for damp than for dry fabrics. In addition, the heat transfer in increased, causing a reduced resistance of damp fabrics to thermal transfer.

Wear tests and laboratory tests of physical characteristics of fabrics have been used extensively by military personnel to find the clothing structures that give optimal comfort. Fonseca (1970) at the U.S. Army Research Institute of Environmental Medicine evaluated 10 underwear-outerwear ensembles for heat transfer properties. The results indicate that the outerwear rather than the underwear is the deciding factor in the thermal characteristics of the fabric layer systems studied.

As a part of the U. S. Army Quartermaster program, Woodcock (1962) developed the moisture permeability index which describes the efficiency of a fabric or fabric system in transferring moisture and its associated heat. The index extends the clo formula to include heat loss from sweat evaporation.

Comfort also depends largely on the geometry of the fabric and the manner in which the fabric is worn on the body (Andreen et al., 1953). When three different types of fabric were tested as to their effect on thermal comfort the results showed that the more porous fabric was colder than two tightly woven fabrics because the insulating layer of air could be disturbed easily.

The basic fabric structure is the major factor influencing air permeability. A direct correlation is found between air permeability and mechanical extension. Woven structures are least extensible and least permeable to air; double-knit fabrics are the most extensible and tend to have the highest values of air permeability; the warp-knits made from synthetic fiber yarns are intermediate for both extensibility and air permeability. Knits tend to have a lower cover factor than their woven counterparts. Even so, Scruggs (1979), in a study of selected fabrics intended for indoor winter wear, found that knit fabrics provide better insulation than woven fabrics because of their thickness and the large amounts of air trapped within the fabric structure.

Accurate estimates of the insulating capacity of multiple layers of fabrics can be obtained by adding values for the individual fabrics involved only if they have smooth surfaces. If the individual fabrics have rough or irregular surfaces, the fabric combinations must be measured directly. Enough air can be enclosed between layers of rough fabrics to cause a significant increase in thermal insulation without causing a measureable change in thickness. On the other hand, with loosely hanging clothing a certain ventilation of air layers can occur, causing a cool feeling, (Fanger, 1972).

As a part of the Army Quartermaster program from research on warmth and comfort of military fabrics, Bogaty and others (1953) investigated the effects of blending varying amounts of synthetic fiber with wool to determine warmth and comfort characteristics. Clothing thickness was found to be the single most important factor affecting insulation value. The synthetic fibers generally made the fabric thinner than the all wool fabric thus lowering the insulating value.

Thermal character and skin contact sensations are related to thermal comfort. Surface hairness of the yarns and fabrics have a profound effect on the comfort factors of insulation and movement of body moisture. Surface fibers contribute substantially to fabric thickness and, therefore, to its insulation. Also, projecting surface fibers separate the fabric from moist skin to keep the fabric from clinging when worn next to the body and causing discomfort (Hollies, 1977).

In a test conducted by Andreen, Gibson, and Wetmore (1953) surface texture was found to contribute to subjective ratings of clothing comfort. Five commercial shirting fabrics were evaluated and the fuzzy textures were rated much warmer than the smooth texture.

The nature of the yarn, whether staple or filament, also partially determines the comfort. Staple yarns provide an insulating air space while filament yarns are often smooth and come in direct contact with the skin, giving a cool feeling, as is the case with many synthetic fibers (Bogaty et al., 1953). Thus many factors that may not relate directly to the thermal insulation value of a fabric may affect its comfort rating and perceived thermal value.

Thermal Properties of Clothing

Of course, we do not actually wear fabric as it is. We wear clothing which is made up of a combination of shapes, designs, and layers. It is clear that the characteristics of a single fabric will be lost in the complexities of a clothing assembly. It is also necessary to remember that clothing is not only the main fabrics; it is the lining, interfacing, trim, and other components on subjective evaluations of the People make their clothing choices on subjective evaluations of the fabrics. This evaluation includes the hand, or the way a fabric feels (Branam, 1977; Greenway, 1977). The warmth or coolness of a fabric or garment is also judged partially by the way it feels.

Rather than being a passive covering for the body, clothing interacts with the air and heat in the environment. Heat loss is reduced or increased by the presence of clothing depending on the thermal properties of the clothing assembly as a whole (Spencer-Smith, 1977; Terry, 1977). Little is known, however, about the interaction of clothing design with body motion and ventilation within the clothing layers (Fourt & Hollies, 1970).

Interestingly, Steadman (1979) indicates it is more cost effective to insulate buildings well and heat the space than to increase the insulation of the people by increasing the amount of clothing worn if at least five people are ususally present in the building space. One significant drawback to this approach is that in most homes there are not five people present most of the time. When there are fewer than five people in the building Steadman estimates that it becomes more economical to insulate the people.

The human body is able to maintain a relatively constant internal temperature as the environmental temperature changes. Thermal comfort is maintained by heat exchange between man and his environment. The processes of the exchange are conduction, convection, radiation, and liquid-vapor transformation (Bazett, 1949; Hardy, 1949; Spencer-Smith, 1976). A number of studies have shown that there is little difference in preferred temperatures and relative humidities between elderly people and college students, males and females, and winter and summer (Peplar, 1972; Rohles & Johnson, 1972). Other studies have not support these finding in all environmental conditions, however

(Gonzales & Nishi, 1976; McIntyre & Gonzalez, 1976; Wyndham, 1969). Hardy (1971) found that people who have higher internal body temperatures generally prefer cooler environments than those with lower internal temperatures.

One fact that has emerged from the many studies of clothing's insulation properties is that no one property of clothing can be evaluated without considering all of the properties and considering them in the specific environment for which the clothing was designed (Fundamentals of Comfort, 1975).

The effect of clothing on thermal comfort is primarily dependent on the physical properties of the fabric, air spaces between the body and clothing and between layers of clothing, and the environmental conditions (Kerslake, 1971). The semi-still layer of air between the skin and clothing offers the most resistance to heat flow and, therefore, is of major importance in providing thermal insulation. The influence of clothing on this semi-still layer of air is highly dependent on such factors as the style and fit of the clothing (Azer, 1976).

An increased understanding of the physiological regulation of body temperature has come about as a result of studies of thermal comfort (Nishi, Gonzalez, & Gagge, 1975). As a result, a method for the direct measurement for the thermal efficiency of clothing while it is being worn has been developed.

The insulative measure of clothing is expressed by the term "clo". The clo value is defined as the amount of insulation necessary to maintain comfort in a normally ventilated room with air movements of less than 10 ft/min, at a temperature of 70° F and a relative humidity of less than 50% while the subject is resting in a sitting position (Brown & Croton, 1957; Meier, 1966).

The upper limit for convenient and comfortable indoor clothing appears to be 3 clo. Although it is not convenient to wear clothing that has a maximum value of 4 to 5 clo, when fuel is very scarce the most economical arrangement would be to add more clothing (Meier, 1966). Humphrey (1978) found in a study of school children's clothing habits that when temperatures changed both during the day and over a period of several days, clothing worn does not conform to the temperature trends evenly. The insulative value of the clothing selected followed the trend of temperatures over a period of time but did not change during a given day as the temperature fluctuated.

Research on the insulation values of combinations of garments has resulted in an estimated insulation value for an ensemble of 0.8 times the sum of the insulation values for the individual items (Miller, 1980).

In 1974, the Federal Energy Administration established indoor winter and summer temperature guidelines of 68-70° F (20.0-21.1° C) and 78-80° F (25.6-26.7° C), respectively, dependent on the relative humidity. Gagge, Nishi, and Nevins (1976) found that in order to maintain thermal comfort at these temperatures winter clothing insulation values need to be between 1.0 and 1.2 clo while summer clothing insulation values of 0.3 clo or less are the most effective. Other studies have determined that humans are sensitive to changes in clothing insulation values as small as 0.3 clo (Fundamentals of Comfort, 1980).

In terms of comfort, the purpose of clothing is to serve as thermal insulation which allows controlled heat loss from the body (Hardy, 1949). Historically, the ability of clothing to protect the wearer from heat or cold was a factor in clothing selection (Ryan, 1966). However, the use of central heating and cooling made this function less important. As the indoor climate is changed in an effort to reduce energy consumption, clothing again becomes important in maintaining thermal comfort.

With the wide range of textile products and clothing designs available there should be the means at hand to provide thermal comfort in the wide variety of environmental, physiological, and psychological conditions that affect people today (Greenwood, 1971). Even so, it must be remembered that the selection of clothing and environmental conditions that fit together to provide optimal thermal comfort is a complex operation that involves a great many interrelated factors.

CHAPTER III

METHODS AND PROCEDURES

Experimental Design

A cross-sectional survey design was used in this study. An exploration of selected factors that may affect the perception of thermal comfort was made. Possible relationships among these factors was also explored. The survey was conducted through interviews and observations in the homes of participants in the study.

The dependent variables chosen for use as measures of the perception of thermal comfort were:

a. dry bulb temperature

b. relative humidity

c. estimated air temperature

d. air movement associated with the heating system

e. sex of the respondent

f. body type

g. age category

h. blood pressure category

i. body temperature category

j. ordinary activity level at home

k. estimated insulation value of clothing worn during the interview

l. estimated insulation value of clothing ordinarily worn at home

m. adjustment made to achieve thermal comfort if too cool

n. estimated perception of thermal comfort in an environment five degrees cooler than usual

Housing data such as an estimate of the size of the room used most frequently, types of furnishings, and orientation of windows and doors were also collected. This information is a part of the exploratory search for additional factors which may affect perceptions of thermal comfort and were not included in the statistical analysis.

The planned procedure was to develop instruments that would determine the perception of thermal comfort and the factors affecting it and would ascertain athe relative importance of clothing in providing thermal comfort in varying environmental conditions. The details of the procedure are presented in the following order: development of instruments, selection of the sample, data collection procedures, and analysis of data.

Development of Instruments

The interview schedule was prepared from a thorough study of the literature on thermal comfort. The questions devised were similar to the types of questions asked by other investigators in similar studies and related fields. Research reports consulted included, but were not limited to, those by the following: Fanger (1972), Goldman (1977), Hardy (1971), Hollies (1977), Rohles (1974) and Seppanen et al. (1972).

In addition to factors known to have an effect upon the perception of thermal comfort a number of highly exploratory items were included in the questionnaire.

The form of the interview schedule was determined by the need to maintain consistency throughout the interviews, the need for clarity,and the necessity of keeping the time demands on the participants to a minimum while still obtaining as much information as possible. A structured format was chosen for the schedule because it could be used quickly and efficiently. Whenever possible, questions were designed to be answered with one or two words. When longer answers were required checklists of possible answers were developed for use by the investigator to assist in recording responses quickly (see Appendix A). Opportunities were given for each participant to comment on any item and to make general comments at the end of the interview.

Observations and measurements made in each residence were recorded on a separate data sheet by the investigator or an assistant during the interview. Observations about the participants' physical characteristics were recorded immediately after each interview.

The face validity of the interview schedule and observation form was accepted following comparison with the previously mentioned scales used for similar research. Since all the interviews were conducted by one investigator no determination of interrater reliability was necessary.

The interview schedule and observation form were approved by the Human Subjects Committee, The University of Tennessee, Knoxville. Written consent for the interview was obtained from each participant.

Selection of the Sample

The sample consisted of two groups of participants selected by different methods. The design of the study necessarily limited the sample to persons who were willing to be interviewed in their homes. All participants lived in Knox County, Tennessee at the time of the interviews.

The selection of respondents in one subsample was based on a table of random numbers developed for the study. The table was based on an estimation of the number of listings in the 1980 telephone directory for the City of Knoxville and surrounding areas in Tennessee. The table of random numbers was generated with a TI programmable 58C Calculator using the Uniform Distribution Sequence of the Random Number Generator Program.

A list of names with addresses and telephone numbers was developed by selecting the entry in the directory that corresponded to the sequence of numbers in the random number table. As names were selected, any random number that resulted in a commercial or organizational name was discarded.

A pool of names was drawn and letters explaining the nature and purpose of the study were mailed to them. A copy of the letter is included in Appendix B. The letters were followed by phone calls asking for appointments to interview members of the household. Appointments were made to interview 30 persons in 14 households. The appointments were kept by all but 5 people, resulting in a subsample of 25 people in 12 households selected at random.

The second subsample was selected from students at The University of Tennessee, Knoxville. Lists of actively enrolled, on-campus graduate students in the College of Home Economics were obtained from all of the Departments. Students selected for participation in the study were matched as closely as possible to members of the first subsample on two factors: type of residence and marital status. This was done in order to duplicate as closely as possible the living conditions of the first subsample.

Students selected were contacted by telephone and the exploratory information sent by letter to the randomly selected group was read to the students. Appointments were made to interview 25 people in 14 households. All appointments were kept.

In both subsets there was a variety of georgraphical locations in the county and in economic status. All participants in the study were 19 years or older and approximately the same number in each group had young children at home.

The fact that selection was based on the telephone directory or by enrollment in graduate school eliminated the possiblity of participation by extremely low income families. None of the families who agreed to participate could be described as having an extremely high income although a high income would not have excluded anyone from the selection process.

Data Collection Procedures

Each family asked to participate in the study received an explantion of the nature and purpose of the study. The information given to the participants may have introduced bias into the study. The investigator believed it was necessary to give such information in order to be able to conduct the interviews in homes at their ordinary temperatures rather than in temperatures adjusted to make the interviewer comfortable as a guest. It was also highly desirable that participants be wearing clothing ensembles similar to those ordinarily worn rather than dressing up to meet a guest. Participants were requrested in the introductory information to wear commonly worn garments.

All of the interviews were conducted between March 10 and 26, 1980. The times of the interviews were set for the convenience of the participants and ranged from 9:30 a.m. to 9:00 p.m . Because the kind of information sought was not highly personal all family members were permitted to remain present during the interviews. Each participant was interviewed individually, however.

Upon arrival for the interview the investigator gave a brief review of the purposes of the study and an explanation of the use of the sling psychrometer brought to determine temperature and humidity.

To reduce bias which could be introduced during the interviews by variations in wording, the questions were read so that they were the same for each person interviewed. The same researcher conducted the interviews for the entire study in order to minimize the effects of variability in interviewer personality and style of interviewing.

If participants asked for clarification of any questions the researcher was prepared to simplify the terms by offering synonyms or rephrasing the question. Only one item was questioned, however. The majority of participants could not reply to the request for a list of words that would describe the clothing they felt was comfortable. They could respond to the question if it were asked as how do you feel when wearing clothes that are comfortable.

Data recorded on the observation form were collected by an assistant during the interview or by the investigator at the end of the interview. Dry bulb and wet bulb temperatures were taken in three locations in the room in which the interview was taking place. A sling psychrometer that had been allowed to come to equilibrium was used. Estimates of room size, types of furnishings, and other housing observations were made by the interviewer or an assistant, or were provided by the participants themselves.

Observations of body type, or weight appropriateness for type of frame, were made by the investigator for all participants. This procedure was used to ensure the use of identical criteria for categorizing participants into the four body types to be used in the study. These observations were recorded immediately after each interview.

Approximate clo values were estimated for three sets of garment combinations described by the participants: clothing worn during the interview and two descriptions of clothing ensembles ordinarily worn at home during the winter. Clo values calculated by Nishi et al. (1976) and Sprague and Munson (1974) were used as a basis for the estimation of the clo values for ensembles in this study.

Participants described their ordinary and usual activity levels in their homes. Using information from Fanger (1972) activity levels were estimated in energy units expressed as watts per square meter of body surface (W/m^2). All estimated activity levels fell within the sedentary range.

The Comfy-Test EQ 21 (Madsen, 1976) was used to gererate a table indicating the percentage of people who would be comfortable in three different environments at selected levels of sedentary activity and at a range of clothing insulation values. The prediction of thermal comfort is expressed as a number which represents the predicted percentage dissatisfied (PPD) with the conditions. A thermal comfort index based on the predicted mean vote (PMV) on a modified thermal comfort scale was generated simultaneously.

The Comfy-Test EQ-21 is an instrument developed by the Thermal Insulation Labratory of the Technical University of Denmark which gives direct information on expected thermal sensation. The Comfy-Test calculates room temperature, which is equivalent to the combined effect of air temperature, mean radiant temperture, and air velocity. Clothing insulation values and activity levels for persons who might occupy the room are preselected. The Comfy-Test measures the dry heat loss that would take place from a person in the room. The table developed from the Comfy-Test EQ-21 was used in the analysis of data.

Analysis of Data

Frequency distributions were analyzed for the two subsamples to determine similarities and differences between groups for the following variables: dry bulb temperature, estimated air temperature, relative humidity, sex, body type, blood pressure category, body temperature category, age category, perception of thermal comfort in the usual home environment, estimated perception of thermal comfort in an environment five degrees cooler than usual, the normal activity level in the home, adjustments made to achieve thermal comfort if too cool, the estimated clo value of clothing being worn during the interview, and the estimated clo value of clothing ordinarily worn in the home environment. In addition, ranges, means, and standard deviations were claculated for the same variables with the exception of the sex of the respondent. These data were used to determine the composition of the groups.

A t-test for significance of difference between the means was used to determine the feasibility of pooling data from the two subsamples. The results indicated that the two groups were similar in most respects for the purposes of the study.

The Shapiro-Wilk W-test (Shapiro & Wilk, 1965) for normality of distribution was applied to the data for the variables dry bulb temperature, estimated air temperature, relative humidity, estimated clo value of clothing being worn during the interview, and estimated clo value of clothing ordinarily worn in the home environment. The W-statistic tests the null hypothesis that the input data values are a random sample from normal distribution. This procedure was used to further verify the suitability of pooling the data.

The chi-square test was applied to selected pairs of variables to determine the probability of relationships. Variables tested were those determined to be of interest by inclusion in the questions developed from each hypothesis. Chi-square is useful when the data are nominal.

Discriminant function analysis was used to ascertain whether a set of predictor variables could be used to predict perceptions of thermal comfort accurately and also to predict ranges of clothing insulation (clo values) that would provide thermal comfort in various environmental conditions. For example, the physical characteristics of subjects might be used as a set of criterion variables for predicting perceptions of thermal comfort. However, unless the accuracy of predictions based on this set of variables is established the predictions cannot be considered reliable. Discriminant function analysis is a method for predicting responses when the criterion data are nominal rather than continuous in nature.

All computer analysis used the programs availiable in the 1979 version of the Statistical Analysis System (Helwig & Council, 1979).

The index of the predicted mean note (PMV) of thermal comfort and the predicted percentage of dissatified (PPD) people generated by the Comfy-test EQ 21 was compared with similar environmental conditions and perceptions of thermal comfort found in the interview data. This allowed the perception of thermal comfort reported by a single study participant and the predicted thermal comfort of a large group of people in a comparable environment to be compared for agreement.

CHAPTER IV

RESULTS

A cross-sectional survey was made to explore selected factors that may affect the perception of thermal comfort in the home environment. The use of clothing in maintaining thermal comfort was of primary interest. The survey was conducted through interviews and observations in homes in Knox County, Tennessee during March, 1980.

The Sample

The sample consisted of two groups of participants. Group I was selected by a random process based on listings in the 1980 telephone directory for Knoxville, Tennessee and surrounding areas. No attempt was made to ascertain the occupation, educational level, or economic status of the participants. However, comments by respondents and observations by the interviewer led to the conclusion that the majority of participants in Group I were in the middle to upper middle income level and were educated beyond the high school level, some participants indicating that they were students at The University of Tennessee, Knoxville. Several participants in Group II had spouses that were employed full time in professional positions in the Knoxville area, making the economic status and educational levels of participants in the two groups more similar than might be expected from the different selection methods used for the groups.

Composition of the groups was determined by analyzing frequency distributions, ranges, means, and standard deviations for a number of variables. Variables determined by direct observation or measurement include air (dry bulb) temperature, relative humidity, air movement associated with the heating system, sex of the respondent, and age category. Values for the following variables were estimated from observations or from responses given by participants during the interviews: perception of thermal comfort in the usual home environment, estimation of thermal comfort in an environment five degrees Fahrenheit cooler than the ususal home temperature, estimated usual room temperature, estimated normal activity level while in the home, adjustments made to achieve thermal comfort if too cold (response to cold), the estimated clo value of clothing being worn during the interview, the estimated clo value of clothing ordinarily worn in the home environment, and body type. Two variables, blood pressure category and body temperature category, are designated as estimated variables even though many participants could give reasonably exact information. By including estimates from those who did not have accurate knowledge of their body temperature or blood pressure, every participant could be categorized for these two variables.

Group I consisted of 25 respondents, 7 males and 18 females, living in 12 households. The number of participants in a household ranged from one to four, with the majority of households consisting of two respondents.

The ages of the participants ranged from the 19-24 age category (Table 1) through the 75 and over category. The mean age category for Group I was 35-44. Participants in Group I were found in each age category. The mean age category in Group II was 25-34, with participants in all age categories except the two oldest, 65-74 and 75 and over.

TABLE 1

DISTRIBUTION OF GROUP I AND GROUP II
BY AGE CATEGORY

Age Category	Group I	Group II
19 - 24	2	2
25 - 34	6	16
35 - 44	4	4
45 - 54	3	1
55 - 64	5	2
65 - 74	4	0
75 - over	1	0
	25	25

As would be expected, the majority of participants in each group were placed in the average category for body type. The majority were also found to be in the average category for blood pressure and body temperature.

Activity levels were estimated from descriptions of ordinary activities engaged in by respondents while at home, either during the day or in the evening. The activity levels are expressed in terms of watts per square meter of body surface (W/m^2). Estimated activity levels could be designated as sedentary for all participants, ranging from 37 to 65 W/m^2 in Group I and from 50 to 74 W/m^2 in Group II. The mean for Group I was estimated as 55 W/m^2 and for Group II the estimated mean was 58 W/m^2.

Estimates of the insulation value (clo) of the clothing being worn at the time of the interview were calculated for each participant. Clo values for Group I ranged from 0.25 to 1.13 with the mean being 0.65. In Group II the range of clo values varied from 0.3 to 1.04 with the mean estimated clo value at 0.70 (Table 2).

TABLE 2

NUMBER OF PEOPLE IN EACH CATEGORY OF ESTIMATED CLO VALUES FOR CLOTHING WORN DURING THE INTERVIEW

Clo Values	Group I	Group II
0.20 - 0.29	1	0
0.30 - 0.39	0	0
0.40 - 0.49	5	2
0.50 - 0.59	6	6
0.60 - 0.69	5	6
0.70 - 0.79	3	4
0.80 - 0.89	1	5
0.90 - 0.99	1	1
1.00 - 1.09	2	1
1.10 - 1.19	1	0
	25	25

Descriptions of two clothing ensembles ordinarily worn at home were obtained from each participant. Estimated clo values were calculated for each ensemble described. The mean for these values was determined and used as the clo value for ordinarily worn clothing (Table 3). In Group I the estimated mean clo value was 0.7 and in Group II the estimated mean was 0.79.

Participants in the study were asked to describe what measures they took when they felt too cool. Responses were coded into three categories for analysis: (1) turn up the heat, (2) add more clothing, and (3) add more of both heat and clothing. In Group I, 7 participants responded that they turned up the heat if they felt too cool while 22 said they put on more clothing. In Group II, 4 respondents said they turned up the heat, 15 responded that they added more clothing, and 6 participants said they did both if they felt too cool.

TABLE 3

NUMBER OF PEOPLE IN EACH CATEGORY OF ESTIMATED CLO VALUES FOR CLOTHING ORDINARILY WORN AT HOME

Clo Values	Group I	Group II
0.40 - 0.49	3	1
0.50 - 0.59	7	1
0.60 - 0.69	5	3
0.70 - 0.79	2	7
0.80 - 0.89	3	8
0.90 - 0.99	1	3
1.00 - 1.09	3	2
1.10 - 1.19	1	0
	25	25

The variables pertaining to the ambient atmosphere that were studied were air (dry bulb) temperature, relative humidity, air movement caused by the heating system, and estimates of usual room temperature made by the participants. These variables were analyzed in terms of households rather than by respondents in order to avoid the repetition of values for a variable.

Air (dry bulb) temperature varied greatly among the households (Appendix C, Figure 2). Homes of I participants ranged in air temperature from 20.2 to 24.8° C (68.3 to 76.7° F) with a mean air temperature of 22.8° C (73.0° F). The homes of Group II respondents ranged from air temperature of 16.8 to 23.9° C (62.3 to 75.0° F). The mean temperature in Group II households was found to be 21.0° C (69.8° F).

Participants were asked to estimate the air temperature usually maintained in the room where the interviews were being held (Appendix C, Figure 3). Estimates of usual room temperature ranged from 19.2 to 23.9° C (67 to 75° F) with a mean of 21.3° C (70.5° F) in Group I. In Group II estimates of usual room temperature ranged from 15.6 to 21.1° C (60.0 to 70.0° F) with a mean of 19.3° C (66.4° F).

Variation in relative humidity was great in both groups of homes. The range in Group I was from 34 % to 63% with a mean relative humidity of 51%. For Group II, relative humidity ranged from 36% to 56% with a mean of 49%. A part of the variation may be accounted for by the fact that on some of the days interviews took place on rainy days and on other days it was sunny and relatively dry. Also, some homes were near a lake and others were not.

Homes were divided into two categories based on the kind of heating system used as the primary source of heat. The two categories were designated forced air systems and radiant systems. The forced air system category includes all methods of heating that distribute heat by the movement of air by mechanical means, e.g. blowers, either continuously or intermittently while heating. The radiant system category includes any method of heating that relies solely on radiation and convection to distribute heat throughout the room, e.g. electrical resistance heating. Group I contained five homes with forced air systems and seven with radiant systems. In Group II there were ten homes with forced air systems and four with radiant systems.

Perceptions of thermal comfort were determined for usual room conditions. In Group I the participants responded as follows: 4 said they usually felt cool, 17 said they were usually comfortable, and 4 usually felt warm. In Group II, 10 usually felt cool and 15 were usually comfortable. None of the participants in Group II said they usually felt warm at their estimated usual winter room temperature.

Estimates of thermal comfort were obtained for conditions with room temperatures five degrees Fahrenheit below the usual winter room temperatures. In Group I, 3 respondents thought they would be miserably cold, 10 estimated they would feel cold, 7 thought they would be cool, and 5 believed they would be comfortable. In Group II, 8 participants believed they could be miserably cold, 13 thought they would feel cold, and 4 estimated they would feel comfortable. None of the respondents in either group believed they would be warm if room temperatures were lowered five degrees Fehrenheit.

A comparison of the frequency distributions, ranges, means, and standard deviations of the variables for each group revealed that there were some differences between the groups. In order to determine the magnitude of these differences and the appropriateness of pooling the data from the groups, three procedures were used. Histograms of the distributions of variables for the complete sample were visually inspected for approximation to normal distribution. Two computerized statistical procedures were used, a t-test for significance of difference between means and the Shapiro-Wilk W-test for normality of distribution of the population.

A visual inspection of the histograms for the sample distributions was made for selected variables to estimate the normality of the distributions. Values for the variables air (dry bulb) temperature and estimated usual room temperatures appeared to be approximately normal in distribution with the exception of two households (Appendix C, Figure 4 and 5).

Values for the relative humidity of the households were examined. The distribution did not appear normal as the values were scattered rather than forming a continuous distribution (Appendix C, Figure 6).

Other variables examined were age category, the clo value of clothing worn during the interview, and the clo value of clothing ordinarily worn.

The distribution of participants by age category was obviously skewed (Appendix C, Figure 7). Distributions for the two variables concerned with clothing worn also appeared to be somewhat skewed (Appendix C, Figure 8 and 9). Because of the difficulty of interpreting the sample distributions, additional tests were applied to the data.

A t-test for significance of difference between means was applied to all variables. The program computed a t-statistic based on the assumption that the variances between the two groups were equal and also computed on approximate "t" based on the assumption that the variances were unequal. The appropriate degrees of freedom for the approximate "t" were computed. An F-statistic was computed to test for equality of the two variances (Helwig & Council, 1979). The appropriate "t" was used to test each variable with the .05 level of confidence used to determine significance. Significant differences were found between groups for five variables: air (dry bulb) temperature estimated usual room temperature, age category, perception of thermal comfort in usual conditions, and estimates of thermal comfort at five degrees Fahrenheit cooler than usual. The results of the t-test are summarized in Table 4.

Because the inspection of the distributions of values for air temperatures and estimated usual room temperature showed two deviant households new t-tests were computed for these two variables after deleting the values for the deviant households. The purpose

TABLE 4

A "t" TEST COMPARISON OF GROUP MEANS

Variable	N	Mean[2]	SD[2]	DF	T
Air temperature					
Group I	12	22.8	1.47	24	2.52*
Group II	14	21.0	2.03		
Relative humidity					
Group I	12	51.2	0.07	24	1.01
Group II	14	28.7	0.06		
Kind of air movement in the heating system					
Group I	12			24	1.10
Group II	14				
Estimate of usual room temperature					
Group I	12	21.3	1.55	24	3.01**
Group II	14	19.3	1.74		
Sex of respondent					
Group I	25			48	-0.88
Group II	25				
Body type					
Group I	25			48	0.25
Group II	25				
Blood pressure category					
Group I	25			42	0.21
Group II	25				
Body temperature category					
Group I	25			48	0.31
Group II	25				
Age category					
Group I	25			38	3.36**
Group II	25				
Activity level					
Group I	25	55.2	7.47	48	-1.22
Group II	25	57.7	7.33		

TABLE 4 (CONTINUED)

Variable	N	Mean[2]	SD[2]	DF	T
Response to cold					
Group I	25			36	-1.39
Group II	25				
Clo value of clothing worn during the interview					
Group I	25	0.65	0.22	48	-0.95
Group II	25	0.70	0.15		
Clo value of clothing ordinarily worn					
Group I	25	0.71	0.21	48	-1.62
Group II	25	0.79	0.14		
Perception of thermal comfort in usual conditions					
Group I	25			48	2.62*
Group II	25				
Estimate of thermal comfort					
Group I	25			48	2.02*
Group II	25				

[a]Means and standard deviations for categorical variables have been omitted.

*$p<.05$
**$p<.01$

was to see if the significant difference between groups was due to these two households. The value of "t" was computed to be 2.04 with 22 degrees of freedom, which is not significant at the .05 level of confidence. The difference in the estimates of usual room temperatures was found to be significant at the .05 level of confidence with the value of "t" being 2.58 with 22 degrees of freedom. Therefore, the assumption must be made that factors other than the two deviant households contributed to the differences in the estimates of usual room temperature.

A second computerized statistical procedure, the Shapiro-Wilk W-test was used to help determine the feasibility of pooling the data. The W-test produces a statistic which indicated the probability that a sample is from a normally distributed population.

The variables air (dry bulb) temperature, relative humidity, estimated usual room temperature, estimated clo values of clothing being worn during the interview, and estimated clo values for clothing ordinarily worn during the winter were selected for analysis. As before, data were analyzed by household when necessary to avoid the repetition of values for a single variable. The .05 level of confidence was used to determine the significance of W. The distribution of two variables, air temperature and age category were shown to be significantly different from values expected in a normally distributed population (Table 5).

TABLE 5

SHAPIRO-WILK W-TEST FOR NORMALITY OF POPULATION DISTRIBUTION

Variable	N	W
Air temperature	26	0.91*
Relative Humidity	26	0.93
Estimate of usual room temperature	26	0.96
Age category	50	0.85**
Estimated clo value or clothing worn during interview	50	0.96
Estimated clo value of clothing ordinarily worn	50	0.96

* $p < .05$.
** $p < .01$.

A second W-test was computed for the variable air (dry bulb) temperature to determine if the deviation from normality could be caused by the two households with unusually low temperatures. The value of W was found to be 0.97, which is not significant. Thus it is reasonable to assume that the deviation from normal distribution can be attributed to two deviant households.

After considering the results of the three preliminary forms of analysis which were applied to the data the decision was made to include the data from the deviant households in the analysis. This decision was made in part because of the exploratory nature of the study and in part because these two households were of special interest by virtue of their unusually low room temperatures.

Results: Analysis of Relationships

A preliminary analysis was made of the number of responses in each possible category for each variable. In the case of two variables, body type and age category, the data needed to be combined into fewer categories to allow for a reasonable number of responses in each category for the analysis.

The variable body type consisted of four categories for classification of respondents: slender, average, heavy, and obese. Only one participant was classified as obese, however. The data for this person was combined with data for those in the heavy category, resulting in the use of three categories in the statistical analysis.

Age of respondent was originally divided into seven categories: 19-24, 25-34, 45-54, 55-64, 65-74, and 75 and over. For some of the statistical procedures the categories were condensed into 19-34, 35-54, and 55 and over. The discussion of the results will indicate which set of age categories was used in the analysis.

The activity category of all the participants was estimated to be the same, i.e. sedentary. Because of this, data for the variables activity level was usually omitted from the statistical analysis and no attempt was made to determine possible relationships between the single variable activity level and the insulation value of clothing ordinarily worn.

High and low categories were assigned to the following variables: dry bulb temperature, relative humidity, estimated room temperature, esimated clo value for clothing being worn during the interview, and estimated clo value for clothing ordinarily worn during the winter. The median was used as the criterion for division in each case. This allowed two-way frequency tables to be generated for these variables. Although fine distinctions were lost, comparisons of these with other variables was then quickly accomplished. Other statistical procedures used to explore relationships among variables were the chi square test for probability of relationship and discriminant function analysis. Since the primary objective of this study was to explore relationships among selected factors that may affect the perception of thermal comfort the data were analyzed by groups of variables. The same statistical procedures were used to analyze the data in each of the groupings. Selected two-way frequencey distributions and a table of chi square values that support the discussion of the findings are included in Appendix C, Figures 10 through 15 and Table 9.

Perception of thermal comfort. The first area of interest was the relationship between the perception of thermal comfort and the physical, psychological, and environmental factors selected for the study. In order to look for possible relationships, the participants were grouped by their perceptions of thermal comfort in usually existing conditions in the home during the winter. The participants divided as follows: 14 said they usually felt cool, 32 reported feeling comfortable, and 4 said they usually felt warm. Because of the small number of responses, data for the four persons who usually felt warm were omitted from some statistical procedures.

The first question explored was that of a relationship between the perception of thermal comfort and the physical characteristics of the respondent. The statistical analysis revealed no differences in the perception of thermal comfort related to the sex, body temperature category, or body type of respondents in this study. Perception of thermal comfort for this group of people does appear to be related to the age category and blood pressure category of the respondent. Using the three condensed age categories for analysis, the chi square value for perception of thermal comfort by age category was 9.93 (p=.007). Blood pressure and age are known to be related, with blood pressure being high more often for older people. The chi square value for the probability of a relationship between a high age category and a high blood pressure category was 22.95, significant at the .0001 level of confidence.

However, the air (dry bulb) temperature found in the home and the age category of the respondent were also found to have highly significant probability of relationship (p=.0005) with participants in higher age categories having the higher air temperatures. This finding affects the interpretation of the apparent relationship between age and perception of thermal comfort in this study.

Discriminat analysis procedures were applied to the data for participants who perceived themselves as cool and as comfortable. If the physical characteristics designated in this study were used to provide an index for categorizing people who are likely to report themselves as cool or an comfortable, the classifications would be accurate only 86% of the time when assigning people to the cool category and accurate no more than 75% of the time for assigning people to the comfortable category. Percentages in this range indicate a weak relationship.

The second question examined was the possibility of a relationship between the perception of thermal comfort and the estimated clo value of clothing worn. Clo values were estimated for each clothing ensemble on the basis of calculations by Nishi et al (1976) and Sprague and Munson (1974). Using chi square analysis, the perception of thermal comfort was found to be related to the insulation value (clo value) of the clothing being worn at the time of the interview (p=.05) but not to the clo value of clothing described as ordinarily worn during the winter. Respondents wearing clothing that was estimated as having high clo values (above the median estimated clo value) while being interviewed reported themselves to be comforable more often than did respondents wearing clothing with an estimated clo value below the median for the sample. This finding is somewhat puzzling, particularly since the relationship between the estimated clo value for clothing worn during the interview and estimated clo value for clothing described as ordinarily worn was highly significant (χ^2=13.5,p=.0002). A partial explanation of the apparent lack of any correlation between the perception of thermal comfort in usually existing conditions and the clo value of clothing ordinarily worn in those conditions may be that a close positive relationship was found between the reported perception of thermal comfort at usually existing conditions and the air temperature at the time of the interview. People who had higher room temperatures at the time of the interview, regardless of the estimated usual room temperature, reported feeling comfortable throughout the winter more often than those who were in cooler room temperatures during the interviews. These findings lead to speculation that phychological factors may affect the memory of sensations of thermal comfort in conditions other than those in which one is situated during the present.

Values for clothing worn during the interview and clothing ordinarily worn were both used in the discriminant analysis procedure. An attempt to classify respondents into categories of those who felt cool and those who felt comfortable based on the insulation values of their clothing was found to successful 63% of the time for the comfortable group and 57% of the time for the cool group. On the basis of these findings it would appear that there is no relationship between the perception of thermal comfort in the home environment and the insulation value of clothing worn. This result is not in agreement with the findings of many other studies done under different conditions. It may be that the questions asked did not measure the desired attributes adequately. It is also possible that psychological or other factors interfered with or masked any relationship that may exist between the perception of thermal comfort and the insulation value of the clothing being worn. The descriptions of ordinarily worn clothing may have been affected by the conditions at the time of the interview of by inaccurate memory. It is also possible that in a home environment the insulation value of clothing is of much less importance to perceptions of thermal comfort than it has been found to be in other environments.

The last question under Hypothesis I that was examined pertained to the possible existence of a relationship between the perception of thermal comfort and selected environmental conditions in the home. A highly significant probability of relationship was found to exist between the air (dry bulb) temperature at the time of the interview and the perception of thermal comfort in usually existing conditions (χ^2 10.27,p=.001). People who were interviewed in cool room temperatures reported feeling cool in usually existing conditions more often than those who were interviewed in warmer room temperatures. The mean dry bulb temperature at the time of the interviews and the mean estimated usual room temperature were quite similar. Thus a relationship between the estimated usual room temperature the perception of thermal comfort at the usual winter room temperature could be expected. The chi square value for the probability of such a relationship was 4.49 (p=.07), indicating that any relationship between the two was weaker than expected.

Perception of thermal comfort also appears to be related to the movement of air associated with the heating system. The chi square value was 6.06, significant at the .02 level of confidence. Respondents who reported that they felt cool often had forced air heating systems. However, since a significant relationship was found to exist between low air temperature and the use of a forced air heating system the results are open to several interpretations. One possibility is that the circulating air distributes heat more evenly throughout the room, providing a sense of thermal comfort at lower temperatures than if the room has variations in temperature from cool to warm.

No relationship was found to exist between the perception of thermal comfort and the relative humidity at the time of the interview in this study. It should be noted that the relative humidity values encountered in the homes studied were generally in the forties and fifties, levels that are quite comfortable at the temperature measured.

Discriminant analysis procedures were applied to the environmental variables air (dry bulb) temperatures, relative humidity, air movement from the heating system, and estimated usual room temperature. If the respondents were classified as perceiving themselves as cool based on the data provided the classification would be accurate 86% of the time. Those who would perceive themselves as comfortable could be successfully classified 88% of the time. Thus it appears that there is some correlation between the perception of thermal comfort as measured in this study and the environmental conditions within the home. The relationship does not appear as strong as might be exptected, however. This may be due to environmental conditions not measured in this study or to factors other than the environmental ones.

The relationship between the perception of thermal comfort in usually existing conditions and the estimation of thermal comfort at five degrees Fahrenheit cooler than usual was subjected to a chi square test. As would be expected, highly significant relationship ($p=.0008$) was found to exist. Participants who described themselves as cool in existing conditions more often anticipated that they would be cold or even miserably cold in the cooler conditions. Those who were comfortable in existing conditions usually expected that they would be comfortable in the lower temperature, too.

Chi square analysis of the relationship between the perception of thermal comfort and the response to being too cool was made. The response to what action would be taken if too cool were categorized as adding more clothing, adding more heat, or adding both more clothing and more heat. No relationship was found to exist between the perception of thermal comfort and the responses individuals made if they became uncomfortably cool.

Clothing insulation value. The second area of interest was the relationship of the insulation value of the clothing worn and the physical characteristics of the wearer as well as the clo value of clothing worn and the thermal comfort conditions studied. Other relationships of interest involving clothing insulation values have been discussed in preceding paragraphs.

An attempt was first made to analyze the data for clo value by dividing it into 11 categories with the lowest category being 0.2000 to 0.2999 clo units and the highest category being 1.1000 to 1.1999 clo. However, there were too few observations in each category for a meaningful analysis. For further analysis the data were simply divided into two categories, low and high, using the median as the dividing line.

The possible relationship between physical characteristics and these two categories of clo values was examined. The results of both the chi square test and discriminant analysis indicate that no relationship exists between the clo value of clothing being worn during the interview and the sex, age category, body type, blood pressure category, and body temperature category of respondents in this study.

Tests of the clo value of clothing ordinarily worn show a similar lack of relationship with physical characteristics with one exception. The insulation value of clothing usually worn and the body type of the individual showed a possible relationship (χ^2=5.48,p=.06). Interestingly, in this study the slender participants were more likely than the heavy participants to wear clothing with low insulation values.

No relationship was found in this study between the estimated clo value category of clothing worn during the interview and the dry bulb temperature, estimated usual air temperature, relative humidity, or air movement from the heating system. When the possible relationship between the insulation value of clothing ususally worn and selected environmental factors was investigated two significant values resulted. A chi square value of 8.01, significant at the .005 level of confidence, was found for the probability of a relationship between ordinarily worn clothing and the air (dry bulb) temperature. Also, the probability of relationship between clothing insulation value and the estimated usual air temperature was significant at p=.01 (χ^2=6.52). In both cases participants reporting wearing clothing with high insulation values had lower air temperatures in their homes. Even so, when all the environmental variables studied were subjected to discriminant function analysis the test results indicated that the amibent environmental variables could not be used to discriminate between persons who wear low insulation clothing and those who wear high insulation clothing. The classification of study participants was accurate no more than 68% of the time.

An interesting relationship appears to exist between the insulation value of clothing worn, both during the interview and usually, and the respondent's response to being too cool. Chi square values were found to be 5.27 (p=.07) for clo value category during interviews and response to cold, and 8.34 (p=.02) for clo value category for usually worn clothing and response when too cool. Respondents in the low clothing insulation categories more often reported that they added heat when too cool, leading to the speculation that these people, for whatever reasons, did not consider increasing clothing insulation value an appropriate action to take when uncomfortably cool. Participants in the high clothing insulation category were more likely to say they usually added both heat and clothing. However the majority of study participants in both categories of clothing insulation said they added more clothing when too cool.

An other interesting finding is that the insulation value of the clothing being worn during the interview and the anticipated perception of thermal comfort at five degrees Fahrenheit cooler than usual appear to be significantly related. The chi square value was 9.30, significant at the .03 level of confidence. A similar relationship was not found between ordinarily worn clothing and the anticipated perception of thermal comfort at cooler temperatures. One possible explantion of these results is that existing conditions, including the insulation value of clothing, have an effect on the ability to generalize to other conditions.

Thermal comfort conditions. The two questions that were examined under Hypothesis II were concerned with the thermal comfort conditions in homes. The respondents were grouped into two categories for study, low dry bulb temperature and high dry bulb temperature. The median was used to divide the two groups. The air temperature was selected for use in this analyais because it si deemed to be the single most important thermal comfort variable. Participants were also categorized into low estimated and high estimated usual air temperature. The same statistical procedures were used to test both sets of data.

The first question examined was the possibility of relationship between selected thermal comfort conditions and the physical characteristics of the respondents. The air (dry bulb) temperature was chosen as the representative environmental variable again because of its importance. The chi square value for a probable relationship between the air temperature category and the age category of the respondents was 15.15, significant at the .0005 level, with older people maintaining higher air temperatures. No other relationships appear to exist between the dry bulb temperature and the physical characteristics measured by the chi square test in this study.

Discriminant analysis indicates a relationship between physical characteristics, e.g. age, body type, blood pressure, body temperature, and sex of the respondent, and the air (dry bulb) temperature. If these characteristics were used to develop an index for predicting the temperature category in the home it would be accurate 91% of the time when classifying those who would have low temperatures and 78% of the time when classifying those who would have high temperatures.

A possible relationship between the estimated usual winter room temperature and physical characteristics was explored. No relationship appears probable as evaluated by the chi square test. Discriminant analysis indicates an ability to correctly assign low and high usual temperatures on the basis of physical characteristics at 81% for low usual temperatures but only 42% for high usual temperatures.

The second question examined under Hypothesis II was that of a possible relationship between air temperature, both at the time of the interview and the estimated usual temperature, and the perceptions of thermal comfort at two temperatures as well as the response to feeling too cool. The chi square analysis for each pair of these variables was discussed under Hypothesis I. Results of the discriminant analysis show that using the three variables, perception of thermal comfort in existing conditions, anticipated perception of thermal comfort at five degrees Fahrenheit cooler than usual, and the action taken when too cool, it was not possible to predict accurately the air temperature to be found in the home. Predictions about air temperature at the time of the interview would be accurate for high temperatures 87% of the time and for low temperatures 61% of the time. Estimated usual room temperature predictions would be accurate for high temperatures 83% and for low temperatures only 45% of the time.

Additional groupings. Respondents were grouped into three categories based on their reported action when they felt cool: (1) those who added more clo value through clothing or other body covering, (2) those who added more heat to the room or moved closed to the source of heat, and (3) those who did both. Based on the chi square test, significant correlations were found between the response to feeling to cool and two variables, the sex of the respondent and the estimated clo value of clothing ordinarily worn. Male participants were more likely to add heat to the room or to move closer to the source of heat while females tended to add clothing (χ^2=9.95,p=.007). A chi square value of 8.34 (p=.02) indicated a significant relationship between the amount of clothing usually worn and the response to feeling too cool. Participants who ordinarily wore clothing with a low clo value were more likely to add heat; those who wore clothing with higher clo values were more likely to respond by adding more clothing.

When all of the physical characteristics were considered together instead of individually in the discriminant analysis, the following results were found: response to feeling too cool by adding heat can be predicted for this group of people 80% of the time, by adding clothing only 43% of the time, and by adding both heat and clothing 83% of the time. An index based on the estimated clo value of the clothing worn could be used to predict those who would add heat 100% of the time for this group, but would predict those who would add more clothing only 56% of the time, and those who would add both heat and clothing 33% of the time.

Chi square tests showed no relationships between the response to feeling too cool and the air temperature, relative humidity, type of heating system, or estimated usual room temperature. Results of the discriminant analysis also indicated that these variables could not be used as indicators to predict the response to feeling too cool.

In addition to the analysis of environmental thermal comfort variables already discussed, air temperature categories were analyzed for possible relationships with a combination of clothing insulation value and activity level. The chi square analysis indicated a single significant relationship and that is between the air temperature and the estimated clo value for clothing ordinarily worn (χ^2=8.01, p=.01). No relationship was found between the clothing insulation values for clothing worn during the interview and the temperature during the interview. The results of discriminant analysis indicate that predictions about the choice of high or low temperatures in the home would be accurate for this group 78% of the time if based on clothing choices and activity levels.

When the estimated usual room temperature and estimated clothing insulation values were explored the chi square value for a probability or relationship between the estimated room temperature and ordinarily worn clothing was significant at the .01 level of confidence (χ^2=6.52). Discriminant analysis results indicate that using clothing choices and activity levels to predict the usual temperatures maintained at home is not feasible. Classifications of low and high usual temperatures would be dependable only 57% and 71% of the time, respectively.

Other Subjective Responses

Responses to a number of questions and several observations made during the interviews were not included in the statistical analysis of the data. Some data did not lend themselves to numerical coding; others could not be incorporated into the analysis for various other reasons. Selected information is presented here for consideration in support of the conclusions and interpretations of the study.

One item requested on the interview schedule was the name of the warmest single item of clothing. Unsolicited comments from the participants indicated that two interpretations were given to the question: (1) name the warmest single item that can be added to clothing already being worn and (2) name the warmest single item that can be worn if only one garment is to be allowed. No attempt was made during later interviews to influence the interpretation given to the question because the discrepancy in interpretations was not noticed until several interviews had been completed. All responses were recorded and tallied. The garment named most often was sweater, being named by 22 respondents (Table 6). Some respondents specified pull-over, cardigan, or turtle-neck styles. Six persons indicated that the sweater should be wool. The next most often named garment was a long robe with long sleeves. Some respondents named robe fabrics such as fleece, brushed nylon, or flannel as well as naming the length of the sleeve and the skirt. One respondent could not settle on a single item of clothing, naming two thought to be of equal warmth.

TABLE 6

CLOTHING NAMED AS WARMEST

Garment	Times Named
Sweater: all styles and fibers	22
Robes: long sleeved, floor length	10
Thermal underwear	7
Sweat Shirts	4
Pyjamas	2
Heavy wool or down-filled socks	2
Flannel dress or gown	1
Long sleeved shirt or blouse	1
Jeans	1
Comforter or blanket	1

Participants were also asked to list words that described comfortable winter clothing. The majority of respondents had difficulty in answering this question. Most gave as the first response, "They're comfortable." They were then asked to give several descriptive words about comfort and the number of responses ranged from two to six words. The most frequently named characteristics were softness and loose fit. Other characteristics mentioned were that the clothing felt warm and was either smooth or fleecy. A tendency was noticed for participants who listed thermal underwear as the single warmest garment to name snug fit as a desirable comfort characteristic while those who perferred loose fit were more likely to name sweaters, robes, or sweat shirts as warm garments. A table of the words given as describing comfortable winter clothing is given in Appendix D.

During the interviews additional information was obtained about housing characteristics that was not subjected to statistical analysis. This information included the type of fuel used to heat the house, the size of the room in which the family spent most of its time (which was also the room where the interview took place), and the number and kind of furnishings. Other information obtained included the number of exterior windows and doors, the compass direction of walls containing windows or exits, and the kind of wall covering in the room. The amount, kind, and location of insulation in the structure was requested but many of the respondents could not provide this information. These various data were visually inspected to determine if any patterns could be seen relating perceptions of thermal comfort to these housing characteristics. None were found.

Participants were also asked if all rooms in the dwelling were kept at the same or differenct temperatures and whether the temperature was the same or different between waking and sleeping hours. No differences were found in the perception of thermal comfort when participants were grouped by variations in temperature among rooms in the house. The mean perception of thermal comfort was 3.7 for participants who kept all rooms at the same temperature and also 3.7 for participants who kept bedrooms or other rooms at cooler temperatures than the main living area. The scale used was three equals a response of cool; four equals a response of comfortable to the question how do you usually feel in this room.

Relative humidity has been shown to affect thermal comfort in a number of previous studies. To ascertain the validity of this in home environments, participants were asked if their homes had humidifers. Four houses had humidifiers, two had dehumidifiers, and 20 either had neither or had a humidifer in a bedroom only. The humidifer and dehumidifer did not appear to affect either the relative humidity or the perception of thermal comfort in this study. The data indicate that the homes with humidifers had relative humidities at the upper end of the range for the entire sample. Homes with humidifers had relative humidity ranging from 34% to 50% and those with dehumidifers had relative humidities of 52% and 56%. Home with neither kind of equipment ranged from 36% to 63% relative humidity.

Comfy-Test EQ-21 Comparisons

The Comfy-Test EQ-21 was used to determine the predicted thermal comfort responses of groups of persons in selected environmental conditions similar to those found in homes during the survey. The Comfy-Test EQ-21 is an instrument designed to give direct information on expected thermal sensation (Fanger, 1972; Madsen, 1976). Ideally, each set of conditions for each individual participant would have been duplicated on the Comfy-Test. Then comparisions could be made between each participant's reported thermal comfort and the predicted thermal comfort of a large group of people in the same situation. However, each set of conditions could not be duplicated in the available laboratory situation. Thus the comparisons are limited to those conditions which were obtainable.

Immediately before using the Comfy-Test in each setting the dry bulb temperature was taken with a thermometer and a relative humidity reading was taken with a Abbeon RH Indicator. These two readings were used to set the water vapor pressure appropriately on the Comfy-Test. Activity level settings and the clo value setting were selected to approximately simulate data obtained from individuals in the study. Readings for room temperature in degrees Centigrade, percentage of dissatisified (PPD) people, and predicted mean vote (PMV) of thermal comfort were recorded for each set of conditions.

As measured by the Comfy-Test EQ 21, room temperature is equivalent to the mean radiant temperature and the air temperature at zero air velocity. Thus the room temperature reading may differ slightly from the air temperature as measured by a standard mercury thermometer.

The PPD takes into consideration that individuals vary in their response to environmental conditions. When a relatively large group of people are exposed to a given set of thermal conditions a number will always be dissatisfied. Theoretically, the smallest obtainable number of dissatisfied persons amounts to 5% of the group, regardless of the thermal conditions or the number of persons.

The predicted mean vote index is based on a modified version of the generally applied ASHRAE scale for thermal comfort:

cold	- 3
cool	- 2
slightly cool	- 1
neutral	0
slightly warm	+ 1
warm	+ 2
hot	+ 3

However, the PMV index as calculated by the Comfy-Test is on a continuous scale rather than in discrete numbers. In order to compare the index with interview data the index values were designated cool, comfortable, and warm. The extreme responses of hot and cold were not obtained on either the Comfy-Test or during the interviews. The measurements used, simulated parameters, and readings from the Comfy-Test are summarized in Table 7.

Survey data which was simulated reasonably well on the Comfy-Test are presented in Table 8. Relative humdity varied among the houses in the survey and could not be controlled during the use of the Comfy-Test. Since relative humidity is known to have less of an effect of thermal comfort than air temperature the variations in relative humidity were noted but not actually considered when the comparisons were made.

Visual inspection of the two sets of data indicate a high degree of agreement between the survey respondents and predictions made

TABLE 7

COMFY-TEST EQ-21 READINGS

Measured Room Conditions		Pre-set Comfy-Test Parameters		Comfy-Test Calculations			
Dry Bulb Temperature (°C)	Relative Humidity (%)	Activity Level (W/m^2)	Clo Value	Room Temperature (°C)	PPD	PMV	Designated Perception of Thermal Comfort
22	50	60	0.6	21.5	50	-1.8	Cool
22	50	60	0.8	21.5	18	-0.8	Comfortable
22	50	70	0.6	21.5	25	-1.0	Cool
22	50	70	0.8	21.5	9	-0.4	Comfortable
22	50	70	1.0	21.5	5	0.0	Comfortable
24	62	50	0.5	24	37	-1.2	Cool
24	62	50	0.6	24	17	-0.7	Comfortable
24	62	50	0.8	24	6	-0.1	Comfortable
24	62	50	1.0	24	8	+0.2	Comfortable
24	62	60	0.6	24	10	-0.5	Comfortable
24	62	70	0.6	24	7	+0.2	Comfortable
24	62	70	1.0	24	25	+0.9	Warm
25	48	60	0.4	24	40	-1.2	Cool
25	48	60	0.6	24	10	-0.5	Comfortable

TABLE 8

SURVEY DATA USED FOR COMPARISON WITH COMFY-TEST EQ-21 RESULTS

Air (Dry Bulb) Temperature (°C)	Relative Humidity (%)	Activity Level (W/m^2)	Clo Value for Ordinarily Worn Clothing	Perception of Thermal Comfort
21.5	36	64	0.8	Comfortable
21.7	52	60	0.6	Comfortable
21.8	56	65	0.7	Comfortable
22.1	48	55	0.7	Comfortable
22.1	48	60	0.8	Comfortable
23.7	50	50	0.6	Comfortable
23.7	50	65	1.1	Comfortable
23.9	46	50	0.7	Comfortable
23.9	46	50	0.7	Comfortable
23.9	46	52	0.5	Comfortable
24.0	65	65	0.6	Comfortable
24.8	57	57	0.5	Comfortable
24.8	57	57	0.5	Comfortable
24.8	57	57	0.5	Warm
24.8	57	57	0.6	Comfortable

by the Comfy-Test. The four respondents who maintained a temperature near 22° C, whose activity levels ranged from 55 to 65 watts per square meter of body surface, and who ordinarily wore clothing calculated at 0.8 clo reported that they were comfortable. The Comfy-Test predicted that from 9 to 18% of any group would be dissatisfied with these conditions but the predicted mean vote of thermal comfort varying from -0.4 to -0.8 is within the comfortable range.

Study participants whose room temperatures were approximately 24C were compared with results from the Comfy-Test at 24C. When respondents and Comfy-Test readings were matched for activity level and clo value of clothing worn, the predicted and reported perceptions of thermal comfort were the same--comfortable. The PPD ranges from -0.7 to +0.9.

Similarly, perceptions of thermal comfort for three of the four respondents who maintained an air temperature of 24.8° C agreed with the perception of thermal comfort predicted by the Comfy-Test EQ 21. The PPD was -0.5.

Testing the Hypotheses

The approach used in this study has been exploratory in nature. Numerous studies of thermal comfort have been done in extreme conditions of nature and in highly controlled laboratory settings. Little work has been done on thermal comfort in ordinary settings such as homes. The variety and number of variables which may affect the perception of thermal comfort in familiar surroundings is not known. The primary purpose of this study was to begin an exploration of the possible relationships among a selected number of factors which may affect perceptions of thermal comfort in the home.

In order to define the scope of the study three hypotheses were formulated. A set of questions was developed from each hypothesis and an attempt was made to answer each question separately before testing the hypothesis as an entity.

Hypothesis I. Perceptions of thermal comfort in the home are independent from personal physical characteristics, normal activity levels, the insulation value of ordinarily worn clothing, and selected environmental conditions within the home.

1. Is the perception of thermal comfort independent of the physical characteristics of the person?

No relationship was found to exist between the perception of thermal comfort and the sex, body type, or body temperature category in this study. Significant relationships were found between the age category and blood pressure category and the perception of thermal comfort in the group studied. Other findings that have a bearing on this relationship are discussed under Hypothesis III, question 1.

2. Is the perception of thermal comfort independent of normal activity levels in the home?

All of the participants in this study reported usual activities that were in the sedentary category. Reports of thermal comfort varied from cool to warm. However, since there were no reported activity levels other than sedentary there was no basis for comparison of perceptions of thermal comfort with differing activity levels. Thus, the question cannot be answered on the basis of data collected in this survey.

3. Is the perception of thermal comfort independent of selected environmental conditions within the home?

It was not surprising to find that the perception of thermal comfort was significantly related to the temperature of the room. Both the air temperature at the time of the interview and the estimated usual air temperature were related positively to the perception of thermal comfort in usually existing conditions. People whose homes had lower air temperatures reported feeling cool more often than those whose homes had higher temperatures.

No relationship was found to exist between the relative humidity of the room as measured at the time of the interview and the perception of thermal comfort in this study. Since a relationship has been found in laboratory studies one was expected in home environments. The range of temperatures and relative humidities existing in the homes studies was rather narrow, however, and relative humidity is of less importance at moderate temperatures.

Perception of thermal comfort does appear to be related to air movement in the room due to forced air heating sytems. Those participants with forced air heating systems reported feeling cooler. However, an examination of the data revealed that homes with forced air heating systems were kept at cooler temperatures than other homes. Because of this second factor the results of the analysis were determined to be inconclusive.

4. Is perception of thermal comfort independent of the estimated insulation value of ordinarily worn clothing?

The data are inconclusive on this point. A positive relationship was found to exist between the perception of thermal comfort as reported for usual conditions in the home and the clothing being worn during the interview. No similar relationship was found between the perception of thermal comfort and ordinarily worn clothing although the correlation between estimated clo values for clothing worn during the interview and clothing ordinarily worn was very highly significant.

Hypothesis I can be neither accepted nor rejected completely based on the results of this study. Several significant relationships were found between the perception of thermal comfort and the variables tested. However, the results of other tests were inconclusive, preventing a clear decision of acceptance or rejection.

Hypothesis II. The insulation provided by the choice of clothing worn in homes is independent of existing thermal conditions, personal physical characteristics, ordinary activity levels, or perception of thermal comfort perceived by family members.

1. Is the insulation value of clothing ordinarly worn independent of the physical characteristics of the wearer?

No relationships were found to exist between the estimated insulation value of clothing worn and the physical characteristics of the participants in this study with one exception: The estimated clo value of clothing ordinarily worn appears to be related to the body type as defined in this study. Persons classified as slender were more apt to wear clothing with low insulation values and those classified as heavy were more apt to wear clothing of higher clo value.

2. Is the insulation value of clothing ordinarily worn independent of selected thermal comfort conditions within the home?

Significant relationships were found between the estimated clo value of clothing worn ordinarily and both the air (dry bulb) temperature during the interview and the estimated usual air temperature. No relationships were found between clothing insulation value and relative humidity or air movement from the heating system in this study.

3. Is the insulation value of clothing ordinarily worn independent of ordinary activity levels within the home?

All participants reported activity levels that were categorized as sedentary. The estimated clo values ranged from 0.4 to 1.2 clo for clothing ordinarily worn during the winter. Although no statistical techniques were applied to these data it would appear from the variation in clo values and uniformity of activity level that no relationship exists for participants in this study.

4. Is the insulation value of clothing ordinarily worn independent of the perception of thermal comfort?

Data pertaining to this question were discussed under Hypothesis I, question 4. The results were inconclusive.

Hypothesis II is partially rejected on the basis of the relationships found between the variables tested and the insulation value of clothing ordinarily worn. The insulation value of clothing worn is related to selected physical characteristics of the wearer, existing thermal conditions, and perception of thermal comfort.

Hypothesis III. Thermal comfort conditions existing in homes are independent of personal physical characteristics or perceptions of thermal comfort held by family members.

1. Are selected thermal comfort conditions in the home independent of the physical characteristics of the occupants?

It was not surprising to find a highly significant relationship between the air temperature, which was used as most representative of the housing factors affecting thermal comfort and the age category of the respondent. Older participants kept their homes warmer than did younger participants. When the physical characteristics defined in this study were grouped for use as indicator variables a definite relationship was found between the physical characteristics of the participants and the temperature maintained in the home.

2. Are selected thermal comfort conditions in the home independent of the perceptions of thermal comfort held by the occupants?

The analysis of the data pertaining to this question has been discussed under Hypothesis I, question 3. Relationships were found between the air temperature and air movement in the room and the perception of thermal comfort in this study.

Based on the findings of this study Hypothesis III is rejected. Thermal comfort conditions in the home are related to personal physical characteristics and the perception of thermal comfort held by family members.

Although no hypothesis was formulated concerning the response to feeling too cool, data collected were subjected to the same tests as were other data. No relationship was observed between the individual's actions when too cool and the selected housing environment variables studied. A relationship was found between the response to cold and one physical characteristic, however. Male respondents were more likely to add heat to the room while female participants were more apt to add clothing when too cool. A relationship was also found between the response to feeling too cool and the estimated clo value of clothing ordinarily worn. Persons wearing higher clothing insulation were more apt to add still more clothing when cool, those wearing low clo value clothing were more likely to add heat to the room.

Consideration was given to the additional information obtained in the survey and from the comparisons with the Comfy-Test readings when interpretation of these findings was made. It appears that the physical characteristics evaluated in this study have a bearing on the temperatures maintained in people's homes. While several relationships of significance were found between individual variables and the perception of thermal comfort, the insulation value of clothing worn, or the choice of room temperature no other group of variables studied appears to be useful as indicator or predictor variables for anticipating conditions in the home environment.

The physical characteristics of the participants were also found to be related to the response to feeling too cool. The variable called response to feeling too cool presupposes an attitude on the part of the participants toward thermal comfort and ways in which to achieve it. However, no relationship was observed between the action taken when uncomfortably cool and the temperature in the home. A relationship was observed between this action and the estimated clo value of the clothing usually worn.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary and Conclusions

The purpose of this study was to explore possible relationships among selected factors that may affect the perception of thermal comfort in a home environment. The objectives of the study were threefold: (1) to obtain meaningful information about the multiplicity of factors that affect the perception of thermal comfort, (2) to empirically evaluate the effect of selected factors on thermal comfort, and (3) to develop guidelines for increasing thermal comfort in cool indoor temperatures through clothing selection. Two of these three objectives were fulfilled.

A cross-sectional survey design was used for the study. The survey instrument was based on findings and recommendations from previous studies in the area of thermal comfort or studies of other effects of environment on individuals. Several highly exploratory questions were also included.

The sample consisted of two groups of participants. One group was chosen at random from the Knoxville and surrounding area telephone directory. The second group was selected from among the graduate school population in the college of Home Economics at The University of Tennessee, Knoxville. The graduate student group was matched as closely as possible with the randomly selected group for type or residence and marital status. A total of 50 adults participated in the study.

Data were collected through interviews and observations made in the homes of the participants. The interview schedule used a structured format designed to help the interviewer maintain consistency throughout the study while eliciting as much information as possible in a brief period of time.

Each family that participated in the study received an explanation of the nature and purpose of the study. While this information may have introduced bias into the study it was deemed necessary in order to conduct the interview in the desired circumstances. These conditions were that the temperature in the home during the interview be maintained as closely as possible to the usual home temperature and that the respondents dress in clothing they ordinarily wore at home.

Responses to interview questions were recorded by the interviewer on forms and check lists designed for that purpose. Observations were recorded during the interview period or immediately afterwards by the interviewer. Data that were not numerical in nature and could be coded to numerical forms were converted for statistical analysis.

Frequency distributions, "t" tests, and the Shapiro-Wilk W-test were used to determine the feasibility of pooling data from the two groups of participants. The results indicated that the two groups were similar for the purposes of this study.

The pooled data were analyzed through frequency distributions, chi square tests, and discriminant function analysis. Comparisons were made between selected survey data and predictions of thermal comfort for similar conditions as determined by the Comfy-Test EQ-21.

The results of these analyses lead to several conclusions. The discrepancies between the findings of studies conducted in controlled-environment conditions indicate that there are factors other than those traditionally studied that affect perceptions of thermal comfort in the home. The findings also lead to the conclusion that we know very little about thermal comfort in a wide range of conditions. Results of this study also indicate that attitudes affect both actions taken to achieve thermal comfort and perceptions of thermal comfort in the home environment.

The variables traditionally studied for their effect on thermal comfort have been air temperature, relative humidity, mean radiant temperature, clothing insulation values, and selected physical characteristics such as age and sex. In this study body type, body temperature, and blood pressure were explored. The results point to a relationship with the perception of thermal comfort. Attitudes toward temperature, specifically toward lower temperatures, also appear to be related to perception of thermal comfort. Those who believed they would be uncomfortably cold in cooler environments also tended to turn up the heat as well as add more clothing when they began to feel cool. These findings suggest that many as yet unstudied environmental, physiological, and psychological factors affect the perception of thermal comfort.

Because the results of the analysis of the role of clothing in the achievement of perceived thermal comfort were inconclusive the proposed guidelines for the selection of clothing for thermal comfort were not developed. The relative importance of clothing in achieving thermal comfort may be less than that of other factors in familiar settings. Until the effect of each variable is fully understood guidelines for clothing selection would be so broad as to be of limited usefulness to the public.

Limitations

A major limitation of this study was the size and composition of the sample. The small sample size was a direct result of the difficulty of obtaining participants who would agree to interviews in their homes. Other limitations of the sample were selection from a single geographic location, absence of participants between the ages of 12 and 18 years old, absence of families with very low incomes, and the use of two selection methods employed in the sampling process. Because of these factors the information obtained cannot be generalized meaningfully to the total population nor to other geographic areas.

In an attempt to interview in a normal setting, participants were informed of the purpose of the study and were requested not to change either the temperature of the home or the clothing they usually wore for the interview. This information and the requests may have caused bias in their responses, particularly to questions about clothing.

Two other sources of possible bias are easily identified. Persons agreeing to participate may have been generally more interested in and informed about energy use and conservation than those refusing to be interviewed. They may also be more aware of various comfort factors and the effect of clothing on thermal comfort.

An additional limitation was identified in the interview schedule. While it would be unrealistic to expect people to keep their homes at extremes of thermal comfort, e.g. hot or cold, a wider range of choices in the question about perception of thermal comfort would have allowed participants to make finer distinctions which might more accurately have reflected their perceptions. The choices slightly warm and slightly cool should have been included as possible responses.

Implications and Recommendations

Certain findings point to conclusions about the study population which cannot be generalized to a larger population because of the limitations of the study as discussed earlier.

A number of trends observed in this study should be developed as hypotheses for further study. These include, but are not limited to, the following topics:

1. Controlled or laboratory environment vs. home environment. Laboratory controlled-environment rooms do not simulate home environments in that there are no windows and doors, furnishings are often sparse and utilitarian, and the problems of thermal asymmetry and variation in temperature from floor to ceiling are often ignored. In actual homes the number of factors affecting thermal comfort make precise evaluation difficult. More needs to be known about the effects of air velocity, e.g. convection heating vs. radiant heating.

2. The psychological effect that the interview conditions had on feelings toward other situations is of interest. Air temperature

at the time of the interview had the highest correlation of all variables with the reported perception of thermal comfort in usually existing conditions. If this relationship were found in other populations there would be implications for both the design of future studies conducted in the field and the further study of psychological factors that affect the perception of thermal comfort.

3. Another finding for this population was that slender people were more likely to wear clothing with lower insulation value than heavy people. Since slender people have less body fat, which is considered to act as insulation, it would seem reasonable to assume that slender people would need more clothing for insulation than heavier people to feel comfortable at the same temperatures. This was not the case in the sample studied, however.

4. Another finding with implications for further study was the difference in response made by men and women toward feeling too cool. Women more often said they added clothing while men more often said they added heat if too cool. If these differences are attitudinal rather than biological the implications for education to achieve thermal comfort is significant.

Additional investigation outside of the scope of this study is needed in order to clarify relationships among the factors that affect the perception of thermal comfort. This recommendation is based on the findings of this exploratory study, including the data that could not be coded numerically and used in the statistical analysis. Techniques need to be employed to measure the mean radiant temperature and the velocity of air movement in homes. The effects of texture, color, and the size and shape of furnishings need to be determined in a form that can be analyzed through statistical procedures. Until the importance of each factor in the environment is understood textiles for apparel and furnishings, garment design, and even the size and configuration of rooms can be engineered for only "average" conditions and "average" people.

Many of the questions raised by this study can best be answered in the laboratory where isolated factors of interest can be examined. An example of this is the question of which is of greater importance in achieving thermal comfort--increasing the insulation value of clothing worn or adding carpet to the floor.

The importance of the interview temperature on perception of thermal comfort at usually existing conditions, the wide variation in actual temperatures that resulted in reports of comfort, and attitudes toward temperature expressed by the study participants suggest another topic for additional exploration. Is there a predetermined set of environmental conditions or a "psychological temperature" at which each person will feel thermally comfortable? If so, how is this determined--by physiological factors, environmental factors, psychological factors, or a combination of these? Also, if this "psychological temperature" does exist do the environmental conditions required for a perception of thermal comfort vary widely among individuals or are the limits narrow?

No attempt was made to determine if attitudes toward temperature, types of clothing, color and texture of furnishings, and size of room affect the perception of thermal comfort. There is some evidence from other studies that room decor and attitude toward the environment affect the perception of thermal comfort. More information is needed about the relationships between attitudes and environmental factors if cooler indoor winter temperatures are to be accepted by a majority of people.

Most of the previous studies of thermal comfort in moderate environments have been conducted in laboratory settings. Little has been done to determine the effect of familiarity with the surroundings. Are there factors that cause perceptions of thermal comfort in familiar surroundings to be different from perception of thermal comfort in new or unfamiliar surroundings?

Additional information is needed about the physical characteristics of people and their feelings of thermal comfort. For example, do people who have high blood pressure or a normal body temperature above or below 98.6° F feel comfortable in thermal conditions that differ from those with low bood pressure or the average body temperature? The results of this study indicate the possibility of correlation between thermal comfort and several physiological factors. Some research findings support this finding; others disagree.

Another area in which more information is needed is what causes people to make the clothing choices they do, especially when these choices do not result in thermal comfort. In this study clothing insulation values similar to those one might expect to find being worn during summer conditions were being worn by some of the people.

Those wearing clothing with low insulation values were as likely to report they were cool as they were comfortable.

The interview question that was most difficult for respondents to answer concerned the characteristics that made clothing comfortable. It would be interesting to know why people cannot describe what makes clothing comfortable. Also, the relationship between the inability to describe comfortable clothing and clothing choices needs to be determined.

Studies of a sample of households over time are needed. All members of the family should be included. More reliable information about the actual thermal comfort conditions and the perceptions of these conditions could be obtained in a longitudinal study.

Similar studies need to be conducted in school classrooms and in business offices or other locations where people may spend long periods of time and where the environment is familiar to the participants. Similarities and difference in factors that affect the perception of thermal comfort in environments other than homes could be useful. As the various factors that affect the perception of thermal comfort become better understood it should become easier to provide thermal comfort by manipulating factors other than the room temperature.

Finally, the findings of the many and varied research studies on thermal comfort need to be compared and the information combined so as to make the best possible use of the body of knowledge already in existence about thermal comfort.

REFERENCES

REFERENCES

Andreen, J. H., Gibson, J. W., & Wetmore, O. C. Fabric evaluation based on physiological measurements of comfort. Textile Research Journal, 1953, 23, 11-22.

Azer, N. Z. The prediction of thermal insulation values of garments from the physical data of their fabrics. ASHRAE Transactions, 1976, 82, 87-106.

Azer, N. Z. & Hsu, S. The prediction of thermal sensation from a simple model of human physiological regulatory response. ASHRAE Transactions, 1977, 83, 88-102.

Bartley, S. B. Principles of perception. New York: Harper & Brothers 1958.

Bazett, H. C. The regulation of body temperatures. In L. H. Newburgh (Ed.). Physiology of heat regulation and the science of clothing. New York: Hagner Publishing Co., Inc., 1949.

Blockley, W. V. Thermal burden of clothing. Environmental Research, 1961, 2, 10-21.

Bogarty, H., Hollies, N. R. S., Hintermaier, J. C., & Harris, M. Some properties of serges made from blends of wool with acrylic type synthetics. Textile Research Journal, 1953, 23, 536-544.

Branam, J. Evaluation of characteristics of fabric hand as perceived by various age groups. Unpublished masters thesis, University of Tennessee, 1977.

Brown, J. R., & Croton, L. M. An experimental method for the determination of the 'clo' value of clothing assemblies. Journal of the Textile Institute Transactions, 1957, 48, T379-T388

Butler, S., & Eicher, J. Clothing as an indicator of quality of life. Paper presented at the Central Region Annual Conference of the Association of College Professors of Textiles and Clothing. Chicago, Ill., 1978

Energy conservation in the home: An energy education/conservation curriculum guide for home economics teachers. Knoxville, Tenn.: University of Tennessee, 1977.

Fahmy, S. M. A., & Slater, K. The use of an acoustic test to predict fabric comfort properties. In N. R. S. Hollies & R. F. Goldman (Eds.). Clothing comfort: Interaction of thermal, ventilation, construction and assessment factors. Ann Arbor: Ann Arbor Science Publishers, Inc., 1977.

Fanger, P. O. Thermal comfort. New York: McGraw-Hill, 1972.

Fanger, P. O., & Langkilde, G. Interindividual differences in ambient temperatures preferred by seated persons. ASHRAE Transactions, 1975, 81, 140-147.

Fonesca, G. F. Heat transfer properties of ten underwear-outerwear ensembles. Textile Research Journal, 1970, 40, 553-558.

Fourt, L., & Hollies, N. R. S. Clothing: Comfort and function. New York: Marcel Dekker, Inc., 1970.

Fundamental of comfort. Clothes, April 15, 1975, 68-69.

Fuzek, J. F., & Ammons, R. L. Techniques for subjective assessment of comfort in fabric and garments. In N. R. S. Hollies & R. F. Goldman (Eds.). Clothing comfort: Interaction of thermal, ventilation, construction and assessment factors. Ann Arbor: Ann Arbor Science Publishers, Inc., 1977.

Gagge, A. P., Nishi, Y., & Nevins, P. G. The role of clothing in meeting FEA energy conservation guidelines. ASHRAE Transactions, 1977, 82, 234-247.

Gagge, A. P., Stolwijk, J. A. J., & Hardy, J. D. Comfort and thermal sensations and associated physiological responses at various ambient temperatures. Environmental Research, 1967, 1, 1-20.

Gagge, A. P., Stolwijk, J. A. J., & Nishi, Y. An effective temperature scale based on a simple model of human physiology. ASHRAE Transactions, 1971, 77, 247-262.

Gagge, A. P., Stolwijk, J. A. J., & Saltin, B. Comfort and thermal sensations and associated physiological responses during exercise at various ambient temperatures. Environmental Research, 1969, 2, 209-229.

Goldman, R. F. Thermal comfort factors: Concepts and definitions. In N. R. S. Hollies & R. F. Goldman (Eds.). Clothing comfort: Interaction of thermal, ventilation, construction and assessment factors. Ann Arbor: Ann Arbor Science Publishers, Inc., 1977.

Gonzalez, R. R., & Nishi, Y. Effect of cool environments on local thermal sensation, discomfort and clothing selection. ASHRAE Transactions, 176, 82, 76-86.

Greenway, K. An investigation of the physical characteristics affecting fabric hand. Unpublished masters thesis, University of Tennessee, 1977.

Greenwood, K., The language of comfort. Paper presented at the Third Shirley Institute International Seminar, Manchester, Eng., 1971.

Hardy, H. B. Jr., Ballou, J. W., & Wetmore, O. C. The prediction of equilibrium thermal comfort from physical data on fabrics. Textile Research Journal, 1953, 23, 1-10.

Hardy, J. D. Heat transfer. In L. H. Newburgh (Ed.). Physiology of heat regulation and the science of clothing. New York: Hafner Publishing Co., Inc., 1949.

Hardy, J. D. Thermal comfort and health. ASHRAE Journal, Feb., 1971, 43-51.

Helwig, J. T., & Council, K. A. SAS user's guide, 1979 edition. Raleigh, N. C.: SAS Institute, Inc., 1979.

Hogan, M. J. Changing our energy behavior. Journal of Home Economics, 1978, 70 (3), 18-21.

Hollies, N. R. S. The comfort characteristics of next-to-skin garments, including shirts. Paper presented at the Third Shirley Institute International Seminar, Manchester, Eng., 1971

Hollies, N. R. S. Fundamental aspects of comfort in clothing. Paper presented at a seminar at the School of Continuing Education, Tennessee State University, Johnson City, Sept., 1976.

Hollies, N. R. S. Psychological scaling in comfort assessment. In N. R. S. Hollies & R. F. Goldman (Eds.). Clothing comfort: Interaction of thermal, ventilation, construction and assessment factors. Ann Arbor: Ann Arbor Publishers, Inc., 1977.

Hollies, N. R. S., Bogaty, H., Hintermaier, J. C., & Harris, M. The nature of a fabric surface: Evaluation by a rate-of-cooling method. Textile Research Journal, 1953, 23, 763-769.

Hollies, N. R. S., Custer, A. G., Morin, C. J., & Howard, M. E. A human perception analysis approach to clothing comfort. Textile Research Journal, 1979, 49, 557-564.

Humphrey, M. A. Study of the thermal comfort of primary school children in summer. Building Research Establishment, Garston, Watford, U. K., 1978. (World Textile Abstracts, 1978, 10, 6569.)

Kemp, S. The consumer's requirements for comfort. Paper presented at the Third Shirley Institute International Seminar, Manchester, Eng., 1971

Kerslake, D. M. Physiological aspects of comfort. Paper presented at the Third Shirley Institute International Seminar, Manchester, Eng., 1971.

Koenig, H. E. Energy conservation: Imperative and opportunity. Paper presented at the Clothing and Energy Resources Workshop, Michigan State University. East Lansing, Mich., 1978.

Latta, B. M. Comfort finishing of synthetic fabrics. In N. R. S. Hollies & R. F. Goldman (Eds.). Clothing comfort: Interaction of thermal, ventilation, construction and assessment factors. Ann Arbor: Ann Arbor Science Publishers, Inc., 1977.

LeBlanc, J. Man in the Cold. Springfield, Ill.: Charles C. Thomas, 1975.

Lee, D. H. K. Physiological objectives in hot weather housing. Washington, D. C.: U.S. Housing and Home Finance Agency, 1953.

Long underwear: A personal way to save energy. Consumer Reports, 1978, 43 (1), 46-49.

Madsen, T. L. Thermal comfort measurements. ASHRAE Transactions, 1976, 82, 60-75.

McIntyre, D. A. Determination of individual preferred temperatures. ASHRAE Transactions, 1976, 82, 219-233.

McNall, P. E. Jr., & Biddison, R. E. Thermal comfort sensations of sedentary persons exposed to asymmetric radiant fields. ASHRAE Transactions, 1970, 76, 123-236.

Mecheels, J. Concomitant heat and moisture transmission properties of textiles. Papter presented at the Third Shirley Institute International Seminar, Manchester, Eng., 1971.

Mecheels, J., & Umbach, K. H. Thermophysiological properties of clothing systems. Melliand Textiber, International (English Ed.), 1976, 5, 1142-1146.

Mehrtens, D. G., & McAlister, K. C. Fiber properties responsible for garment comfort. Textile Research Journal, 1962, 32, 658-664.

Meier, R. L. Science and economic development: New patterns of living (2nd. ed.). Cambridge: The M. I. T. Press, 1966

Middleburg, P. H. Some observations on the relations between physiological criteria for clothing and some individual human factors. Journal of the Textile Institute, 1979, 9, 411-412.

Miller, J. A. Wearing the right clos. Science News, 1980, 117, 396-397.

Morrison, B. M., & Gladhart, P. M. Energy and families: The crisis and the response. Journal of Home Economics, 1976, 68 (1), 15-18.

Nevins, R. G., Gonzalez, R. R., Nishi, Y., & Gagge, A. P. Effect of changes in ambient temperature and level of humidity on comfort and thermal sensations. ASHRAE Transactions, 1975, 81, 169-182.

Nevins, R. G., & McNall, P. E. Jr. Proposed classification of human response to the environment. ASHRAE Journal, June, 1971, 44-47.

Nevins, R. G., Rohles, F. H. Jr., Springer, W., & Feyerherm, A. M. Temperature-humidity chart for thermal comfort of seated persons. ASHRAE Transactions, 1966, 72, 283-291.

Nishi, Y., Gonzalez, R. R., &. Gagge, A. P. Direct measurement of clothing heat transfer properties during sensible and insensible heat exchange with thermal environmental. ASHRAE Transactions, 1975, 81, 183-199.

Nishi, Y., Gonzalez, R. R., Nevins, R. G., & Gagge, A. P. Field measurement of clothing thermal insulation. ASHRAE Transactions, 1976, 82, 248-259.

Paolucci, B. (Moderator) Forum on energy and the family: Discussion by the participants. Journal of Home Economics, 1976, 68 (1), 6-14.

Peplar, R. D. The thermal comfort of students in climate controlled and non-climate controlled schools. ASHRAE Transactions, 1972, 78, 97-109.

Porter, T., & Mikellides, B. Color for architecture. New York: Van Nostrand Reinhold Co., 1976.

Psychology Today Newspapter Enterprise Association. You think you're hot? It's all psychological. Knoxville News-Sentinel, July 23, 1980.

Random House dictionary of the English language, the unabridged edition. New York: Random House, Inc., 1966.

Rees, W. H. Physical factors determining the comfort appearance of textiles. Paper presented at the Third Shirley Institute International Seminar, Manchester, Eng., 1971.

Renbourn, E. T. The psychology of clothing with materials in mind. Paper presented at the Third Shirley Institute International Seminar, Manchester, Eng., 1971.

Rohles, F. H. Jr. Environmental psychology: A bucket of worms. Psychology Today, 1967, 1 (2), 54-63.

Rohles, F. H. Jr. The modal comfort envelope. ASHRAE Transactions, 1970, 76, 308-317.

Rohles, F. H. Jr. Psychological aspects of thermal comfort. ASHARE Journal, Jan., 1971, 86-90.

Rohles, F. H. Jr. The measurement and prediction of thermal comfort ASHRAE Transactions, 1974, 80, 98-114.

Rohles, F. H. Jr. Comfort and the man-environment system. Paper presented at the Clothing and Energy Resources Workshop, Michigan State University, East Lansing, Mich., 1978.

Rohles, F. R. Jr., Hayter, R. B., & Berglund, L. G. Comfort and cold and warm discomfort during summer and winter in Northern and Southern United States. ASHRAE Transactions, 1975, 81, 146-156.

Rohles, F. H. Jr., & Johnson, M. A. Thermal comfort in the elderly. ASHARE Transactions, 1972, 78, 131-137.

Rohles, F. H. Jr., & Nevins, R. G. The nature of thermal comfort for sedentary man. ASHRAE Transactions, 1971, 77, 239-246.

Rohles, F. H. Jr., Woods, J. E., & Nevins, R. G. The effects of air movement and temperature on the thermal sensations of sedentary man. ASHRAE Transactions, 1974, 80, 101-119.

Rudd, N. N. Energy use: The need for research. Journal of Home Economics, 1978, 70 (5), 24-26.

Rudd, N. N., & Lonstreth, M. Strategies for energy conservation. Journal of Home Economics, 1978, 70 (3), 40-43.

Ryan, M. S. Clothing: A study in human behavior. New York: Holt, Rinehart & Winston, Inc., 1966.

Scruggs, B. J. Laboratory measurement and evaluation of thermal and selected comfort and durability properties of twelve textile fabrics intended for indoor winter wear with lowered temperatures. Paper presented at the Central Region Annual Conference of the Association of College Professors of Textiles and Clothing. Columbus, Ohio, 1979.

Seppanen, O., McNall, P. E., Munson, D. M., & Sprague, C. H. Thermal insulating values for typical indoor clothing ensembles. ASHRAE Transactions, 1972, 78, 120-130.

Shapiro, S. S., & Wilk, M. B. An analysis of variance test for normality. Biometrika, 1965, 52, 591-611.

Spencer-Smith, J. L. The physical basis of clothing comfort, part 1. General review. Clothing Research Journal, 1976, 4 (3), 126-238.

Spencer-Smith, J. L. The physical basis of clothing comfort, part 2. Heat transfer through dry clothing assemblies. Clothing Research Journal, 1977, 5 (1), 3-17.

Sprague, C. H., & McNall, P. E. Jr. The effects of fluctuating temperature and relative humidity on the thermal sensation (thermal comfort) of sedentary subjects. ASHRAE Transactions, 1970, 76, 146-156.

Sprague, C. H., & Munson, D. M. A composite method for estimating thermal insulating values of clothing. ASHRAE Transactions, 1974, 80, 120-129.

Steadman, R. G. Keeping warm and saving energy. Paper presented at the Western Region Annual Conference of the Association of College Professors of Textiles and Clothing. Denver, Colo. 1979.

Terry, D. A preliminary investigation of the physical characteristics affecting fabric hand. Unpublished masters thesis, University of Tennessee, 1977.

Torgerson, W. S. Theory and methods of scaling. New York: John Wiley and Sons, Inc., 1958.

Treolar, L. R. G. Physics of textiles. Physics Today, 1977, 30 (12), 23-30.

Vokac, Z., Kopka, V., & Keul, P. Physiological responses and thermal, humidity, and comfort sensations in wear trials with cotton and polypropylene vests. Textile Research Journal, 1976, 46, 30-38.

Wallenberger, F. T., Franz, K., Dullaghan, N. E. & Schrof, W. E. J. Summer comfort features and fabric performance in next-to-skin fabrics--Wear tests with cotton and Dacron/Orlon fabrics. American Society of Mechanical Engineers publication (Paper No. 78-TEX-5).

Werden, J. E., Fahnstock, M. K., & Galbraith, R. L. Thermal comfort of clothing of varying fiber content. Textile Research Journal, 1959, 24, 640-651.

Woodcock, A. H. Moisture transfer in textile systems. Textile Research Journal, 1962, 32, 719-725

Wyndham, C. H. Adaptation to heat and cold. Environmental Research, 1969, 2, 442-469.

Wyon, D. P. The role of the environment in building today: Thermal aspects (Factors affecting the choice of a suitable room temperature). Build International, 1973, 6, 39-54.

Yaglou, C. P. Thermometry. In L. H. Newburgh (Ed.). Physiology of heat regulation and the science of clothing. New York: Hafner Publishing Co., Inc., 1949.

APPENDICES

APPENDIX A

Address # _____ Interview # _____

1. How is your home heated?

   Ceilheat ___ radiators ___ baseboard ___ fireplace(s) ___

   space heaters ___ wood or coal stove ___ floor furnace(s) ___

   forced air with vents in ceiling ___ upper wall ___

   lower wall ___ other ____________________

2. Does your home have a humidifer? yes ___ no ___

   If yes: Is it for the whole house or just one room? house ____

   room ___ If room: Which room? ____________________

3. What direction does your house face? N ___ S ___ E ___ W ______

4. Does your house have any insulation? Yes ___ No ___

   If yes: Where? attic ___ walls ___ under floor ___

   What kind? fiberglass ___ foamed in ___ rigid foam __

   foam pellets ___ other ________________

   How much? ____________________

5. In the winter what temperature do you usually keep your home during the daytime and evening while you are here? ____________

6. Do you keep all the rooms about the same temperature? Yes __ No __

   If no: What temperature do you keep the room you spend the most time in? __________ Is this the room where you spend most of your time? Yes ___ No ___

   If no: Ask to move to the most used room. Take measurements in that room.

7. In the room you use most (this room) do you usually feel warm, comfortable, or cool? warm ___ comfortable ___ cool ___

8. When you feel cool what do you usually do to warm up? __________

____

9. How do you think you would feel if you kept your home 5 degrees cooler during the day and evening? ____________________

10. What temperature do you keep the house at night when you are in bed? ______________________________

11. At night are you generally warm, comfortable or cool?
warm ___ comfortable ___ cool ___

12. How do you think you would feel if you kept your home 5 degrees cooler at night? ______________________________

13. Please describe the clothes you are wearing now and tell me what they are made of if you can. This check sheet will help you. We can just circle the clothing and write in what it's made of.

14. Are these the kinds of clothes you usually wear around the house? Yes ___ No ___ If no: Would you describe what you usually wear on this second sheet?

15. What other kinds of clothing are you comfortable in at these temperatures besides the ones you have already told me about? (Use check sheets as needed.)

16. What one item of clothing do you think would add the most warmth if you had to live in a cooler home? ____________________

17. How do you describe clothes that are comfortable? warm ___
cool ___ soft ___ fuzzy ___ smooth ___ snug ___ loose ___
other ______________________________

18. What do you usually do during the winter in this room (the room

you use the most)? watch TV ___ play cards, etc. ___ study ___ read ___ sew, etc. ___ cook ___ clean ___ dance ___ have hobby: name ________________ other __________________________

These last three questions are very personal. Please answer them only if you really want to.

19. Do you know if you have high blood pressure? Yes ___ No ___ ? ___ Low blood pressure? Yes ___ No ___ ? ___

20. Do you know your exact body temperature? ____________________

21. Please check your age category:

12-18 ___

19-24 ___

25-34 ___

35-44 ___

45-54 ___

55-64 ___

65-74 ___

75&up ___

CLOTHING DESCRIPTION
CHECK SHEET

Address # _____ Interview # _____

Sheet # _____

Clothing	What it's made of
Shirt or Blouse sleeveless short sleeves long sleeves V or U neck turtle or cowl neck with a tie light weight heavy weight	
Sweaters sleeveless short sleeves long sleeves V or U neck turtle neck open cardigan light weight heavy weight	
Vest light weight heavy weight	
Jacket light weight heavy weight buttoned up open	
Pants shorts knee length long light weight heavy weight	
Robe or Dress V or U neck high neck light weight heavy weight sleeveless short sleeves long sleeves above knee knee length below knee ankle length	

Clothing	What it's made of
<u>Socks or Hose</u> low-cut ankle length knee length panty hose tights leg warmers light weight heavy weight	
<u>Underwear</u> <u>Top</u> tank or camisole "T" long sleeved "T" regular weight thermal weight <u>Bottom</u> short knee length ankle length regular weight thermal weight <u>Other</u> half slip full slip ankle length bra girdle	
<u>Shoes</u> <u>Indoor</u> open back slippers boots thongs cloth quilted cloth plastic leather fur <u>Outdoor</u> sandals pumps oxfords loafers clogs cloth plastic leather fur	
<u>Other</u> afghan Snugsack blanket	

Address # ____

OBSERVATIONS

1. Dry bulb temp. ___ Wet bulb temp. ___ Air movement ___

___	___	___
___	___	___
___	___	___

2. Location of room in the house: interior ___ corner ___

   3 sides open ___

3. Majority of windows face: N ___ S ___ E ___ W ___

4. Approx. size of room: length ___ width ___ ceiling height ___

   Flooring: smooth ___ carpet ___

5. Furnishings: sofa(s) ___ chairs ___ tables ___

   lamps ___ other ______________________

Address #	Interview #	Male	Female	Underwt.	Average	Heavy	Obese

APPENDIX B

THE UNIVERSITY OF TENNESSEE
KNOXVILLE
COLLEGE OF HOME ECONOMICS

DEPARTMENT OF TEXTILES AND CLOTHING

February, 1980

You have an opportunity to take part in a study about clothing comfort in the winter. Only 60 families in the Knoxville area will be selected to be a part of this study.

As energy costs go up and saving energy is encouraged, the temperatures we use in our homes are likely to be cooler than in the past. If families can be helped to choose clothing that keeps them warm at cool indoor temperatures they can save more energy and keep heating bills down. In addition to helping families in the Knoxville area, the results of this study can be used to help families all over the country. In order to help families select warmer clothing it is important to know a few things about how they are living now.

We hope you will be interested in this study and be willing to help. We would like to come to your home to ask you some questions about the clothing you usually wear at home. We also need to know what your normal activities are while you are at home because the kind of clothing needed for comfort depends partly on how active you are.

Some other things that affect comfort are the temperature of the room, the humidity of the air, and whether or not the air is moving. If you help with the study these things will be measured in the room where you are being interviewed. You will also be asked a few questions about your home and yourself that are important for us to know in order to help other families.

Any and all members of your household over 12 years of age who are not sick may be a part of this study if they are interested. Each person may decide to help or not, as they wish. Even if you or a member of your household has agreed to be in the study you may change your mind at any time and withdraw from the study.

If you agree to help, any and all information you give us will be kept confidential. No one will be able to find out how you answered any of the questions. Also, you will be sent a summary of the study with suggestions for choosing clothing that will keep you the warmest.

We will appreciate your help in this study. Within the next few days we will telephone to talk with you about being in the study.

Sincerely,

B. C. Goswami
B. C. Goswami
Associate Professor
Textiles and Clothing

Ann Vanderpoorten
Ann Vanderpoorten
Doctoral Student
Home Economics

APPENDIX C

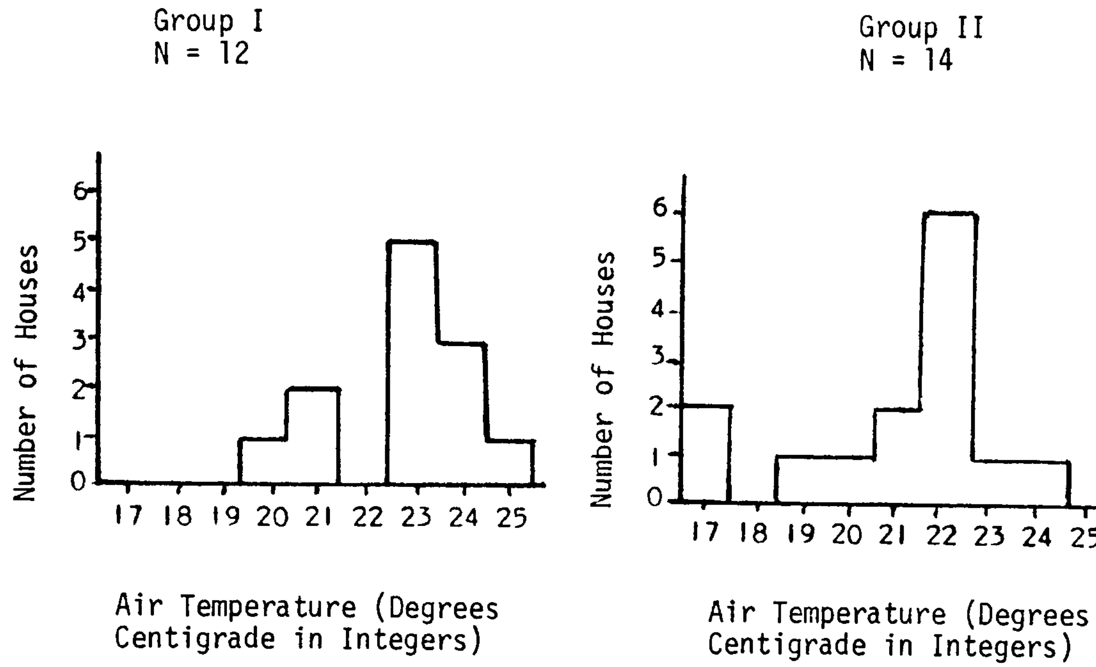

FIGURE 2. Distribution of Air (Dry Bulb) Temperatures in Group I and Group II Households

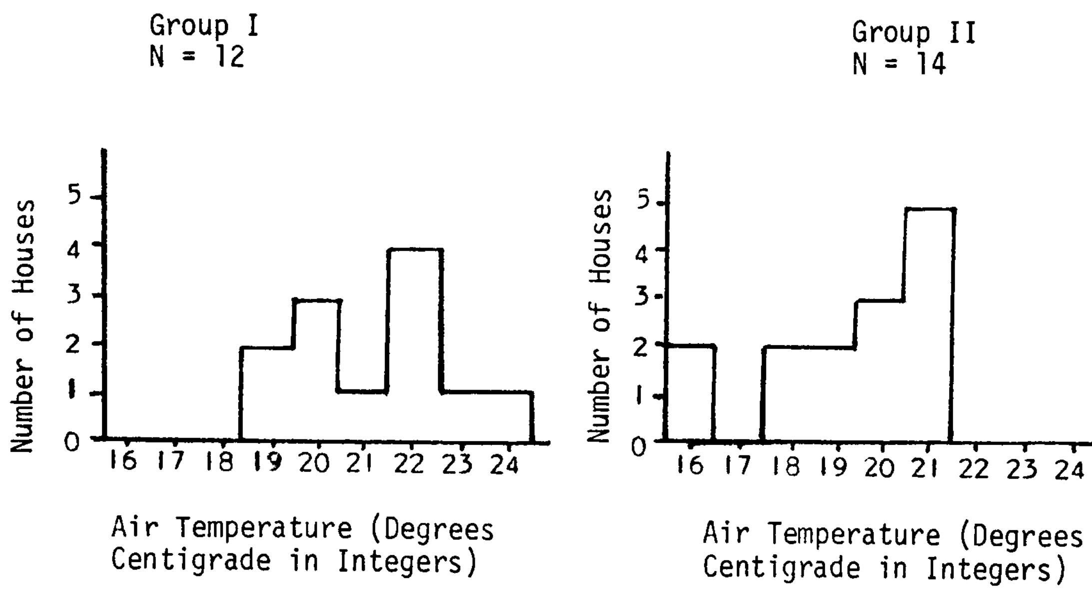

FIGURE 3. Distribution of Estimated Usual Room Temperatures for Group I and Group II Households

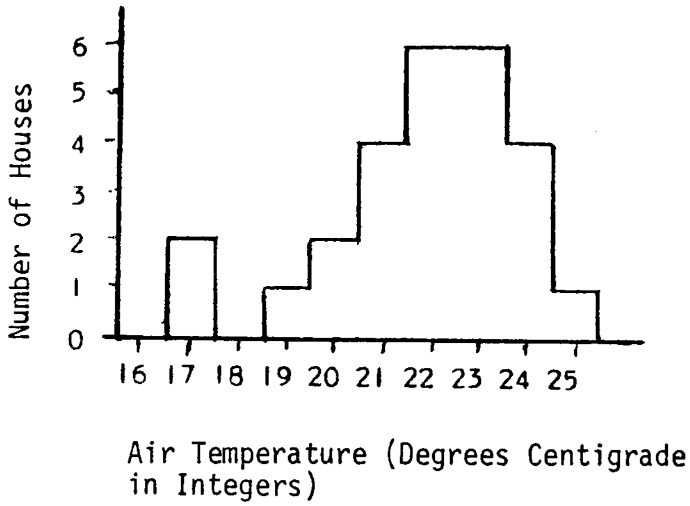

FIGURE 4. Distribution of Households by Air (Dry Bulb) Temperatures

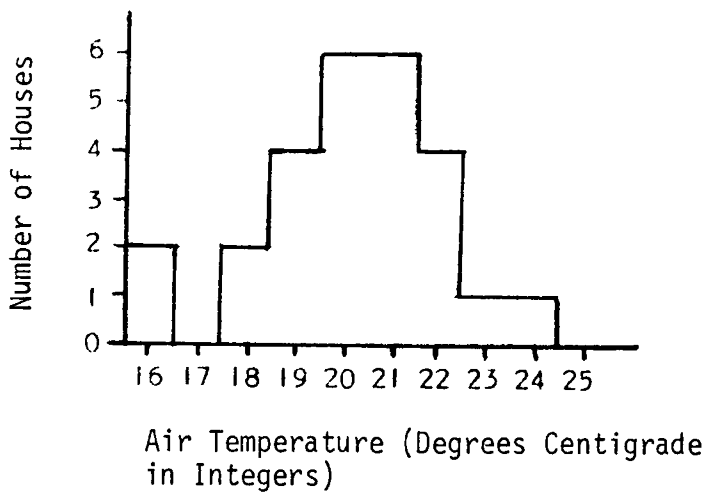

FIGURE 5. Distribution of Households by Estimated Usual Room Temperatures

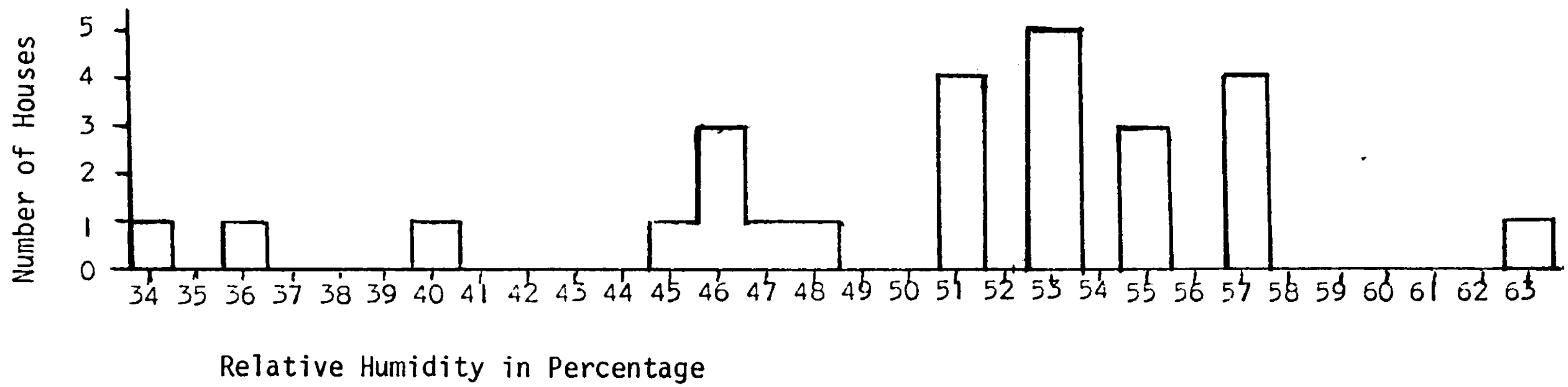

FIGURE 6. Distribution of Households by Relative Humidity

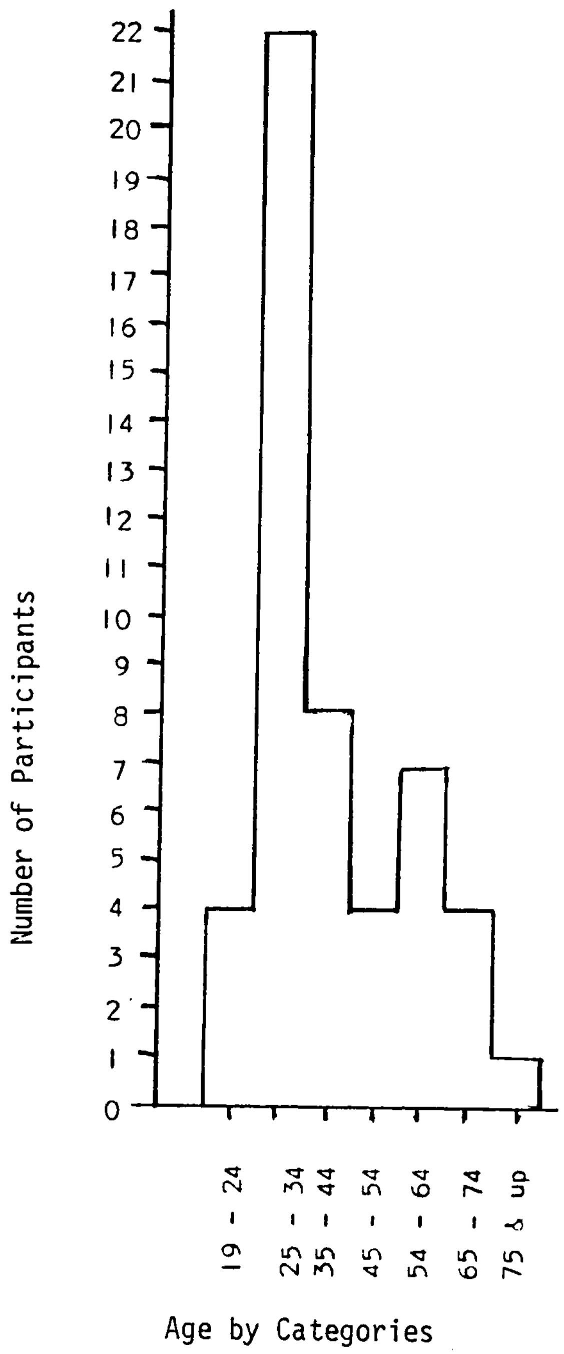

FIGURE 7. Distribution of Participants by Age Category

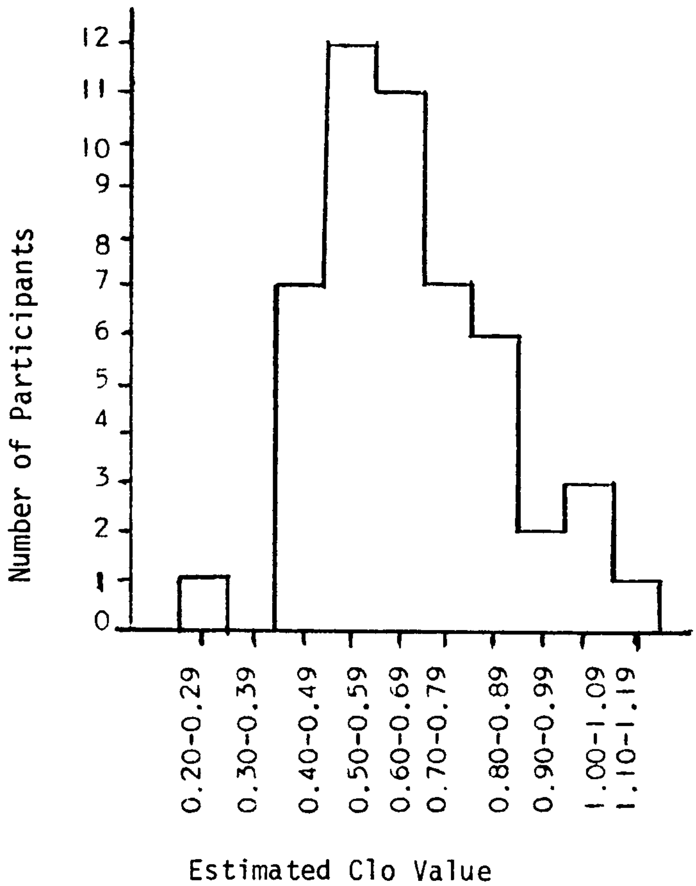

FIGURE 8. Distribution of Participants by Estimated Clo Values for Clothing Worn during the Interviews

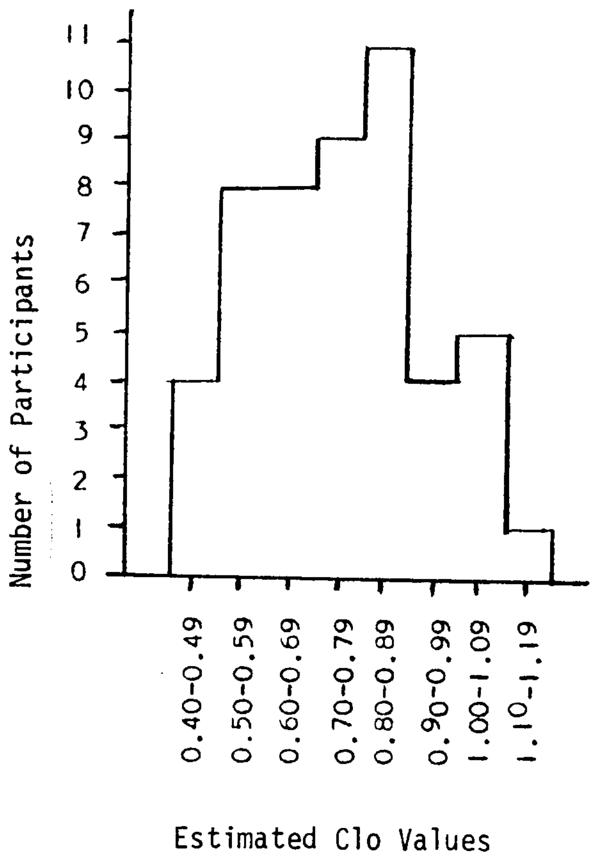

FIGURE 9. Distribution of Participants by Estimated Clo Values of Ordinarily Worn Clothing

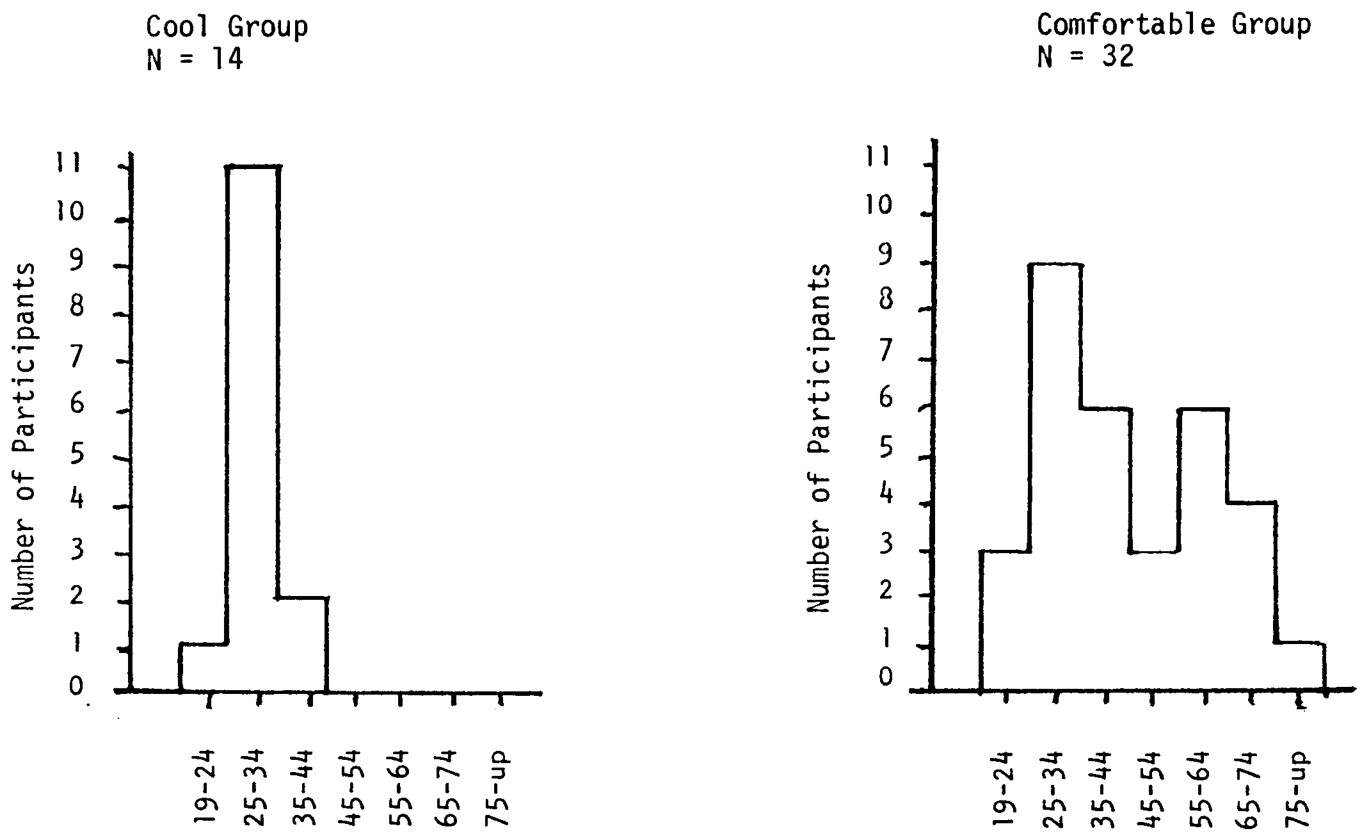

FIGURE 10. Distribution of Participants by Age Categories--Participants Grouped by Perception of Thermal Comfort at Usually Existing Conditions

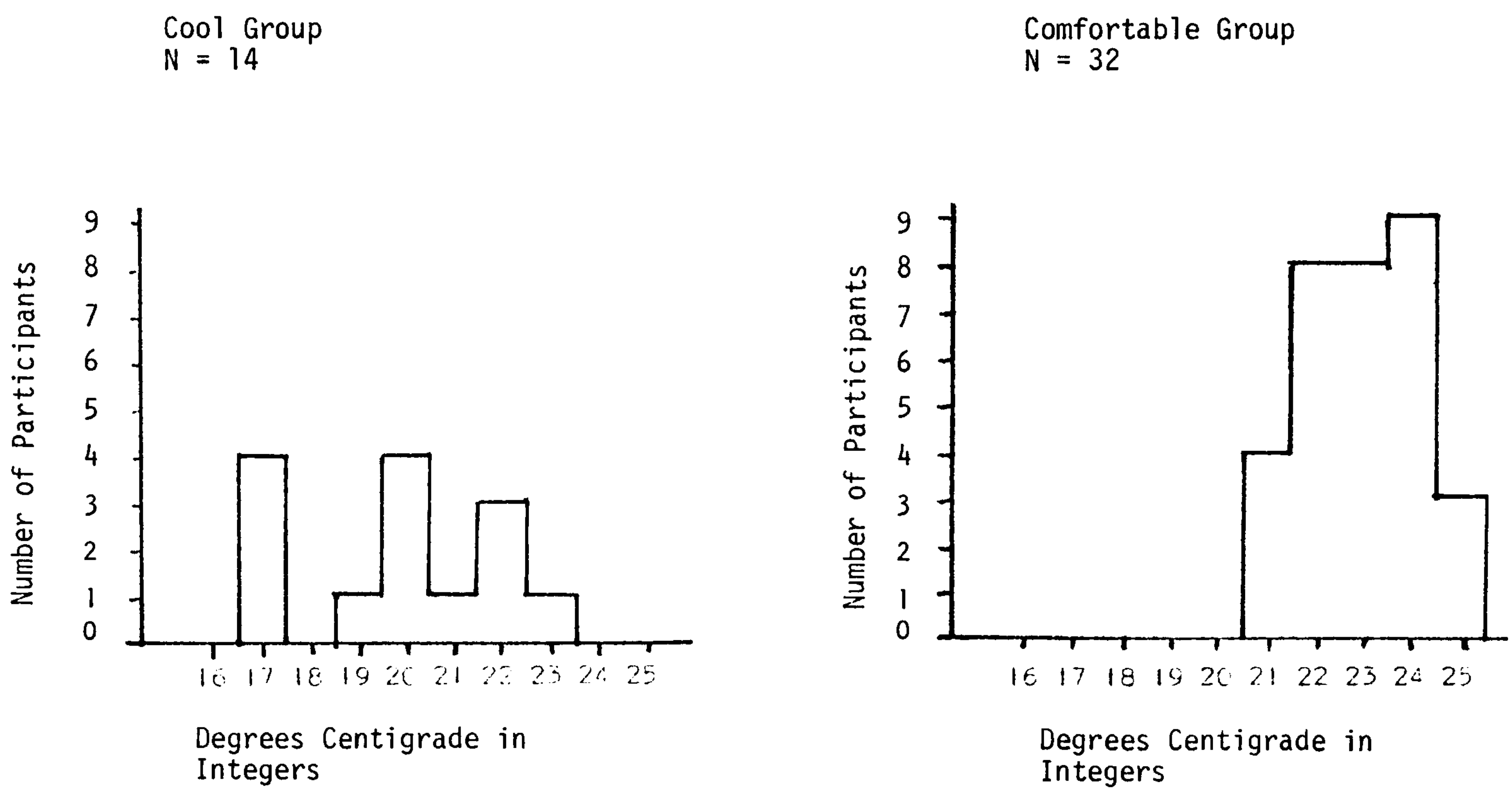

FIGURE 11. Distribution of Participants by Air (Dry Bulb) Temperature--Participants Grouped by Perception of Thermal Comfort at Usually Existing Conditions

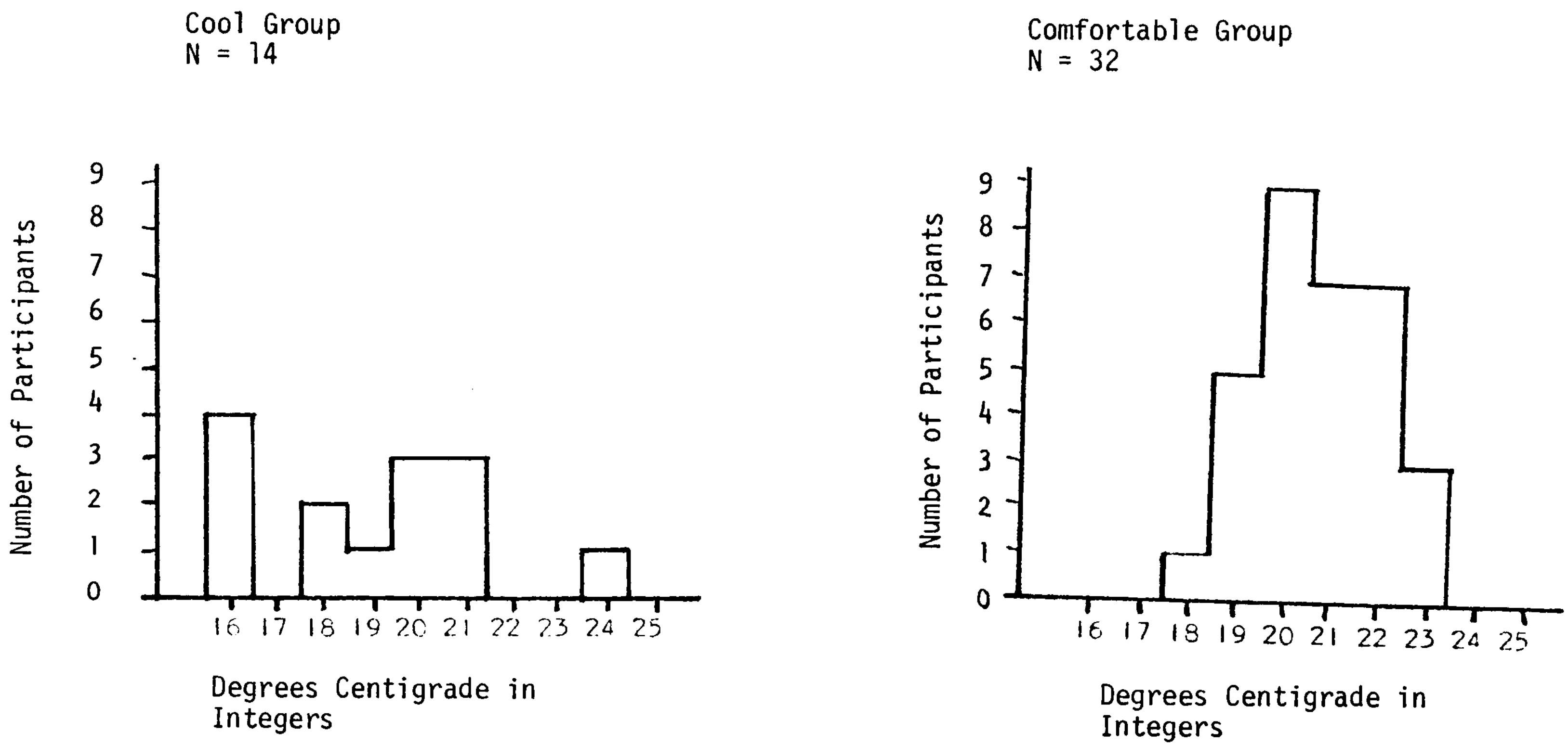

FIGURE 12. Distribution of Participants by Estimated Usual Room Temperatures--Participants Grouped by Perception of Thermal Comfort at Usually Existing Conditions

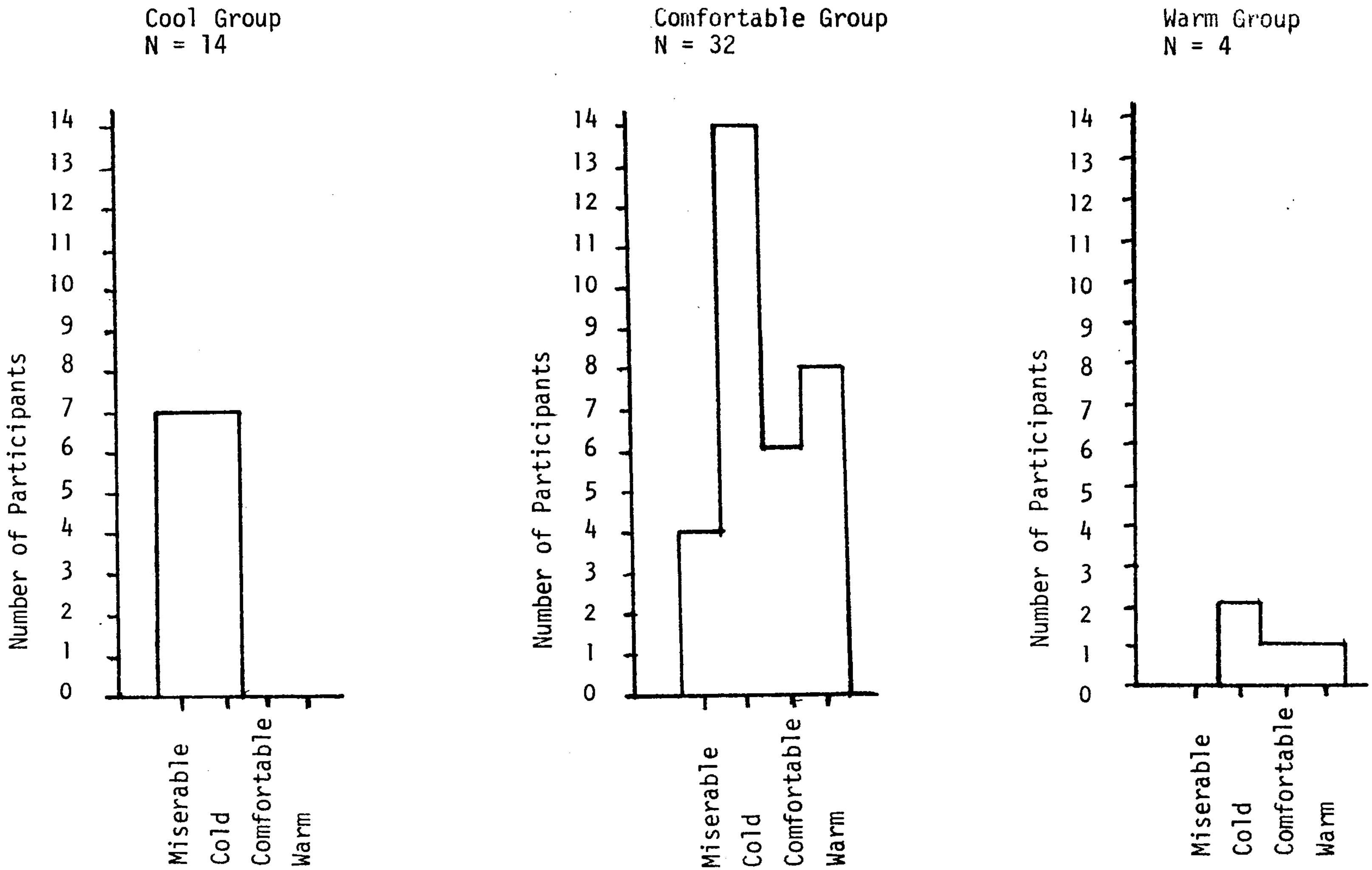

FIGURE 13. Distribution of Participants by Perception of Thermal Comfort at 5° F Cooler Than Usually Existing Conditions--Participants Grouped by Perception of Thermal Comfort at Existing Conditions

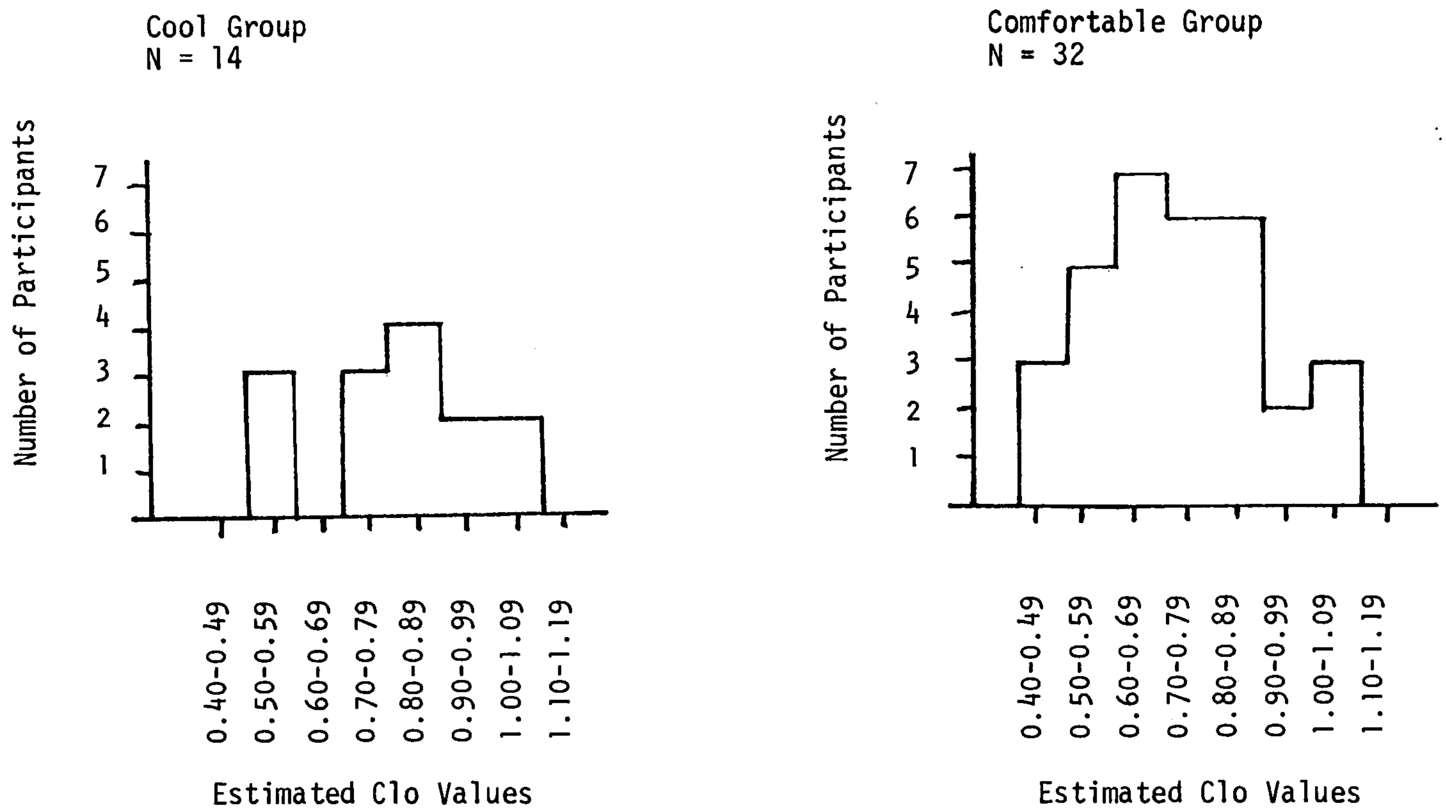

FIGURE 14. Distribution of Participants by Estimated Clo Values of Ordinarily Worn Clothing--Participants Grouped by Perception of Thermal Comfort in Usually Existing Conditions

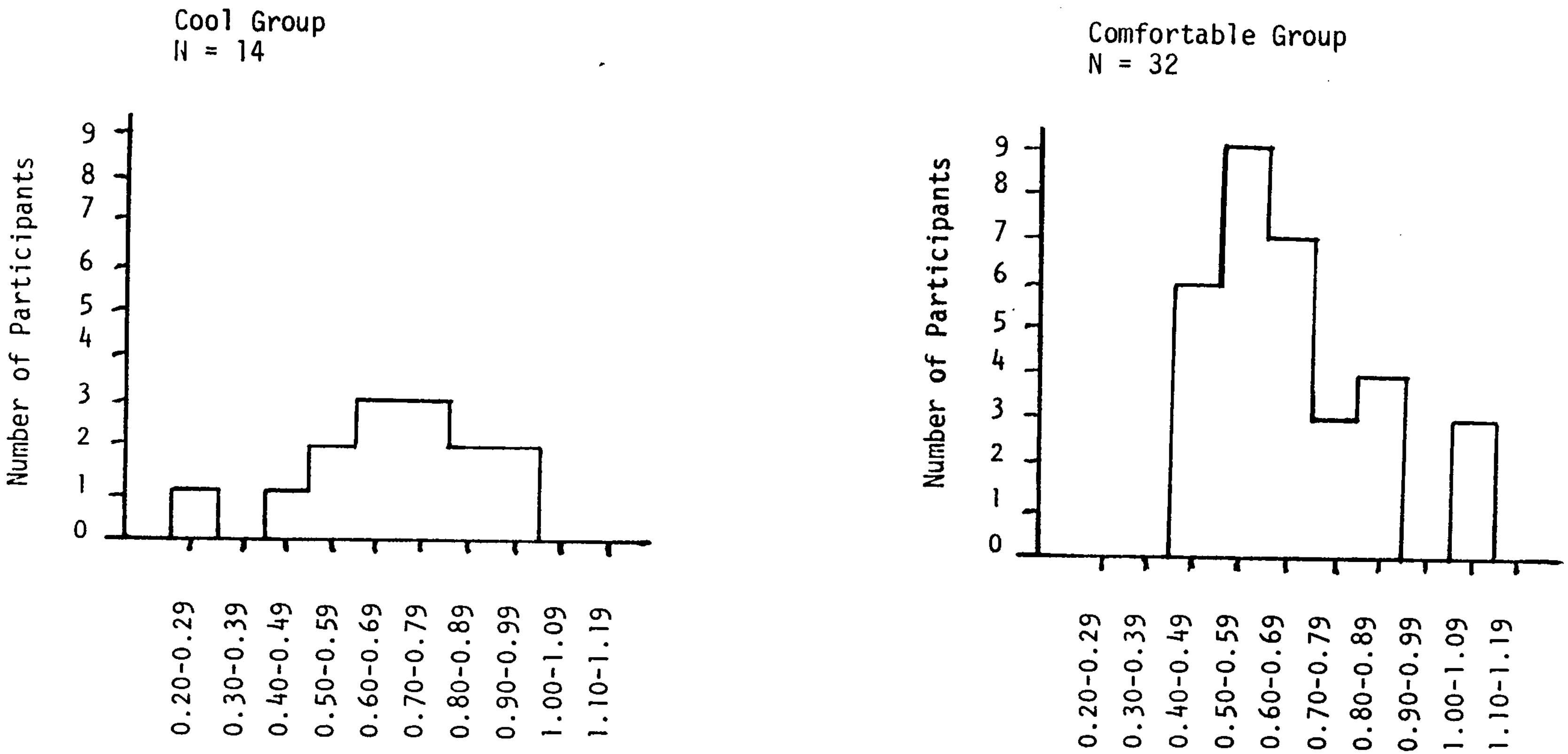

FIGURE 15. Distribution of Participants by Estimated Clo Values for Clothing Worn During the Interview--Participants Grouped by Perception of Thermal Comfort in Usually Existing Conditions

TABLE 9

CHI SQUARE TEST FOR PROBABILITY OF RELATIONSHIPS AMONG SELECTED VARIABLES

	Perception of Thermal Comfort in Existing Conditions	Sex	Body Type	Blood Pressure	Body Temperature	Age Category[2]	Clo Value Clothing Worn During Interview	Clo Value Clothing Ordinarily Worn	Response to Cold	Perception of Thermal Comfort at 5° F Cooler	Air (Dry Bulb) Temperature Category	Estimated Usual Air Temperature Category	Air Movement in Heating System
Sex	2.21												
Body Type	0.33	0.66											
Blood Pressure	4.46[a]	1.28	9.98*										
Body Temperature	0.87	4.07	5.10	1.72									
Age Category[2]	9.93**	----	2.26	22.95***	2.66								
Clo Value--Clothing Worn During Interview	3.70*	2.23	3.09	3.07	1.23	1.28							
Clo Value--Clothing Ordinarily Worn	1.64	0.09	5.48[a]	1.67	3.42	1.95	13.52***						
Response to Cold	1.40	9.95**	2.07	4.39	2.38	3.16	5.28[a]	8.34*					
Perception of Thermal Comfort at 5° F Cooler	11.94**	0.76	2.50	5.12	6.99	6.69	9.30*	2.26	7.59				
Air (Dry Bulb) Temperature Category	10.27**	1.21	0.26	2.69	3.16	15.15***	1.28	8.01**	0.97	4.47			
Estimated Usual Air Temperature Category	4.49*	0.01	0.45	3.47	0.71	4.19	0.08	6.52**	4.19	1.85	5.06*		
Air Movement in Heating System	6.06**	----	----	----	----	6.16*	0.32	0.32	0.78	4.44	4.12*	3.18*	
Relative Humidity Category	0.00	----	----	----	----	----	2.00	0.72	3.48	0.74	1.28	----	0.00

N = 50 except where noted.
[1]Data for "warm" responses omitted; N = 46.
[2]Age Categories condensed to three categories.

[a]$p < 0.10$
*$p < 0.05$
**$p < 0.01$
***$p < 0.001$

APPENDIX D

TABLE 10

WORDS USED TO DESCRIBE COMFORTABLE CLOTHING

Descriptive Word	Times Named
Soft	38
Loose fit, moderately loose	30
Feels warm	17
Smooth but not silky	13
Fleecy, fuzzy, fluffy, high loft	12
Snug, moderately snug	10
Thick fabric, bulky, heavy	9
Cotton	9
Layers of clothing	5
Not scratchy, not wool, doesn't itch	5
Stretchy, non-binding, gives with movement	5
Casual	4
Fits well	4
Wool, wooly, furry	4
Polyester	3

SAMPLES OF UNSOLICITED COMMENTS

FROM RESPONDENTS

When I'm too cold I go stand by the fireplace for a few minutes and drink hot tea.

I feel cool at this temperature but I prefer feeling cool. It keeps me alert.

I'm very comfortable at this temperature. I hardly ever turn the heat higher than this. (Air temperature was 75 F.) You see, I always sit on this heating pad for my back.

If someone could just invent a way to keep feet warm we could all keep our houses cooler.

When I feel too cool I wrap up in my electric blanket.

We keep the thermostat set on 55 but our apartment stays warm from the Ceilheat in the apartment below. (Air temperature was 77 F.)

I like lots of variety in my clothes. Sometimes I wear a T-shirt and shorts, sometimes I wear wool pants and a flannel shirt, but I always feel comfortable.

VITA

Ann Vanderpoorten was born in Little Rock, Arkansas. After graduation from Hot Springs High School, Hot Springs, Arkansas she went on to complete the Bachelor of Science degree in Zoology from the University of Arkansas. She later graduated with high honors with a Bachelor of Science degree in Home Economics from the University of Arkansas. Her Master of Science degree was awarded in 1973 from Texas Tech University in Clothing and Textiles after completion of the master's thesis "Pattern Alteration: A Comparison of Two Methods of Effectiveness of Fit and Attainment of Skill by Students in Beginning Construction."

In the fall of 1978, she entered the interdisciplinary doctoral program in Home Economics at The University of Tennessee. The Ph.D. degree was awarded in December, 1981. Her major areas of study at the doctoral level were textiles and clothing, interior design, and educational curriculum and instruction.

After receiving her M.S. degree, she accepted a position as clothing specialist with the Texas Agricultural Extension Service. She returned to that position in 1980. She held both research and teaching assistantships at Texas Tech University and teaching assistantships at The University of Tennessee. In addition, she has worked as a residence hall counselor at both Texas Tech University and the University of Arkansas, Director of Adult Activities for the YWCA in Tulsa, Oklahoma, and Director of Youth Activities for the YWCA in Hot Springs, Arkansas.

She is a member of American Home Economics Association, Association of College Professors of Textiles and Clothing, Omicron Nu, Phi Upsilon Omicron, and Epsilon Sigma Phi.