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Determination of the Thermoneutral Zone in Young Males and Females

by

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DETERMINATION OF THE THERMONEUTRAL ZONE IN YOUNG MALES AND FEMALES

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To determine the thermoneutral zone (TNZ) in young men and women, 14 women and 6 men between the ages of 18 and 37 were studied. Rectal temperature, skin temperature (seven sites), heart rate, blood pressure, VO2 (ml/kg/min), and a perceived comfort index were measured while resting for 2 hours in an environmental room. Subjects were exposed to 7 different air temperatures ranging from 15 to 36°C. Values for the measurements were observed at each temperature. The estimated thermoneutral zone (TNZ) for the males in this study ranged between approximately 27 and 30°C and for the females between 26 and 31.5°C.

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CHAPTER 1

Introduction

Many animals including humans have a temperature zone in which they are the most comfortable, that is, a range of temperature in which the animal expends the least amount of energy in a thermoregulatory capacity. In this zone, at rest, a scientific assessment of the animal (or man) would result in minimum values for O_2 consumption, and psychological stress. This temperature zone is called the thermoneutral zone (TNZ).

The thermoregulatory mechanism of man tries to maintain his temperature within relatively narrow limits. Man accomplishes this by maintaining a heat balance between the amount of heat produced by basal metabolic heat production, muscular exercise, & digestion, and the amount of heat lost by way of radiation, convection, conduction, and evaporation. By carefully controlling the environmental conditions, it is possible to monitor several physiological variables to determine the TNZ and assess what major mechanisms are used.

The accurate determination of the TNZ requires controlling all environmental conditions. The environmental chamber allows for the control of air movement, air temperature, and humidity. The amount of clothing is standardized. These factors all modify heat loss or gain. The amount of heat gained can be standardized by having the subjects at rest; withholding food three hours prior to the measurement; and permitting no exercise during or three hours prior to testing. To offset circadian rhythm effects on metabolism, the experimental periods can be set for the same time of day. In women, effects of the menstrual cycle can be minimized by eliminating testing times just before, during or just after the menstrual period. Acclimatization can be prevented by allowing several days between testing procedures. Normal healthy individuals were used as subjects during determination of the TNZ.

Purpose of Study:

The primary purpose was to determine the thermoneutral zone (TNZ) of a small group of adult men and women under sixty years of age. This age group was decided upon because a similar study involving older individuals was planned and by this study using younger subjects, a comparison between age groups would be possible.

Significance of Study:

The practical application of this study is its application to working and living environments which are often controlled by man. The artificial control of temperature and other environmental factors are high consumers of energy and represent a considerable financial burden on society. If the thermal comfort zone of man can be established, then the physical, intellectual, and perceptual performance may be maximized in all working, learning, or living areas by creating those environmental conditions. Further, if this thermoneutral zone is established within different age groups, then even greater efficiency would be possible as temperature settings may be set for specific age groups at their optimum performance value. These data can be used to enhance performance and comfort, and conserve on energy and cost. In older individuals this may be increasingly important as the number of people over the age of 65 continues to rise and the amount of available energy supplies decrease.

Procedure:

Twenty (20) subjects, 6 male and 14 female volunteered for the study. A physiological profile was established for each subject which included a determination of percent body fat. Cardiorespiratory fitness was assessed with a submaximal bicycle ergometer test, used by the National YMCA (Golding, et al. 1982) and subjects were found to be above average in fitness level.

Each subject was exposed to seven different air temperatures in an environmental chamber: 15, 20, 25, 27, 30, 33, and 36°C, for a duration of two hours. The physiological parameters assessed during exposure to each air temperature included: heart rate, blood pressure, rectal temperature, rate of oxygen consumption, and skin temperatures at seven different sites. A psychological assessment of perceived comfort was also evaluated. These measurements evaluated the thermoregulatory mechanisms and established the thermoneutral zone.

Limitations and Assumptions:

Due to the time requirements for the subjects, recruiting of volunteers was difficult. Only twenty subjects of the original 30 tested completed all phases of the study.

All studies are limited in scope due to time, facilities, and personnel.

The limitations of this study were:

1. The small number of subjects, especially males (6) limited inferences about the population. Statistics used to show differences due to the sex of the subject lose power when a small sample is used.

2. It was assumed that subjects followed the testing guidelines regarding eating and exercising prior to being tested.

3. All the subjects lived in the dry, hot climate of Las Vegas, Nevada and were assumed to be acclimatized to this local environmental condition. Therefore, the TNZ may vary from individuals conditioned to different

environments.

4. Complete control and standardization of the testing was impossible both in the human subjects and in the research equipment. For example, the individual differences in the subjects amount of body fat and also the level of cardiovascular fitness which are believed to be strong influences in the delicate heat balance mechanism could not be controlled. These differences within the subjects makes it difficult to make inferences about the general population of differences between sexes.

Definitions:

1. Resting metabolic rate (RMR) - metabolism of an individual while in a resting state.

2. Basal metabolic rate (BMR) - metabolism of an individual while in a complete resting, awake, and postabsorbtive state in a thermoneutral environment (more than 8 hours in humans).

3. MET - metabolic rate of an individual at complete rest is one MET.

4. Circadian - time period of about 24 hours.

5. Environmental chamber - room in which temperature, humidity, and air movement are controlled.

6. Dry bulb temperature (db) - temperature of a gas or mixture of gases shielded from radiation.

7. Wet bulb temperature (wb) - temperature recorded

of a aspirated thermometer covered with a wet sleeve.

8. $\dot{V}O_2$ - amount of oxygen picked up by the blood, in the lungs per minute (ml/kg/min).

CHAPTER 2

Review of the Related Literature

The zone of thermoneutrality or the thermoneutral zone (TNZ) is recognized by environmental physiologists as " the range of ambient temperature within which metabolic rate is at a minumum, and within which temperature regulation is achieved by nonevaporative physical processes alone" (Bligh and Johnson, 1973). The TNZ is bounded at it's lower end by the lower critical temperature (LCT), which is defined as "the ambient temperature below which the rate of metabolic heat production of a resting thermoregulating animal increases by shivering and/or nonshivering thermogenic processes to maintain thermal balance" (Bligh and Johnson, 1973). The upper end of the TNZ is called the upper critical temperature (UCT). The UCT is defined as "the ambient temperature above which thermoregulatory evaporative heat loss processes of a resting thermoregulating animal are recruited" (Bligh and Johnson, 1973).

Man is a homeotherm which means he is capable of maintaining his internal body temperature at a relatively constant level, while being exposed to a wide range of environmental conditions. He does this by maintaining a balance between heat production and heat loss. This is expressed by the equation:

$$M = E + Cv + Cd + R + S$$

where:

M = metabolic heat production (heat gain)

E = evaporation (heat necessary to change water from the liquid to the vapor state)

Cv = convective heat transfer (exchange of heat between an object and the current of gas or liquid flowing past)

Cd = conduction (transfer of heat between objects in physical contact)

R = radiation (exchange of heat between objects)

S = heat storage (S=0 at thermal equilibrium)

The amount and the avenue of heat loss is dependent upon ambient temperature. Resting subjects, in a room at 25°C will lose 67% of their heat through radiation and 23% through evaporation. In a hot room of 35°C, however, heat lose through radiation decreases to 4% whereas evaporative loss increases to 90% (Folk, 1974).

Heat loss through convection and conduction are dependent upon:

1) the amount of air or water which flows next to the body;

2) the temperature gradient between the body and that of the circulating air or water;

3) the body surface area exposed or in contact with the

environment;

4) the thermal conductivity of the substances involved; and

5) the density of the body (Wells,1986).

Heat loss through evaporation is dependent upon:

1) the temperature gradient between skin temperature and the environment. (The skin temperature is dependent upon the temperature gradient between the body core temperature and the skin which, in turn, relates to the amount of blood volume, flow, and distribution of blood vessels and how much vasodilation or vasoconstriction is occurring).

2) ambient temperature; and

3) relative humidity (Wells,1986).

Radiation heat loss is dependent upon:

1) the temperature gradient between skin temperature and the environment; and

2) the surface area of the body exposed to the environment (Wells,1986).

In humans, the hypothalamus which is located at the base of the brain stem, acts as a thermostat. One of the functions of the anterior area of the hypothalamus is to control heat loss. This is accomplished through the mechanisms of vasodilation and sweating. A function of the posterior area of the hypothalamus is heat conservation which is accomplished by controlling vasoconstriction and shivering (Wells,1980).

Many studies have attempted to determine the temperature of thermal comfort (Partridge and MacLean (1935), Bedford (1936), Houghten et.al. (1937-1939), Tasker (1938), Rummel et.al. (1939), McConnell and Spiegelman (1940), Chester (1942), Rowley et.al. (1947), Goromosov (1968), Rao (1952), Ellis (1952,1953), Webb (1952-3,1959), Black (1954-55), Hickish (1955), Angus and Brown (1957), Hindmarsh and MacPherson (1962), Snellen (1962), Wyndham (1963), Ballantyne et.al. (1967), Wyon et.al. (1968)). In most of these studies, the amount of clothing and the activity level of the individuals was not documented. The temperature at which thermal comfort of an individual is experienced changes dramatically with clothing and activity. Therefore the practical applications of these studies are limited.

Some psychological studies were completed in an environmental chamber in a laboratory. These are more beneficial because the variables that affect the sensation of thermal comfort are controlled (Houghten and Yaglou (1923,1925), Drysdale (1950), Mom et.al. (1947), Nielsen (1947), Koch et.al. (1960), Fahnestock et.al. (1963,1967)).

In 1966, Nevins et.al. developed a comfort chart (air temperature vs relative humidity) for sedentary people wearing a specific amount and kind of clothing in an environment with a constant air velocity of 0.1 m/s.

McNall et.al.(1967), determined thermal comfort conditions for three different levels of physical activity. These psychological studies developed data for specific conditions.

Several pertinent investigations have determined similar thermal comfort zones. Ladell in 1949, monitoring nude subjects, determined it to be 28-31.6°C for males and 27-32.6°C for females. Ambler (1955) and Rao (1952) determined the thermal comfort zone in lightly clothed subjects to be 26°C. Ellis (1953) found comfort conditions for 57 lightly clothed male and female subjects to be 27°C. Webb's finding in 1959 was 28.9°C for 20 males dressed in shirts, pants, and shoes. Gagge (1967), found comfort conditions to exist for 3 male subjects dressed only in shorts between 28 and 30°C. Fanger (1972) found it to be between 25.5 and 25.7°C for many nude males and females. The psychological determination of the TNZ by finding thermal comfort conditions were assessed in these studies by use of either a comfort scale for which subjects would vote their degree of comfort or a questionnaire from which the subject's answers were analyzed.

Few studies have actually measured the metabolic activity of the subjects and arrived at the TNZ. Erikson (1956), observed a lower critical temperature of the TNZ between 25 and 27°C on 5 male subjects dressed in shorts and shoes. Golding and Yousef (1989), working with 49 similarly dressed (cotton shirt, shorts, and socks) male and female subjects found the TNZ to exist between 28 and 33°C.

Most of the varitability in the temperature findings for the thermal comfort and the thermal neutral zones can be explained due to variations in clothing or the amount of physical movement performed by the subjects.

Temperature Regulation

History. As early as 1764, Tillet (1764), while performing experiments on the effect of high temperatures on insects, had to expose a female lab assistant to temperatures of 112°C. The assistant's job was to read the temperature of an oven from the inside. Human tolerance to extreme temperatures was evidenced by the assistant's ability to continue recording the oven's temperature in spite of the heat to which she was subjected. Surprised by this level of tolerance, Tillet proceeded to expose a dog and cat to the same temperature, but the animals failed to survive. It became apparent that human thermoregulatory mechanisms differed from those of animals and are superior to some animals.

Ben Franklin (1750) noted that his internal body temperature remained normal even in hot weather. He correctly attributed the lack of heat increase in his body to the cooling effect of the evaporation of sweat.

In 1850, when England's expanding colonies included countries located in the tropics, John Davy, an early scientist, recorded several important observations about his own adaptation to the tropical environment. Upon arriving in the tropical climate, Davy noted an increase in his body temperature, an increase in the degree of sweating, and a decrease in the amount of urination. Also of great importance, he observed that dehydration gave rise to higher body temperatures and that physical activity caused increases in both heart rate and internal body temperature when compared to resting values (Davy, 1850).

From environmentally controlled experiments in the early 1900's, British scientists disclosed several important findings. Since humidity was known to have a profound effect on body temperature, Haldane (1905) concluded that the wet bulb temperature was a better indicator of comfort than the dry bulb reading. He also concluded that oral temperatures do not reveal the true body core temperature even though they can be used as an indicator of body temperature. Hunt (1912) found that it is possible to determine the percentage of heat transferred either through radiation or conduction in varying ambient conditions.

Experiments on the effects of cold temperatures on human subjects came later in the 1900's. It was determined that during cold stress, a close correlation between an individual's thickness of surface fat and his/her body insulation value exists (Carlson,et.al.,1958; Keatinge,1960). These studies concluded that body fat can be an indicator of cold tolerance. In general, the greater the fat content, the higher the tolerance.

Individual differences in tolerance to warm and neutral environments was found to vary greatly. Keatinge (1978) found that factors such as sweat rate and vasoconstrictor tone (how constricted the blood carrying vessels remain) contribute to the body's ability to transfer heat.

Heat Transfer. Heat flows from warm to cool temperatures. In the human, this heat transfer is affected by several factors:

1. Body Surface area. The greater the surface area of the body, the more heat that can be transferred.

2. The speed of movement of the environment surrounding the body (liquid or air). During convection, faster moving liquid or air will transfer more heat than slower moving air. Therefore, heat will continually be gained or lost until the temperature of the environment and the human are in equalibrium.

3. The conductive properties of the materials losing and gaining the heat. All material, depending upon its molecular structure, will transfer heat at different rates. A highly dense substance will transfer heat faster than a less dense material. This is illustrated by the use of steering wheel covers. In the summer, the hard dense steering wheel is often hot to the touch unless it is covered by a soft, less dense material.

4. The temperature gradient between the regions of heat transfer. The greater the gradient, the greater the rate of heat transfer.

The human body constantly produces heat through normal metabolic activity. It must gain or lose heat in order to maintain a constant core temperature of approximately 37°C. When there is an excess of core heat, the unclothed body attempts to remove it by the following sequence of events:

1. The heat is transferred from the body core to the skin. Since the skin temperature is usually lower than the core temperature, the heat flows from the core, through the area around the core known as the shell (e.g., muscles, fat), to the skin. This transfer of heat is dependent upon the following factors:

a. The surface area of the body tissue involved and the tissue's conductive properties. The greater the surface area the larger the amount of heat transferred and different tissues exhibit different conductive properties and therefore exchange heat at different rates.

b. The amount of blood flow to the skin. Heat is carried by blood molecules from the core to the skin (blood convection). The greater the movement or volume of blood, the more heat is transferred.

c. The temperature gradient between the core and the skin. The larger the gradient, the greater the heat transfer.

2. The heat is transferred from the skin to the environment. This process is dependent upon the following factors:

a. The temperature gradient between the skin and the environment. Again, the larger the gradient, the greater the transfer.

b. The surface area of the body exposed to the environment. The greater the area of exposure, the greater the transfer.

c. The speed of the environment (liquid or air) as it moves over the skin. An increase in speed is an increase in heat transfer.

d. The conductive and convective properties of the environment. High conductive and convective properties yield greater transfers.

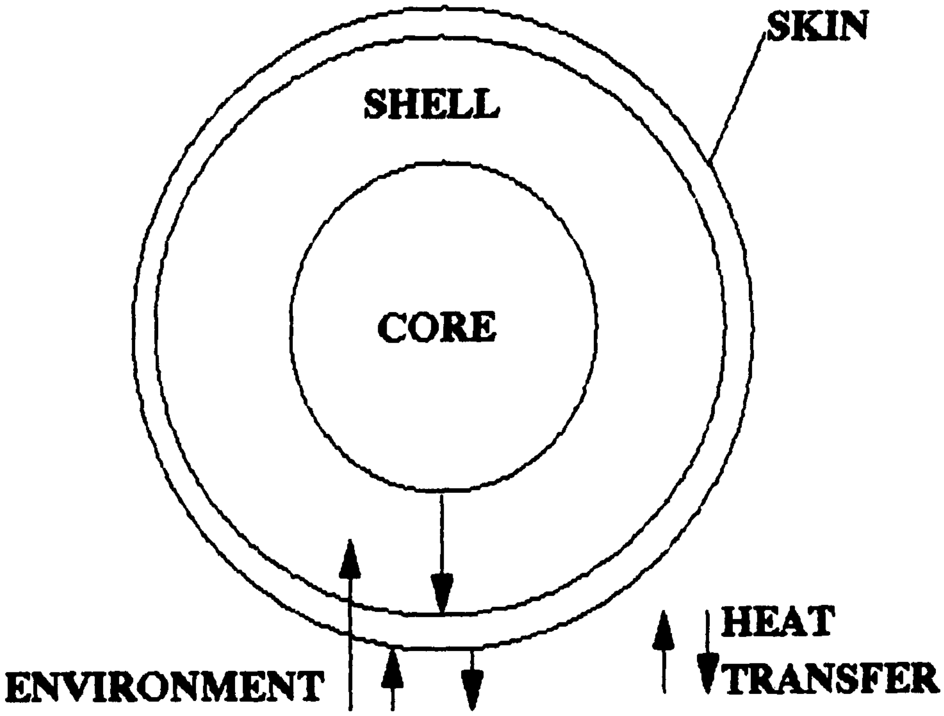
e. The ambient humidity (effects evaporation of sweat). The lower the humidity, the greater the transfer.

Several other factors also affect heat transfer. Heat is transferred 25 times faster by convection in water as opposed to air. Heat flows towards the cooler temperature, so when the environmental temperature is greater than the core temperature (as in desert heat), heat will flow towards the core. Some heat will be absorbed by the skin, but most of this will be lost in the evaporative sweating process, if present. The water in sweat evaporates spontaneously at any temperature above 0°C. For every one ml of water evaporated, 0.580 kcals of heat (energy) are lost; as energy is required to change a liquid into a gas. This heat loss is known as the latent heat of vaporization. Heat exchange from the body core to the environment is presented in diagram form in Fig.1.

For every layer of clothing or shelter from the environment, an additional step in the transfer of heat is required. Any clothing will act as a layer of insulation from the core (in the same manner as the skin). Heat transfer, in this situation, also depends upon the temperature gradient, amount of air movement, the surface area covered, and humidity.

If the heat loss from the body exceeds its heat production, mechanisms that either prevent heat loss or increase heat production must be initiated. Heat loss can be prevented by behavior modifications such as additional clothing or shelter, or changing the surface area exposed

Fig. 1. Heat transfer between the body's core and the environment.



to the cooler environment by "curling up". Heat production can be augmented by increasing voluntary muscle movement through motion or exercise, and/or by increasing involuntary muscle action such as in shivering.

When the body either has to lose heat or gain heat in order to be "comfortable", energy is required. This energy is manifested as an increase in the metabolic rate. As previously noted, the TNZ refers to that range of temperatures within which metabolic rate is at a minimum. Therefore, any thermoregulatory response that causes the body temperature to move outside this range transfers an individual outside his/her TNZ.

Gender. Sexual differences in thermoregulation are debatable. Men and women were exercised at the same percentage of maximum VO2 in hot environments. No significant difference between the groups was noted in respect to heat tolerance (Paolone,Wells,& Kelly,1977; Weinman et al.,1967). However, early research found women to be less tolerant than men in hot environments. In these studies cardiovascular fitness levels were not standardized (young male army recruits and older female nurses were used as the subjects). Also in many later, more controlled studies women were found to be less tolerant of heat than men. Even when women were exercised at the same percentage of max VO2, they recorded lower sweat rates and higher heart rates, rectal temperatures, and skin temperatures (Yousef and Dill, 1974; Yousef et al., 1984; Fox et al., 1969).

It has been observed that women generally sweat less than men even though they have as many sweat glands (Wyndham et al.,1965). Men often sweat less efficiently than women (more sweat than can be evaporated from their skin) but during many hot conditions more sweat is beneficial.

Comparisons of men and women during heat exposure have shown that women exhibit higher heart rates than men at a given percentage of VO2 max. The implication is that women have a lower stroke volume than men at a given cardiac output (Wells and Haymes, 1986). They must, therefore, compensate by increasing their heart rate. As long as women are able to compensate in this manner, to carry heat away from the body core, this sexual difference (if there is one) will have no impact on thermal adjustments.

In a cold environment, women usually have the advantage of a higher insulative shell due to a higher percent of body fat (McArdle, Katch, & Katch, 1986). Researchers have shown that women have lower skin temperatures than men while resting in the cold due to this additional insulation (Buskirk et al.,1963; Wyndham et al.,1964). The reduced temperature gradient between the skin and the environment (in cool environments) reduces heat loss. These observations were later verified in a study that showed women in a cold environment decreased core temperature slower than men (Sloan et.al.,1973).

There are differences in the distribution of fat between men and women. In women the fat thickness on the limbs is considerably greater than men in relation to trunk fat (Sloan,Keatinge, 1973). This would lessen the ability to dissipate heat in warm environments because when exposed to warm environments, blood is transferred to the periphery to aid in heat loss and any extra insulation in the form of fat would lessen heat loss.

The importance of body surface area in temperature regulation was probably noted first by Fales in 1907. He observed that larger men were less able to tolerate heat than smaller men. In hot environments, where heat is transferred from the environment to the body, the extra surface area would become disadvantageous. Women have a greater body surface area to mass ratio which enables them to transfer more heat than men per kilogram of body weight. Kollias et al. (1974), verified this in a study which showed women lost heat more rapidly than men when immersed in cold water.

Exercise. Exercise has a great effect on caloric expenditure. Davy (1850), was the first to observe that an increase in physical activity results in an increase in body temperature and heart rate. Heat production during exercise can increase up to 10 times that of basal metabolism (McArdle, Katch, & Katch,1986). Body temperature rises proportionally to the level of exercise (Lind,A.R.,1963).

The heat produced during exercise must be dissipated in order to maintain thermal balance. The body must have the capacity to transfer the heat from the core to the skin, and then from the skin to the environment. In conditions of thermal loading (during exercise or exposure to a hot environment), there is a controlled increase in skin blood flow which allows heat to be transferred from the core to the skin. This is accomplished through vasodilation and an increase in heart rate. In hot environments, evaporation of sweat from the skin surface removes the heat from the body. Thus, increased skin circulation and evaporation are the primary mechanisms of preventing hyperthermia. If the environment is cool, then the heat is readily lost to the environment by radiation and convection.

With the onset of exercise, there is an increase in the sweating rate. This increases the volume of sweat thereby increasing the rate of evaporation. The resultant cooling increases the skin-to-ambient-temperature gradient (Folinsbee et al., 1978). Under conditions of high radiant heat (high solar heat load) or high humidity, the evaporative process is retarded. If sustained heavy exercise in a hot or humid environment is continued, the needs generated by the exercise and the needs of thermoregulation conflict. The exercise creates the need to provide blood to the muscle (O2 supply and waste elimination) while the thermoregulatory system needs to provide blood to the skin surface for heat elimination. At this point, visceral vasoconstriction occurs and may even lead to hepatic failure. Also, stroke volume can actually decrease as a result of blood pooling in cutaneous veins and as a result of reduced plasma volume (lost as evaporated sweat) (Case, 1985).

The metabolic rate is the most important physiological factor in determining the desired temperature for comfort (Clark,R.P.and Edholm, O.G., 1985). It is, therefore, important that exercise be eliminated as a factor when determining the thermoneutral zone at resting values.

Fitness. Some studies support the hypothesis that cardiovascular fitness effects thermal comfort. As the individual becomes more fit, certain parameters effect thermoregulation. 1) Fit individuals have an earlier onset of the sweating mechanism (Dreosti, 1935) so that in warm environments more heat is lost from the core and the core has a lower temperature. Lower core temperature enables greater tolerance to higher environmental heat. 2) Fit people have more efficient vasodilation (Le Blanc, 1975) allowing the body to lose excess heat. This, also, translates to lower core temperatures than those with decreased skin blood flow and probably a higher degree of comfort in warm environments. 3) An increase in blood volume is associated with physical training (Yousef et al., 1972). This blood volume increase could have a very favorable effect during conditions of thermal stress as there is more fluid for the sweating response. An increased blood volume would also be benificial when there is a competitive bid for blood from the muscles and skin as during exercise in the heat. It may help prevent hepatic failure.

The benefits of cardiovascular fitness in cold tolerance needs more definitive research. There is some evidence that training may help acclimatize a person to the cold. One study observed a higher tolerance to cold because core temperature was allowed to decrease to a lower level before the body found it necessary to initiate a shivering response in trained distance runners as opposed to sedentary controls (Baum, Bruck, & Schwennicke, 1976). Fit individuals tend to have a better tolerance of cold, possibly because of better peripheral circulatory control (Le Blanc, 1975).

Age. The energy required for normal metabolic activity in a resting individual decreases with age (Calloway & Zanni, 1980). The basal metabolic rate difference between 20 year olds and those about 65 years old is approximately 4 kcal/m2/hr (Boothby and Sandiford, 1929; Robertson and Reid, 1952). This difference may be due to increased sedentary lifestyes of older individuals and/or possible age related disabilities (Fanger, 1972; Bogert, Briggs & Calloway, 1973).

Since metabolic activity decreases with age, one might expect an increase in the temperature of the TNZ in the elderly. Rudeiko (1965), did find that 80 - 90 year old persons preferred slightly warmer environments than younger persons. However, Fanger (1972) found no such increase. His observations showed that insensible perspiration in the elderly was lower than for a college age group. The decrement found in the evaporative heat loss was about the same as the decrement in metabolic rate. Since these two factors offset each other in heat balancing, Fanger believed this was the reason he failed to find a difference in the thermoneutral zone between the old and the young.

It should be noted that Fanger (1973), while performing studies in carefully controlled climate chambers, was also unable to show differences in thermal comfort between fat and thin individuals, males or females, or following any acclimatization effect. Similarly, no thermal comfort differences relating to age or sex were found by Golding and Yousef (1989). Rohles (1969), likewise, found no difference in the preferred temperature for elderly persons (mean age of 75 years). His study, however, used a more subjective method (questionnaires).

Total mass of active muscle tissue has also been shown to decline with age. A decrease in muscle mass of about 33% was observed between 30 and 80 year old subjects (Tzankoff and Norris, 1977). Since muscle tissue is metabolically active, any decrease in the volume of muscle mass could be expected to result in a lower metabolic rate.

Other investigators have observed a decrease in the maximal oxygen uptake of about 40% between the age of 30 and 80 (Asmussen et al., 1975; Dill et al., 1963; Robinson, 1938; Dehn and Bruce, 1972). If correction for the lower muscle mass is made ($\dot{V}O2$ determined per kg of muscle mass), then age appears to have minimal effect on the $\dot{V}O2$ max. This may indicate that the decrease in $\dot{V}O2$ associated with aging could be explained to a large extent by the decrease in muscle mass.

A decline in the oxygen transport system could also be a factor in the decreased max $\dot{V}O2$ associated with age. Extensive evidence indicates that a decrease in heart rate is observed with advancing age, and some data show a decrease in stroke volume with increased age (Astrand, 1970). Since the product of heart rate and stroke volume is cardiac output, decreasing either factor would limit the oxygen transporting capability.

Maintaining heat balance in the cold, as it relates to age, has had limited investigation. Wagner et.al.(1974), found a reduced vasoconstrictor response to the cold in the elderly and, therefore; more rapid cooling. Blood flow recordings also showed higher values in the elderly (reduced vasoconstrictor response) in a study by Collins, et al., (1977). In these studies, no ill effects or symptoms of hypothermia were observed.

Some elderly people have gross defects in vasoconstriction and in metabolic response to cold. This is associated with degenerative changes (loss) of central thermoregulating neurons. These neurons sense temperature changes and relay the information to the hypothalamus. Without them, cold stimuli will not be perceived and the vasoconstrictor response will not be initiated (Keatinge, 1978). This results in an increased heat loss to the environment. When functioning properly, vasoconstriction results in conservation of heat as the associated decrease in blood flow to the skin effectively increases insulation (MacMillan, et al., 1967).

Hydration. In hot environments (when the ambient temperature exceeds 33°C), the primary avenue for heat loss in man or woman is the evaporation of sweat. This process can cause a marked decrease in the total body water, and it is important to replace that water loss in order to prevent compromising the thermoregulatory functions. Dehydration of even 2% can have a noticeable effect upon man's ability to thermoregulate properly (Pitts, Johnson, and Consolazio, 1944; Adolph, 1947; Astrand and Saltin, 1964; Saltin, 1964). Hunt (1912) advocated drinking water freely during work in the heat, to make up for evaporative losses.

Adolph (1947) noted that when an individual is sweating rapidly, his sensations of thirst are not strong enough to replace all the water lost through sweating. This was referred to as "voluntary dehydration". Other investigators have noted that man was not able to replace all the water lost through sweat, when drinking "ad-lib" during heavy workloads or during heat exposure (Eichna et al., 1945; Greenleaf, 1966; Strydom and Holdsworth, 1968).

The eccrine sweat gland is the thermoregulatory sweat gland. Eccrine sweat contains 98% water. The other 2% is made up of several constituents, of which the major one is NaCl (salt). When people sweat, more water than other constituents (mostly salt) is lost so the blood becomes more highly concentrated as sweating continues. Since humans drink in order to maintain blood osmotic pressure, or the balance between water and osmotic constituents (Dill, 1975), they need only drink enough water to satisfy the pre-sweat osmotic pressure. In cases where they replace less osmotic constituents than water, their intake of water may be insufficient. Hypohydration refers to a diminished water content in relation to osmotic content. Therefore, Greenleaf and Sargent (1965), suggested the phrase "voluntary dehydration" should be replaced by "involuntary hypohydration".

Some investigators have shown that if subjects replace all the water that is lost through the sweat response, they show signs of exhaustion long after those subjects that only replace the water loss on an "ad-lib" basis (Pitts et al., 1944; Bean and Eichna, 1943).

At rest or moderate work levels in the heat, individuals are able to replace all water loss (Adolph, 1947; Dill et al., 1973). In Dill's study (1973), a water and salt solution was taken every seven to eight minutes for 2 hours, while the subjects walked at 100 m/min. They were able to replace the water loss. The importance of water replacement while exercising in the heat has been widely studied (Davy, 1850; Talbert and Haugen, 1927; Dill et al., 1933; Adolph and Dill, 1938; Pitts et al., 1944; Eichna et al., 1945; Adolph, 1947; Blyth and Burt, 1961; Collins and Weiner, 1962; Greenleaf and Sargent, 1965;

Greenleaf, 1966; Strydom and Holdsworth, 1968; Greenleaf and Castle, 1971; Neilsen et al., 1971; Horstman and Horvath, 1972; Dill et al., 1973; Greenleaf et al., 1974; Nadel et al., 1980; Greenleaf et al., 1983; Sawka et al., 1983).

Dill et al. (1973) suggested drinking water before and during times of extreme exercise. He also proposed that water replacement is best accomplished by ingesting small amounts of water at frequent intervals. This method of fluid replacement is presently recommended by the American College of Sports Medicine.

As the level of dehydration increases, heart rate and core temperature become elevated (Davy, 1850). According to Dill et al. (1973), the rise in heart rate is due to a decreased stroke volume (the volume of blood decreases as fluid is lost through sweating). At a given work level, the cardiac output must supply enough oxygen and nutrients to perform the task. If the stroke volume is decreased, then the cardiac output is reduced and the heart compensates by increasing its rate until the same volume of blood is circulating each minute.

The first sign of heat related stress is a rapidly increasing heart rate. Studies have demonstrated that when fluid lost through sweating is replaced, lower heart rates occur than when unable to replace the fluid (Davy, 1850; Adolph, 1947; Dill et al., 1973; Blyth and Burt, 1961;

Nadel et al., 1980; Nielsen et al., 1971; Pitts et al., 1944; Stydom and Holdsworth, 1968). These studies verify that fluid replacement can slow down or prevent possible thermoregulatory difficulties.

The rectal (core) temperature is also kept normal if fluid replacement is available to subjects exercising in the heat (Greenleaf and Castle, 1971; Pitts et al., 1944; Greenleaf et al., 1974; Nielsen, 1974; Strydom and Holdsworth, 1968; Gisolfi and Copping, 1974; Blyth and Burt, 1961). Nielsen (1974) theorized that the more stable core temperature was associated with a faster onset of sweating as was exhibited by those subjects who drank water during his experiments. He demonstrated that the earlier the sweating response, the better the cooling effect as more heat is dissipated by the evaporation of sweat. This, subsequently, allows for a lower core temperature as less heat is stored in the body.

Skin temperature, another physiologic index of thermoregulation, decreases as blood flow to the skin increases (during exercise). This is due to the cooling effect of evaporative heat loss. Nadel et al. (1980) observed that blood flow to the forearm increased in subjects who were hydrated and exercising in the heat. He suggested this was due to a lower threshold for fluid replacement during cutaneous vasodilation.

Dehydration can impair the body's ability to thermoregulate as the associated reduction in blood volume (decreased cardiac output and peripheral circulation) may compromise circulation to one or more body regions. Heart rates accelerate and since there is less fluid available for sweating, the capacity of the sweat glands becomes reduced. Cellular function may also be suppressed during excessive sweating as fluid is transferred from intracellular areas in order to compensate for the extracellular fluid loss (Haymes and Wells, 1986).

Costill et al., (1975) found that the addition of electrolytes to drinking water was of minimal value in the prevention of dehydration. Although his subjects maintained electrolyte levels, they still dehydrated 3% during repeated days of work in the heat. He also observed that drinks containing a glucose concentration of greater than 2.5% retard the absorption of water from the gastrointestinal tract. Therefore, for comfort, during prolonged exercise (when carbohydrate replacement is required) only weak glucose solutions should be ingested, and electrolyte replacement should occur after exercise is completed.

Clothing. The insulatory value of clothing affects the physiologic changes of thermoregulation in various climatic environments.

During World War 11, research was initiated to determine the best insulatory fibers for clothing, an important relationship between dead air space and the warmth of clothing was discovered (Kerslake, 1972; Burton and Edholm, 1955). This dead air space provides a high insulatory value as air is a poor conductor of heat (Kerslake, 1972). The research focus soon switched to providing clothing capable of maintaining a specific layer of air thickness. It was found that the type of fiber had little effect on the insulatory value of the clothing as long as the still air layer was trapped in relatively small compartments. If the compartment is 0.5 cm^3 or larger, differences in air temperatures within the spaces will occur. This leads to greater air movement (hot air rises) which decreases the insulatory value of the clothing (Clark and Edholm, 1985).

If wind is allowed to penetrate the clothing, the dead air space will be disturbed, thus lowering the insulatory value. Therefore, the outside layer should be designed in such a way as to prevent wind from entering the garment (Belding et al., 1947).

The insulatory value of clothing is also reduced if the garments become wet (Pugh, 1966). Clothing should, therefore, be permeable to water vapor so that water evaporated from the skin passes through and is not allowed to condense on the inside lining.

Compressibility of clothing is an important factor in determining the insulatory effect. If the dead air space becomes compressed, the insulatory value decreases. Materials that regain their orginal shape quickly are better insulators than those that remain compressed. Kaufman (1983), observed that when standing on a stone surface the heat lost from compressed boots was nearly comparable to standing in bare feet. It was also noted that immersion in water caused clothing to compress, thus lowering the insulatory value of the clothing by 50% (Hall and Polte, 1956).

Using clothing in layers is beneficial as one can vary the insulation to the environment easily by removing or opening a layer. This decreases the insulatory effectiveness by disturbing the still air. During work the body produces more heat and layers can be removed or added to meet the demands of the situation.

The amount of insulatory value of clothing is referred to as "clo" units. One clo represents the thermal insulation provided by the normal indoor clothing of a sedentary worker in comfortable indoor surroundings (Bligh and Johnson, 1973). Gagge, Burton, and Bazett (1941) first used the clo unit to describe the insulation required to keep a seated subject comfortable at an air temperature of 21°C in an air movement of 0.1 m/s. In practical terms, this is equal to an ordinary suit with shirt and pants, etc. Thermal insulation can be increased to 2 clo by putting on an overcoat and to about 4 clo with special arctic clothing (Sloan, 1979).

In hot environments it is necessary to differentiate between a hot, dry desert environment and a hot, humid tropical environment. Clothing in hot humid environments is detrimental as it impairs heat loss through evaporation as well as through convection. Horvath and Shelley (1946) observed that clothes increased the heart rate and rectal temperature. Therefore, a minimum of clothing is preferred in these surroundings. If clothing is worn, it should be made of light material and be loose fitting.

In hot dry environments, clothing is necessary to protect one from direct and reflected solar radiation. Heat will be trapped between the skin and the clothing until it is expelled by movement. Therefore, the clothing in desert climates should be bulky so that bellows of air can be expelled from the clothing during the day. White material is most beneficial in desert environments as it will reflect sunlight.

Air Movement. Convective heat loss increases as the velocity of air movement increases. There is a sharp increase in the amount of heat loss between still air and air movement of 2.5 mph. At wind speeds greater than 2.5 mph, there is a more gradual increase in the amount of heat loss (Haymes and Wells, 1986). A decrease in insulation is the cause of the heat loss. Pugh (1967), observed a drop in body core temperature in subjects who wore wet clothing in cold temperatures with a wind speed of 5-10 mph. In this situation, the extra heat produced from shivering was not sufficient enough to maintain a heat balance with the environment. When subjects under similar conditions did not have wet clothing, the heat produced by shivering was enough to maintain a constant core temperature (Horvath, 1948; Pugh, 1966).

During cold, windy, environmental conditions (dry or humid), the body core temperature will drop if the clothing insulatory value or the exercise level are not adequate. For example, Haymes et al. (1982), found that an athlete wearing 1.6 clo will lose heat faster than his body will produce it if his energy output is less than 10 METS, with an ambient temperature of -20°C and a wind speed of 9.5 mph (wind chill index = -30°C).

The wind chill index is a figure used to show the combined effect of temperature and air velocity. Since the skin temperature decreases with wind velocity, an increased danger of frostbite occurs at temperatures below -30°C (adjusted by the wind chill index) (Sharkey, 1975). If the outer garment is wind resistant, skin temperatures and core temperatures are better maintained (Haymes et al., 1982; Haymes and Dickinson, 1978).

<u>Dietary Thermogenesis</u>. Metabolism is elevated during and after eating as the digestion of food requires energy. An increase in heat production also accompanies the increase in metabolism (Buskirk, Iampietro, & Welch, 1957). This specific dynamic action (SDA) lasts between 4-6 hours with a peak occuring 1-2 hours after the meal (Fanger, 1972).

Fat has a small SDA effect. Carbohydrates produce a caloric heat value of about 7% of the food consumed, and protein has a heat value of about 18% of the food calories. Protein not only has the largest caloric effect, but its SDA effect lasts for a longer duration (Folk, 1974). For most mixed diet meals, the SDA usually amounts to 10-15% of the basal metabolic rate (Passmore and Robson, 1968).

The SDA could have a significant effect on thermal comfort. Fanger (1972) estimated a meal rich in protein could decrease the perceived thermal comfort zone as much as 1 degree C for several hours.

<u>Seasonal Variations</u>. Environmental factors, as they relate to the change of seasons, may have an effect on resting metabolism. Although most European and American investigators have failed to find seasonal variations in the basal metabolic rate in humans (Folinsbee, et al., 1978), Japanese and Korean researchers have, in contrast,

reported such seasonal variations (Lee, et al., 1972; Sasaki, 1966; Yoshimura, et al., 1966). Gustafson and Benedict (1928) observed lower resting metabolism in the winter as compared to the spring. The conflicting data may actually indicate other changes that sometimes accompany seasonal changes, such as dietary alterations, physical exertion changes, or some other independent variable.

Circadian Rhythm. Haldane (1905) noted the diurnal (day to night) rhythm of internal body temperature: the temperature reaches a high point sometime prior to sleep, and; the temperature reaches a low point sometime prior to waking. This difference in body core temperature has been shown to change 0.3-0.5°C during a 24 hour period (Fanger, 1972). It may, therefore, be possible to determine a particular rhythm related to the preferred comfort temperature. Studies have, however, failed to determine any differences between preferred comfort on subjects tested in the afternoon and in the evening, or between two different time periods of the same day (Nevins et al., 1966; Fanger, 1972).

If any influence of the circadian rhythm upon comfort conditions exists, it is probably small and of no practical significance (Fanger, 1972).

Menstrual Cycle. Body temperature in the basal state will vary slightly during the menstrual cycle. The temperature in the postovulatory period of the menstrual cycle is higher than during the preovulatory period (Midgley and Jaffe, 1966).

Although some variability was observed, there was no statistical difference in perceived comfort in a study comparing the preferred temperatures of women (Fanger, 1972). This study compared menstrual to nonmenstrual women and preovulatory to postovulatory women.

Some investigators found that women tended to sweat at a lower rate than men (Wyndham, et al., 1965). Kawahata (1960) suggested that sex hormones were the cause of this difference. He believed that since testosterone is anabolic in nature it would stimulate sweating and since estrogen is catabolic in nature it would inhibit sweating. Another study observed that the sweating threshold for women in the postovulatory phase was as much as 0.4°C higher than men's, with a much smaller difference noted in the preovulatory phase (Bittel and Henane, 1975). Since men would begin sweating earlier, it is suggested that men receive more thermoregulatory benefit than women in the postovulatory phase, as heat would be lost faster through the evaporation of sweat.

Other investigators, however, found no significant difference in the sweating response to heat during various phases of the menstrual cycle, (Wells and Horvath, 1973-4; Sargent and Weinman, (1966), despite the variation in estrogen levels during the phases (Sargent and Weinman, 1966).

Bittel and Henane (1975) also reported that women's body core temperature during the postovulatory phase was higher than men's. This would indicate that women have a higher metabolic rate during this period than men. If so, it is possible that the thermoneutral zone for women during this phase may shift slightly lower in temperature.

Acclimatization. Acclimatization refers to the adaptive changes that occur within an organism in response to changes in the natural climate (Bligh and Johnson, 1973). Acclimation, on the other hand, refers to the adaptive changes that occur within an organism in response to experimentally induced changes in a particular climatic environment, such as ambient temperature in a controlled environment (Bligh and Johnson, 1973). Therefore, investigators that study the physiologic effects on subjects who move from one climate to another, or on subjects who remain in an area with changing climates (seasonal changes) are studying the process of acclimatization. Investigators who experimentally change the climate, such as in an environmental chamber, and study the associated physiologic changes are studying the process of acclimation.

Acclimatization:a historical review. The first individual to hypothesize that the body needed an adjustment time period in order to successfully exist in a new environment was Lind (1733). He compared individuals who moved from one environment to another as well as plants that were transplanted from one place to another. He stated that after a change of environment (in humans or plants), some change must happen within their constitutions if they are to do well within their new environments.

In the late 1700's, European army personnel recognized that strong exertion during first day arrivals in tropical areas were often harmful (Jackson, 1789). By the mid 1800's, when Europeans were moving troops in tropical areas, it was a common practice to use native troops during the initial military actions while the European troops were held in reserve. This gave the Europeans time to adjust to their new climate.

Many of the early researchers derived conclusions about acclimatization by observing the physiologic changes that occurred within their own bodies. Crombie noted, from 1288 personal readings, that his oral body temperature was higher in Bengal than in England and that the differences were greater during the first weeks of residence in Bengal (Crombie, 1873).

Boileau (1878) suggested that an increased sweat rate in warm environments could adequately compensate for the increase in body temperature. He believed the increased cooling effect made possible by the greater amount of sweat, and hence evaporation, would eliminate the excess heat caused by the warm environment.

By 1897 the term acclimatization was commonly used, but because of the many deaths of Europeans in tropical areas, Sanborn (1897) stated that complete acclimatization was impossible. Rogers (1907) presented contrary views to Sanborn, and due to evidence presented through several studies, acclimatization of humans to hot environments was finally accepted by the 1930's.

Some of the early classic studies that verified the fact that humans can adequately adjust to hot environments included Barcroft (1923), who noted that soon after arrival to a tropical climate, man adjusted to heat by the augmentation of the total blood volume. This not only gave more volume that could be converted to sweat, but allowed for more total area in which heat could be transferred from the body core to the skin. Sundstroem (1927), published a review on the physiologic effects of tropical climate, and Ciliento (1925), who observed that work had a beneficial effect on the acclimatization process in man. He stated that "The one feature in common with all these colonies where success is recorded is that residents worked, and worked hard, and it is probable that, far from being an impossibility for the white man, work is the factor which will render it ultimately possible for him to adapt himself entirely to his new environment."

Vernon (1923) noted a decrease in his heart rate and an increase in his sweat rate over time as his body acclimatized. For example, at 100.7°F body temperature, his pulse rate was 131 (while performing light work) before acclimatization and 120 after acclimatization.

After these investigators added their contributions to the knowledge of acclimatization, only a few researchers doubted a person's ability to adjust to hot environments (Stigler, 1915; Schieckele, 1947).

As acclimatization became accepted, more refined analysis under controlled experimentation began to occur. Dill, et.al.(1933) reported a decline in the concentrations of sodium and chloride in sweat during the first 6 days of a stay in the hot desert. He believed that the conservation of salt was beneficial to the acclimatization process by improving body fluid composition and volume. Dill was responsible for many observations about the effects of heat acclimatization on human subjects. Along with his observations on electrolyte concentrations during acclimatization, he noted other adaptive responses pertaining to acclimatization. He observed that a lack of sleep had an adverse effect upon the process. Well rested individuals acclimatized faster than those with insufficient sleep. He also found that fluid intake had a favorable effect. Subjects that were well hydrated acclimatized faster than those who were deprived of adequate hydration.

The classical experimental study of males and acclimatization was made by Dreosti (1935). His approach became the model on which other studies of acclimatization were based. While observing 20,000 native underground mine workers in South Africa (City Deep Mine), Dreosti developed a heat tolerance test based on the mens' ablilty to shovel rock. As evidenced by decreases in body temperature and increases in sweat rate, primarily within the first 14 days of shoveling in the heat, he determined that the men were indeed able to acclimatize. Favorable acclimatization responses continued for another two weeks, but the adjustments to the heat were small compared to the first 14 days. He also noted that acclimatization would not occur if the subject worked in a cool place.

The incidence of heatstroke in South African gold mines has been reduced, due to a routine developed after much experimentation (Strydom and Kok, 1970; Wyndham et al., 1973). Recruits currently acclimatize by working 4 hours a day in a chamber with saturated air at 31.7°C and an air movement at 0.4 m/sec. The work progressively increases over the next 8-9 days. Oral temperature is recorded hourly and if the recruit's temperature reaches

39°C, the work is terminated. Maximum effects from acclimatization are reached only if subjects participate in strenuous work in hot environments (Strydom et al., 1966). If the miner is moved to a cooler environment, the benefits achieved by acclimatization progressively decline over a three week period (Williams, et al., 1967). There is some evidence that miners may acclimatize more rapidly to heat if on a daily dose of ascorbic acid (250 mg of vitamin C) (Strydom, et al., 1976). A climatic suit can be worn if environmental conditions are extreme (Strydom, et al., 1975).

Robinson, et.al.(1943), found that acclimatization to heat would occur with short daily periods of work (1-1.5 hours) and that the benefits of acclimatization could be retained for about 3 weeks. Robinson also noticed that subjects could work for longer periods of time at the same intensity following acclimatization.

The importance of the cardiovascular system was emphasized by Taylor et al.(1943). They found that half of the improved performance of subjects occurred within the first 4 days of exposure to warm environments. The primary benefits of acclimatization were determined to originate with the cardiovascular responses. They noted decreased heart rates and increased stroke volumes within the first 4 days but only a small increase in sweat rate (4%). Eichna, et al.(1945) also confirmed the importance of cardiovascular responses when they noted that more fit individuals tended to acclimatize faster than less fit individuals.

While studying the effects of hot humid environments upon the acclimatization process, Eichna, et al. (1945), confirmed that many of Dill's observations in hot dry climates also applied to humid environments. They found that lack of sleep hindered the acclimatization process and that those who replaced all fluids lost through sweat (forced fluid intake) out performed those on voluntary fluid replacement.

Horvath and Shelley (1946) observed that individuals who are acclimatized to hot environments are also acclimatized to less hot environments. An individual may, however, exhibit a tolerance to a specific warm environment and when moved to a hotter environment, not have the ability to tolerate it.

The earlier onset of sweating during heat acclimatization is a localized training response (Fox, et al., 1964). One arm on an individual was exposed several times to a hot environment, and then the entire individual was exposed to the same heat. The arm that had the previous heat exposures produced a greater sweat response than the remainder of the body. This indicates that the increase in sweat rate during heat acclimatization, as was observed by numerous investigators, is not due to stimulation of the central nervous system but rather to a localized response.

Acclimatization, as it relates to female subjects, has only been investigated during the last 30 years. Some studies showed that when working at the same percentage of their work capacity (for example 50% of $\dot{V}O2$ max), the females exhibited similar potentials as the men in their ability to acclimate (Kupprat, Drinkwater, and Horvath 1980). During some initial experiments, female subjects were studied using similar techniques and procedures as male subjects (Cleland et al., 1964). The females were able to acclimatize, but their capacity to make adjustments to the environment was less than males. Other studies found that females were less tolerant of heat than men, as their sweat rates were lower and their heart rates, skin temperatures, and rectal temperatures were higher (Yousef and Dill, 1974; Yousef et al., 1984; Fox et al., 1969). These studies showed differences between the sexes while they were working at the same percentage of their work capacity.

The body can, over a period of time, successfully adjust to existence in hot climates. Although not completely understood, certain physiologic adaptive changes occur during heat acclimatization. The following is a summary of those adaptive responses that are partially understood:

1. an increase in the sweat rate (Vernon, 1923);

2. an earlier onset of sweating (Fox, et al., 1964);

3. a more complete and efficient distribution of sweat (Frishancho, 1979);

4. improved maintenance of body fluid volume and fluid composition (Dill, et al., 1933);

5. an increase in the amount of work output (Robinson et al., 1943);

6. a decrease in heart rate, skin temperature, and body core temperature (Horvath and Yousef, 1981);

7. acclimatization is a temporary process, most measureable adjustments to the climate are lost if more than three weeks passes between exposures (Williams, et al., 1967; Robinson, et al., 1943);

8. fit individuals tend to acclimatize easier (Eichna, et al., 1945);

9. short intermittent periods of exercise or work (about 1.5 hours per day) will inhance the process (Robinson, et al., 1943; Strydom, et al., 1966);

10. if one is acclimatized for severe climates, then the benefits are retained for less severe climates (Horvath and Shelley, 1946);

11. the process begins after the first exposure and is well developed in 4-7 days (Dreosti, 1935; Taylor, et al., 1943);

12. it takes about two weeks to approach full acclimatization, but the benefits can be retained with periodic exposures (Dreosti, 1935), and;

13. if one is acclimatized for hot dry environments, then mostly the improved adaptations will be observed in hot wet environments (Eichna, et al., 1945).

Acclimatization to cold exposure has been investigated, but the population of people acclimatized to the cold is small. Most individuals insulate themselves from the cold with specialized clothing and shelters. Studies conducted during polar expeditions predict that individuals may more effectively maintain their core temperatures without increasing their metabolic rate when exposed to cold environments for prolonged durations (Wyndham, Plotkin, & Munro 1964). It has been postulated that an increase in peripheral insulation (body fat) is the reason for this prediction. Goldsmith (1977), and Bodey (1978), noted an increase in body fat during cold exposure.

Another form of insulative acclimatization has been observed in Australian aborigines (Scholander et al., 1958). The aborigines were able to increase their insulatory capacity through peripheral vasoconstriction. It is possible to adjust to the cold by increasing metabolic activity through muscle movement or shivering.

During the study on the aborigines, Europeans were able to successfully adjust to the cold by increasing their resting metabolic rate by 50% while sleeping. The Korean women divers, known as the Ama, have been observed to have a 30% increase in their basal metabolic rate during the winter (Hong, 1973).

Another possible adjustment to cold exposure may be vascular acclimatization. It has been observed that those who habitually expose their hands to cold, such as fisherman, show an increase and a more rapid onset of vasodilation (Leblanc, 1975). This is accompanied by a decrease in sympathetic reactivity, i.e., a smaller increase in heart rate and blood pressure.

Much more experimentation is needed before the exact mechanisms of all the various physiological systems are known in the complex process of acclimatization.

Summary. Since environmental physiologists recognize the TNZ as the range of temperature within which resting metabolic rate is at a minimum, the best index in the determination of the TNZ is $\dot{V}O2$. The body thermoregulates by balancing heat production and heat loss. Heat production is altered by muscular movement (exercise), digestion, shivering, climate, and may vary with age, gender, time period (season or circadian), cardiovascular fitness, acclimatization or hydration. Heat loss is modified by air movement, air temperature, humidity, clothing, and skin blood flow. Heat is transferred by the physical avenues of radiation, convection, conduction, and evaporation.

Some early investigators noted important aspects of human temperature regulation but many mechanisms remain unknown. Most studies have relied on psychological estimates of perceived comfort for a determination of what is physiologically most comfortable (most energy efficient). These comfort estimates seem to correlate well with TNZ determinations arrived at by monitoring $\dot{V}O2$, especially when clothing and physical exertion are comparable.

Chapter 3

Methodology

Twenty subjects volunteered and participated in a study designed to determine the TNZ in young men and women. Subjects were required to spend two hours in an environmental room, at seven different temperatures while selected physiological parameters were monitored. The temperatures selected were 15, 20, 25, 27, 30, 33, and 36°C. These temperatures were selected because the literature has suggested that the TNZ is in this temperature range. The lower temperatures were selected farther apart because lightly clothed individuals had previously shown that thermoregulatory adjustments were needed at temperatures below 25°C and readings at 15 and 20°C would ensure a determination of the Lower Critical Temperature. Skin temperatures at seven sites, heart rate, blood pressure, rectal temperature, $\dot{V}O_2$, and a perceived comfort were monitored every 25 minutes during the 2 hours in the environmental chamber.

SUBJECTS:

Student volunteers were recruited from classes at the University of Nevada at Las Vegas.

During the first meeting of the subjects the following information was given:

1. subjects were briefed on the purpose and design of the study which were:

a) subjects were tested on seven separate testing days (7 temperatures) and each session was three hours in duration.

b) one hour, prior to the first experimental session, was used for pretest measurements and test orientation. The pretest measurements include skinfold measurements from which percent bodyfat was estimated; a submaximal cycle ergometer test to predict maximum work capacity and maximum VO2; and height and weight measurements.

2) subjects were instructed not to eat, smoke, or exercise 3 hours prior to experimental sessions.

3) experimental sessions were at least two days apart.

4) women subjects were not tested one day prior to, during, or one day after the menstrual period.

5) the experimental sessions were at about the same time of day (each subject either began at 11am or 1pm).

Table 1 presents the subjects descriptive data. These data indicate that the subjects were young people of about average height and weight. The male mean predicted $\dot{V}O_2$ max. of 46.5 ml/kg/min places them at about the 75 percentile rating (above average) for the general population of young males while the female mean predicted $\dot{V}O_2$ max. of 43 ml/kg/min places them at about the 80 percentile rating (above average) for the general

Table 1. PHYSICAL DATA - FEMALE (N=14)

	AGE (yrs.)	HT. (cm.)	WT. (kg.)	% FAT	$\dot{V}O2$ MAX (ml/kgmin)
MEAN	27.64	166.93	62.47	22.99	43.10
STD.DEV.	4.92	5.64	9.27	5.39	11.12
MAX	36.00	176.30	80.74	32.40	59.49
MIN	18.00	157.00	46.73	15.00	26.02

PHYSICAL DATA - MALE (N=6)

	AGE (yrs.)	HT. (cm.)	WT. (kg.)	% FAT	$\dot{V}O2$ MAX (ml/kg min)
MEAN	30.67	177.12	78.96	15.02	46.54
STD.DEV.	5.19	1.73	9.91	5.21	13.00
MAX	37.00	179.00	90.12	21.00	70.73
MIN	23.00	174.00	60.25	6.70	30.26

population of young females. The female average percent fat of 23% is about average for young females and the male average percent fat of 15% indicates the males were slightly leaner than average (70 percentile) for young males in the general population. These data are compared with norms developed by the YMCA (Golding et al., 1982).

EQUIPMENT:

1) Environmental chamber - (Environator Corporation West) This chamber had a temperature range from 0 to 70 degrees Centigrade. The relative humidity was set to be below 50 percent. The dimensions of the chamber were 64 inches wide, 84 inches high, and 91 inches long. Air movement was between 1.0 and 1.5 m/min.

2) psychrometer - the dry bulb temperature and the wet bulb temperature were measured using a battery operated Vista Scientific psychrometer. The measurements were collected prior to and at 60 minutes in the exposure period.

3) A Yellow Springs Instruments Tele-thermometer and a thermocouple rectal probe lubricated with mineral oil and inserted 10 cm into the rectum was used to measure the rectal temperature (see appendix J).

4) A Bailey Instruments (Model BAT-12) digital thermocouple and a special skin probe was used to measure skin temperature at seven different sites (forehead, chest, upper arm, finger, thigh, calf, big toe) and averaged to obtain a mean skin temperature (see appendix I).

5) O2 analyzer - the Servomex 570A O2 Analyzer measures the paramagnetic susceptibility of the O2 content of a gas by means of a proven magneto-dynamic measuring cell in the range 0 to 100% O2 (Servomex, 1984).(see appendix B for calibration)

6) CO2 analyzer - the Anarad 411 CO2 Analyzer is a non-directive infrared gas analyzer used to measure the infrared absorbtion of carbon dioxide gas in a sample in the range 0 to 10% CO2 (Anarad, 1981).(see appendix B for calibration)

7) Calibration gases for calibrating analyzers - Nitrogen

was used to zero the gas analyzers, then a calibration gas (15% oxygen and 4.45% carbon dioxide) was used. The calibration gases were analyzed on a micro Scholander gas analyzer. The O2 analyzer was confirmed to be calibrated after a second calibration procedure which zeroed with nitrogen gas and then adjusted to room air oxygen percentage (see Appendix B).

8) gas meter (Harvard Volume Meter) and thermometer - used to measure the volume and temperature of expired air.

9) the weight of the subjects was determined before and after each exposure period with a Scale-Tronix scale accurate to 0.01 kg.

Miscellaneous Equipment:

1) EKG - a Lumiscribe Astrograph III monitored heart rate. Supplies included : electrodes, conduction cream, tape, and ether to clean the electrodes.

2) Sphygmomanometer - a Digitronic printing digital sphygmomanometer with a range of 20-280 mmhg measured in intervals of one mmhg was used to measure arterial blood pressure in the right arm.

3) Vacuum pump - used to evacuate the sample bags.

4) Barometric pressure was measured by a mercury column.

5) comfort index chart - a chart scale between 1 and 10 was used to denote a perceived comfort index.(appendix C)

6) Three stop watches, a timing clock, four meteorological

balloons, 3 mouthpieces ,2 hoses and 3 nose clips, and fourteen gas sample bags.

Testing Protocol:

A. Pre-test sequence:

1. Subjects reported to the Human Performance Laboratory and were briefed on the purpose and design of the study and the procedures and measurements were explained.

2. Subjects read and signed an informed consent form.(see appendix D)

3. Height and weight of the subjects were taken and recorded.

4. Skin fold measurements (pectoral, abdomen, ilium, scapula, tricep, and front thigh for men; thigh, ilium, abdomen, tricep, and scapula for women) were taken to determine a percent fat evaluation according to the Y's Way To Physical Fitness (Golding, et al. 1982).

5. A submaximal cycle ergometer test was done from which maximum $\dot{V}O2$ was predicted (see Appendix F).

6. Instructions for future sessions were given.

B. Preparation prior to subject testing:

1. The temperature controls on the environmental chamber were adjusted for the desired temperature and relative humidity two days prior to testing, whenever possible, to allow for stabilization. A 24 hour minimum

stabilization period was needed. The environmental rooms were rechecked several hours before testing and adjustments were made, if necessary.

2. Prepare the rectal probes.

3. Evacuate all gas sample bags.

4. Check all gas collection equipment for leaks (meteorological balloons, and breathing valves).

5. Check the EKG paper supply to insure enough for the test.

6. Check the reading from each thermocouple used for skin temperature measurements, confirm that they are working accurately.

7. Allow one hour for the gas analyzers to warm up.

C. Subjects testing protocol:

1. Subjects completed the pretest questionnaire (see Appendix G).

2. The rectal probe was inserted by the subject (see appendix J).

3. The subject was weighed wearing the rectal probe and a previously weighed 0.53 kg. robe.

4. The subject dressed in cotton shirt and shorts and reclined in the resting room outside the environmental chamber.

5. A timer was started for total time reference.

6. A Lumiscribe astrograph 111 EKG monitored heart

rate using a CM (Manubrium & V4) lead.

7. The barometric pressure, wet and dry bulb temperature were taken.

8. The O2 and CO2 analyzers were calibrated (see Appendix B).

9. At the end of 10 minutes of resting, HR, BP, rectal temperature, skin temperature at seven sites, and a comfort index was recorded.

10. After one minute of breathing through the valve and hose to clear the equipment, expired air was collected for 10 minutes.

11. The number of minutes of the expired air collection and identification number of the collection bag was recorded, a one liter gas sample bag was used to collect a sample from the meteorological balloon for analysis. The meteorological balloon was then emptied through a gas meter and the volume (one liter was added for the sample bag) and temperature of the expired air were recorded.

12. The sample bag number was recorded (the sample bags were numbered between 1 and 50 and the meteorlogical balloons labeled with letters A to E. The sample bag contents were analyzed for percent CO2 and percent O2. A second analysis was performed and a 0.1 or less percent difference was recorded, otherwise the analysis was repeated.

13. The subject was moved from the resting room into the environmental chamber, and a timer started.

14. At the end of 10 minutes all measurements were recorded (see step 9).

15. The subject cleared the gas collection and measureing equipment for one minute. After which a 10 minute sample of expired air was collected.

16. This procedure (steps 9-12) was repeated every 25 minutes throughout the stay in the environmental chamber.

17. At 60 minutes (half way through the experimental period), wb and db temperatures in the environmental chamber were recorded.

18. The O2 and CO2 analyzers were re-calibrated after every two analyses.

19. During sessions at lower temperatures, if shivering occurred, the time of the onset of shivering was recorded and the number of minutes in the environmental chamber before shivering occurred was determined.

20. At the end of the 120 minutes in the environmental chamber the subject was again weighed wearing only the robe and the rectal probe.

21. The subject removed the rectal probe.

22. The subject dressed and if the temperature of the environmental chamber was cool then they were offered hot chocolate before leaving.

23. An appointment was made for the next testing

session.

D. Protocol for analysis of data:

1. The sample bag data were reviewed and any questionable data rechecked in a repeat analysis.

2. The rectal probes were cleaned thoroughly with soap water and a brush and then immersed in a strong disinfecting solution.

3. The battery operated O2 analyzer was put into a "charge" mode.

4. The Bailey Instruments (Model Bat-12) digital thermocouple was recharged over night.

5. The Scale-Tronix scale used to weigh the subjects was left to recharge in the resting room area.

6. The battery for the volume meter was replaced weekly.

STATISTICAL TREATMENT:

This study used descriptive statistics to summarize the data and allow provisional interpretations. The findings were compared to other studies that investigated similar parameters. The major findings are presented in graph form then described and compared to similar studies in the text.

Chapter 4

Results and Discussion

This chapter presents and discusses the data obtained when twenty subjects were monitored at rest for 120 minutes in each of seven temperatures (15, 20, 25, 27, 30, 33, and 36°C). The data collected included resting metabolism ($\dot{V}O2$ ml/kg/min), rectal temperature, mean skin temperature, comfort index, heart rate, and blood pressure. The raw data is presented in appendix A.

Physical Characteristics of the Subjects

The physical characteristics of the subjects are presented in Table 2 .

The 14 female subjects had a mean age of 27.6 years (range was 18-36 years). The mean female estimated maximum $\dot{V}O2$ was 43.1 ml/kg/min and the mean percent body fat for the females was 22.99 percent. The 6 male subjects were comparable to the females in age (mean of 30.7 years and range between 23 and 37 years) and estimated maximum $\dot{V}O2$ was 46.5 ml/kg/min. The male percent body fat of 15 % was much lower than the female percent body fat but not unusually different from what would normally be expected in the American general population (Golding et al., 1982).

Table 2. Physical Characteristics of the Subjects.

FEMALES (N=14)

SUBJEC	AGE (YRS.)	HT. (cm.)	WT. (KG.)	BSA (m2)	PERCE FAT	ESTIMATE MAX VO2 (ml/kg/min)
1	32	173.0	70.79	1.82	30.9	26.02
3	25	176.3	73.69	1.88	22.6	43.95
4	30	167.0	52.87	1.56	15.0	59.00
6	36	160.5	60.65	1.61	23.9	33.60
8	29	167.0	55.86	1.60	22.7	32.10
9	26	163.7	46.73	1.47	16.1	44.62
13	27	172.0	80.74	1.93	24.6	46.69
14	28	166.2	57.12	1.62	16.2	59.49
15	25	165.0	62.76	1.68	21.6	57.74
16	18	175.3	73.96	1.87	30.5	28.57
17	22	170.0	67.53	1.76	25.5	35.94
18	34	159.5	60.58	1.60	32.4	37.47
19	33	157.0	54.34	1.53	17.5	41.73
20	22	164.5	56.95	1.61	22.4	56.54
MEAN	27.6	166.9	62.5	1.68	22.99	43.10
STD.DE	4.9	5.6	9.3	0.14	5.39	11.12
MAX	36.0	176.3	80.7	1.93	32.40	59.49
MIN	18.0	157.0	46.7	1.47	15.00	26.02

MALES (N=6)

SUBJEC	AGE (YRS.)	HT. (cm.)	WT. (KG.)	BSA (m2)	PERCE FAT	ESTIMATE MAX VO2 (ml/kg/min)
2	23	174.0	79.31	1.93	9.9	48.52
5	37	179.0	89.40	2.06	20.5	34.68
7	30	176.5	60.25	1.73	6.7	70.73
10	25	177.7	77.00	1.93	15.9	30.26
11	34	179.0	77.69	1.94	16.1	44.55
12	35	176.5	90.12	2.06	21.0	50.48
MEAN	30.7	177.1	79.0	1.94	15.02	46.54
STD.DE	5.2	1.7	9.9	0.11	5.21	13.00
MAX	37.0	179.0	90.1	2.06	21.00	70.73
MIN	23.0	174.0	60.3	1.73	6.70	30.26

<u>$\dot{V}O2$ and TNZ</u>

Erikson described the LCT as the temperature where insulation has reached its maximum and below which, at lower temperatures, heat production must be initiated to maintain heat balance within the body. In studies on tropical animals the LCT has been found between 22 and 27°C. In arctic animals the LCT ranges between 15 and -- 40°C. Therefore, man acts as a tropical animal in respect to thermal regulation (Erikson et al., 1956). Erikson defined the LCT in his study by finding a linear regression of $\dot{V}O2$ values determined in cooler temperatures and the point that this line intersected a resting $\dot{V}O2$ value which was determined in a comfortable environment.

In the present study, the LCT was observered to occur between 25 and 30°C for females and between 26 and 28°C for males. These values are similar to the LCT found in other studies that used $\dot{V}O2$ to determine the TNZ. Erikson et al.(1956), reported a LCT between 25 and 27°C in 5 male subjects dressed in shorts and shoes. Golding and Yousef (1989), reported a LCT between 25 and 28°C in 49 subjects dressed in cotton shirt, shorts and socks (see Fig. 4).

The most pertinent studies (similar clothing insulation) to the present study in the determination of the TNZ which used a comfort index to find the TNZ also found the TNZ to exist at temperatures greater than 25°C (Ladell, 1949; Rao, 1952; Ellis, 1953; Ambler, 1955; Webb, 1959; Gagge et al., 1967; Fanger, 1972).

Since the TNZ has been shown to exist at temperatures above 25°C, the values found at 15, 20, and 25°C were used to find a linear regression of cool $\dot{V}O2$ values. A resting $\dot{V}O2$ line was determined by a linear regression of the two lowest $\dot{V}O2$ values found at 25 and 30°C (see Table 3). To determine an estimate for the UCT a linear regression between the 30°C value and 33°C value was used. The 36°C point was discounted because of lack of data at the upper temperatures. Fig.2 and Fig.3 present the TNZ based on $\dot{V}O2$ which was considered the primary criterion for measurement. The minimal level for $\dot{V}O2$ in the female subjects was between air temperatures from approximately 26 to 31.5°C. This, therefore, is considered the TNZ for females in this study. The minimal values for $\dot{V}O2$ in the male subjects was observed between air temperatures 27 to 30°C. Likewise, this range is considered the TNZ for the male subjects in this study. In a similar study, the TNZ was observed between 28 and 33°C regardless of age or sex (Golding and Yousef, 1989).

Rectal Temperature

Data for rectal temperature are presented in Table 4 and Figure 5. The rectal temperature increased above values found in the TNZ (as determined by $\dot{V}O2$) at air temperatures of 33°C and above. At an air temperature of

Table 3. Average $\dot{V}O2$ (ml/kg/min) of final hour of exposure in each testing temperature.

Males (N=6)

SUBJEC	15 DEG.	20 DEG.	25 DEG.	27 DEG.	30 DEG.	33 DEG.	36 DEG.
2	4.62	4.30	4.08	4.00	4.21	4.09	3.93
5	4.86	4.21	3.61	3.16	3.28	3.40	3.63
7	6.61	5.77	4.81	4.24	4.65	4.62	5.12
10	4.57	3.91	4.13	3.55	3.60	3.41	3.59
11	3.75	3.31	3.46	3.27	3.29	3.71	3.44
12	3.74	3.37	3.46	3.77	3.37	4.20	3.77
MEAN	4.69	4.15	3.93	3.67	3.73	3.91	3.91
STD.DE	0.96	0.82	0.48	0.38	0.52	0.44	0.56
MAX	6.61	5.77	4.81	4.24	4.65	4.62	5.12
MIN	3.74	3.31	3.46	3.16	3.28	3.40	3.44

Females (N=14)

SUBJEC	15 DEG.	20 DEG.	25 DEG.	27 DEG.	30 DEG.	33 DEG.	36 DEG.
1	3.86	4.08	3.24	3.01	2.82	3.00	2.77
3	4.61	3.78	3.99	3.63	3.14	3.57	3.90
4	6.38	5.98	4.48	4.23	4.52	4.32	4.82
6	5.38	4.96	3.80	3.82	3.63	3.40	3.53
8	4.42	4.17	4.10	3.95	3.52	3.83	4.45
9	8.05	6.67	4.86	4.59	3.93	3.88	4.25
13	3.86	4.01	3.47	3.22	3.17	3.48	3.64
14	5.04	5.05	3.71	4.11	5.01	4.40	4.42
15	4.07	4.23	3.67	3.92	3.58	3.47	3.63
16	4.40	3.75	3.04	3.25	3.09	3.58	3.16
17	3.18	3.13	2.98	3.07	2.81	3.30	3.31
18	5.22	3.93	3.30	3.49	3.77	3.59	3.52
19	6.55	5.99	4.40	3.62	3.96	4.46	4.03
20	5.73	4.40	3.71	4.48	3.46	4.02	3.71
MEAN	5.05	4.58	3.77	3.74	3.60	3.74	3.80
STD.DE	1.25	0.98	0.54	0.49	0.60	0.42	0.54
MAX	8.05	6.67	4.86	4.59	5.01	4.46	4.82
MIN	3.18	3.13	2.98	3.01	2.81	3.00	2.77

Fig. 2. The TNZ determined by linear regression of V̇O2 values.

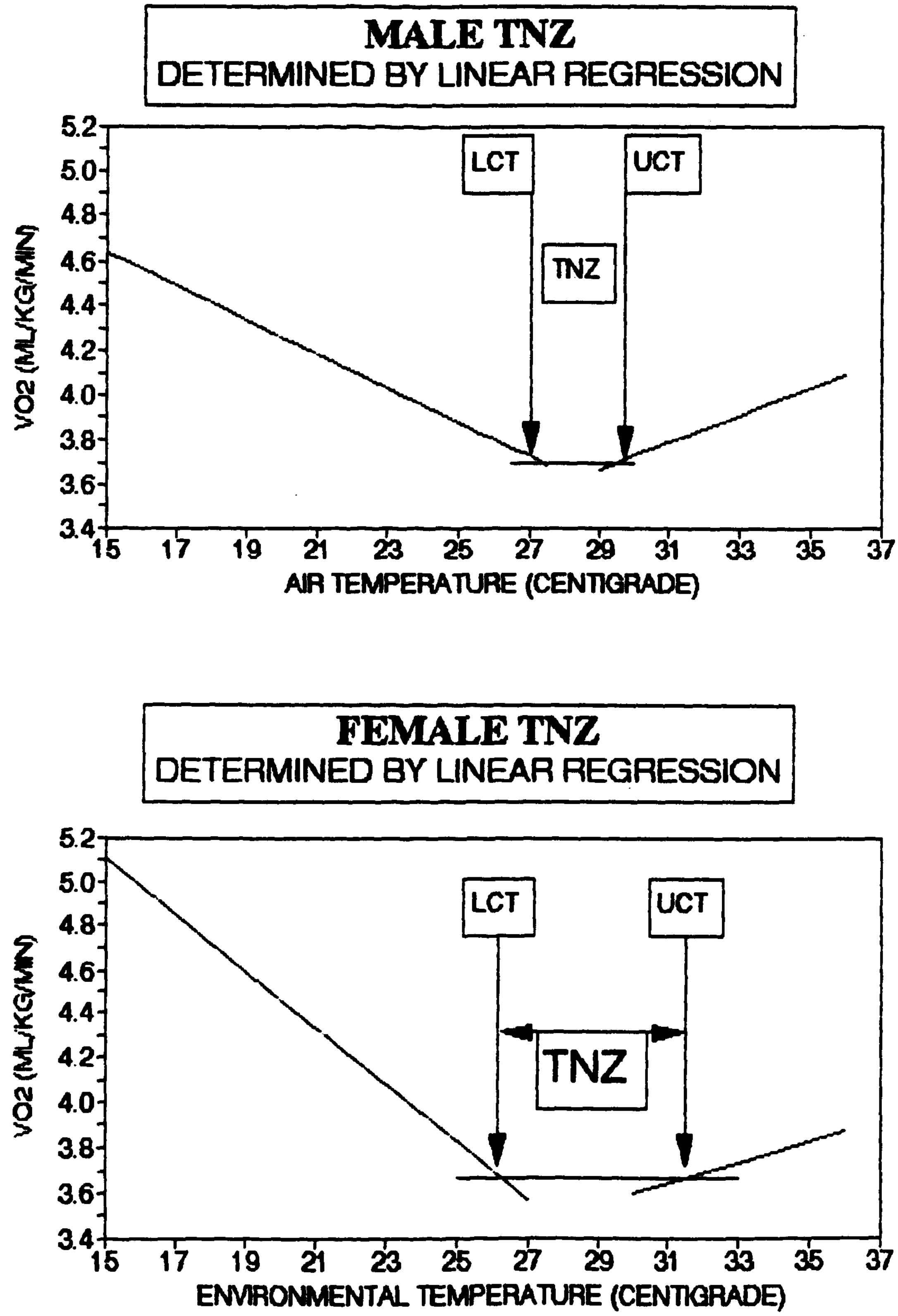
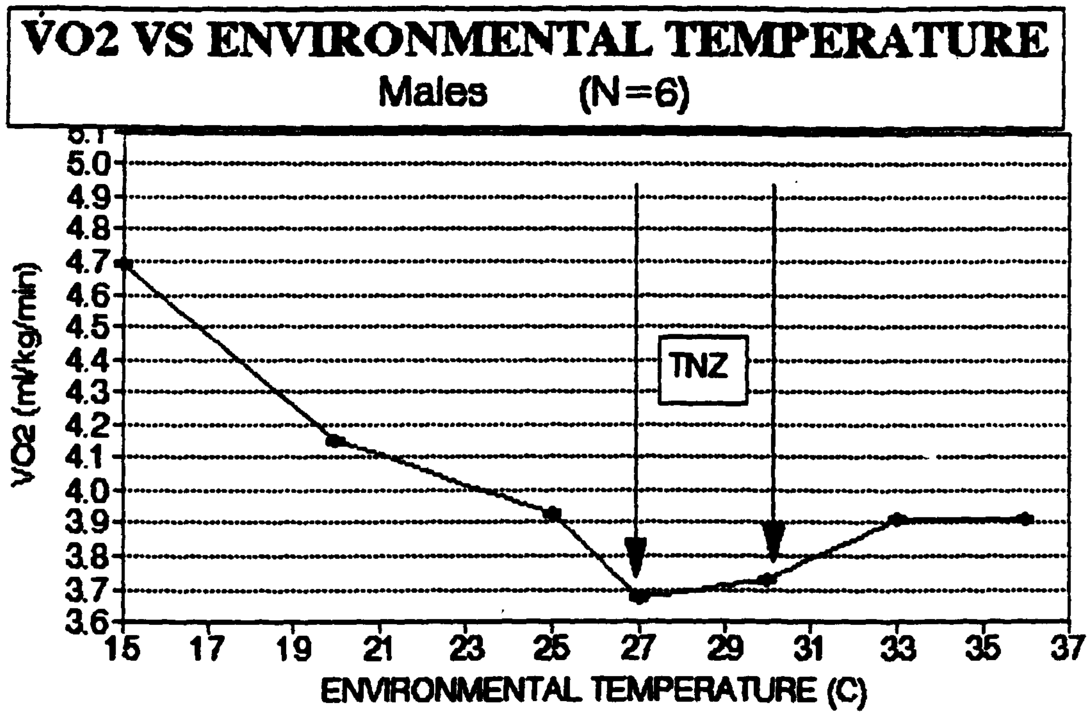


Fig. 3. The Thermoneutral Zone (TNZ) based on V̇O2 (ml/kg/min) during the final hour of exposure in each testing temperature.



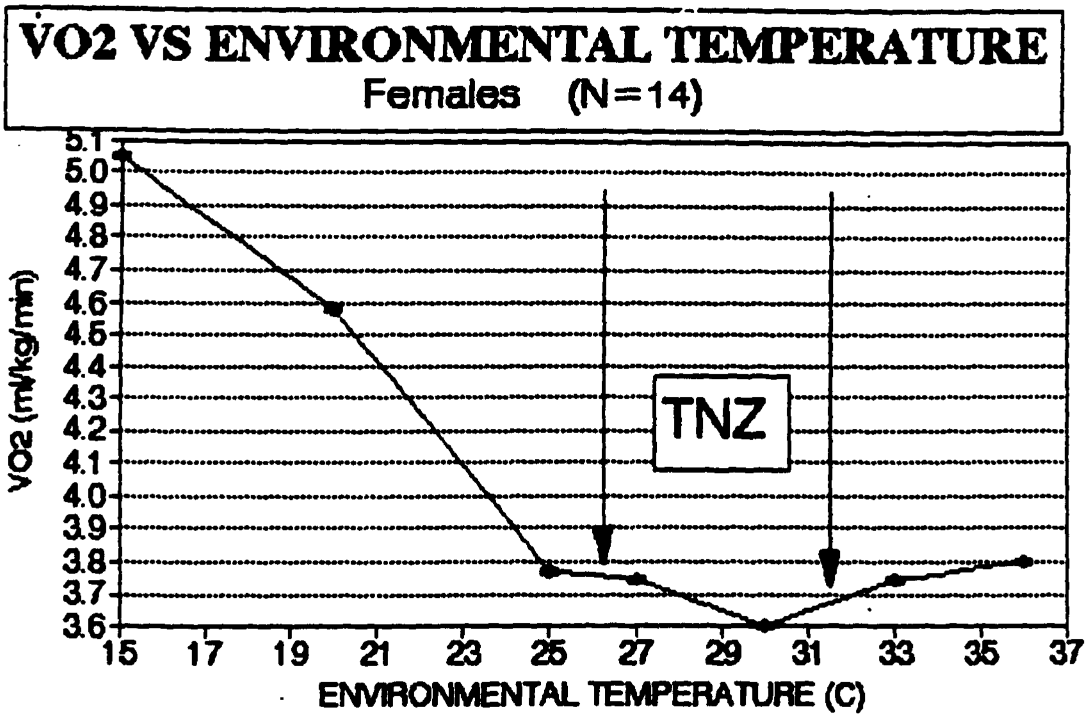


Fig. 4. Lower Critical Temperature Range by Author

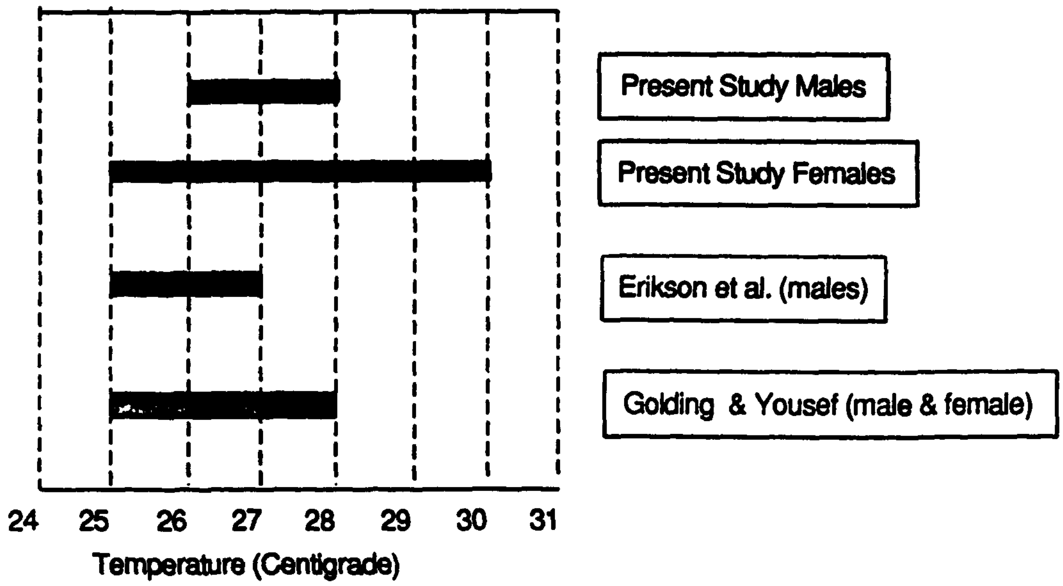


Fig. 5. RECTAL TEMPERATURE VERSUS ENVIRONMENTAL TEMPERATURE

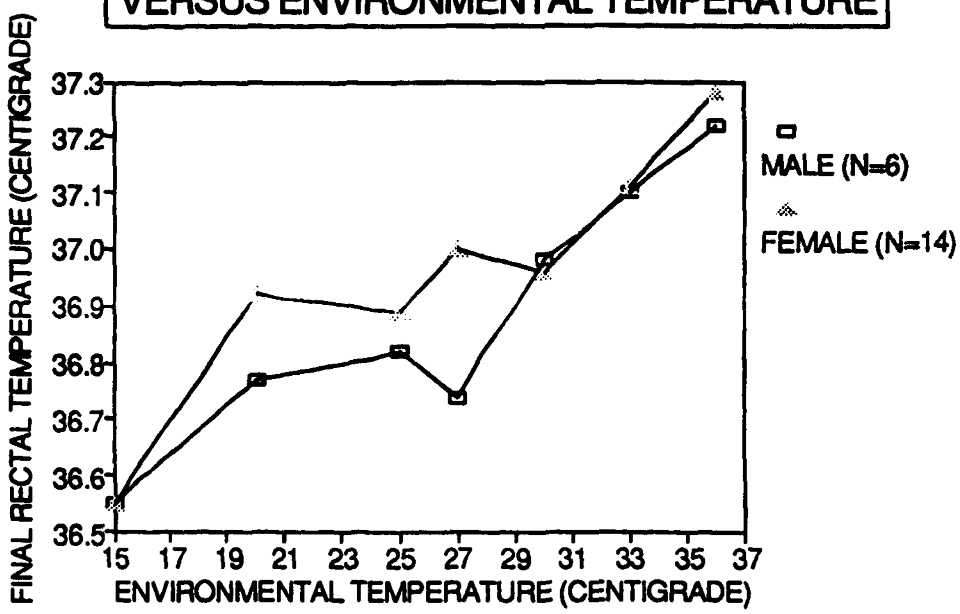


Table 4. Rectal temperature, final reading in each testing temperature.

Males (N=6)							
SUBJEC	15 DEG.	20 DEG.	25 DEG.	27 DEG.	30 DEG.	33 DEG.	36 DEG.
2	36.5	36.9	37.1	37.0	37.1	37.2	37.0
5	36.0	36.4	36.3	36.3	36.8	36.8	37.2
7	36.4	36.4	36.8	36.7	36.9	37.2	37.3
10	37.2	37.1	37.2	36.9	37.1	37.2	37.3
11	36.4	36.7	36.8	36.8	36.9	37.3	37.2
12	36.8	37.1	36.7	36.8	37.1	37.0	37.3
MEAN	36.55	36.77	36.82	36.74	36.98	37.10	37.22
STD.DE	0.37	0.29	0.29	0.22	0.12	0.16	0.11
MAX	37.2	37.1	37.2	37.0	37.1	37.3	37.3
MIN	36.0	36.4	36.3	36.3	36.8	36.8	37.0

Females (N=14)							
SUBJEC	15 DEG.	20 DEG.	25 DEG.	27 DEG.	30 DEG.	33 DEG.	36 DEG.
1	36.3	36.9	36.9	37.0	36.4	36.8	37.0
3	37.0	37.0	37.2	37.0	36.9	37.1	37.3
4	34.0	36.4	36.7	36.0	37.2	37.1	37.1
6	37.2	37.2	37.2	37.3	36.9	37.3	37.4
8	36.6	36.8	36.8	37.1	37.2	36.8	37.8
9	36.5	37.1	37.1	37.3	37.0	37.4	37.5
13	36.6	37.0	36.8	36.8	37.0	37.7	37.2
14	35.8	37.0	36.6	36.7	37.0	37.1	36.8
15	37.2	36.5	37.3	37.3	37.0	37.2	37.4
16	37.0	36.6	36.2	37.1	36.9	37.1	37.2
17	36.2	36.6	36.8	36.8	36.9	36.5	37.2
18	37.3	37.5	37.1	37.3	36.8	37.0	37.6
19	37.3	37.0	37.1	37.3	37.5	37.7	37.3
20	36.7	37.3	36.7	37.0	36.8	36.8	37.2
MEAN	36.55	36.92	36.89	37.00	36.96	37.11	37.28
STD.DE	0.83	0.30	0.28	0.34	0.24	0.33	0.24
MAX	37.3	37.5	37.3	37.3	37.5	37.7	37.8
MIN	34.0	36.4	36.2	36.0	36.4	36.5	36.8

15°C the rectal temperature was lower than values found within the TNZ. At the environmental temperatures reported in this study, the rectal temperature never varied far from values normally expected in comfortable environments. Thermal equilibrium can be maintained by the body until body core temperature (approximately rectal temperature) reaches 40.6°C (Ladell, 1949). Ladell (1949), believed rectal temperature is a close indication of deep tissue temperature.

Looking at the rate of change for rectal temperature in the two extremes of environmental temperature used in this study (15 and 36°C), in Figure 6, the rate of change in rectal temperature in cool environments (15°C) shows that in females, rectal temperatures drop slower than male rectal temperatures. This is due to the increased insulation in the form of higher body fat content present in the female subjects.

In Figure 6, the rate of change in rectal temperature in a warm environment (36°C) shows two main trends. First, the male subjects exhibit the ability to be more heat tolerant than the females as indicated by the slower rise in rectal temperature. A higher rectal temperature in females while in warm environments has been observed by other investigators (Yousef and Dill, 1974; Yousef et al., 1984; Fox et al., 1969). Second, most individuals suddenly exposed to a high environmental temperature show an initial drop in rectal temperature of 0.5°F as the skin circulation opens up reflexly (Ladell, 1949). This redistribution of blood brought about by vasodilation of peripheral blood vessels in response to warm skin temperature leaves less blood in the rectum and therefore less heat. The present study agrees with Ladell's findings for an initial drop in rectal temperature on sudden exposure to high environmental temperature.

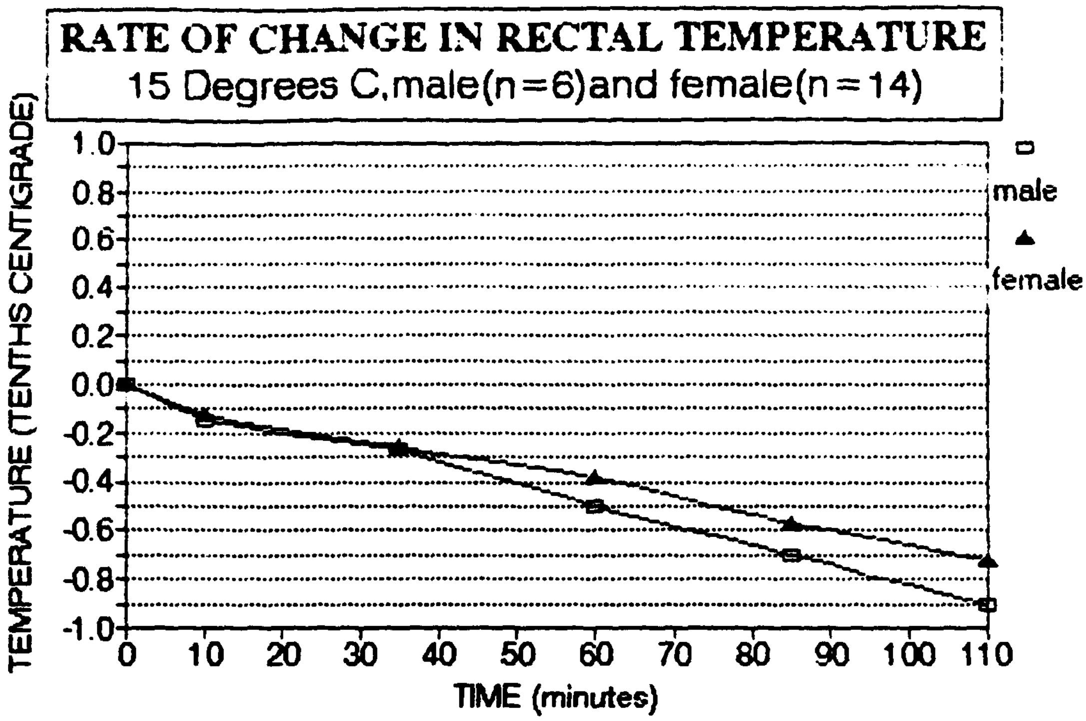
Mean Skin Temperature

The mean skin temperature in this study was derived at by use of a weighting formula. The weighting factors for each of the seven areas used in this study was first used and developed by Hardy and DuBois (1938). The percentage of the total for each area in the determination of mean skin temperature is as follows:

1) head = 0.07
2) chest = 0.35
3) arm = 0.14
4) finger = 0.05
5) thigh = 0.19
6) calf = 0.13
7) toe = 0.07

The data presented in Table 5 and Fig. 7 represent the mean skin temperature that was obtained by using the

Fig. 6. Rate of change for rectal temperature in the two extremes of environmental temperature.



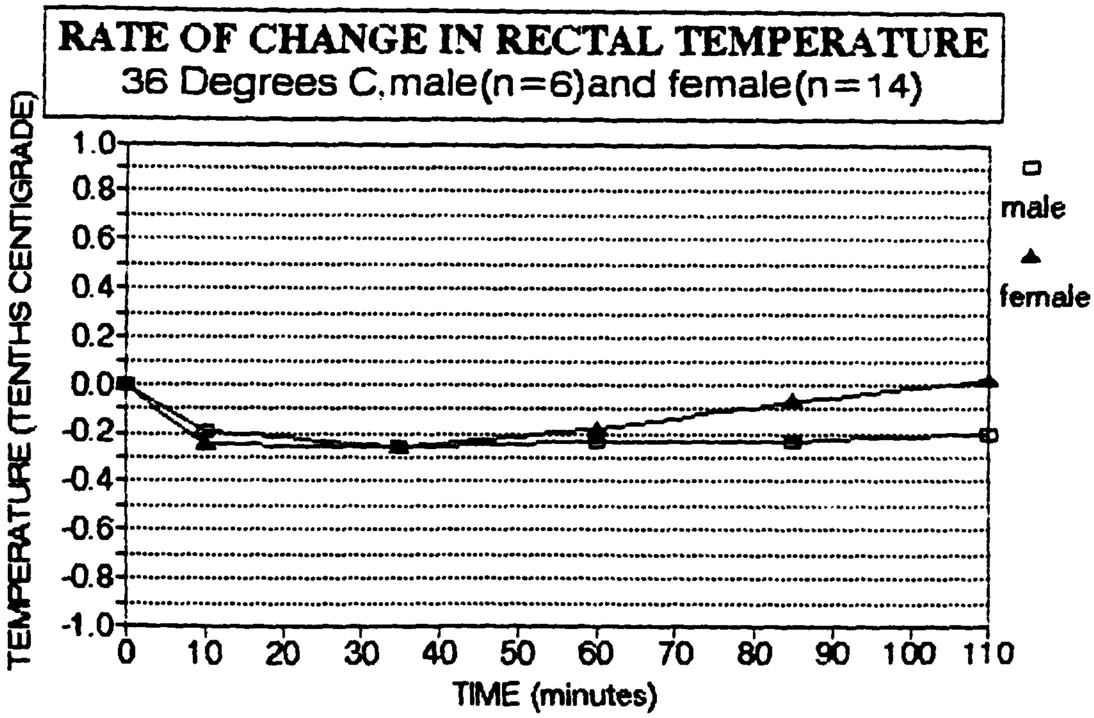


Table 5. Mean Skin Temperature, final data in each testing temperature.

Males (N=6)							
SUB.	15 DEG.	20 DEG.	25 DEG.	27 DEG.	30 DEG.	33 DEG.	36 DEG.
2	25.66	28.58	31.11	33.20	34.20	34.70	35.30
5	28.06	28.57	31.23	32.50	34.40	35.70	35.70
7	29.20	29.45	31.59	32.10	33.70	35.50	36.10
10	25.67	28.20	31.28	31.80	33.90	35.50	36.10
11	26.41	27.51	30.24	31.00	33.00	34.70	34.90
12	25.84	28.12	31.33	32.40	32.70	34.40	35.70
MEAN	26.81	28.41	31.13	32.17	33.66	35.07	35.63
STD.D	1.35	0.59	0.42	0.67	0.61	0.50	0.43
MAX	29.20	29.45	31.59	33.20	34.40	35.70	36.10
MIN	25.66	27.51	30.24	31.00	32.70	34.40	34.90
Females (N=14)							
SUB.	15 DEG.	20 DEG.	25 DEG.	27 DEG.	30 DEG.	33 DEG.	36 DEG.
1	25.79	27.32	30.07	31.10	32.60	35.00	36.20
3	26.31	28.39	31.40	33.10	34.10	35.40	36.14
4	26.29	29.03	31.11	31.50	33.50	35.20	35.90
6	26.55	28.42	30.67	32.10	33.60	35.70	36.10
8	26.16	28.38	30.42	32.50	33.60	35.20	36.20
9	28.00	29.11	31.30	32.20	33.90	35.60	36.50
13	25.38	28.26	30.44	32.10	33.40	35.50	36.40
14	26.11	28.56	30.78	32.20	32.20	35.60	35.50
15	27.04	28.75	30.77	31.70	33.10	35.40	35.20
16	25.32	27.20	30.66	30.70	32.70	35.50	35.60
17	25.92	27.44	29.53	31.20	32.80	35.10	35.50
18	25.54	27.87	30.69	32.40	32.10	35.20	35.30
19	27.12	28.32	30.37	32.40	32.90	35.50	35.40
20	26.70	28.25	30.57	31.90	33.00	35.10	35.70
MEAN	26.30	28.24	30.63	31.91	33.10	35.35	35.83
STD.D	0.72	0.57	0.46	0.62	0.58	0.21	0.41
MAX	28.00	29.11	31.40	33.10	34.10	35.70	36.50
MIN	25.32	27.20	29.53	30.70	32.10	35.00	35.20

Fig. 7. Mean Skin Temperature, final data in each temperature.

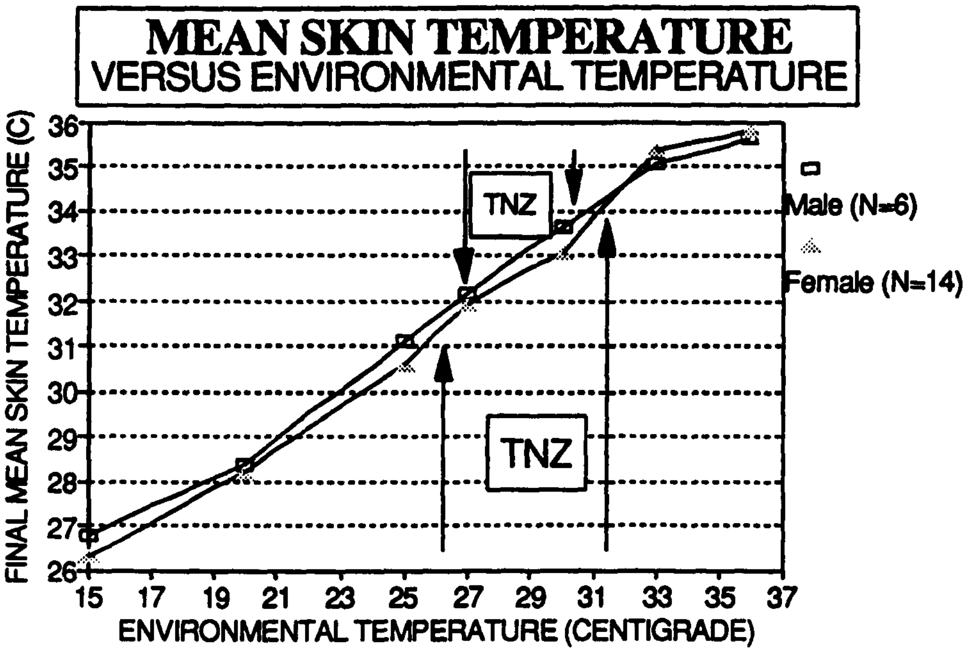
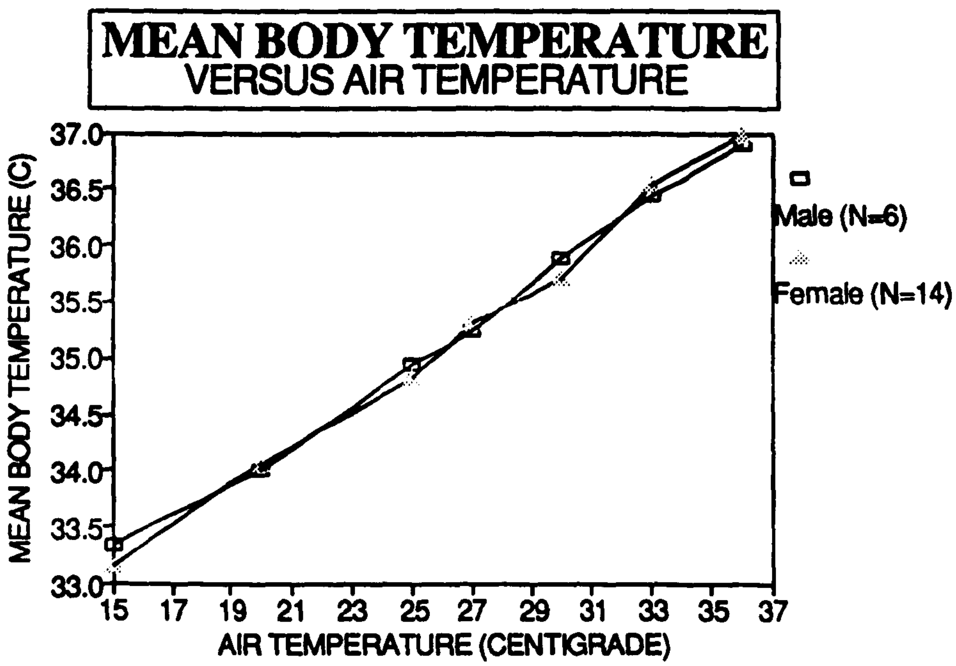


Fig. 8. Mean body temperature, final data in each testing temperature.



last values recorded in each of the testing temperature settings and weighting them according to the factors recommended by Hardy and DuBois (1938).

Bazett (1938), has shown local skin circulation can increase ten times in response to heat. To accomplish this, the cardiac output must be increased to deliver the blood to the skin. In addition, because there is a limited supply of blood, the increased blood flow to the skin is accompanied by vasoconstriction elsewhere in the body (Ladell, 1949).

An animal compensates initially to cool temperatures by increasing the insulation between it and the environment (Erikson, 1956). This is accomplished via vasoconstriction of the blood vessels in the skin. This reduction in skin circulation performs two functions which lessen the heat loss from the body. First, with the absence of blood in the skin there is also less heat. This means that the temperature gradient between the skin and the environment is less. The lower the temperature gradient, the slower the rate of heat transfer. Second, when the blood is transferred away from the skin, the result is an increase in the thickness of insulating tissue. The increase in the thickness of the barrier between the cool environment and the body core also translates into a decrease of heat loss.

In this study, the final mean skin temperature was similar for males and females at all testing temperatures (see Fig. 7). In the cold and neutral temperatures (15,20,25,27,and 30°C), the females had slightly cooler mean skin temperatures than the males. Several studies have reported that women have lower skin temperatures than men when resting in the cold (Buskirk et al., 1963; Wyndham et al., 1964; Ladell, 1949). These authors suggested that the lower female skin temperatures are due to a higher skinfold thickness in females. Because there is thicker insulation between the blood vessels and the skin, skin temperatures decrease more in females than males. Ladell stated that in a cool environment a women's skin may be 2°F cooler than a man's skin. The present study does show that the female's skin temperature was about 1°F less than the male subjects in cool environments. In the warm temperatures (33 and 36°C), the present study shows the females had slightly higher mean skin temperatures than the males. The higher skin temperatures in warm environments of females has been recorded in other studies (Yousef and Dill, 1974; Yousef et al., 1984; Fox et al., 1969). It was suggested that since males begin to sweat at lower temperatures than females and exhibit a larger sweating response, the cooling effect from the evaporation of sweat would explain the lower skin temperatures for males in warm environments.

The preferred mean skin temperature is reported to be about 33°C (Weiner and Edholm, 1981; Rao, 1952; and Hardy, 1954). In the present study, the optimum mean skin temperature of 33°C is found within the boundaries of the thermoneutral zone in both male and female subjects (determined by $\dot{V}O2$). Therefore, this study is in agreement with studies that indicate the preferred mean skin temperature is about 33°C. The TNZ as determined by $\dot{V}O2$ is presented as the area between the arrows for males and females (see Fig. 7).

Mean Body Temperature

Mean skin temperature and rectal temperature are sometimes used together to determine an estimate of the overall body temperature. This estimate is called the mean body temperature. To determine mean body temperature in a cold or neutral environment, 0.66 * rectal temperature is added to 0.34 * mean skin temperature. In a warm environment, 0.79 * rectal temperature is added to 0.21 * mean skin temperature.

If the optimum preferred mean skin temperature is assumed to be 33°C and a rectal temperature of 37°C is used in the above formula, then a mean body temperature of 35.6°C would be the optimum mean body temperature. In the present study, the mean body temperature of 35.6°C was arrived at during exposure to 29-30°C environmental temperature for both males and females (see Fig. 8). This is within the thermoneutral zone as determined by $\dot{V}O2$ in this study. Therefore, the mean body temperatures exhibited in this study are in agreement with other studies that indicate 33°C is the preferred skin temperature and 37°C is the normal core temperature in humans.

Gagge (1967), determined a change in average body temperature was associated with discomfort. The average mean body temperature for males and females as it relates to environmental temperature is presented in Figure 8 and Table 6. The present study agrees with Gagge's determination because below the TNZ the mean body temperature decreases and above the TNZ the mean body temperature increases. Comfort is closely associated with the TNZ. Within the temperature range tested in this study, the mean body temperature increased as environmental temperature increased. The mean body temperature would level out at higher temperatures because evaporation of sweat would decrease the skin temperature.

Comfort Index

The average of the comfort ratings during the final hour of exposure at each of the testing temperatures are presented in Table 7. This data and the comfort scale used to rate perceived comfort in the present study is

Table 6. The average Mean Body Temperature using final Mean Skin Temperatures and rectal temperatures during exposure in each testing temperature.

Values in degrees centigrade
Males (N=6)

DEGREES (C) ROOM TEMP.	FINAL MEAN SKIN TEMP.	FINAL MEAN RECTAL TEMP.	FINAL MEAN BODY TEMP.
15	26.81	36.55	33.34
20	28.41	36.77	34.01
25	31.13	36.82	34.94
27	32.17	36.74	35.23
30	33.66	36.98	35.88
33	35.07	37.10	36.43
36	35.63	37.22	36.89

Values in degrees centigrade
Females (N=14)

DEGREES (C) ROOM TEMP.	FINAL MEAN SKIN TEMP.	FINAL MEAN RECTAL TEMP.	FINAL MEAN BODY TEMP.
15	26.30	36.55	33.17
20	28.24	36.92	34.06
25	30.63	36.89	34.82
27	31.91	37.00	35.32
30	33.10	36.96	35.69
33	35.35	37.11	36.53
36	35.83	37.28	36.98

Table 7. Average score from the comfort scale index during the final hour of exposure in each testing temperature.

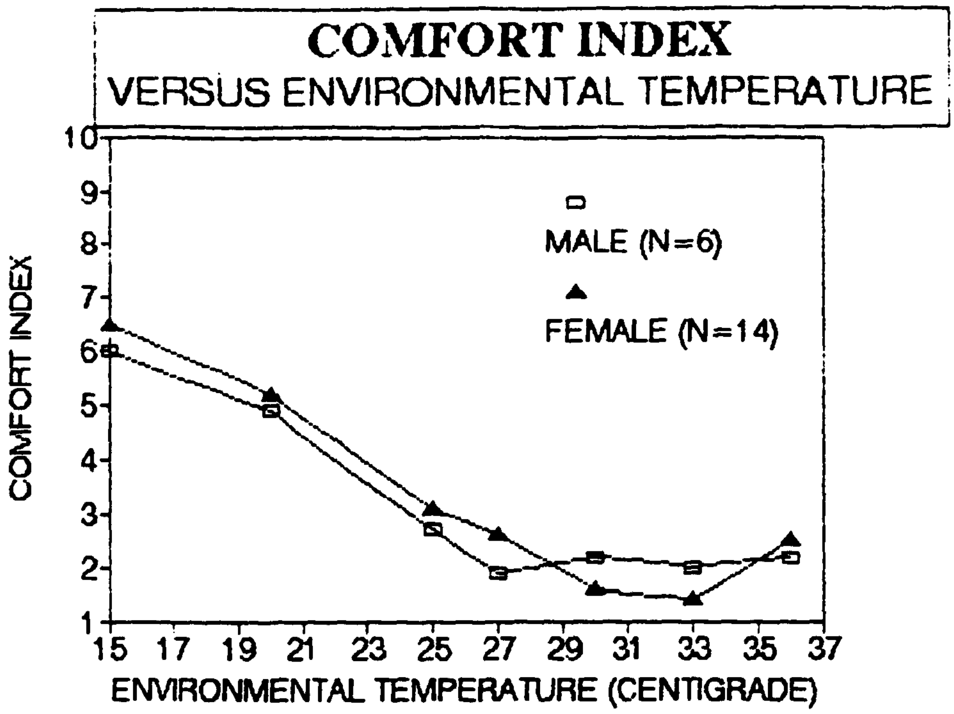
Males (N=6)

SUBJEC	15 DEG.	20 DEG.	25 DEG.	27 DEG.	30 DEG.	33 DEG.	36 DEG.
2	5.7	4.0	2.0	1.5	2.0	1.3	2.0
5	7.9	7.3	3.0	2.3	2.3	1.8	3.0
7	7.3	4.3	3.7	2.3	2.0	2.7	3.0
10	4.7	6.5	3.0	2.0	4.3	1.0	1.0
11	6.5	3.5	2.2	1.3	1.3	3.0	2.0
12	4.0	3.7	2.0	2.0	1.5	2.0	2.0
MEAN	6.0	4.9	2.7	1.9	2.2	2.0	2.2
STD.DE	1.4	1.5	0.6	0.4	1.0	0.7	0.7
MAX	7.9	7.3	3.7	2.3	4.3	3.0	3.0
MIN	4.0	3.5	2.0	1.3	1.3	1.0	1.0

Females (N=14)

SUBJEC	15 DEG.	20 DEG.	25 DEG.	27 DEG.	30 DEG.	33 DEG.	36 DEG.
1	7.8	5.2	3.3	5.0	2.0	1.0	2.0
3	5.7	4.5	3.0	2.3	2.0	1.5	3.0
4	9.0	7.7	5.0	3.0	2.3	2.0	2.0
6	6.0	5.3	3.7	2.0	2.0	1.0	2.0
8	5.5	5.5	3.8	2.7	2.0	2.0	3.0
9	8.3	5.7	3.0	4.0	2.5	1.7	3.0
13	3.3	3.0	2.7	1.0	1.0	1.0	2.0
14	6.0	3.3	2.3	1.5	1.0	1.7	2.0
15	6.0	8.0	3.7	1.0	1.0	1.0	1.0
16	7.0	5.0	3.8	3.0	2.0	2.3	3.0
17	6.3	4.7	1.7	2.2	1.5	1.3	5.0
18	6.3	5.5	3.3	2.2	1.0	1.0	2.0
19	7.2	7.0	2.5	2.0	1.0	1.7	2.0
20	6.0	3.0	1.8	4.0	1.0	1.0	3.0
MEAN	6.5	5.2	3.1	2.6	1.6	1.4	2.5
STD.DE	1.3	1.5	0.9	1.1	0.6	0.4	0.9
MAX	9.0	8.0	5.0	5.0	2.5	2.3	5.0
MIN	3.3	3.0	1.7	1.0	1.0	1.0	1.0

Fig. 9. Average comfort score during the final hour of exposure in each testing temperature.



COMFORT SCALE

10 - EXTREMELY UNCOMFORTABLE : I MUST QUIT
9 - EXTREMELY UNCOMFORTABLE : QUESTION IF I CAN GO ON
8 - VERY UNCOMFORTABLE :
7 - UNCOMFORTABLE : WOULD LIKE TO QUIT
6 - UNCOMFORTABLE : BUT BEARABLE
5 - NOT VERY COMFORTABLE : BUT EASILY BEARABLE
4 - A LITTLE DISCOMFORT : SOME STRESS
3 - A LITTLE DISCOMFORT : NO STRESS
2 - COMFORTABLE : NO STRESS
1 - EXTREMELY COMFORTABLE : COULD SIT HERE INDEFINITELY

presented in Figure 9. A lower comfort score relates to a higher degree of perceived comfort.

Ladell noted that the acceptable indoor climate depends upon the clothing. Among the numerous studies that have determined a comfort zone by the use of comfort scores (ie. a numbered comfort scale) a large study by Bedford (1948) in which he questioned 2000 subjects (mostly female) noted a low comfort zone of 15.5 to 20°C. This low comfort zone was due to two factors. 1) The subjects were doing light factory work during the temperature determination and 2) the subjects were wearing appropriate factory clothing. In Bedford's study, he stated " females usually prefer rather warmer temperature conditions than males". In the present study, the male subjects averaged number 2 on the comfort scale at 27°C. This correlates to being comfortable with no stress. The female comfort average was not as low on the comfort scale till about 29°C. Therefore the females preferred the temperature about 2°C warmer than males before they gave the highly comfortable score of 2. This study is in agreement with Bedford's suggestion that females prefer warmer temperatures when the subjects are resting in temperatures below 29°C.

The present study agrees with some other findings by Ladell (1949). Ladell determined the comfort zone of the males to be 28 - 31.6°C and for the females 27 - 32.6°C.

These findings are in agreement with the TNZ determination in this study of 27 - 30°C for males and 26 - 31.5°C for females. Ladell stated " females have a wider comfort zone than men ...". The range of the male comfort zone in Ladell's study is similar to the range of the TNZ in this study. Also, the female ranges are similar. The male comfort zone was narrower than the female comfort zone (3-3.5 vs 5.5 degrees C). The comfort zone between Ladell's study and the present study differ by 1°C. This small difference could be due to the absence of clothes in Ladell's subjects as opposed to light clothing worn in this study. Ladell's conclusion that within the comfort zone heat production was at its lowest is in agreement with the male subject data. The males indicated 27°C as the most comfortable temperature (see Fig. 9) and the lowest $\dot{V}O2$ for males was measured at 27°C. The females lowest $\dot{V}O2$ was measured at 30°C. While 30°C was extremely comfortable, 33°C was slightly more comfortable according to the comfort scale index for females.

Other studies to observe similar comfort zones were:

1) Rao (1952) when 6 ordinarily clothed (for a tropical climate) subjects found 26°C to be most comfortable.

2) Ellis (1953) when 57 male and female subjects wearing light clothing determined 27°C to be the most comfortable temperature.

3) Webb (1959) when 20 male subjects wearing slightly less than 1 clo found 28.9°C to be most comfortable.

4) Gagge (1967) when three male subjects dressed in shorts had a comfort zone 28 - 30°C.

5) Fanger (1972) in a large study on male and female nude subjects determined the optimum comfort temperature to be about 25.6°C.

The males scored temperatures of 27,30,33, and 36°C as being quite comfortable while females scored temperatures of 30 and 33°C as being the most comfortable (see comfort index ratings in Table 7 and Fig. 9).

Most studies have used perceived comfort as the primary criteria in the determination of the TNZ. When $\dot{V}O2$ and perceived comfort are recorded during an investigation, the results indicate a high correlation with each other. Fig. 10 presents the relationship of perceived comfort and VO2 in determining the TNZ in this study. The males LCT is observed to be 27°C in both $\dot{V}O2$ and by comfort index. The males perceived the temperature to be nearly as comfortable in the warm testing temperatures as in their TNZ. This may indicate a sweat response and subsequent evaporation, cooled their skin and therefore provided a comfortable environment. The female TNZ, as indicated through the comfort index, was between 2 and 3 degrees C warmer than the TNZ determined by $\dot{V}O2$. In this study, the male TNZ was entirely contained within the

Fig. 10. V̇O2 compared with perceived comfort index in determination of TNZ.

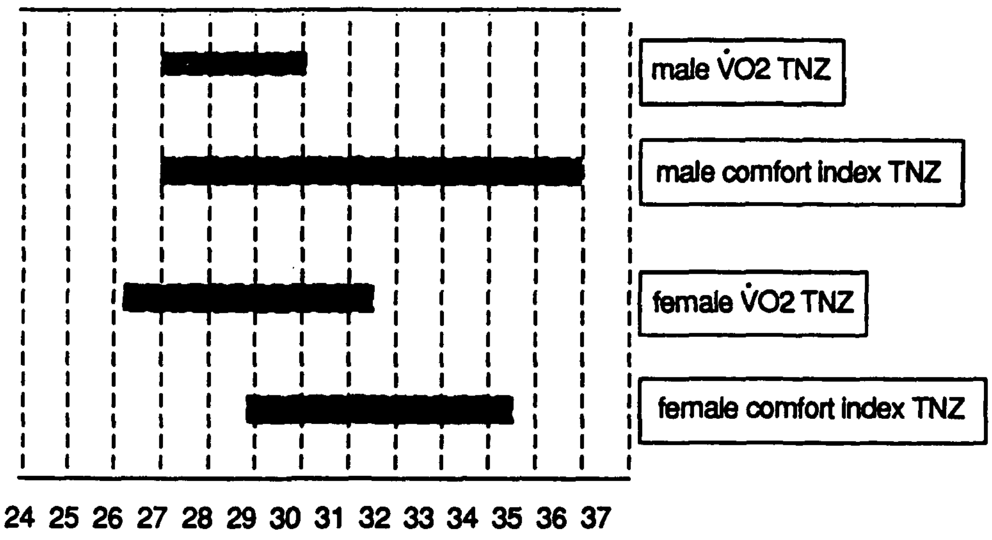


Fig. 11. Average heart rate during the final hour of exposure in each testing temperature.

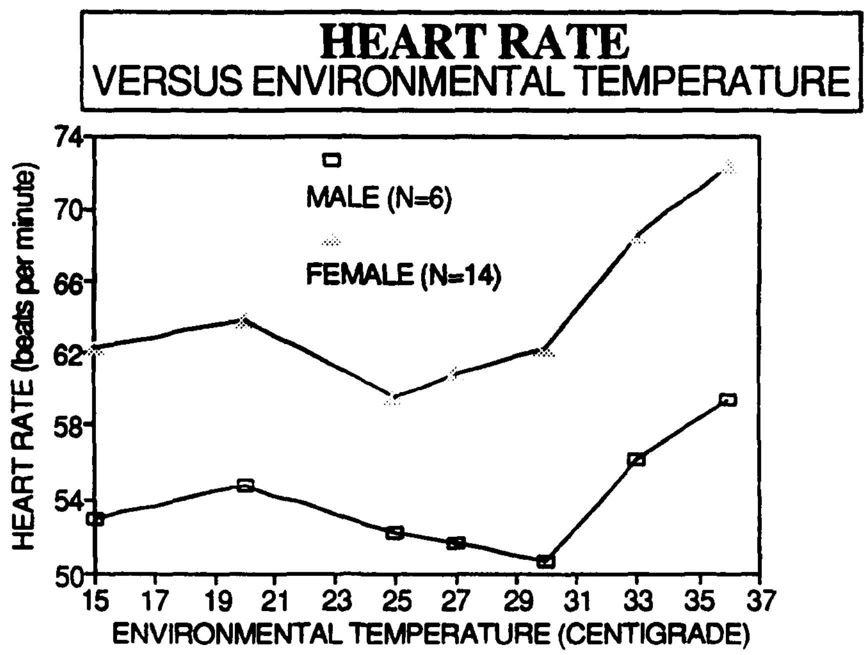


Table 8. Average heart rate during the final hour of exposure in each testing temperature.

Males (N=6)

SUB.	15 DEG.	20 DEG.	25 DEG.	27 DEG.	30 DEG.	33 DEG.	36 DEG.
2	61	68	55	53	58	72	58
5	68	67	59	62	68	61	74
7	41	40	44	36	39	47	48
10	67	69	71	68	55	62	59
11	40	44	40	46	41	49	63
12	41	41	44	45	43	46	55
MEAN	53.0	54.8	52.2	51.7	50.7	56.2	59.5
STD.D	12.5	13.2	10.7	10.8	10.5	9.5	7.9
MAX	68.0	69.0	71.0	68.0	68.0	72.0	74.0
MIN	40.0	40.0	40.0	36.0	39.0	46.0	48.0

Females (N=14)

SUB.	15 DEG.	20 DEG.	25 DEG.	27 DEG.	30 DEG.	33 DEG.	36 DEG.
1	71	78	67	75	62	76	81
3	64	71	64	60	60	66	75
4	58	56	54	51	56	58	62
6	70	78	55	61	67	67	72
8	53	51	49	53	55	61	78
9	68	73	67	69	70	71	90
13	53	61	53	54	61	69	67
14	50	53	53	55	66	72	62
15	60	58	55	60	51	63	66
16	80	78	74	66	71	87	80
17	52	56	50	57	57	53	69
18	66	66	67	70	73	82	72
19	59	59	68	60	64	75	79
20	68	57	59	61	59	61	61
MEAN	62.3	63.9	59.6	60.9	62.3	68.6	72.4
STD.D	8.4	9.5	7.7	6.7	6.3	9.0	8.2
MAX	80.0	78.0	74.0	75.0	73.0	87.0	90.0
MIN	50.0	51.0	49.0	51.0	51.0	53.0	61.0

temperatures perceived as most comfortable. The females recorded similar TNZs (between perceived comfort and $\dot{V}O2$) but the perceived comfort range was warmer by about two degrees centigrade.

Heart Rate

The mean heart rate values are presented in Table 8 and Figure 11. These values are the average of the final hour of exposure (3 recordings) in each testing temperature. The lowest mean heart rate values for the males were found within the TNZ determined by $\dot{V}O2$ (27 - 30°C). The female low mean heart rate was measured at 25°C which was slightly cooler than the low end of the TNZ as determined by $\dot{V}O2$. Both male and female subjects had an increase in mean heart rate values at temperatures above 30°C.

Vasoconstriction in response to cold caused a marked drop in both skin temperature and heart rate, which indicates the rapid shifting of blood away from the skin (Gagge et al., 1967). The rate of change in heart rate over 110 minute time period during exposure to 15°C is presented in Figure 12. The drop in heart rate is observed in both male and female subjects but the male heart rates exhibited a much greater rate of change than the female heart rates.

In warm environments (36°C), a difference between males and females in heart rate response is indicated in Figure 12. The females exhibited a continuous rise in heart rate upon exposure to 36°C that seemed to level out sometime after 30 minutes. The males had an initial drop in heart rate followed by a slight rise and after 35 minutes another drop in heart rate. At the end of 110 minutes of exposure to 36°C heat, the males showed a drop of 5 bpm while the females showed an increase of 5-6 bpm. It has been speculated that these differences are the result of women having a lesser venous return to the heart because of higher cutaneous blood flow (Haymes and Wells, 1986). These authors indicate that the stroke volume of women may be smaller than that of a man at a given cardiac output in warm temperatures. Other studies have found female heart rate to rise faster than male heart rate in warm environments (Yousef and Dill, 1974; Yousef et al., 1984; Fox et al., 1969).

Blood Pressure

Systolic blood pressure data are presented in Table 9 and Figure 13. The values are the average of the final hour of exposure (3 recordings) at each testing temperature. The lowest systolic blood pressures are observed within the TNZ (as determined by $\dot{V}O2$). Males and females both recorded the lowest systolic blood pressures in 30°C. Below this temperature there is a continuous rise in blood pressure due to vasoconstriction. The diastolic blood pressure data also shows higher pressure in cool temperatures due to vasoconstriction (Table 10, Figure 13). Unlike systolic blood pressure, the lowest diastolic blood pressures are not found within the TNZ. The pressure seems to continue to drop as the temperature increases. As the temperature increases, the blood vessels continue to dilate. This would decrease pressure.

Pulse Pressure

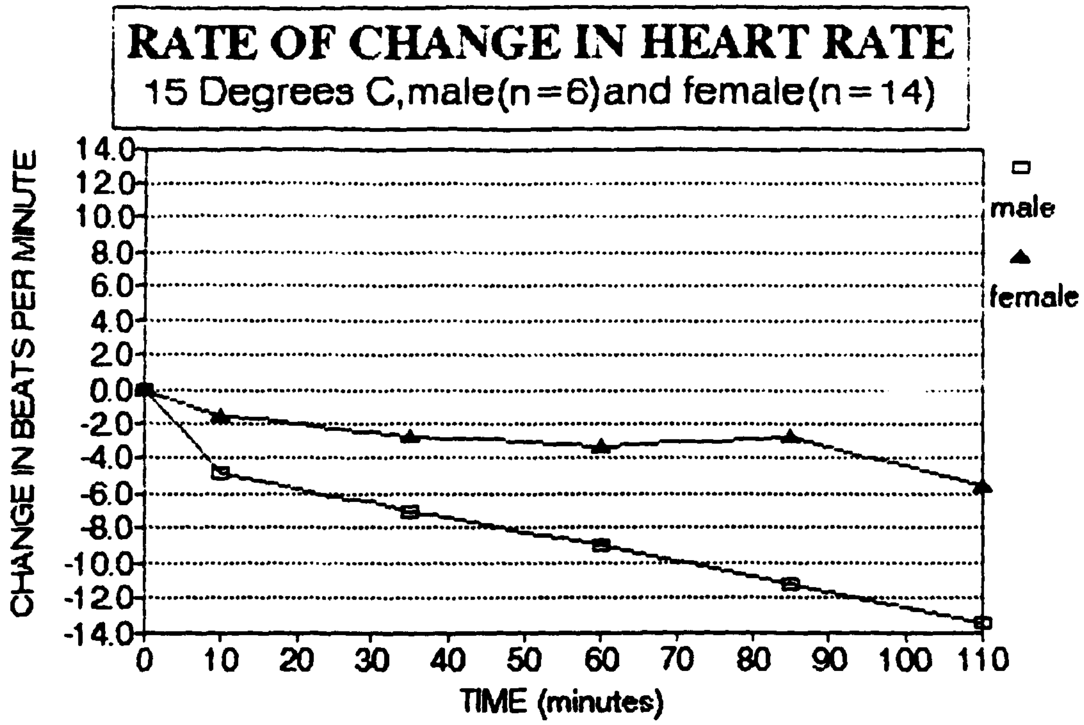
The pulse pressure is the difference between the systolic and the diastolic blood pressure. The pulse pressure values are presented in Table 11 and Fig. 14. The smallest pulse pressure was observed at 25°C for both male and female subjects.

In warm environments, blood is transferred to the skin when vasodilation occurs. The venous return of this increased blood supply causes blood pooling and therefore the heart must work harder to circulate the blood. This extra work translates into an increase in pulse pressure. In Fig. 14, the highest pulse pressure values are observed in the warm temperatures (33 and 36°C) and the largest pulse pressure is found at the warmest temperature for both male and female subjects.

Summary

This study investigated the physiologic changes in rectal temperature, mean skin temperature, blood pressure,

Fig. 12. Rate of change for heart rate in the two extremes of environmental temperature.



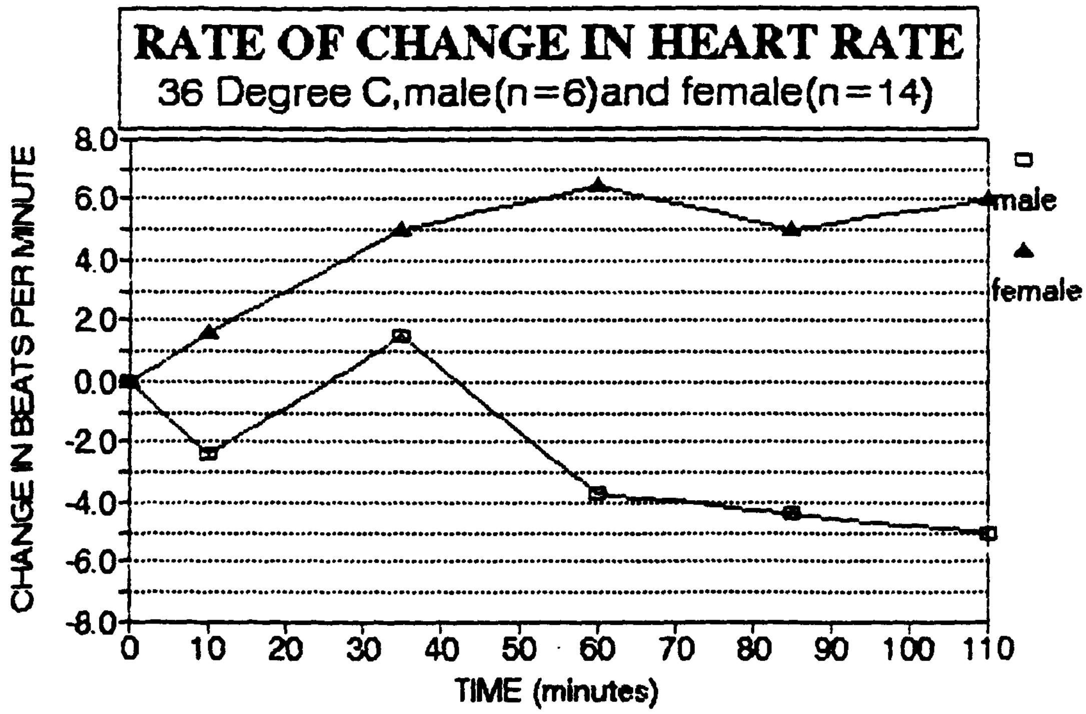


Table 9. Average systolic blood pressure during the final hour of exposure in each testing temperature.

Males (N=6)

SUB.	15 DEG.	20 DEG.	25 DEG.	27 DEG.	30 DEG.	33 DEG.	36 DEG.
2	138	136	130	133	130	126	124
5	130	128	120	118	108	109	104
7	124	120	107	100	100	116	110
10	126	117	122	119	113	100	105
11	130	127	123	125	110	129	135
12	129	114	111	108	112	121	116
MEAN	129.5	123.7	118.8	117.2	112.2	116.8	115.7
STD.D	4.4	7.5	7.7	10.8	9.0	10.0	11.0
MAX	138.0	136.0	130.0	133.0	130.0	129.0	135.0
MIN	124.0	114.0	107.0	100.0	100.0	100.0	104.0

Females (N=14)

SUB.	15 DEG.	20 DEG.	25 DEG.	27 DEG.	30 DEG.	33 DEG.	36 DEG.
1	100	116	105	107	103	102	109
3	111	113	116	112	108	107	105
4	126	122	112	105	120	102	112
6	129	114	123	122	112	114	105
8	137	128	125	116	119	111	124
9	118	112	96	93	104	102	105
13	126	120	116	121	105	120	126
14	121	117	112	108	108	115	113
15	125	119	116	110	104	104	103
16	111	117	120	116	111	104	97
17	115	110	94	110	104	103	117
18	129	110	125	122	103	117	107
19	121	113	114	115	108	116	103
20	105	113	101	106	97	104	100
MEAN	119.6	116.0	112.5	111.6	108.4	108.6	109.0
STD.D	9.9	4.8	9.7	7.6	5.5	6.3	8.2
MAX	137.0	128.0	125.0	122.0	120.0	120.0	126.0
MIN	100.0	110.0	94.0	93.0	103.0	102.0	97.0

Table 10. Average diastolic blood pressure during the final hour of exposure in each testing temperature.

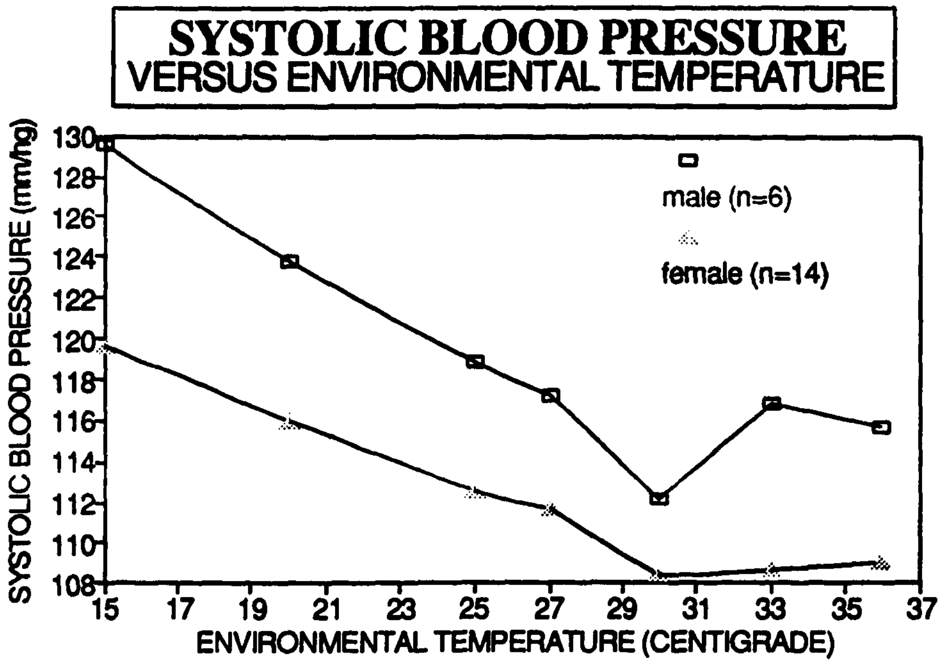
Males (N=6)

SUB.	15 DEG.	20 DEG.	25 DEG.	27 DEG.	30 DEG.	33 DEG.	36 DEG.
2	79	95	83	52	79	80	67
5	88	91	83	74	69	57	66
7	71	71	66	56	52	51	56
10	87	81	81	75	73	56	52
11	79	74	78	76	67	69	71
12	80	79	74	69	68	71	61
MEAN	80.7	81.8	77.5	67.0	68.0	64.0	62.2
STD.DEV	5.7	8.6	6.0	9.5	8.2	10.1	6.6
MAX	88.0	95.0	83.0	76.0	79.0	80.0	71.0
MIN	71.0	71.0	66.0	52.0	52.0	51.0	52.0

Females (N=14)

SUB.	15 DEG.	20 DEG.	25 DEG.	27 DEG.	30 DEG.	33 DEG.	36 DEG.
1	81	82	79	76	69	72	68
3	63	70	73	72	68	57	52
4	83	73	72	68	68	57	60
6	86	86	83	82	68	72	63
8	85	88	80	78	72	66	60
9	84	78	69	59	64	67	60
13	91	80	90	92	73	81	80
14	91	74	83	77	75	84	79
15	91	84	79	72	71	64	64
16	74	81	79	82	75	75	68
17	80	80	71	71	64	70	79
18	88	75	87	87	81	74	67
19	92	81	83	78	73	77	78
20	75	69	76	68	69	57	64
MEAN	83.1	78.6	78.9	75.9	70.8	69.5	67.3
STD.DEV	7.9	5.5	5.9	8.2	4.6	8.4	8.4
MAX	92.0	88.0	90.0	92.0	81.0	84.0	80.0
MIN	63.0	69.0	69.0	59.0	64.0	57.0	52.0

Fig. 13. Average blood pressure values for the final hour of exposure in each testing temperature.



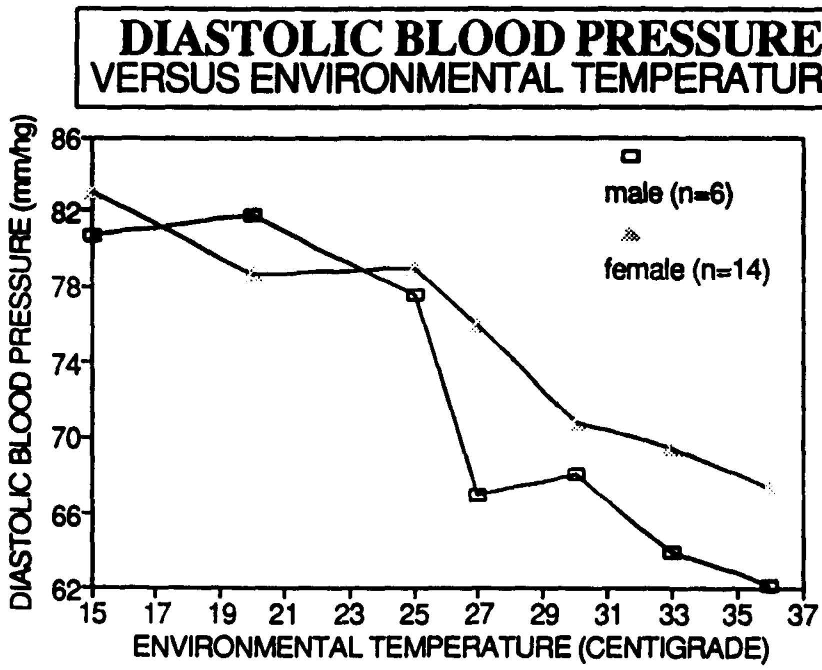


Table 11. Average pulse pressure during the final hour of exposure in each testing temperature.

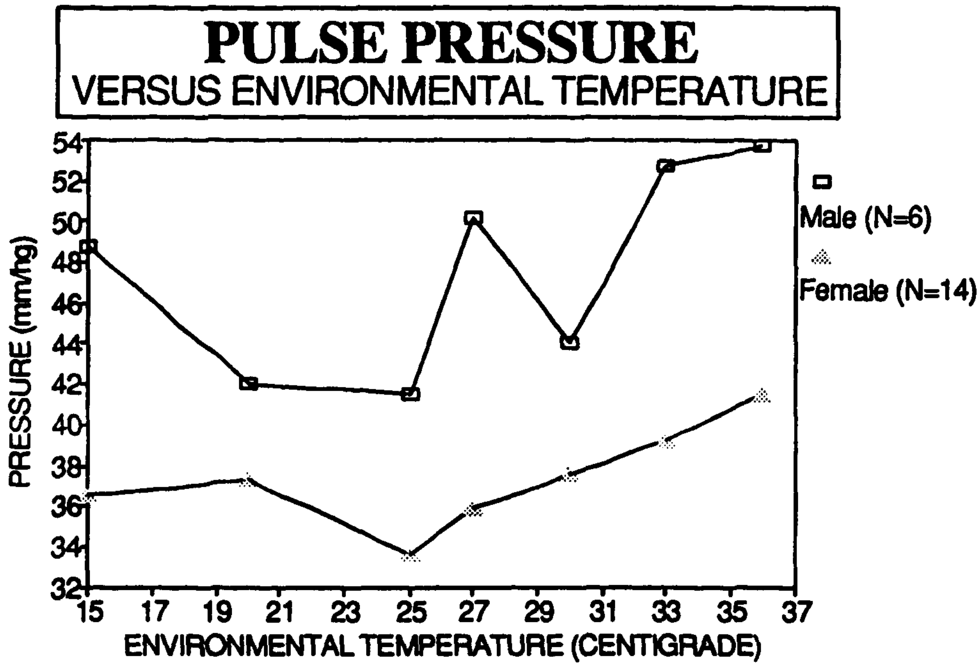
Males (N=6)

SUB.	15 DEG.	20 DEG.	25 DEG.	27 DEG.	30 DEG.	33 DEG.	36 DEG.
2	60	42	47	81	51	45	57
5	41	37	37	44	39	52	38
7	53	49	41	44	47	65	55
10	39	36	42	44	40	44	53
11	51	53	45	49	43	60	64
12	49	35	37	39	44	50	56
MEAN	48.8	42.0	41.5	50.2	44.0	52.7	53.8
STD.D	7.1	6.8	3.7	14.1	4.1	7.6	7.9
MAX	60.0	53.0	47.0	81.0	51.0	65.0	64.0
MIN	39.0	35.0	37.0	39.0	39.0	44.0	38.0

Females (N=14)

SUB.	15 DEG.	20 DEG.	25 DEG.	27 DEG.	30 DEG.	33 DEG.	36 DEG.
1	19	34	26	31	34	30	41
3	48	42	43	41	39	49	53
4	43	49	40	37	52	45	51
6	44	28	40	40	43	42	42
8	52	40	45	37	47	44	63
9	34	33	27	34	40	34	45
13	35	40	26	29	32	39	46
14	30	43	29	31	33	32	33
15	34	35	36	38	34	40	39
16	37	36	41	35	36	30	29
17	35	30	24	40	40	33	38
18	41	36	38	35	22	44	40
19	29	32	31	36	35	40	25
20	30	44	25	38	28	47	36
MEAN	36.5	37.3	33.6	35.9	37.5	39.2	41.5
STD.D	8.3	5.7	7.2	3.5	7.2	6.2	9.5
MAX	52.0	49.0	45.0	41.0	52.0	49.0	63.0
MIN	19.0	28.0	24.0	29.0	22.0	30.0	25.0

Fig. 14. Average pulse pressure during the final hour of exposure in each testing temperature.



heart rate, and resting metabolism in young subjects (18--37 years old). Each subject rated their perceived comfort by use of an index scale.

In this study, the primary criterion in the determination of the TNZ was $\dot{V}O2$. The minimal $\dot{V}O2$ values for females was found between 26 and 31.5°C. Males exhibited the least metabolic activity between 27 and 30°C. These findings are similar to those found in other studies (Erikson et al., 1956; Yousef and Golding, 1989). The females exhibited a wider range for the TNZ than the males in this study.

The rectal temperature, assumed to approximate core temperature, at temperatures of 33 and 36°C exhibited a slight rise when compared to values observed within the temperature range of the TNZ. Likewise, rectal temperature at 15°C was lower than values found within the TNZ. The rate of change in the rectal temperature at the coolest temperature (15°C) shows the female to be more tolerant than the male in the cold, as their rectal temperature dropped at a slower rate than the males. Greater tolerance to the cold is probably due to increased insulation from a higher percent fat content in the females. In contrast, the males showed a higher tolerance to warm temperatures than the females as evidenced by a slower rise in rectal temperature. A characteristic drop in rectal temperature upon initial exposure to warm temperature was exhibited by both sexes. The redistribution of blood caused by vasodilation of peripheral blood vessels leaves less blood in the rectum and therefore, less heat.

A preferred mean skin temperature of 33°C has been observed in the most comfortable temperature ranges (Weiner and Edholm, 1981; Rao, 1952; and Hardy, 1954). The preferred mean skin temperature of 33°C was found within the TNZ in both male and female subjects in this study.

The mean body temperature rises as the environmental temperature rises. If 33°C is assumed to be the preferred skin temperature and 37°C is used as the rectal temperature, then 35.6°C would be the optimum mean body temperature. In both males and females the 35.6°C mean body temperature is found within the TNZ temperature range as determined by $\dot{V}O2$.

The male subjects rated a temperature of 27°C as the most comfortable on a perceived comfort index. This temperature was also the temperature of least metabolic activity in males. While resting in temperatures below 29°C, the female subjects preferred slightly warmer temperatures than the males as evidenced by the perceived comfort index. Perceived comfort is a good indicator of thermal neutral environments. Although this study indicates temperatures may be perceived as neutral even after metabolism begins to rise in warm temperatures.

At temperatures above 30°C both the male and female subjects exhibited an increase in their heart rates. The males heart rates dropped faster than females when exposed to a cool temperature (15°C). At a warm temperature (36°C), after a two hour exposure period, males showed a drop in heart rate of 5 bpm while females showed an increase of 5-6 bpm. This difference may be due to females having a lesser venous return to the heart because of higher cutaneous blood flow (Haymes and Wells, 1986).

The lowest systolic blood pressures were observed in the TNZ in both the males and females. As the temperature decreased the systolic blood pressure increased due to vasoconstriction. Diastolic blood pressure data also indicates higher pressure in cool temperatures due to vasoconstriction. Diastolic blood pressure continued to decrease as temperature increased due to increasing vasodilation.

The pulse pressure is the difference between systolic and diastolic blood pressure. The smallest pulse pressure was observed at 25°C for both the male and female subjects. In warm environments, blood is transferred to the skin when vasodilation occurs. The venous return of this increased blood supply causes blood pooling and the heart must work harder to circulate the blood. This causes an increase in pulse pressure. The highest pulse pressures were observed in the warm testing temperatures (33 and 36°C).

Chapter 5

Summary

The purpose of this study was to measure resting metabolism ($\dot{V}O_2$ ml/kg/min), rectal temperature, mean skin temperature, a comfort index, heart rate, and blood pressure for 120 minutes in each of seven temperatures (15,20,25,27,30,33, and 36°C) to determine the TNZ. $\dot{V}O_2$ was the primary criterion used to determine the TNZ. Male and female data were observed separately for all recorded measurements.

Fourteen females and six male subjects participated in this study. The females had a mean age of 27.6 years, a mean percent body fat of 22.99, and a mean estimated $\dot{V}O_2$ maximum of 43.1 ml/kg/min. The males averaged 30.7 years of age, had a mean percent body fat of 15, and an estimated mean $\dot{V}O_2$ maximum of 46.5 ml/kg/min.

Data for all measurements were recorded after 10 minutes resting outside the environmental chamber, after 10 minutes in the environmental chamber, and every 25 minutes thereafter until a two hour exposure period was completed in each testing temperature.

Discriptive statistics were used to describe observations made on males and females and to compare the findings in this study to other similar or related studies.

Conclusions

This study supports the following conclusions:

1. The approximate TNZ as determined by $\dot{V}O2$ was between 26 - 31.5°C and 27 - 30°C for the females and males respectively.

2. In this study, at 33 and 36°C, rectal temperatures were slightly higher than in temperatures within the TNZ and at 15°C, rectal temperatures were lower than rectal temperatures measured while in the TNZ.

3. The rate of change in rectal temperature indicated that the males in this study were more heat tolerant than the females in warm (36°C) environments.

4. The females in this study were better able to conserve body heat in a cool temperature (15°C).

5. The mean skin temperature was between 31.5 and 34°C during thermally neutral environmental temperatures.

6. The females in this study exhibited cooler mean skin temperatures than males in neutral and cool environments.

7. Perceived comfort is a good indicator of the TNZ. Since it resulted in similar values to those found by $\dot{V}O2$ determination of the TNZ.

8. Discomfort was associated with temperatures of 25°C and cooler. As the temperature decreased the discomfort increased.

9. Mean heart rate values increased for males and

females in temperatures above 30°C.

10. The rate of change in heart rate showed a faster decrease for these male subjects in 15 and 36°C environments.

11. Blood pressure increases as temperature decreases in temperatures below 30°C.

12. Pulse pressure is higher in warm environments than in neutral and cool environments.

Recommendations

Based on the results and observations in this study, the following recommendations are suggested for future research:

1. A larger sample size would allow for more precise estimates of population characteristics.

2. When determining the TNZ, higher testing temperatures are needed to more accurately measure the UCT.

3. The subjects diet should be more tightly controlled. A similar meal 3-4 hours prior to testing is recommended.

4. The duration of exposure to the testing temperatures should be longer.

5. Try to develop a method of collecting the data which neither interrupts the subject or the environment (collect data from outside the environmental chamber).

Based on observations from this study, the following general recommendations are purposed:

27 to 31°C may be the most comfortable and efficient temperature range for young adults, but only when they are completely at rest and lightly clothed.

1. In cold environments, wearing an additional amount of clothing will keep an individual comfortable while allowing the indoor temperature to be kept several degrees lower thus saving money and energy.

2. In cold environments, while one is active indoors temperatures below 27°C will be comfortable. Therefore, if an individual knows his active hours, he could adjust the thermostat accordingly and again save money and energy.

3. In warm environments, as little clothing as possible is the most efficient manner to dress. The more clothing that covers the body will result in more cost and energy to keep one comfortable.

4. Air movement allows one to be comfortable in warmer temperatures. Therefore, use of low energy consuming fans, or if the temperature is only slightly warm, opening windows will allow one to keep comfortable and perserve cost and energy.

APPENDIX A

Raw Data

APPENDIX A, DATA AT 15 DEGREES CENTIGRADE

SUBJECT	MEAN $\dot{V}O2$ (ml/kg/min)	$\dot{V}O2$ (ml/kg/min) (STPD) T 1	T 2	T 3	T 4	T 5	T 6	$\dot{V}E$ (ATPS) T 1	T 2	T 3	T 4	T 5	T 6
1	3.86	2.72	3.60	3.96	3.85	3.79	3.94	53.4	57.7	63.4	61.4	67.4	62.7
2	4.62	4.48	4.96	4.77	4.52	4.75	4.57	83.8	93.3	89.8	83.6	86.8	85.4
3	4.61	3.80	4.72	4.34	4.58	4.54	4.72	62.4	70.3	65.8	70.8	68.6	69.5
4	6.38	4.13	5.49	5.57	6.47	6.26	6.43	83.1	80.0	84.9	86.8	83.6	72.6
5	4.86	3.23	3.64	4.17	5.18	4.96	4.45	76.7	64.0	86.2	100.3	104.6	86.1
6	5.38	0.00	3.70	4.17	4.98	5.59	5.59		70.1	66.8	70.4	95.6	92.1
7	6.61	5.26	6.22	6.73	6.04	7.00	6.80	68.6	77.3	83.3	82.0	95.1	92.1
8	4.42	3.41	3.94	3.81	3.94	4.22	5.08	46.5	52.2	48.7	52.4	54.8	53.4
9	8.05	3.94	7.05	6.94	7.11	6.31	10.74	57.9	77.4	96.8	102.4	86.4	126.9
10	4.57	3.92	3.92	3.88	3.83	4.76	5.13	110.7	77.3	79.6	76.6	92.3	123.0
11	3.75	3.62	3.21	3.18	3.75	3.92	3.57	78.6	64.2	66.7	74.5	79.2	76.6
12	3.74	3.55	3.81	3.75	3.42	3.75	4.04	79.5	83.7	78.5	71.2	80.7	87.2
13	3.86	3.69	3.57	3.53	3.38	3.69	4.51	71.7	66.3	68.0	66.1	69.0	81.6
14	5.04	3.65	3.87	3.90	5.75	5.08	4.29	60.2	59.7	58.7	83.4	72.4	63.3
15	4.07	3.47	4.48	3.97	4.23	4.07	3.91	56.0	72.7	58.9	69.7	65.4	52.4
16	4.40	3.50	3.82	3.53	4.59	4.17	4.44	38.5	57.7	52.0	68.1	60.3	65.7
17	3.18	2.80	3.13	3.15	2.96	3.08	3.52	57.1	55.0	54.9	54.1	53.2	59.9
18	5.22	3.28	4.27	4.79	5.18	5.26	5.22	54.3	69.6	74.1	84.9	83.8	82.8
19	6.55	3.88	4.96	5.26	6.40	6.52	6.72	56.3	64.1	70.4	75.1	76.7	84.9
20	5.73	3.53	3.30	5.27	5.84	6.09	5.25	65.3	56.0	101.3	82.0	132.5	133.4

SUBJECT	MEAN COMFORT	COMFORT INDEX T 1	T 2	T 3	T 4	T 5	T 6	BARO. PRESSURE	WEIGHT (KG)
1	7.8	1.0	5.0	6.0	7.0	8.0	8.5	719	70.17
2	5.7	1.5	2.0	3.0	5.0	6.0	6.0	724	79.26
3	5.7	2.0	3.0	4.0	5.0	6.0	6.0	722	73.73
4	9.0	2.0	3.0	6.0	9.0	9.0	9.0	724	54.08
5	7.9	2.0	3.0	6.0	7.0	8.0	8.8	722	89.47
6	6.0	1.0	3.0	4.0	5.0	6.0	7.0	726	61.55
7	7.3	1.0	2.0	4.0	6.0	8.0	8.0	717	63.04
8	5.5	1.0	4.0	4.0	4.5	5.5	6.5	725	55.73
9	8.3	2.0	5.0	7.0	7.5	8.5	9.0	725	46.26
10	4.7	2.0	3.0	3.0	4.0	4.5	5.5	722	75.79
11	6.5	1.0	3.0	4.0	6.0	6.5	7.0	709	77.53
12	4.0	1.0	2.0	3.0	3.0	4.0	5.0	719	88.56
13	3.3	1.0	3.0	3.0	3.0	3.0	4.0	710	79.00
14	6.0	1.0	2.0	3.0	3.5	7.0	7.5	713	57.86
15	6.0	1.0	6.0	6.0	6.0	6.0	6.0	716	66.93
16	7.0	1.5	2.5	4.0	6.0	8.0	7.0	715	74.58
17	6.3	1.0	3.0	5.0	6.0	6.0	7.0	718	67.49
18	6.3	1.0	3.8	5.0	6.0	6.5	6.5	719	59.91
19	7.2	1.5	3.0	5.5	6.5	7.0	8.0	712	54.21
20	6.0	1.0	1.5	2.5	3.5	6.5	8.0	716	55.96

APPENDIX A, DATA AT 15 DEGREES CENTIGRADE

SUBJECT	FE O2 (ATPS) T 1	T 2	T 3	T 4	T 5	T 6	FE CO2 (ATPS) T 1	T 2	T 3	T 4	T 5	T 6
1	16.80%	15.90%	15.90%	15.90%	16.40%	15.90%	3.70%	4.30%	4.20%	4.10%	3.70%	4.05%
2	16.10%	16.10%	16.10%	16.05%	16.00%	16.10%	4.00%	4.10%	4.10%	3.95%	3.95%	3.95%
3	15.80%	15.30%	15.40%	15.50%	15.40%	15.25%	4.35%	4.60%	4.45%	4.40%	4.30%	4.45%
4	17.90%	16.90%	16.90%	16.80%	16.80%	16.60%	3.10%	3.50%	3.40%	3.50%	3.40%	3.50%
5	16.60%	16.30%	16.00%	15.70%	16.10%	15.70%	3.90%	4.00%	4.20%	4.30%	4.10%	4.30%
6	17.50%	16.90%	16.60%	17.00%	16.90%	17.10%	2.80%	3.25%	3.40%	3.20%	3.20%	3.30%
7	15.30%	15.00%	15.00%	15.50%	15.50%	15.50%	5.10%	5.30%	5.20%	4.80%	4.80%	4.70%
8	16.30%	16.20%	16.00%	16.20%	16.10%	16.15%	3.90%	3.80%	4.00%	3.80%	3.80%	3.80%
9	17.20%	17.90%	17.80%	17.90%	17.75%	18.35%	3.80%	3.20%	3.10%	3.00%	3.10%	2.70%
10	18.20%	17.00%	16.80%	17.10%	17.40%	19.00%	2.90%	3.40%	3.35%	3.20%	3.00%	2.20%
11	17.15%	16.85%	17.05%	16.85%	16.90%	17.15%	3.25%	3.40%	3.20%	3.30%	3.30%	3.05%
12	16.30%	16.20%	16.00%	16.00%	16.15%	16.15%	4.25%	4.35%	4.40%	4.25%	4.15%	4.20%
13	16.30%	16.10%	16.25%	16.30%	16.10%	15.95%	3.55%	3.60%	3.60%	3.60%	3.70%	3.80%
14	16.90%	16.60%	16.50%	16.30%	16.25%	16.40%	3.30%	3.60%	3.60%	3.90%	3.80%	3.70%
15	16.20%	16.20%	15.80%	16.25%	16.10%	16.30%	3.90%	3.90%	4.00%	3.90%	4.10%	3.90%
16	16.30%	16.40%	16.30%	16.30%	16.20%	16.30%	3.70%	3.75%	3.70%	3.80%	3.80%	3.75%
17	17.10%	16.50%	16.50%	16.70%	16.45%	16.40%	3.40%	3.85%	3.70%	3.60%	3.80%	3.80%
18	16.80%	16.70%	16.50%	16.70%	16.60%	16.60%	3.40%	3.60%	3.60%	3.60%	3.60%	3.50%
19	16.60%	16.05%	16.20%	15.60%	15.60%	15.95%	3.60%	4.15%	4.10%	4.35%	4.40%	4.20%
20	17.40%	17.10%	17.50%	16.50%	17.90%	18.80%	3.20%	3.40%	3.20%	3.10%	2.80%	2.20%

SUBJECT	GAS TEMPERATURE (C) T 1	T 2	T 3	T 4	T 5	T 6	WATER VAPOR PRESSURE (mm/Hg) T 1	T 2	T 3	T 4	T 5	T 6
1	24.5	25.3	25.9	26.2	26.8	26.8	23.2	24.3	25.2	25.5	26.4	24.4
2	26.3	26.5	26.5	27.0	27.0	26.8	25.8	26.1	26.1	26.7	26.7	26.4
3	25.5	26.0	26.5	26.5	27.1	26.9	24.6	25.2	26.1	26.1	27.1	26.6
4	25.0	25.2	25.2	25.5	25.8	25.8	23.8	24.0	24.0	24.6	24.9	24.9
5	23.9	24.0	24.7	24.8	24.8	24.9	22.4	22.4	23.5	23.5	23.5	23.8
6	26.2	26.0	26.0	25.9	25.5	25.5	25.5	25.2	25.2	25.2	24.6	24.6
7	25.0	26.0	26.2	26.8	26.8	27.0	23.8	25.2	25.5	26.4	26.4	26.7
8	25.1	25.4	25.8	26.0	26.2	26.1	24.0	24.3	24.9	25.2	25.5	25.5
9	25.0	25.2	25.5	25.5	25.8	25.8	23.8	24.0	24.6	24.6	24.9	24.9
10	24.0	23.5	23.3	23.0	23.2	24.0	22.4	21.8	21.6	21.1	21.3	22.4
11	27.0	27.2	27.2	27.0	27.1	27.0	26.7	27.1	27.1	26.7	27.1	26.7
12	25.7	26.0	26.4	26.6	26.8	26.8	24.9	25.2	25.8	26.1	26.4	26.4
13	25.2	25.6	25.8	25.9	26.0	26.0	24.0	24.6	24.9	25.2	25.2	25.2
14	25.4	25.9	26.1	26.2	26.3	26.4	24.3	25.2	25.5	25.5	25.8	25.8
15	24.8	25.5	26.0	26.2	26.4	26.8	23.5	24.6	25.2	25.5	25.8	26.5
16	25.1	25.4	25.8	26.2	26.3	26.3	24.0	24.3	24.9	25.5	25.8	25.8
17	24.8	24.9	25.0	25.0	25.0	25.0	23.5	23.8	23.8	23.8	23.8	23.8
18	25.4	26.0	26.4	26.8	27.0	27.0	24.3	25.2	25.8	26.4	26.7	26.7
19	26.1	25.9	25.9	25.9	26.0	25.9	25.5	25.2	25.2	25.2	25.2	25.2
20	25.0	25.1	25.5	25.5	26.0	26.0	23.8	24.0	24.6	24.6	25.2	25.2

APPENDIX A, DATA AT 15 DEGREES CENTIGRADE

SUBJECT	FINAL RECTAL TEMPERATURE	RECTAL TEMPERATURE T 1	T 2	T 3	T 4	T 5	T 6	SYSTOLIC BLOOD PRESSURE T 1	T 2	T 3	T 4	T 5	T 6
1	36.3	37.1	37.1	37.0	36.9	36.6	36.3	101	105	100	90	103	107
2	36.5	37.6	37.3	37.2	37.0	36.8	36.5	135	138	138	136	135	144
3	37.0	37.4	37.4	37.3	37.1	37.0	37.0	102	115	109	111	111	111
4	34.0	37.0	36.0	35.1	34.5	34.0	34.0	107	124	121	125	130	122
5	36.0	37.2	36.7	36.7	36.5	36.3	36.0	124	124	129	126	132	131
6	37.2	37.8	37.7	37.7	37.5	37.4	37.2	112	118	126	133	128	127
7	36.4	37.5	37.4	37.2	36.8	36.6	36.4	104	110	126	125	125	121
8	36.6	37.2	37.1	37.0	36.9	36.7	36.6	121	123	124	127	138	145
9	36.5	37.5	37.4	37.3	37.0	36.6	36.5	104	112	119	122	112	120
10	37.2	37.5	37.6	37.5	37.4	37.3	37.2	122	117	120	124	126	129
11	36.4	37.5	37.4	37.2	36.8	36.6	36.4	124	139	133	122	133	135
12	36.8	37.4	37.4	37.3	37.2	37.0	36.8	119	123	125	127	128	132
13	36.6	37.3	37.2	37.2	37.1	36.9	36.6	125	122	118	128	126	123
14	35.8	36.8	36.6	36.4	36.3	36.1	35.8	103	104	102	115	124	125
15	37.2	37.4	37.3	37.5	37.5	37.5	37.2	108	122	114	130	125	120
16	37.0	37.4	37.4	37.4	37.2	37.2	37.0	114	103	120	104	111	117
17	36.2	36.8	36.7	36.7	36.5	36.4	36.2	111	109	103	113	116	116
18	37.3	37.5	37.6	37.5	37.5	37.3	37.3	106	129	121	132	140	114
19	37.3	37.2	37.3	37.5	37.4	37.3	37.3	103	120	115	120	118	126
20	36.7	37.4	37.2	36.7	37.1	36.9	36.7	91	104	101	111	95	110

SUBJECT	MEAN H.R.	HEART RATE T 1	T 2	T 3	T 4	T 5	T 6	DIASTOLIC BLOOD PRESSURE T 1	T 2	T 3	T 4	T 5	T 6
1	71	83	75	71	75	71	68	70	70	70	72	87	85
2	61	80	70	74	72	56	54	66	69	79	69	82	85
3	64	71	65	68	68	63	60	53	61	57	57	74	59
4	58	60	56	58	58	56	60	74	78	80	78	85	86
5	68	60	68	71	71	63	71	64	80	82	82	90	93
6	70	65	60	63	63	71	75	83	86	83	86	80	91
7	41	55	48	42	40	43	41	53	54	60	72	83	57
8	53	63	58	53	50	56	52	79	81	91	79	84	91
9	68	68	75	71	68	68	68	71	73	75	82	82	89
10	67	75	75	65	63	74	63	81	80	80	78	89	94
11	40	64	52	48	42	40	38	81	78	88	81	81	74
12	41	52	44	44	44	42	38	60	66	77	75	77	87
13	53	60	56	65	56	52	52	81	89	88	89	92	91
14	50	58	60	48	57	53	39	75	84	82	91	93	90
15	60	63	75	70	58	60	63	63	90	77	91	90	91
16	80	83	79	74	83	83	74	73	80	79	62	76	84
17	52	65	57	55	56	56	45	79	80	74	77	82	82
18	66	68	68	71	68	68	63	80	91	83	92	91	81
19	59	58	58	60	52	65	60	78	88	84	88	103	85
20	68	62	64	62	68	66	70	50	64	58	74	76	75

APPENDIX A, DATA AT 15 DEGREES CENTIGRADE

SUBJECT	FINAL MEAN SKIN TEMPERATURE	MEAN SKIN TEMPERATURE (C) T 1	T 2	T 3	T 4	T 5	T 6	FOREHEAD (C) T 1	T 2	T 3	T 4	T 5	T 6
1	25.8	32.0	28.6	27.0	26.7	26.2	25.8	33.5	30.9	30.6	30.2	30.0	28.4
2	25.7	33.4	29.8	28.1	27.1	26.5	25.7	34.0	31.9	31.6	30.5	31.3	30.1
3	26.3	33.7	29.8	28.6	27.4	27.8	26.3	35.1	33.1	32.9	31.1	31.9	30.4
4	26.3	32.4	28.3	27.5	27.2	26.7	26.3	33.5	29.3	30.1	29.7	29.1	29.0
5	28.1	32.9	30.4	28.4	28.4	27.9	28.1	33.8	32.6	30.6	31.5	31.5	31.3
6	26.5	33.2	29.1	27.4	27.3	26.9	26.5	34.9	33.3	30.6	32.2	31.4	31.1
7	29.2	33.7	31.1	30.3	29.4	29.1	29.2	34.4	32.5	30.1	30.5	30.8	29.3
8	26.2	32.6	29.3	27.7	26.6	26.4	26.2	33.5	30.8	29.6	28.5	28.6	28.2
9	28.0	32.1	30.0	29.3	28.8	28.2	28.0	34.0	31.6	30.5	29.7	29.3	28.0
10	25.7	30.9	28.5	27.2	26.5	25.9	25.7	33.3	30.6	29.9	29.9	29.8	29.1
11	26.4	32.6	30.0	28.4	27.3	26.7	26.4	32.5	30.0	29.5	29.5	27.6	27.8
12	25.8	32.8	29.5	28.0	26.6	26.3	25.8	33.3	30.2	30.4	30.3	27.1	27.6
13	25.4	32.3	29.0	27.5	26.8	26.0	25.4	33.7	32.0	31.1	29.6	28.3	28.0
14	26.1	33.1	28.8	26.9	27.0	26.7	26.1	34.1	31.2	30.4	29.4	29.2	29.2
15	27.0	32.3	28.7	27.0	26.7	27.1	27.0	34.4	32.6	31.4	30.1	29.2	29.2
16	25.3	32.7	29.2	28.1	26.4	25.5	25.3	33.2	31.5	36.9	31.0	30.4	29.8
17	25.9	32.4	29.0	27.2	26.8	26.3	25.9	33.5	31.4	30.3	30.3	30.6	30.0
18	25.5	33.2	28.8	30.0	26.5	26.2	25.5	34.4	32.4	31.3	31.7	31.8	29.6
19	27.1	32.5	29.4	27.3	27.6	27.2	27.1	33.3	31.3	30.5	29.6	29.9	28.1
20	26.7	32.4	29.0	27.4	26.4	25.8	26.7	33.6	30.3	35.8	25.9	29.9	29.2

SUBJECT	CHEST (C) T 1	T 2	T 3	T 4	T 5	T 6	UPPER ARM (C) T 1	T 2	T 3	T 4	T 5	T 6
1	33.4	32.2	30.5	31.5	31.5	31.5	31.3	27.1	24.8	23.7	23.3	22.6
2	33.3	32.0	30.3	30.6	29.2	28.5	33.8	29.7	28.2	26.2	26.5	25.2
3	35.1	33.4	32.8	32.8	33.4	32.3	32.5	28.4	27.1	26.3	26.1	25.6
4	35.1	33.6	32.9	33.8	33.2	32.6	31.8	27.7	28.8	28.2	26.9	26.7
5	34.1	33.4	32.1	33.3	32.8	33.2	32.5	28.7	27.3	27.4	27.3	27.7
6	35.3	33.8	32.4	33.4	33.4	33.4	33.1	27.7	25.8	25.0	24.9	24.5
7	34.5	34.6	34.6	34.8	34.0	34.0	33.2	30.5	30.7	29.1	27.6	29.5
8	34.2	33.0	33.1	32.5	32.9	33.0	32.6	28.9	26.2	24.9	24.8	24.3
9	34.3	34.1	34.4	34.1	34.4	33.8	31.3	27.3	25.8	24.8	25.2	24.3
10	32.5	31.5	31.3	31.0	30.5	30.5	29.4	28.5	27.2	26.7	26.3	25.9
11	32.9	32.7	31.8	31.0	30.5	30.6	31.3	28.8	28.0	27.0	26.7	25.4
12	33.6	33.2	32.1	30.6	31.5	30.9	32.7	29.1	27.5	26.2	26.0	25.3
13	33.9	33.2	32.9	32.4	31.7	31.4	31.6	28.0	25.4	25.0	24.8	23.2
14	34.1	32.3	29.8	31.5	31.4	31.1	32.4	28.4	26.9	25.6	25.6	25.7
15	34.1	32.2	32.0	32.0	33.3	32.3	31.0	27.1	24.5	24.0	24.3	23.9
16	33.3	31.7	30.8	29.8	29.7	29.6	31.7	28.5	25.8	24.6	24.1	22.8
17	33.0	31.0	30.8	30.8	30.8	30.7	32.4	27.5	25.9	25.2	24.5	24.0
18	33.5	32.2	39.8	31.3	31.3	29.4	32.1	27.7	25.6	24.6	24.3	24.8
19	34.2	33.3	31.3	33.1	33.4	32.9	32.0	28.2	26.8	27.0	26.2	25.5
20	33.2	33.5	31.7	31.4	30.5	33.3	31.9	27.5	25.7	25.6	25.1	25.1

APPENDIX A, DATA AT 15 DEGREES CENTIGRADE

SUBJECT	CALF (C) T 1	T 2	T 3	T 4	T 5	T 6	BIG TOE (C) T 1	T 2	T 3	T 4	T 5	T 6
1	31.5	27.8	25.5	24.7	23.6	22.9	26.5	18.7	16.4	16.3	16.0	15.6
2	33.5	29.8	28.7	27.5	26.2	25.6	33.2	20.4	16.5	15.7	15.7	15.3
3	32.7	27.5	26.3	24.3	25.7	23.4	33.0	20.6	16.7	15.7	15.6	15.3
4	31.6	26.1	24.4	22.5	22.7	22.6	24.2	16.5	15.3	15.2	15.0	14.8
5	32.3	32.2	26.7	25.7	25.3	25.1	32.1	19.3	16.9	16.9	16.0	16.8
6	32.5	26.2	24.8	23.6	22.7	22.4	25.1	17.0	15.2	14.8	14.7	14.8
7	33.6	30.0	28.8	26.3	26.9	26.1	32.8	19.8	17.7	16.6	15.9	16.0
8	32.5	27.3	24.6	23.1	22.5	21.6	25.3	17.5	16.2	16.2	15.4	15.5
9	32.3	28.9	26.5	26.3	24.8	26.1	24.4	19.9	18.6	16.8	16.4	16.1
10	31.9	28.7	26.6	25.5	23.3	23.5	23.4	18.0	17.8	16.1	15.9	15.9
11	33.2	29.4	26.9	26.0	25.0	25.0	32.8	20.5	16.5	16.0	15.0	15.1
12	32.2	28.0	26.5	24.6	24.2	24.0	31.7	19.2	17.2	16.3	15.6	14.9
13	31.8	26.6	24.1	23.2	22.5	21.4	26.3	18.5	16.4	15.3	15.1	14.8
14	32.5	26.1	25.0	23.7	22.6	22.3	31.2	19.6	17.0	16.2	16.5	16.1
15	32.6	26.4	24.6	23.9	25.6	25.6	25.5	19.9	16.2	15.8	15.5	16.2
16	31.8	27.4	25.5	23.6	22.3	22.5	33.8	21.4	17.2	15.8	16.0	15.3
17	32.1	30.9	26.3	25.9	23.5	23.8	32.2	19.7	16.3	15.5	15.2	15.1
18	33.1	27.8	26.0	24.7	24.4	24.4	33.8	18.1	16.3	15.8	15.4	15.4
19	32.1	27.3	25.1	24.4	23.3	24.0	25.5	19.8	17.1	17.4	16.5	15.7
20	32.4	26.0	23.5	22.9	20.8	21.9	30.9	18.7	16.8	15.6	15.2	15.8

SUBJECT	FINGER (C) T 1	T 2	T 3	T 4	T 5	T 6	THIGH (C) T 1	T 2	T 3	T 4	T 5	T 6
1	30.5	24.2	21.5	19.1	18.4	17.8	32.2	27.4	27.0	25.8	25.0	24.5
2	33.8	26.6	22.7	20.1	19.9	18.7	33.0	29.5	27.8	25.9	25.5	24.8
3	32.5	27.3	22.3	19.5	19.8	18.1	32.8	28.5	27.9	25.6	25.1	22.5
4	31.8	25.3	21.0	18.1	17.8	17.6	31.0	25.5	24.1	23.6	22.9	22.4
5	32.7	27.9	25.2	23.6	23.0	22.2	31.3	28.8	27.6	26.2	25.3	25.4
6	33.1	24.7	22.4	22.1	21.2	19.8	32.2	27.4	26.0	24.3	23.4	22.7
7	33.4	26.9	23.0	20.5	22.0	21.9	33.0	30.5	29.8	28.4	28.8	29.0
8	33.0	26.5	23.9	22.0	21.9	20.6	32.1	28.6	25.3	23.5	22.8	22.7
9	30.1	24.6	21.1	20.4	20.5	20.4	31.0	29.7	30.1	30.2	27.3	27.7
10	28.6	23.3	21.2	20.3	19.0	17.3	30.6	27.5	24.3	22.8	22.8	22.6
11	32.7	29.5	27.6	24.5	26.2	22.1	32.7	29.7	27.5	25.8	25.2	25.2
12	32.5	25.4	21.6	19.5	18.8	18.8	31.9	28.4	26.8	25.1	24.1	23.4
13	30.4	24.0	21.2	20.5	19.3	19.2	32.3	27.7	25.8	24.9	23.9	23.2
14	32.9	26.4	23.6	22.6	19.6	21.5	32.4	27.6	25.9	26.1	26.2	23.6
15	33.1	26.2	22.1	19.7	19.6	17.8	31.4	27.4	25.0	25.4	24.4	26.3
16	33.7	27.0	26.4	25.2	22.2	22.1	32.2	28.7	27.7	25.7	23.6	24.1
17	32.0	28.3	21.5	23.2	23.1	20.4	31.5	28.0	26.7	24.9	24.4	23.9
18	33.8	25.3	21.1	19.7	19.6	19.4	32.8	27.6	24.7	24.0	23.3	23.6
19	32.4	26.0	22.2	20.7	19.8	19.6	32.2	28.2	25.9	24.9	24.0	25.6
20	32.1	24.6	20.7	18.5	19.1	18.4	31.6	28.1	26.1	26.3	25.2	24.3

APPENDIX A, DATA AT 20 DEGREES CENTIGRADE

SUBJECT	MEAN $\dot{V}O_2$ (ml/kg/min)	$\dot{V}O_2$ (ml/kg/min) (STPD) T 1	T 2	T 3	T 4	T 5	T 6	$\dot{V}E$ (ATPS) T 1	T 2	T 3	T 4	T 5	T 6
1	4.08	2.79	3.28	4.23		4.28	3.89	63.7	53.5	63.1	LOST	66.3	57.4
2	4.30	3.83	3.72	3.79	4.32	4.41	4.17	78.7	83.2	82.6	93.3	85.7	80.6
3	3.78	3.48	3.65	3.28	3.86	3.84	3.64	78.0	91.9	65.2	81.4	79.3	73.2
4	5.98	4.24	4.98	5.09	5.49	6.16	6.29	81.0	78.8	76.0	73.9	82.4	85.1
5	4.21	3.06	3.73	3.72	4.19	4.24	4.19	76.9	87.3	86.9	98.6	98.5	96.5
6	4.96	3.61	3.73	3.72	4.11	5.39	5.38	71.5	61.7	63.1	73.5	88.2	87.0
7	5.77	5.45	5.55	5.52	5.74	6.52	5.07	85.7	88.5	77.5	74.9	80.4	68.8
8	4.17	3.52	3.88	3.79	3.88	4.11	4.50	53.3	54.2	48.1	52.6	51.9	60.1
9	6.67	4.08	5.90	8.22	5.98	7.56	6.46	72.5	104.8	109.1	122.6	112.0	121.3
10	3.91	3.85	3.97	3.83	4.03	3.89	3.79	86.0	80.1	82.6	70.3	87.7	84.0
11	3.31	3.53	2.85	2.97	3.16	3.14	3.64	77.0	63.5	66.0	72.5	73.7	85.5
12	3.37	3.09	3.38	3.45	3.22	3.28	3.62	58.2	81.4	80.5	75.4	76.8	80.9
13	4.01	3.21	3.55	3.86	3.89	4.08	4.06	46.1	52.0	56.5	59.9	59.5	63.6
14	5.05	4.85	4.31	4.67	3.80	5.85	5.50	76.0	66.6	68.3	58.4	68.7	64.3
15	4.23	3.91	4.59	5.41	3.79	4.20	4.70	65.1	59.2	54.6	48.6	58.7	69.2
16	3.75	3.46	3.73	3.71	3.45	3.76	4.03	35.5	78.0	83.3	74.3	71.1	72.7
17	3.13	3.07	3.22	3.20	3.24	3.07	3.09	37.7	37.3	35.7	38.3	36.1	37.4
18	3.93	3.15	3.42	3.64	3.85	4.28	3.66	57.7	68.9	69.5	70.7	81.5	67.7
19	5.99	3.94	4.25	4.70	5.48	5.85	6.63	60.0	56.1	55.0	76.8	87.8	83.5
20	4.40	3.56	4.51	4.91	4.54	4.61	4.05	66.9	73.7	74.5	76.0	78.4	90.2

SUBJECT	MEAN COMFORT	COMFORT INDEX T 1	T 2	T 3	T 4	T 5	T 6	BARO. PRESSURE	WEIGHT (KG)
1	5.2	2.0	3.0	4.0	4.5	5.0	6.0	725	70.23
2	4.0	2.0	3.0	3.0	3.5	4.0	4.5	720	80.06
3	4.5	2.0	3.0	3.5	4.0	4.5	5.0	722	73.22
4	7.7	1.0	4.0	6.0	7.0	8.0	8.0	724	54.08
5	7.3	2.0	5.0	6.0	7.0	7.0	8.0	727	90.77
6	5.3	2.0	3.0	4.0	5.0	5.5	5.5	727	60.82
7	4.3	1.0	2.0	4.0	4.0	4.0	5.0	720	61.13
8	5.5	2.0	4.0	4.5	5.0	6.0	5.5	722	56.76
9	5.7	2.0	4.0	4.0	4.0	6.0	7.0	726	47.15
10	6.5	3.0	3.0	6.0	6.0	6.5	7.0	725	76.60
11	3.5	1.5	2.0	2.0	3.0	3.5	4.0	710	79.39
12	3.7	2.0	3.0	3.0	3.0	4.0	4.0	727	90.45
13	3.0	1.0	2.0	2.0	2.5	3.0	3.5	713	79.73
14	3.3	1.0	2.0	3.0	3.0	3.5	3.5	722	58.22
15	8.0	2.0	7.0	7.0	8.0	8.0	8.0	718	62.56
16	5.0	1.0	3.0	4.0	5.0	5.0	5.0	715	73.97
17	4.7	1.0	2.0	2.5	3.5	5.0	5.5	712	67.76
18	5.5	1.0	3.0	4.0	5.0	5.5	6.0	719	61.00
19	7.0	1.0	3.0	6.0	6.0	7.0	8.0	720	54.38
20	3.0	1.5	2.0	2.5	3.0	3.0	3.0	713	57.76

APPENDIX A, DATA AT 20 DEGREES CENTIGRADE

SUBJECT	FE O2 (ATPS)						FE CO2 (ATPS)					
	T 1	T 2	T 3	T 4	T 5	T 6	T 1	T 2	T 3	T 4	T 5	T 6
1	17.40%	16.10%	15.65%	16.05%	15.80%	15.60%	3.20%	3.85%	4.20%	4.00%	4.20%	4.15%
2	16.45%	16.80%	16.70%	16.55%	16.20%	16.20%	3.95%	3.70%	3.75%	3.90%	4.10%	4.00%
3	17.20%	17.50%	16.75%	17.00%	16.90%	16.80%	3.20%	3.35%	3.40%	3.15%	3.30%	3.30%
4	17.60%	17.00%	16.80%	16.40%	16.40%	16.40%	3.20%	3.40%	3.40%	3.50%	3.40%	3.60%
5	16.80%	16.50%	16.50%	16.50%	16.50%	16.45%	3.70%	3.95%	3.90%	4.00%	3.80%	3.90%
6	17.50%	17.20%	17.30%	17.50%	17.20%	17.60%	2.80%	3.10%	3.00%	2.80%	2.95%	2.95%
7	16.40%	16.50%	16.40%	16.10%	15.80%	16.00%	4.30%	4.05%	4.10%	4.20%	4.50%	4.40%
8	16.70%	16.35%	15.90%	16.20%	15.90%	16.15%	3.50%	3.80%	4.15%	4.00%	4.10%	4.00%
9	17.70%	17.75%	17.20%	18.30%	17.85%	18.45%	3.50%	3.30%	3.50%	2.80%	3.00%	2.90%
10	17.70%	17.40%	16.90%	16.10%	17.10%	17.00%	3.30%	3.40%	3.50%	3.60%	3.20%	3.40%
11	16.75%	16.80%	16.80%	16.90%	17.00%	17.00%	3.30%	3.40%	3.30%	3.30%	3.20%	3.20%
12	15.45%	16.60%	16.50%	16.50%	16.50%	16.30%	4.80%	4.00%	3.90%	3.90%	3.90%	4.00%
13	14.60%	14.70%	14.70%	15.00%	14.70%	15.30%	5.00%	4.90%	4.80%	4.60%	4.70%	3.50%
14	16.70%	16.60%	16.40%	16.60%	15.50%	15.50%	3.60%	3.80%	3.80%	3.70%	3.70%	3.60%
15	16.65%	16.50%	15.50%	16.50%	16.80%	17.00%	3.60%	3.70%	3.60%	3.60%	3.60%	3.45%
16	16.70%	16.80%	16.70%	16.90%	16.40%	16.20%	3.90%	3.70%	3.75%	3.60%	3.80%	3.85%
17	16.50%	16.25%	16.05%	16.30%	16.30%	16.40%	3.60%	3.70%	3.90%	3.80%	3.70%	3.75%
18	17.10%	17.40%	17.25%	17.10%	16.90%	17.05%	3.30%	3.20%	3.15%	3.25%	3.30%	3.20%
19	16.80%	16.20%	15.70%	16.40%	16.70%	16.00%	3.70%	4.10%	4.10%	4.20%	3.90%	4.10%
20	17.60%	17.70%	17.50%	17.80%	17.80%	18.50%	3.30%	3.30%	3.30%	3.10%	3.25%	2.70%

SUBJECT	GAS TEMPERATURE (C)						WATER VAPOR PRESSURE (mm/Hg)					
	T 1	T 2	T 3	T 4	T 5	T 6	T 1	T 2	T 3	T 4	T 5	T 6
1	24.3	25.0	25.2	LOST	25.8	25.8	22.9	23.8	24.0	LOST	24.9	24.9
2	24.4	24.4	24.5	24.5	24.8	24.7	22.9	22.9	23.2	23.2	23.5	23.5
3	25.0	25.4	25.6	25.9	26.1	26.3	23.8	24.3	24.6	25.2	25.5	25.8
4	26.0	26.5	26.8	27.0	26.9	26.9	25.2	26.1	26.4	26.7	26.7	26.7
5	24.9	24.9	25.0	25.0	25.0	25.0	23.8	23.8	23.8	23.8	23.8	23.8
6	24.2	24.9	24.9	25.0	25.0	25.0	22.6	23.8	23.8	23.8	23.8	23.8
7	23.8	24.0	24.4	24.5	24.7	24.5	22.1	22.4	22.9	23.2	23.5	22.9
8	24.2	24.0	23.5	23.3	23.0	23.0	22.6	22.4	21.8	21.6	21.1	21.1
9	26.8	26.2	26.1	26.0	25.5	25.5	26.4	25.5	25.5	25.2	24.6	24.6
10	23.5	23.9	23.9	24.0	24.2	24.5	21.8	22.4	22.4	22.4	22.6	23.2
11	26.0	26.2	26.9	27.0	27.1	27.0	25.2	25.5	26.7	26.7	27.1	26.7
12	25.0	25.1	25.5	26.0	26.0	26.1	23.8	24.0	24.6	25.2	25.2	25.5
13	25.2	26.1	26.6	26.8	27.0	27.1	24.0	25.5	26.1	26.4	26.7	27.1
14	24.8	25.0	25.1	25.2	25.4	25.4	23.5	23.8	24.0	24.0	24.3	24.3
15	24.2	24.9	24.9	25.0	25.0	25.1	22.6	23.8	23.8	23.8	23.8	24.0
16	24.9	25.5	26.0	26.3	26.5	26.9	23.8	24.6	25.2	25.8	25.8	26.7
17	25.1	25.5	25.8	26.0	26.1	26.1	24.0	24.6	24.9	25.2	25.5	25.5
18	25.5	26.0	26.1	26.5	26.4	26.8	24.6	25.2	25.5	26.1	25.8	26.4
19	24.8	25.0	25.1	25.2	25.5	25.5	23.5	23.8	24.0	24.0	24.6	24.6
20	26.2	26.9	26.9	27.1	27.3	27.3	25.5	26.7	26.7	27.1	27.4	27.4

APPENDIX A, DATA AT 20 DEGREES CENTIGRADE

SUBJECT	FINAL RECTAL TEMPERATURE	RECTAL TEMPERATURE T 1	T 2	T 3	T 4	T 5	T 6	SYSTOLIC BLOOD PRESSURE T 1	T 2	T 3	T 4	T 5	T 6
1	36.9	37.3	37.2	37.2	37.1	37.0	36.9	103	111	109	117	114	118
2	36.9	37.5	37.3	37.3	37.2	37.1	36.9	128	146	128	139	137	133
3	37.0	37.7	37.5	37.4	37.3	37.1	37.0	109	108	111	105	114	119
4	36.4		37.2	37.0	36.5	36.4	36.4	115	113	113	115	121	131
5	36.4	37.0	36.8	36.7	36.5	36.5	36.4	115	122	128	128	126	131
6	37.2	37.6	37.5	37.5	37.4	37.2	37.2	105	108	102	115	108	118
7	36.4	37.4	37.2	37.1	36.9	36.8	36.4	102	116	125	115	119	127
8	36.8	37.2	37.1	37.1	36.9	36.8	36.8	114	123	121	124	118	142
9	37.1	37.3	37.4	37.3	37.2	37.1	37.1	92	93	104	111	113	111
10	37.1	37.4	37.4	37.4	37.2	37.1	37.1	120	112	115	112	124	116
11	36.7	37.4	37.4	36.7	37.1	36.8	36.7	123	128	115	129	122	130
12	37.1	37.5	37.3	37.2	37.1	37.1	37.1	118	110	106	108	116	118
13	37.0	37.5	37.4	37.3	37.2	37.1	37.0	121	117	117	117	127	116
14	37.0	37.3	37.3	37.2	37.3	37.3	37.0	102	106	110	128	110	114
15	36.5	37.5	37.3	37.3	36.9	36.8	36.5	112	119	115	116	122	119
16	36.6	37.7	36.4	36.2	36.9	36.8	36.6	116	115	116	121	114	115
17	36.6	36.8	36.8	36.8	36.7	36.7	36.6	106	108	119	107	108	114
18	37.5	37.9	37.9	37.8	37.7	37.6	37.5	109	103	104	102	115	114
19	37.0	37.3	37.3	37.4	37.2	37.1	37.0	105	109	110	115	105	118
20	37.3	37.4	37.2	37.4	37.4	37.3	37.3	94	97	111	109	118	112

SUBJECT	MEAN H.R.	HEART RATE T 1	T 2	T 3	T 4	T 5	T 6	DIASTOLIC BLOOD PRESSURE T 1	T 2	T 3	T 4	T 5	T 6
1	78	75	75	68	79	70	85	78	83	82	81	83	82
2	68	85	75	60	75	70	60	74	87	87	93	99	92
3	71	60	65	71	71	70	71	64	70	64	66	70	75
4	56	64	52	52	52	52	63	72	63	77	76	72	72
5	67	65	70	68	63	71	68	73	81	84	89	93	92
6	78	65	68	71	68	83	83	81	87	92	81	92	84
7	40	43	47	42	39	44	36	46	66	71	69	69	76
8	51	60	58	56	50	52	52	80	79	75	80	96	87
9	73	71	71	75	72	71	75	61	67	77	81	84	70
10	69	65	68	68	68	75	63	80	72	81	79	81	83
11	44	65	52	52	44	47	41	64	82	77	70	74	78
12	41	44	43	34	55	33	36	55	72	65	78	76	83
13	61	75	63	60	54	63	65	86	76	80	79	82	78
14	53	68	63	60	52	52	56	76	75	80	60	81	82
15	58	58	59	58	58	58	58	75	82	75	81	89	82
16	78	94	79	79	75	79	79	76	75	80	79	73	90
17	56	62	57	56	56	58	54	71	76	71	78	75	86
18	66	75	71	68	68	65	65	75	77	72	65	75	84
19	59	65	59	56	54	64	59	74	76	81	84	78	80
20	57	60	56	60	58	56	57	64	74	67	64	72	71

APPENDIX A, DATA AT 20 DEGREES CENTIGRADE

SUBJECT	FINAL MEAN SKIN TEMPERATURE	MEAN SKIN TEMPERATURE (C) T 1	T 2	T 3	T 4	T 5	T 6	FOREHEAD (C) T 1	T 2	T 3	T 4	T 5	T 6
1	27.3	30.9	29.0	28.2	28.1	27.9	27.3	33.5	32.0	31.6	31.3	31.3	30.5
2	28.6	32.9	29.7	29.1	28.8	28.5	28.6	33.8	31.8	31.4	32.2	32.1	31.5
3	28.4	32.6	30.0	29.8	29.1	29.0	28.4	34.2	33.4	33.0	33.0	32.9	32.6
4	29.0	32.8	30.4	29.7	29.3	29.8	29.0	33.7	32.2	31.2	29.6	30.5	29.6
5	28.6	32.5	30.7	29.5	29.6	29.2	28.6	33.5	32.1	31.8	31.2	30.9	30.1
6	28.4	31.5	29.6	29.3	28.7	28.7	28.4	34.2	33.5	32.7	32.8	32.6	32.6
7	29.5	32.3	31.1	30.2	30.2	29.6	29.5	33.1	33.7	33.9	32.8	32.4	31.4
8	28.4	31.9	30.5	29.3	28.9	28.6	28.4	33.0	31.1	30.3	30.4	30.0	29.5
9	29.1	32.4	29.9	29.7	29.5	29.5	29.1	33.8	31.4	32.0	29.6	28.0	29.0
10	28.2	32.2	30.0	28.8	28.9	28.3	28.2	33.8	31.3	29.8	31.5	31.1	31.6
11	27.5	32.3	30.4	29.3	28.5	27.8	27.5	32.8	31.4	31.0	30.3	30.4	29.7
12	28.1	32.0	29.7	27.7	28.6	28.4	28.1	32.9	27.6	31.9	28.9	29.3	28.8
13	28.3	32.7	30.1	29.4	28.6	28.3	28.3	33.5	31.5	31.2	30.4	30.3	31.0
14	28.6	32.2	30.1	29.3	29.3	29.0	28.6	32.9	31.4	31.9	31.5	32.0	31.2
15	28.7	31.7	30.6	29.9	29.7	24.1	28.7	34.0	32.0	31.0	32.4	32.1	31.4
16	27.2	31.7	29.2	28.6	27.7	27.4	27.2	30.3	27.1	31.7	26.9	30.2	31.2
17	27.4	31.7	29.5	28.2	27.7	27.5	27.4	32.9	31.8	31.6	31.4	31.6	31.6
18	27.9	32.9	29.6	29.1	28.6	28.1	27.9	33.8	32.4	32.8	32.5	32.2	31.8
19	28.3	31.7	29.8	29.4	28.5	28.3	28.3	33.3	31.9	31.6	31.3	31.1	30.1
20	28.3	32.4	29.9	29.1	28.7	28.5	28.3	33.9	32.1	31.9	31.8	31.8	30.4

SUBJECT	CHEST (C) T 1	T 2	T 3	T 4	T 5	T 6	UPPER ARM (C) T 1	T 2	T 3	T 4	T 5	T 6
1	32.8	32.4	31.8	32.2	32.1	31.0	29.9	28.2	26.9	26.7	26.3	26.2
2	33.8	32.2	31.5	31.9	31.8	32.5	32.0	29.5	28.9	28.4	28.0	28.2
3	34.1	33.0	33.0	32.6	33.0	32.8	31.5	29.3	27.7	27.9	26.8	26.9
4	34.5	34.7	34.2	33.7	34.3	33.5	34.3	30.1	30.4	29.7	29.6	29.1
5	34.0	33.2	32.8	32.9	33.4	33.2	31.6	29.7	28.8	28.3	28.2	27.6
6	34.3	33.2	33.6	33.5	33.5	33.3	31.1	28.8	28.2	26.2	27.7	27.0
7	33.5	33.7	34.0	33.7	33.9	33.5	31.0	31.5	29.4	29.8	28.9	29.1
8	33.5	33.1	32.6	32.9	32.8	32.8	31.1	29.8	28.1	26.9	26.6	26.6
9	34.4	33.2	33.6	33.6	34.7	33.5	31.2	28.8	27.9	28.0	27.8	27.9
10	33.5	32.4	31.6	32.0	31.5	31.9	31.5	29.9	29.0	28.4	28.4	28.4
11	32.9	32.4	31.8	31.4	30.6	30.7	32.0	30.5	29.2	28.1	27.3	26.8
12	32.0	32.5	32.0	32.4	32.2	31.9	31.8	29.4	28.5	28.7	28.5	28.0
13	34.4	32.9	32.9	32.2	32.2	32.4	31.9	29.4	27.6	26.9	26.2	26.2
14	32.5	32.5	32.1	32.4	32.5	31.8	31.7	29.5	29.0	28.6	28.4	27.6
15	32.5	33.2	33.3	33.6	34.0	33.3	32.3	31.2	31.4	28.2	27.1	26.4
16	32.1	31.0	30.5	30.6	30.4	29.5	31.4	28.4	27.3	26.7	26.0	26.2
17	32.7	32.1	31.4	30.9	31.1	30.9	30.5	28.2	26.6	26.3	25.6	25.5
18	33.6	32.9	32.5	32.7	32.3	32.2	31.3	28.3	28.1	26.9	26.4	26.2
19	33.5	32.7	32.9	32.5	32.7	32.7	30.5	28.8	27.9	27.2	26.6	27.3
20	34.5	33.8	33.6	33.5	33.5	33.6	31.2	28.9	28.0	27.7	27.6	27.3

APPENDIX A, DATA AT 20 DEGREES CENTIGRADE

SUBJECT	CALF (C)						BIG TOE (C)					
	T 1	T 2	T 3	T 4	T 5	T 6	T 1	T 2	T 3	T 4	T 5	T 6
1	30.3	27.2	25.8	25.5	25.5	25.2	25.7	20.7	20.4	20.3	20.1	19.6
2	32.2	28.7	27.6	27.5	26.7	26.6	32.7	21.9	20.8	20.0	19.9	19.7
3	31.6	28.1	29.6	27.4	27.1	26.2	30.5	22.6	20.9	20.6	20.3	19.8
4	32.4	28.6	26.2	26.4	26.3	26.1	23.6	20.6	19.2	18.8	18.9	18.7
5	31.9	29.8	27.8	28.3	28.0	25.8	27.7	22.6	20.6	20.2	19.8	19.8
6	31.2	27.6	26.5	25.4	25.5	24.5	22.6	20.5	20.5	20.5	20.1	20.0
7	31.7	30.8	28.6	28.8	28.0	27.9	31.8	21.9	20.2	20.9	20.3	20.5
8	31.7	30.3	27.7	26.9	26.5	26.1	23.4	21.4	20.7	20.6	20.3	20.5
9	31.7	26.8	27.4	27.7	27.1	26.4	27.5	26.2	22.2	20.5	20.3	20.9
10	31.9	28.9	26.7	27.2	26.3	25.1	27.7	22.6	20.7	20.5	20.4	19.9
11	32.3	29.4	28.3	27.4	27.0	26.4	30.2	22.4	20.6	19.9	19.7	19.4
12	32.2	28.7	27.5	27.1	26.8	26.4	31.2	23.8	2.5	20.1	19.7	20.0
13	32.0	28.2	27.1	25.7	25.3	24.7	29.1	21.3	20.5	19.8	19.6	19.5
14	31.7	29.1	27.6	28.3	28.0	27.8	32.1	23.7	20.8	20.5	20.2	20.3
15	31.9	30.8	28.8	29.8	27.8	26.5	23.7	21.9	21.0	21.4	20.4	19.2
16	30.9	28.3	27.2	25.8	26.3	26.3	33.2	24.6	23.2	20.5	20.0	20.1
17	31.2	28.6	26.8	26.2	25.5	25.9	29.3	22.2	20.4	19.9	19.7	19.7
18	32.5	27.8	27.2	26.8	25.4	25.1	33.7	22.9	20.7	20.2	20.0	19.9
19	31.7	29.2	28.9	26.4	26.7	26.2	24.5	21.6	20.5	20.4	20.0	19.5
20	31.2	27.3	26.1	25.9	24.9	24.6	28.2	20.7	19.3	18.7	18.8	18.8

SUBJECT	FINGER (C)						THIGH (C)					
	T 1	T 2	T 3	T 4	T 5	T 6	T 1	T 2	T 3	T 4	T 5	T 6
1	29.0	26.4	25.1	24.0	23.0	22.7	30.2	27.4	26.5	25.9	26.0	25.7
2	33.3	26.7	27.0	24.3	23.4	22.9	31.9	29.0	28.5	27.3	27.1	26.7
3	31.0	26.0	25.1	24.0	23.5	22.6	31.7	28.8	28.7	27.6	27.7	26.0
4	33.5	24.5	23.2	22.4	21.5	21.6	31.9	28.3	28.4	28.5	29.8	28.3
5	32.4	29.9	27.2	25.8	24.4	24.9	32.3	30.3	28.1	29.2	27.1	26.3
6	26.7	24.5	25.0	24.1	23.5	24.0	30.2	28.0	27.2	26.5	26.1	25.9
7	31.7	25.9	23.5	24.0	23.0	23.7	31.6	30.0	29.1	29.1	27.3	27.4
8	30.8	26.7	24.4	24.4	23.6	23.9	32.8	30.6	29.5	28.1	27.5	26.8
9	32.6	27.9	23.9	23.4	24.2	24.2	31.5	28.3	29.0	29.1	28.2	28.1
10	32.2	27.4	26.5	24.4	22.2	23.5	31.6	29.4	28.1	27.8	27.0	26.4
11	31.8	30.2	28.8	25.6	24.1	23.7	31.9	29.8	28.3	27.3	26.3	26.1
12	32.2	27.7	26.4	24.4	23.3	22.7	31.7	28.8	27.2	26.7	26.7	26.6
13	31.5	26.8	25.3	24.1	24.0	23.0	31.8	30.2	29.3	29.1	28.5	28.2
14	33.2	29.3	28.0	26.9	24.2	25.1	32.0	29.0	28.0	28.0	27.1	26.8
15	32.9	26.5	24.0	23.3	22.9	22.3	31.5	29.0	27.5	27.3		27.7
16	32.2	28.4	26.8	25.8	26.0	24.7	31.6	29.6	28.4	27.7	25.9	26.1
17	31.9	27.0	24.0	23.2	23.6	23.1	31.3	28.8	27.4	26.7	25.9	26.0
18	34.1	26.4	25.7	23.4	22.8	22.6	32.0	27.9	27.3	26.6	26.3	25.9
19	32.4	25.6	24.6	23.0	22.9	23.2	31.4	28.8	28.0	26.9	25.8	26.4
20	31.5	25.7	23.4	22.7	22.1	22.5	31.6	28.8	27.7	26.8	26.6	25.8

APPENDIX A, DATA AT 25 DEGREES CENTIGRADE

SUBJECT	MEAN V̇O2 (ml/kg/min)	V̇O2 (ml/kg/min) (STPD) T 1	T 2	T 3	T 4	T 5	T 6	V̇E (ATPS) T 1	T 2	T 3	T 4	T 5	T 6
1	3.24	2.99	3.13	2.97	3.26	3.16	3.30	66.7	59.3	48.8	51.6	54.4	60.9
2	4.08	4.48	3.81	4.29	4.00	4.04	4.19	89.0	89.0	83.0	68.2	66.7	67.1
3	3.99	3.73	3.94	4.14	3.96	3.87	4.14	77.2	80.6	85.9	79.3	79.9	82.7
4	4.48	4.53	4.24	4.53	4.19	4.83	4.41	75.3	71.2	71.0	61.8	68.7	66.4
5	3.61	2.95	3.57	4.09	3.69	3.65	3.50	74.4	81.9	92.7	80.9	81.8	76.7
6	3.80	3.58	3.51	3.48	3.65	3.72	4.04	59.0	57.5	61.7	59.8	61.1	64.4
7	4.81	5.63	6.29	5.81	4.94	4.67	4.82	85.3	95.2	84.1	64.3	63.4	59.6
8	4.10	3.65	3.64	3.77	3.72	4.47	4.10	56.3	53.2	55.1	51.6	61.1	53.3
9	4.86	5.05	4.73	5.50	5.05	4.89	4.65	99.0	80.6	86.8	73.9	72.0	68.5
10	4.13	3.69	4.05	4.22	4.22	4.04		88.6	86.5	86.4	96.8	87.6	
11	3.46	3.20	3.57	3.18	3.12	3.29	3.98	72.1	69.7	61.0	63.5	64.6	74.4
12	3.46	3.69	3.69	2.94	3.55	3.37	3.45	82.9	83.6	64.0	80.7	71.6	72.8
13	3.47	3.03	3.16	2.83	3.39	3.47	3.55	63.3	62.3	57.9	66.6	67.2	70.6
14	3.71	3.58	3.64	3.75	3.62	3.67	3.84	59.9	55.0	57.2	54.8	54.9	57.1
15	3.67	3.31	3.36	3.40	3.53	3.59	3.88	53.1	55.7	55.9	58.1	57.6	63.3
16	3.04	2.23	2.35	2.49	3.16	2.95	3.02	36.8	33.6	36.9	46.8	43.7	41.7
17	2.98	3.32	3.06	3.06	2.98	2.95	3.01	55.8	49.2	51.7	49.0	50.3	51.7
18	3.30	3.20	3.29	2.89	3.33	3.38	3.20	53.0	57.2	53.6	62.1	59.7	56.6
19	4.40	4.19	4.01	4.16	4.57	4.22	4.43	29.0	55.7	52.9	53.3	51.4	66.5
20	3.71	3.31	3.27	3.39	3.67	3.89	3.58	62.1	48.3	60.5	69.7	71.6	63.6

SUBJECT	MEAN COMFORT	COMFORT INDEX T 1	T 2	T 3	T 4	T 5	T 6	BARO. PRESSURE	WEIGHT (KG)
1	3.3	2.0	2.0	2.0	3.0	4.0	3.0	721	70.79
2	2.0	2.0	2.0	2.0	2.0	2.0	2.0	723	79.31
3	3.0	2.0	3.0	3.0	3.0	3.0	3.0	726	73.69
4	5.0	2.0	2.0	3.0	5.0	5.0	5.0	725	52.87
5	3.0	2.0	2.0	3.0	3.0	3.0	3.0	718	89.40
6	3.7	3.0	3.0	3.0	3.0	4.0	4.0	723	60.65
7	3.7	1.0	2.0	3.0	3.0	4.0	4.0	726	60.25
8	3.8	2.0	3.0	3.0	3.5	4.0	4.0	725	55.86
9	3.0	2.0	2.0	3.0	3.0	3.0	3.0	726	46.73
10	3.0	2.0	3.0	3.0	3.0	3.0	3.0	716	77.00
11	2.2	1.0	1.5	1.5	2.0	2.0	2.5	715	77.69
12	2.0	2.0	2.0	2.0	2.0	2.0	2.0	713	90.12
13	2.7	1.0	1.0	1.0	2.0	3.0	3.0	713	80.74
14	2.3	1.0	1.5	1.5	2.0	2.5	2.5	713	57.12
15	3.7	1.0	2.0	3.0	3.0	4.0	4.0	713	62.76
16	3.8	2.0	2.0	3.0	3.5	4.0	4.0	710	73.96
17	1.7	1.0	1.5	1.5	1.5	1.5	2.0	720	67.53
18	3.3	1.0	2.5	3.0	3.0	3.5	3.5	713	60.58
19	2.5	1.0	1.5	2.0	2.5	2.5	2.5	724	54.34
20	1.8	2.0	1.5	1.5	1.5	2.0	2.0	718	56.95

SUBJECT	FE O2 (ATPS)						FE CO2 (ATPS)					
	T 1	T 2	T 3	T 4	T 5	T 6	T 1	T 2	T 3	T 4	T 5	T 6
1	17.30%	16.65%	16.10%	15.90%	16.30%	16.60%	3.20%	3.70%	3.80%	4.00%	3.70%	3.50%
2	16.40%	16.40%	16.30%	16.70%	16.60%	16.40%	3.95%	3.90%	3.90%	3.65%	3.60%	3.70%
3	16.95%	16.90%	16.95%	16.80%	16.90%	16.80%	3.30%	3.30%	3.30%	3.40%	3.40%	3.35%
4	17.30%	17.35%	17.10%	16.90%	16.75%	17.00%	3.20%	3.10%	3.30%	3.30%	3.40%	3.15%
5	16.85%	16.50%	16.45%	16.30%	16.40%	16.30%	3.60%	3.70%	3.70%	3.80%	3.70%	3.80%
6	16.85%	16.80%	17.10%	16.80%	16.80%	16.70%	3.20%	3.30%	3.10%	3.30%	3.30%	3.30%
7	16.30%	16.30%	16.15%	15.65%	15.90%	15.40%	4.40%	4.40%	4.30%	4.60%	4.25%	4.70%
8	16.80%	16.60%	16.60%	16.40%	16.35%	16.15%	3.65%	3.70%	3.70%	3.70%	3.70%	3.70%
9	18.10%	17.70%	17.50%	17.30%	17.30%	17.30%	3.00%	3.30%	3.30%	3.20%	3.30%	3.30%
10	17.15%	16.70%	16.55%	16.95%	16.80%		3.70%	4.00%	4.00%	3.90%	3.65%	
11	17.00%	16.85%	16.80%	17.00%	16.90%	16.70%	3.20%	3.30%	3.20%	3.20%	3.10%	3.20%
12	16.25%	16.05%	16.10%	16.30%	16.00%	15.95%	4.10%	4.20%	4.10%	3.90%	4.10%	4.15%
13	16.50%	16.25%	16.40%	16.25%	16.20%	16.30%	3.60%	3.70%	3.60%	3.60%	3.50%	3.50%
14	17.00%	16.60%	16.60%	16.60%	16.55%	16.50%	3.30%	3.50%	3.60%	3.50%	3.50%	3.60%
15	16.40%	16.50%	16.50%	16.50%	16.40%	16.50%	3.80%	3.90%	3.70%	3.75%	3.70%	3.55%
16	15.20%	15.50%	15.15%	15.15%	15.15%	14.80%	4.80%	4.55%	4.65%	4.60%	4.60%	4.60%
17	16.40%	16.20%	16.40%	16.30%	16.45%	16.50%	3.70%	3.80%	3.70%	3.70%	3.60%	3.50%
18	16.75%	16.90%	16.95%	17.15%	16.95%	16.95%	3.40%	3.40%	3.30%	3.20%	3.30%	3.30%
19	14.80%	16.50%	16.10%	16.20%	15.90%	16.75%	4.85%	3.70%	4.00%	3.90%	4.10%	3.80%
20	17.40%	16.90%	17.20%	17.40%	17.30%	17.20%	3.10%	3.45%	3.30%	3.20%	3.25%	3.20%

SUBJECT	GAS TEMPERATURE (C)						WATER VAPOR PRESSURE (mm/Hg)					
	T 1	T 2	T 3	T 4	T 5	T 6	T 1	T 2	T 3	T 4	T 5	T 6
1	24.0	24.7	24.5	24.8	24.9	24.9	22.4	23.4	23.1	23.5	23.6	23.6
2	23.4	23.8	23.9	23.9	24.0	24.0	21.6	22.1	22.3	22.3	22.4	22.4
3	23.5	23.9	24.1	24.2	24.5	24.7	21.7	22.3	22.5	22.6	23.1	23.4
4	24.5	24.6	24.6	24.7	24.8	24.8	23.1	23.2	23.2	23.3	23.5	23.5
5	24.0	24.0	24.2	24.5	24.6	24.6	22.4	22.4	22.6	23.1	23.2	23.2
6	23.0	23.5	23.8	23.9	23.9	24.0	21.1	21.7	22.1	22.3	22.3	22.4
7	25.0	25.0	25.1	25.1	25.1	25.2	23.8	23.8	23.9	23.9	23.9	24.0
8	24.5	24.6	24.6	24.7	24.7	24.8	22.1	23.2	23.2	23.4	23.4	23.5
9	23.5	24.0	23.9	24.1	24.0	24.0	21.7	22.4	22.3	22.5	22.4	22.4
10	23.5	24.0	24.3	24.5	24.5		21.7	22.4	22.8	23.1	23.1	
11	25.0	25.1	25.5	25.8	25.8	26.0	23.8	23.9	24.5	24.9	24.9	25.2
12	25.8	26.8	26.3	27.1	27.1	27.4	24.9	26.4	26.6	26.9	26.9	27.4
13	25.1	25.8	26.1	26.3	26.8	26.9	23.9	24.9	25.4	25.7	26.4	26.6
14	25.0	25.2	26.0	26.0	26.2	26.5	23.8	24.0	25.2	25.2	25.5	26.0
15	26.0	26.1	26.3	26.3	26.7	26.6	25.2	25.4	25.7	25.7	26.3	26.1
16	26.0	26.2	26.9	27.0	27.0	27.1	25.2	25.5	26.6	26.7	26.7	26.9
17	23.9	24.3	24.8	24.9	25.0	25.0	22.2	22.8	23.5	23.6	23.8	23.8
18	25.0	25.8	26.7	26.8	26.9	27.0	23.8	24.9	26.3	26.4	26.6	26.7
19	24.2	24.9	25.1	25.1	25.2	25.2	22.6	23.6	23.9	23.9	24.0	24.0
20	26.3	27.0	27.0	27.1	27.2	27.3	25.7	26.7	26.7	26.9	27.1	27.2

APPENDIX A, DATA AT 25 DEGREES CENTIGRADE

SUBJECT	FINAL RECTAL TEMPERATURE	RECTAL TEMPERATURE T 1	T 2	T 3	T 4	T 5	T 6	SYSTOLIC BLOOD PRESSURE T 1	T 2	T 3	T 4	T 5	T 6
1	36.9	37.1	37.0	37.0	37.0	36.9	36.9	111	109	106	102	101	111
2	37.1	37.6	37.4	37.3	37.2	37.1	37.1	133	132	138	125	131	133
3	37.2	37.6	37.4	37.3	37.1	37.2	37.2	107	114	120	116	116	117
4	36.7	37.8	37.5	37.4	37.3	37.2	36.7	100	112	115	114	106	116
5	36.3	37.1	36.4	36.4	36.2	36.3	36.3	109	115	109	117	121	122
6	37.2	37.6	37.5	37.4	37.2	37.3	37.2	103	106	119	118	127	123
7	36.8	37.4	37.1	37.2	36.9	36.8	36.8	109	114	118	114	111	96
8	36.8	37.2	36.9	36.8	36.8	36.8	36.8	113	115	120	126	125	124
9	37.1	37.7	37.6	37.5	37.3	37.2	37.1	92	105	117	98	93	98
10	37.2	37.5	37.2	37.2	37.2	37.2	37.2	124	126	125	126	123	118
11	36.8	37.7	36.5	36.7	37.2	36.9	36.8					122	123
12	36.7	37.2	37.0	36.8	36.8	36.7	36.7	108	104	104	113	108	111
13	36.8	37.2	37.0	36.9	36.8	36.8	36.8	118	110	116	113	118	118
14	36.6	36.8	36.8	36.8	36.7	36.7	36.6	111	109	106	109	113	115
15	37.3	37.5	37.4	37.5	37.4	37.2	37.3	109	109	116	109	119	119
16	36.2	37.3	37.1	36.8	36.7	36.3	36.2	121	115	119	119	120	121
17	36.8	37.3	37.2	37.1	36.9	36.9	36.8	97	98	98	95	91	97
18	37.1	37.2	37.1	37.1	37.1	37.0	37.1	109	114	114	137	126	112
19	37.1	37.1	37.0	37.1	37.1	37.1	37.1	111	116	117	108	117	118
20	36.7	37.2	36.7	36.7	36.4	36.2	36.7	102	95	104	100	94	108

SUBJECT	MEAN H.R.	HEART RATE T 1	T 2	T 3	T 4	T 5	T 6	DIASTOLIC BLOOD PRESSURE T 1	T 2	T 3	T 4	T 5	T 6
1	67	71	70	58	60	68	72	83	81	71	73	87	77
2	55	70	70	64	56	55	54	69	80	79	81	79	89
3	64	65	70	66	69	65	59	67	76	69	71	75	74
4	54	58	60	58	56	52	54	72	72	68	70	71	75
5	59	56	58	56	60	59	58	85	78	83	82	85	82
6	55	60	60	58	56	54	54	80	71	72	83	77	88
7	44	48	50	50	41	48	43	56	58	64	59	73	66
8	49	57	47	57	53	50	45	73	75	85	79	86	75
9	67	66	70	70	68	64	68	58	74	69	65	65	77
10	71	68	79	80	68	85	60	75	73	81	87	82	73
11	40	50	67	47	43	39	39					80	76
12	44	55	51	47	47	44	42	57	70	61	69	76	76
13	53	58	58	56	54	50	56	80	80	89	85	90	95
14	53	53	54	52	54	56	50	84	81	84	82	85	83
15	55	60	56	58	54	56	56	71	72	78	73	60	85
16	74	75	79	75	75	75	71	75	75	73	84	75	78
17	50	56	54	54	51	48	52	76	70	61	68	69	75
18	67	65	71	79	88	58	56	79	79	88	94	85	81
19	68	60	65	75	77	63	65	69	83	78	84	80	86
20	59	57	54	64	61	54	63	71	70	69	70	76	81

APPENDIX A, DATA AT 25 DEGREES CENTIGRADE

SUBJECT	FINAL MEAN SKIN TEMPERATURE	MEAN SKIN TEMPERATURE (C) T 1	T 2	T 3	T 4	T 5	T 6	FOREHEAD (C) T 1	T 2	T 3	T 4	T 5	T 6
1	30.1	31.4	30.9	30.7	30.4	30.1	30.1	33.3	33.0	33.1	33.2	33.0	32.8
2	31.1	32.6	31.8	31.8	31.5	31.0	31.1	34.2	33.9	33.5	34.1	33.5	33.6
3	31.4	32.7	31.8	31.6	31.6	31.7	31.4	33.8	34.3	33.9	34.6	34.7	34.6
4	31.1	31.7	31.0	30.9	30.8	30.9	31.1	33.1	33.4	31.9	32.9	33.1	33.0
5	31.2	31.4	31.5	31.3	31.4	31.5	31.2	32.6	33.3	32.6	32.8	32.2	32.0
6	30.7	31.1	30.9	31.1	30.9	30.9	30.7	33.6	33.2	33.8	34.0	33.7	34.0
7	31.6	32.9	32.2	31.8	32.0	31.7	31.6	33.9	33.2	33.8	34.4	33.9	34.1
8	30.4	31.8	31.0	30.7	30.7	30.7	30.4	33.4	32.5	32.7	32.4	32.3	31.3
9	31.3	31.7	31.5	30.8	30.8	31.0	31.3	33.3	33.7	33.6	32.7	32.8	33.4
10	31.3	31.8	31.7	31.7	31.5	31.3	31.3	31.7	33.3	33.0	32.5	33.4	33.0
11	30.2	32.0	31.4	31.3	30.5	30.2	30.2	31.9	32.2	32.1	31.5	31.9	31.8
12	31.3	33.4	32.6	32.1	31.8	31.5	31.3	33.7	33.6	32.8	33.7	33.6	33.3
13	30.4	32.3	32.0	31.4	31.2	30.7	30.4	32.7	33.4	33.3	32.8	32.0	32.6
14	30.8	32.0	30.9	30.5	30.4	30.7	30.8	33.5	33.0	30.2	33.2	32.9	32.5
15	30.8	32.6	31.7	30.9	31.2	31.0	30.8	33.3	33.3	33.3	33.0	32.2	31.6
16	30.7	32.5	31.2	31.1	30.9	30.3	30.7	34.4	33.5	33.9	33.3	33.9	33.7
17	29.5	30.9	30.3	30.0	29.7	29.8	29.5	32.6	32.3	32.2	32.3	32.5	32.3
18	30.7	33.3	31.8	31.3	31.0	30.6	30.7	34.2	33.9	33.1	33.9	32.6	33.6
19	30.4	31.5	30.9	30.8	30.5	30.6	30.4	34.1	33.3	33.3	33.0	33.6	33.6
20	30.6	32.0	31.2	30.9	30.8	30.6	30.6	32.8	33.1	33.1	33.3	33.0	32.7

SUBJECT	CHEST (C) T 1	T 2	T 3	T 4	T 5	T 6	UPPER ARM (C) T 1	T 2	T 3	T 4	T 5	T 6
1	33.2	33.0	33.5	33.3	33.0	33.2	31.0	30.2	29.7	29.3	29.3	28.9
2	33.5	33.7	34.5	34.1	33.8	34.4	32.1	31.5	31.3	31.0	30.3	30.3
3	34.8	34.4	34.0	34.2	34.4	34.2	31.5	30.6	31.0	30.8	30.7	30.3
4	33.8	34.2	34.3	33.8	34.0	34.7	31.6	30.8	30.6	30.6	31.0	31.0
5	33.2	34.0	33.9	33.7	34.0	33.7	31.0	30.6	30.5	30.7	30.8	30.6
6	33.5	34.1	34.2	34.2	34.5	34.1	30.2	29.5	29.5	29.6	29.6	29.1
7	33.7	34.5	34.7	35.0	34.7	34.4	32.3	31.3	31.1	31.6	31.0	31.1
8	34.0	33.6	33.8	34.1	34.1	33.9	30.5	30.3	30.0	30.0	29.9	29.5
9	34.2	34.4	33.7	34.0	34.2	34.8	31.0	30.4	30.1	30.1	30.0	30.2
10	33.8	33.8	33.9	33.9	33.8	33.8	33.2	31.6	31.4	31.3	31.4	31.3
11	32.0	32.2	32.9	32.0	31.7	32.6	31.2	31.1	30.6	30.3	30.0	30.0
12	33.9	34.5	34.0	34.3	34.3	34.5	32.7	31.8	31.6	31.2	30.6	30.4
13	33.8	34.1	33.7	33.9	33.3	32.7	31.0	30.8	30.5	30.4	30.1	29.9
14	33.8	32.7	32.9	32.7	33.7	33.8	31.4	31.1	30.4	30.5	30.7	30.7
15	34.4	34.2	33.7	34.3	34.0	34.5	32.5	31.7	31.4	30.0	31.0	30.4
16	33.7	33.0	33.1	33.4	32.4	33.1	31.3	30.3	30.2	29.5	29.4	29.4
17	32.1	32.1	32.0	31.8	32.3	32.0	29.2	28.9	28.8	28.6	28.6	28.5
18	33.9	33.4	33.4	32.6	33.0	33.6	32.0	30.6	29.7	29.4	29.4	29.7
19	34.6	33.5	33.9	33.9	34.0	33.5	28.6	30.3	29.6	29.9	29.6	29.7
20	32.9	33.3	33.4	33.6	33.4	33.6	31.2	29.8	29.4	29.1	28.9	29.1

APPENDIX A, DATA AT 25 DEGREES CENTIGRADE

SUBJECT	CALF (C) T 1	T 2	T 3	T 4	T 5	T 6	BIG TOE (C) T 1	T 2	T 3	T 4	T 5	T 6
1	31.5	29.5	28.8	28.4	27.7	28.0	25.4	25.2	24.8	24.8	24.5	24.9
2	31.5	30.3	29.7	30.0	29.1	29.4	32.4	27.0	26.3	24.4	23.9	24.0
3	32.2	30.4	30.2	30.5	30.0	29.7	26.8	25.7	25.0	25.0	25.0	25.0
4	31.9	29.5	29.4	29.3	29.1	29.0	21.1	22.9	23.3	23.0	24.0	23.3
5	32.0	30.2	30.1	29.6	29.9	29.3	26.0	25.6	25.1	25.3	25.7	25.6
6	30.8	29.6	29.7	29.3	29.0	28.9	22.6	23.6	24.5	24.5	24.2	24.6
7	32.2	31.2	31.5	31.4	31.5	31.4	31.7	27.7	25.0	24.8	25.0	25.0
8	31.0	28.8	28.1	27.7	27.9	27.8	24.7	24.5	24.7	24.8	24.8	24.8
9	31.6	29.5	28.9	28.7	28.9	28.8	22.6	26.9	26.4	26.9	25.6	26.5
10	32.3	31.8	31.5	30.9	30.3	30.0	23.3	24.0	23.8	24.0	24.0	23.8
11	32.6	30.5	29.8	29.2	29.4	29.0	32.3	29.7	29.0	25.9	24.5	23.5
12	33.0	31.8	30.2	29.9	29.5	29.0	32.9	29.3	28.7	26.5	25.3	24.6
13	31.1	31.0	30.2	29.7	29.6	29.3	30.4	26.6	26.0	25.7	25.5	25.5
14	30.9	30.7	29.3	28.3	28.1	28.6	25.9	24.4	24.7	24.5	24.4	24.6
15	31.1	29.3	28.3	29.1	28.6	28.5	27.4	24.8	24.7	23.3	23.8	23.1
16	32.4	30.4	30.0	29.4	28.8	29.4	26.0	24.4	24.8	24.6	24.2	24.0
17	30.9	29.7	29.0	28.4	28.1	27.8	28.9	25.3	24.5	24.5	24.5	24.5
18	32.5	30.6	30.5	29.5	29.0	28.4	32.8	26.3	25.4	25.3	25.2	25.1
19	31.2	29.7	29.9	28.7	28.4	28.4	22.6	23.3	23.2	23.1	23.8	23.5
20	31.9	30.0	29.2	29.1	29.4	29.0	31.1	26.9	26.0	25.2	24.8	24.4

SUBJECT	FINGER (C) T 1	T 2	T 3	T 4	T 5	T 6	THIGH (C) T 1	T 2	T 3	T 4	T 5	T 6
1	28.9	28.3	27.2	27.2	26.9	26.2	30.5	30.5	30.0	29.3	28.7	28.5
2	32.5	31.0	31.3	30.2	28.6	27.4	31.6	30.7	30.2	30.1	29.8	29.5
3	32.0	29.4	29.0	27.9	29.0	27.5	31.8	31.0	30.7	30.6	30.8	30.4
4	26.4	26.2	26.2	26.0	26.0	26.2	32.3	29.8	29.8	29.7	29.6	29.5
5	27.8	29.5	28.5	28.5	28.1	28.4	30.6	30.6	30.6	31.2	31.3	31.0
6	27.6	27.1	28.2	27.4	26.6	26.9	30.6	30.0	29.5	29.2	28.9	28.7
7	33.2	30.5	27.3	27.9	27.7	27.9	32.5	30.9	30.3	30.1	29.7	29.4
8	32.3	29.4	28.1	27.4	27.7	27.4	31.0	30.6	29.7	29.3	29.2	29.0
9	30.0	29.3	28.1	27.8	27.5	28.5	30.9	29.8	28.7	28.4	29.4	29.1
10	26.5	29.0	27.0	26.3	26.2	26.1	31.4	31.0	31.7	31.5	30.8	31.0
11	32.3	31.8	31.7	29.6	28.5	27.6	31.9	30.8	30.2	30.5	29.9	29.5
12	32.7	31.9	32.0	30.5	29.2	28.8	33.4	31.2	31.3	30.7	30.4	30.2
13	32.8	29.8	28.6	27.9	27.4	27.3	31.8	31.5	30.6	30.3	29.5	29.3
14	31.8	29.1	30.6	28.9	27.4	27.0	31.7	29.7	29.4	29.3	29.4	29.4
15	33.2	29.9	29.9	29.5	27.8	25.7	31.7	31.0	28.9	30.4	30.3	29.6
16	33.3	30.3	29.1	27.7	27.9	28.4	32.6	31.0	30.9	30.5	29.9	29.9
17	30.6	28.5	28.2	27.3	27.0	26.6	30.2	30.0	29.7	29.3	28.9	28.5
18	33.8	29.8	28.1	27.8	27.3	27.4	33.2	32.5	31.6	31.9	30.3	29.5
19	30.8	28.2	26.7	25.7	26.5	26.2	30.7	30.0	29.6	28.8	29.1	28.9
20	31.2	30.7	30.3	29.5	29.1	27.6	31.0	30.2	29.9	29.3	29.4	29.4

APPENDIX A, DATA AT 27 DEGREES CENTIGRADE

SUBJECT	MEAN $\dot{V}O2$ (ml/kg/min)	$\dot{V}O2$ (ml/kg/min) (STPD) T 1	T 2	T 3	T 4	T 5	T 6	$\dot{V}E$ (ATPS) T 1	T 2	T 3	T 4	T 5	T 6
1	3.01	2.87	2.88	2.69	2.93	2.91	3.20	61.0	51.0	48.0	48.5	54.2	65.2
2	4.00	3.93	3.99	4.10	4.20	4.03	3.77	73.8	78.0	80.1	80.3	81.9	79.4
3	3.63	3.67		3.67	3.66	3.64	3.59	71.6	74.4	74.7	70.8	78.0	70.9
4	4.23	4.08	3.85	4.17	4.22	4.26	4.20	76.2	64.1	65.3	59.7	62.4	60.1
5	3.16	2.92	3.86	3.61	3.61	3.08	2.79	69.7	102.0	71.1	93.7	66.5	38.6
6	3.82	3.95	3.42	3.80	3.90	3.56	4.01	80.8	67.5	71.3	68.6	63.0	61.4
7	4.24	4.48		4.41	4.02	4.36	4.35	67.7		62.5	65.5	60.1	65.0
8	3.95	3.61	3.77	4.09	3.85	3.93	4.07	56.3	51.6	58.6	58.8	54.8	54.1
9	4.59	4.92	5.09	4.75	4.74	4.70	4.34	104.8	99.1	92.7	81.7	79.5	72.0
10	3.55	3.68	3.69	3.94	3.43	3.70	3.53	89.1	70.7	76.7	63.5	76.2	74.8
11	3.27	3.48	3.22	2.84	3.02	3.31	3.48	80.5	76.8	70.4	71.4	77.2	80.9
12	3.77	3.77	3.58	3.75	3.71	3.84	3.74	77.4	75.9	75.5	76.5	77.5	75.7
13	3.22	3.08	3.16	3.03	3.12	3.38	3.15	71.6	69.4	64.3	67.3	67.2	66.7
14	4.11	4.28	4.17	4.03	4.14	4.30	3.90	65.2	61.8	61.1	61.6	64.5	60.4
15	3.92	4.12	3.83	3.79	3.76	3.88	4.13	65.0	58.2	58.8	54.6	57.8	67.0
16	3.25	2.85		3.13	3.20	3.30	3.25	50.6		58.1	55.6	61.6	57.9
17	3.07	3.19	3.11	3.15	3.03	3.03	3.15	44.5	41.8	44.3	41.7	45.1	48.1
18	3.49	3.47	3.52	3.59	3.50	3.36	3.61	62.5	67.7	68.7	65.4	71.0	65.9
19	3.62	3.87	3.70	3.54	3.67	3.64	3.56	57.8	51.3	46.3	49.2	54.0	50.2
20	4.48	4.44	8.28	3.93	4.17	4.46	4.82	65.5	98.1	35.9	83.7	54.2	62.8

SUBJECT	MEAN COMFORT	COMFORT INDEX T 1	T 2	T 3	T 4	T 5	T 6	BARO. PRESSURE	WEIGHT (KG)
1	5.0	2.0	3.0	5.0	5.0	5.0	5.0	718	69.60
2	1.5	1.5	1.5	2.0	1.5	1.5	1.5	715	78.77
3	2.3	3.0	2.0	3.0	2.0	3.0	2.0	721	74.58
4	3.0	2.0	1.0	2.0	3.0	3.0	3.0	721	54.08
5	2.3	3.0	2.0	2.0	2.0	3.0	2.0	710	91.10
6	2.0	3.0	3.0	2.0	2.0	2.0	2.0	716	60.51
7	2.3	2.0	2.0	2.0	2.0	2.0	3.0	718	60.00
8	2.7	1.0	2.0	2.0	2.0	3.0	3.0	716	57.61
9	4.0	6.0	3.0	6.0	3.0	6.0	3.0	715	47.55
10	2.0	5.0	3.0	2.0	2.0	2.0	2.0	716	76.74
11	1.3	1.0	1.0	1.0	1.0	1.5	1.5	711	80.86
12	2.0	2.0	2.0	2.0	2.0	2.0	2.0	718	89.72
13	1.0	1.0	1.0	1.0	1.0	1.0	1.0	720	80.57
14	1.5	1.0	1.0	1.0	1.5	1.5	1.5	722	56.97
15	1.0	1.0	1.0	1.0	1.0	1.0	1.0	720	63.21
16	3.0	1.0	2.5	2.5	3.0	3.0	3.0	716	74.01
17	2.2	1.0	1.0	2.0	2.0	2.0	2.5	713	66.92
18	2.2	1.0	2.0	2.0	2.0	2.5	2.0	717	60.04
19	2.0	1.0	1.5	1.5	2.0	2.0	2.0	716	53.72
20	4.0	3.0	3.0	4.0	4.0	4.0	4.0	710	56.18

APPENDIX A, DATA AT 27 DEGREES CENTIGRADE

SUBJECT	FE O2 (ATPS)						FE CO2 (ATPS)					
	T 1	T 2	T 3	T 4	T 5	T 6	T 1	T 2	T 3	T 4	T 5	T 6
1	17.10%	16.40%	16.40%	16.10%	16.60%	16.90%	3.50%	3.80%	3.90%	3.90%	3.70%	3.70%
2	16.10%	16.30%	16.30%	16.20%	16.45%	16.60%	4.15%	3.90%	3.90%	4.00%	3.90%	3.80%
3	16.55%		16.70%	16.50%	16.90%	16.60%	3.60%		3.60%	3.70%	3.50%	3.60%
4	17.50%	17.15%	16.95%	16.60%	16.75%	16.60%	3.40%	3.50%	3.50%	3.50%	3.40%	3.70%
5	16.90%	17.10%	16.60%	18.10%	17.20%	16.05%	3.70%	3.45%	3.80%	3.20%	3.50%	3.90%
6	17.60%	17.50%	17.60%	17.65%	17.25%	17.35%	2.75%	2.70%	2.95%	2.60%	3.00%	2.90%
7	16.35%	15.95%	16.10%	16.70%	16.00%	15.90%	4.10%	4.35%	4.10%	3.70%	4.05%	4.20%
8	16.60%	16.10%	16.30%	16.60%	16.20%	16.00%	3.90%	3.90%	3.80%	3.50%	3.75%	3.80%
9	18.20%	18.00%	18.00%	17.65%	17.60%	17.55%	2.90%	2.90%	2.90%	3.10%	3.10%	3.10%
10	17.30%	16.80%	16.70%	16.70%	16.70%	16.80%	3.20%	3.60%	3.45%	3.50%	3.50%	3.50%
11	16.90%	17.00%	17.10%	16.95%	16.90%	16.90%	3.20%	3.20%	3.20%	3.20%	3.20%	3.15%
12	15.90%	16.10%	15.80%	15.90%	15.70%	15.80%	4.25%	3.80%	4.20%	4.10%	4.30%	4.20%
13	16.85%	16.65%	16.50%	16.60%	16.25%	16.50%	3.80%	3.80%	3.90%	3.70%	3.90%	3.80%
14	16.70%	16.60%	16.65%	16.60%	16.60%	16.75%	3.50%	3.50%	3.60%	3.50%	3.60%	3.40%
15	16.45%	16.20%	16.30%	16.00%	16.10%	16.50%	3.30%	3.75%	3.60%	3.70%	3.70%	3.40%
16	16.15%	16.50%	16.30%	16.00%	16.30%	16.10%	3.80%	3.70%	3.80%	3.95%	3.85%	3.90%
17	15.50%	15.30%	15.50%	15.40%	15.80%	15.90%	4.15%	4.20%	4.20%	4.15%	3.90%	3.95%
18	17.10%	17.30%	17.30%	17.20%	17.60%	17.10%	3.10%	3.05%	3.00%	3.10%	2.90%	3.20%
19	16.70%	16.45%	16.20%	16.30%	16.50%	16.50%	3.80%	3.70%	3.80%	3.75%	3.70%	3.70%
20	17.70%	16.60%	17.30%	17.30%	17.40%	18.30%	3.35%	3.50%	3.40%	3.40%	3.25%	2.80%

SUBJECT	GAS TEMPERATURE (C)						WATER VAPOR PRESSURE (mm/Hg)					
	T 1	T 2	T 3	T 4	T 5	T 6	T 1	T 2	T 3	T 4	T 5	T 6
1	26.0	26.5	26.5	27.0	27.0	27.0	25.2	26.0	26.0	26.7	26.7	26.7
2	24.8	24.9	25.0	24.9	24.9	25.0	23.5	23.6	23.8	23.6	23.6	23.8
3	26.8	26.8	26.8	26.8	26.8	26.8	26.4	26.4	26.4	26.4	26.4	26.4
4	25.0	25.0	25.3	25.5	25.3	25.5	23.8	23.8	24.2	24.5	24.2	24.5
5	23.8	24.0	24.0	24.0	24.0	24.0	22.1	22.4	22.4	22.4	22.4	22.4
6	22.5	22.9	23.1	23.4	23.8	24.0	20.5	21.0	21.2	21.6	22.1	22.4
7	24.0		24.0	24.1	24.2	24.2	22.4		22.4	22.5	22.6	22.6
8	26.0	26.5	26.5	26.8	26.8	26.8	25.2	26.0	26.0	26.4	26.4	26.4
9	26.0	26.2	26.4	26.4	26.5	26.5	25.2	25.5	25.8	25.8	26.0	26.0
10	23.0	23.1	23.3	23.5	23.8	23.8	21.1	21.2	21.4	21.7	22.1	22.1
11	26.9	27.0	27.9	28.0	28.0	28.2	26.6	26.7	28.2	28.3	28.3	28.7
12	26.1	26.9	27.3	27.8	28.1	28.0	25.4	26.6	27.2	28.0	28.5	28.3
13	26.5	26.9	27.3	27.5	27.7	27.7	26.0	26.6	27.2	27.5	27.9	27.9
14	24.5	24.9	25.1	25.6	25.9	26.0	23.1	23.6	23.9	24.6	25.1	25.2
15	26.1	26.7	27.0	27.8	27.9	27.9	25.4	26.3	26.7	28.0	28.2	28.2
16	26.9	27.5	28.0	28.2	28.2	28.6	26.6	27.5	28.3	28.7	28.7	29.4
17	25.3	26.0	26.3	26.9	26.9	26.9	24.2	25.2	25.7	26.6	26.6	26.6
18	27.0	27.6	27.7	27.9	28.0	28.0	26.7	27.7	27.9	28.2	28.3	28.3
19	26.9	27.2	27.5	27.8	27.8	27.9	26.6	27.1	27.5	28.0	28.0	28.2
20	24.0	24.0	24.0	24.0	24.0	24.1	22.4	22.4	22.4	22.4	22.4	22.5

APPENDIX A, DATA AT 27 DEGREES CENTIGRADE

SUBJECT	FINAL RECTAL TEMPERATURE	RECTAL TEMPERATURE T 1	T 2	T 3	T 4	T 5	T 6	SYSTOLIC BLOOD PRESSURE T 1	T 2	T 3	T 4	T 5	T 6
1	37.0	37.4	37.3	37.2	37.1	37.0	37.0	106	104	106	107	104	110
2	37.0	37.7	37.3	37.4	36.9	37.1	37.0	133	148	138	127	134	139
3	37.0	37.3	37.2	37.0	36.9	36.9	37.0	116	102	110	114	113	110
4	36.0	37.5	36.7	36.6	36.6	36.2	36.0	108	106	102	104	104	107
5	36.3	37.0	36.8	36.4	36.3	36.4	36.3	118	113	117	116	117	121
6	37.3	37.8	37.5	37.4	37.3	37.3	37.3	97	110	126	111	122	132
7	36.7	37.4	37.0	36.8	36.8	36.8	36.7	101	99	101	104	99	98
8	37.1	37.3	37.2	37.2	37.1	37.1	37.1	110	126	111	114	119	114
9	37.3	37.4	37.4	37.4	37.3	37.3	37.3	100	97	102	94	99	87
10	36.9	37.5	37.2	37.1	37.0	36.9	36.9	122	120	112	123	120	114
11	36.8	37.4	37.3	37.1	36.9	36.9	36.8	129	128	122	124	122	129
12	36.8	37.5	37.2	37.0	36.8	36.8	36.8	113	108	104	100	109	116
13	36.8	37.5	37.2	37.0	36.9	36.8	36.8	122	114	120	114	125	124
14	36.7	37.3	37.2	36.9	36.8	36.9	36.7	104	105	107	110	105	109
15	37.3	37.4	37.1	36.8	37.2	37.3	37.3	119	100	104	114	107	109
16	37.1	37.3	37.2	37.1	37.0	37.1	37.1	98	112	115	111	121	117
17	36.8	37.1	36.8	36.8	36.7	36.7	36.8	114	110	111	108	112	111
18	37.3	37.5	37.5	37.4	37.4	37.3	37.3	118	115	117	125	116	125
19	37.3	37.4	37.4	37.4	37.4	37.4	37.3	114	107	104	114	114	116
20	37.0	37.5	37.2	37.1	37.1	37.2	37.0	102	108	95	108	106	104

SUBJECT	MEAN H.R.	HEART RATE T 1	T 2	T 3	T 4	T 5	T 6	DIASTOLIC BLOOD PRESSURE T 1	T 2	T 3	T 4	T 5	T 6
1	75	78	80	78	82	72	72	77	74	74	74	82	72
2	53	85	65	50	52	58	50	63	68	56	48	61	47
3	60	65	63	60	58	60	63	74	64	61	72	73	70
4	51	60	54	52	50	52	50	66	64	66	66	66	73
5	62	63	76	72	65	62	60	66	68	75	74	73	75
6	61	65	64	65	61	62	60	74	78	86	84	63	79
7	36	40	44	37	35	37	35	54	61	66	58	45	65
8	53	58	50	56	56	50	54	60	62	81	67	76	92
9	69	70	58	72	75	68	65	54	54	70	60	56	61
10	68	75	63	62	70	70	65	74	80	65	75	80	70
11	46	54	48	48	48	45	44	68	75	68	74	76	77
12	45	54	43	45	44	48	43	60	66	69	61	77	70
13	54	54	52	62	55	50	58	88	75	87	85	96	96
14	55	63	54	57	54	54	56	80	75	75	75	77	80
15	60	94	56	58	75	50	56	77	61	68	61	81	74
16	66	81	75	75	62	70	66	80	60	77	82	81	82
17	57	70	60	58	59	51	60	67	70	72	72	70	70
18	70	71	71	70	71	71	68	92	82	84	87	92	83
19	60	60	60	64	56	60	63	79	75	76	78	80	77
20	61	59	64	68	57	58	68	64	61	59	70	64	71

APPENDIX A, DATA AT 27 DEGREES CENTIGRADE

SUBJECT	FINAL MEAN SKIN TEMPERATURE	MEAN SKIN TEMPERATURE (C) T 1	T 2	T 3	T 4	T 5	T 6	FOREHEAD (C) T 1	T 2	T 3	T 4	T 5	T 6
1	31.1	31.7	31.8	32.1	32.0	31.7	31.1	34.0	33.8	34.0	34.2	33.5	32.9
2	33.2	33.4	33.7	33.8	33.2	33.2	33.2	35.3	35.2	35.2	34.8	34.9	35.0
3	33.1	34.1	33.5	33.3	33.2	32.9	33.1	35.3	34.8	34.9	34.7	35.0	34.7
4	31.5	31.6	31.9	32.0	32.0	32.0	31.5	32.7	32.9	33.7	33.5	33.8	33.8
5	32.5	32.1	32.8	32.7	32.7	32.6	32.5	34.4	34.0	34.1	33.8	34.1	34.0
6	32.1	30.4	31.7	32.1	32.1	32.2	32.1	33.3	34.4	34.4	34.1	34.1	34.3
7	32.1	32.4	32.2	32.2	32.2	32.2	32.1	33.6	34.0	33.8	32.5	30.8	34.2
8	32.5	32.9	32.8	32.5	32.5	32.5	32.5	33.4	33.6	32.9	33.3	32.8	33.3
9	32.2	32.6	32.8	32.8	32.8	32.3	32.2	33.5	34.7	34.9	34.7	34.5	33.0
10	31.8	29.9	32.0	31.8	31.8	31.5	31.8	32.1	34.1	34.2	34.2	34.0	33.9
11	31.0	32.1	32.1	31.7	31.1	31.2	31.0	32.3	32.9	31.9	32.7	32.9	33.0
12	32.4	32.6	32.9	32.7	32.6	32.3	32.4	32.3	33.7	33.6	32.9	33.1	31.1
13	32.1	32.9	32.6	32.7	32.6	32.4	32.1	33.9	34.0	33.9	33.8	34.0	33.6
14	32.2	32.8	32.8	32.5	32.2	32.1	32.2	33.4	34.1	33.9	33.8	34.0	34.1
15	31.7	33.2	32.5	32.3	32.1	32.0	31.7	33.4	33.4	33.9	33.5	33.2	33.8
16	30.7	31.8	31.3	30.8	30.7	30.8	30.7	33.8	33.5	33.2	33.2	33.1	33.1
17	31.2	31.2	31.5	31.4	31.1	31.1	31.2	33.2	33.3	33.1	33.0	33.2	32.9
18	32.4	33.9	33.1	32.8	32.5	32.3	32.4	34.2	34.8	35.0	34.6	34.7	34.4
19	32.4	32.6	32.6	32.6	32.3	32.2	32.4	34.5	35.0	34.8	34.3	34.6	34.7
20	31.9	31.6	31.7	32.0	31.9	32.0	31.9	34.7	34.1	34.6	34.5	34.8	34.6

SUBJECT	CHEST (C) T 1	T 2	T 3	T 4	T 5	T 6	UPPER ARM (C) T 1	T 2	T 3	T 4	T 5	T 6
1	33.8	33.5	34.4	33.7	33.2	32.3	30.5	30.4	30.6	30.6	30.3	30.1
2	35.5	35.2	35.6	34.9	35.0	35.2	32.2	33.8	33.0	32.8	32.9	32.7
3	34.9	34.8	34.8	35.0	34.8	34.9	32.8	32.6	32.8	32.8	32.8	32.7
4	32.7	34.0	34.0	34.2	34.4	33.8	32.0	31.8	32.3	32.0	32.1	31.8
5	34.1	34.7	34.6	34.3	34.6	34.3	31.8	32.4	31.9	32.0	31.9	32.0
6	34.2	34.9	34.9	34.6	35.1	34.9	28.5	30.2	30.9	30.7	31.2	31.2
7	34.3	34.2	34.4	34.5	34.5	34.5	32.2	31.2	31.3	31.8	32.3	32.1
8	34.6	34.7	34.8	34.7	34.9	34.7	32.0	32.0	31.7	31.1	31.3	31.5
9	34.6	35.3	35.4	35.5	35.0	34.7	31.9	31.7	31.6	31.6	30.7	31.2
10	30.7	33.5	33.8	33.9	33.2	34.2	30.4	31.5	31.4	31.0	31.4	31.3
11	32.5	32.9	32.6	31.5	32.1	31.5	32.0	32.4	31.7	31.2	31.3	31.1
12	33.4	34.6	34.2	34.6	34.2	34.8	32.8	32.4	32.3	32.2	32.2	32.3
13	34.1	34.0	34.6	34.6	34.9	34.6	33.0	32.5	32.4	32.4	31.7	31.8
14	33.7	33.9	34.1	33.7	33.8	33.8	32.4	32.3	32.2	32.2	32.2	32.4
15	34.4	34.4	34.5	34.8	34.7	34.2	32.7	32.1	32.1	31.3	31.2	31.2
16	32.3	32.0	32.0	32.2	32.1	32.1	30.3	30.5	30.1	30.2	30.7	30.4
17	33.2	33.2	33.3	33.0	33.3	33.4	29.9	30.2	30.4	30.3	30.1	30.2
18	34.9	34.0	34.3	34.0	33.9	34.4	32.5	33.2	32.1	32.0	32.1	31.7
19	34.6	34.8	35.1	35.0	35.0	35.1	32.1	31.6	31.4	31.3	31.3	31.7
20	34.4	34.7	35.1	34.9	35.0	35.0	30.5	30.6	31.6	31.6	31.7	31.3

APPENDIX A, DATA AT 27 DEGREES CENTIGRADE

SUBJECT	CALF (C) T 1	T 2	T 3	T 4	T 5	T 6	BIG TOE (C) T 1	T 2	T 3	T 4	T 5	T 6
1	31.6	31.3	30.5	29.9	30.2	29.8	25.6	27.1	27.1	26.9	27.6	27.2
2	32.7	33.4	33.5	32.4	32.5	32.0	27.9	27.9	28.5	28.1	27.5	27.8
3	33.4	33.6	32.7	31.8	31.4	31.5	33.1	29.0	27.9	27.8	27.7	27.8
4	31.7	30.6	30.7	31.0	30.3	29.9	23.0	25.3	26.1	26.3	26.0	25.4
5	31.9	32.9	31.8	31.5	31.1	31.3	23.3	26.2	27.7	27.7	27.5	27.9
6	29.2	30.4	30.6	30.6	30.6	30.4	21.4	25.2	26.2	25.9	26.9	26.6
7	31.9	30.6	30.4	30.4	31.1	30.0	26.1	28.2	28.9	28.6	27.8	27.0
8	32.5	32.0	31.0	32.1	31.2	30.4	26.2	27.1	27.4	27.4	27.2	27.3
9	32.3	31.4	30.8	30.8	30.4	30.3	26.0	26.8	27.3	27.6	27.6	28.1
10	31.5	32.5	32.0	30.8	30.5	30.7	21.8	25.9	25.5	25.9	25.2	25.8
11	32.3	31.1	30.9	30.5	30.3	30.5	30.7	30.0	29.6	29.2	27.6	27.0
12	32.1	31.7	31.9	31.7	30.6	31.2	32.3	31.6	31.4	30.4	29.8	28.3
13	31.8	30.6	30.6	30.4	30.1	29.3	26.9	27.2	27.4	27.3	27.0	26.9
14	32.5	31.9	31.1	30.9	30.7	31.0	31.3	30.0	30.0	29.2	28.7	27.7
15	32.4	30.6	30.2	30.6	29.5	29.4	31.9	27.8	26.9	26.3	26.6	25.8
16	30.6	31.4	30.0	29.4	29.7	29.8	33.0	27.5	26.7	25.8	25.9	25.8
17	31.5	31.1	30.3	30.0	29.9	29.7	24.9	26.1	26.5	26.3	26.6	26.5
18	33.4	32.2	31.9	31.2	31.0	30.6	34.2	29.2	27.9	27.7	27.7	27.8
19	32.7	32.2	31.3	30.9	30.7	30.7	26.1	26.5	26.4	26.0	26.0	26.2
20	31.0	30.6	30.1	30.1	30.1	30.4	22.8	24.7	25.3	25.7	25.2	25.4

SUBJECT	FINGER (C) T 1	T 2	T 3	T 4	T 5	T 6	THIGH (C) T 1	T 2	T 3	T 4	T 5	T 6
1	28.5	27.6	28.4	28.9	28.9	28.3	31.1	31.9	32.3	33.3	32.4	31.8
2	31.2	32.1	32.3	32.5	30.9	31.0	33.0	33.0	32.9	32.6	32.7	32.4
3	34.8	33.2	33.1	31.2	32.3	31.6	33.7	33.2	32.8	33.0	32.0	32.7
4	31.8	31.7	30.0	28.6	28.2	27.4	31.8	31.2	31.3	31.2	31.4	30.5
5	32.2	32.3	31.3	30.8	30.1	30.2	31.2	31.9	32.3	32.6	32.6	32.1
6	26.4	27.4	28.7	28.4	28.5	28.7	28.7	30.1	30.9	32.1	30.9	30.7
7	30.2	31.1	29.4	28.4	28.2	28.0	31.6	31.2	31.5	31.5	32.0	31.5
8	30.7	29.7	30.5	29.4	29.6	29.1	33.5	32.8	32.0	32.1	32.5	32.9
9	32.9	32.4	32.8	32.3	31.5	32.7	31.8	31.7	31.7	31.2	30.8	30.6
10	27.4	27.8	27.3	28.0	27.4	27.3	29.7	31.7	31.0	31.4	31.4	31.3
11	32.1	32.2	31.9	31.9	30.9	31.1	31.9	31.4	31.3	30.8	30.8	31.0
12	31.9	32.6	32.2	30.8	31.2	30.5	31.8	31.4	31.2	31.1	30.7	31.5
13	33.2	32.0	30.6	29.5	28.9	28.4	33.0	33.1	33.1	32.7	32.3	31.9
14	33.4	32.7	32.7	31.8	31.4	31.0	31.7	32.2	31.3	31.1	30.5	31.3
15	33.3	33.0	31.8	30.8	30.2	30.1	32.4	32.0	31.4	30.8	31.5	30.6
16	33.0	31.8	30.1	29.2	30.2	29.3	31.4	30.8	30.7	30.4	30.3	30.0
17	27.5	28.7	28.7	28.4	28.9	28.2	30.6	31.7	31.5	30.6	30.3	30.6
18	34.5	32.8	31.4	31.5	30.9	31.6	33.2	32.7	32.5	32.0	31.8	31.7
19	28.6	29.3	30.3	29.7	29.3	29.0	32.2	32.0	32.0	31.3	31.1	31.4
20	31.9	27.7	27.8	28.2	27.8	27.1	30.9	30.5	30.5	30.3	30.6	30.2

APPENDIX A, DATA AT 30 DEGREES CENTIGRADE

SUBJECT	MEAN $\dot{V}O2$ (ml/kg/min)	$\dot{V}O2$ (ml/kg/min) (STPD) T 1	T 2	T 3	T 4	T 5	T 6	$\dot{V}E$ (ATPS) T 1	T 2	T 3	T 4	T 5	T 6
1	2.82	2.85	2.56	2.53	2.73	2.72	3.00	57.3	47.5	47.5	47.8	48.4	52.4
2	4.21	3.75	3.83	3.82	4.05	4.20	4.39	80.0	82.1	81.2	83.8	87.0	82.7
3	3.14	3.40	3.36		2.81	3.15	3.46	72.1	76.7		63.6	68.2	78.2
4	4.52	4.60	4.31	4.50	4.40	4.57	4.60	66.6	58.0	65.0	58.6	58.6	64.5
5	3.28		3.52	3.84	3.43	3.11	3.29	83.6	81.0	86.2	79.2	68.0	72.4
6	3.63	3.47	3.50	3.48	3.66	3.81	3.43	65.0	59.2	57.3	61.0	61.8	54.5
7	4.65	4.57	4.76	4.63	4.73	4.77	4.45	72.6	73.4	69.4	72.2	70.8	62.4
8	3.52	3.57	3.40	3.52	3.49	3.60	3.47	54.3	51.8	52.7	52.7	52.7	52.4
9	3.93	4.39	3.57	3.91	4.02	3.92	3.86	72.6	55.4	65.0	62.7	62.0	66.6
10	3.60	3.73	3.45	3.52		3.56	3.64	84.8	72.1	66.7		70.7	79.5
11	3.29	3.19	2.66	3.06	3.09	3.14	3.64	80.5	31.9	74.7	75.3	74.9	87.1
12	3.37	3.73	3.59	3.51	3.20	3.52	3.40	81.6	76.8	75.1	68.6	75.4	71.2
13	3.17	3.11	2.93	3.20	3.30	3.04	3.17	59.0	56.3	62.6	64.6	56.6	58.3
14	5.01	5.09	5.31	4.55	5.42	4.57	5.03	69.6	69.6	63.7	65.4	63.3	66.1
15	3.58	3.84	3.99	3.63	3.78	3.29	3.66	71.3	69.4	64.5	65.4	54.2	58.1
16	3.09	3.04	3.32	3.07	3.14	3.07	3.05	58.7	59.6	56.0	57.5	55.7	57.2
17	2.91	2.99	2.98	2.94	2.75	2.84	2.85	54.9	54.4	52.6	51.2	52.8	53.0
18	3.77	3.39	3.63	3.52	3.73	3.73	3.84	58.9	55.6	55.4	61.6	56.0	57.5
19	3.96	3.97	3.86	4.04	3.91	4.11	3.87	78.1	60.7	63.3	58.2	63.8	56.4
20	3.46	3.75	3.75	4.03	3.49	3.24	3.64	66.5	61.4	73.3	56.0	52.0	64.4

SUBJECT	MEAN COMFORT	COMFORT INDEX T 1	T 2	T 3	T 4	T 5	T 6	BARO. PRESSURE	WEIGHT (KG)
1	2.0	1.0	2.0	2.0	2.0	2.0	2.0	716	69.03
2	2.0	3.0	2.0	2.0	2.0	2.0	2.0	718	78.91
3	2.0	2.0	2.0	2.0	2.0	2.0	2.0	716	74.24
4	2.3	1.0	1.0	2.0	2.0	2.0	3.0	726	54.09
5	2.3	2.0	2.0	2.0	3.0	2.0	2.0	724	89.80
6	2.0	1.0	1.0	1.0	2.0	2.0	2.0	721	60.92
7	2.0	1.0	1.0	1.0	2.0	2.0	2.0	721	59.81
8	2.0	1.0	2.0	2.0	2.0	2.0	2.0	717	56.67
9	2.5	3.0	2.0	2.0	2.0	2.5	3.0	721	47.38
10	4.3	2.0	2.0	3.0	4.0	4.0	5.0	721	76.49
11	1.3	1.5	1.5	1.0	1.0	1.5	1.5	725	79.84
12	1.5	1.0	1.5	1.5	1.5	1.5	1.5	715	90.05
13	1.0	1.0	1.0	1.0	1.0	1.0	1.0	720	78.54
14	1.0	1.0	1.0	1.0	1.0	1.0	1.0	719	58.00
15	1.0	1.0	1.0	1.0	1.0	1.0	1.0	726	63.55
16	2.0	1.0	1.0	1.0	2.0	2.0	2.0	719	73.96
17	1.5	1.0	1.0	1.0	1.5	1.5	1.5	718	66.99
18	1.0	1.0	1.0	1.0	1.0	1.0	1.0	722	60.08
19	1.0	1.0	1.0	1.0	1.0	1.0	1.0	714	53.80
20	1.0	1.0	1.0	1.0	1.0	1.0	1.0	718	57.19

APPENDIX A, DATA AT 30 DEGREES CENTIGRADE

SUBJECT	FE O2 (ATPS)						FE CO2 (ATPS)					
	T 1	T 2	T 3	T 4	T 5	T 6	T 1	T 2	T 3	T 4	T 5	T 6
1	17.00%	16.70%	16.70%	16.40%	16.50%	16.40%	3.50%	3.60%	3.70%	3.90%	3.70%	3.80%
2	16.30%	16.70%	16.70%	16.60%	16.60%	16.20%	3.90%	3.70%	3.60%	3.60%	3.60%	3.85%
3	16.95%	17.20%	16.80%	17.15%	17.00%	17.15%	3.30%	3.20%	3.40%	3.25%	3.30%	3.25%
4	17.05%	16.85%	17.10%	16.85%	16.70%	17.00%	3.50%	3.50%	3.40%	3.30%	3.40%	3.40%
5		16.50%	16.40%	16.50%	16.30%	16.30%		3.60%	3.60%	3.60%	3.60%	3.70%
6	17.20%	16.85%	16.75%	16.80%	16.70%	16.60%	3.15%	3.20%	3.20%	3.15%	3.20%	3.30%
7	16.50%	16.40%	16.30%	16.40%	16.30%	16.00%	4.20%	4.15%	4.05%	3.90%	3.85%	4.20%
8	16.65%	16.65%	16.60%	16.65%	16.50%	16.60%	3.75%	3.75%	3.65%	3.55%	3.70%	3.70%
9	17.80%	17.30%	17.50%	17.30%	17.40%	17.65%	3.40%	3.65%	3.60%	3.70%	3.40%	3.35%
10	17.00%	16.70%	16.30%		16.50%	16.50%	3.60%	3.60%	3.85%		3.70%	3.70%
11	17.30%	17.15%	17.20%	17.15%	17.10%	17.10%	3.20%	3.10%	3.10%	3.30%	3.20%	3.25%
12	16.20%	16.10%	16.10%	16.10%	16.10%	16.00%	4.00%	4.00%	3.90%	3.90%	3.90%	3.90%
13	16.30%	16.35%	16.40%	16.40%	16.20%	16.15%	3.60%	3.55%	3.60%	3.60%	3.60%	3.65%
14	16.10%	15.90%	16.20%	16.00%	16.15%	16.40%	3.90%	4.00%	3.80%	3.95%	3.80%	3.60%
15	17.15%	17.10%	17.20%	17.10%	16.90%	16.80%	3.70%	3.65%	3.40%	3.50%	3.70%	3.60%
16	16.50%	16.20%	16.25%	16.30%	16.25%	16.40%	3.85%	3.90%	3.95%	3.75%	3.80%	3.70%
17	16.75%	16.70%	16.65%	16.80%	16.80%	16.80%	3.65%	3.70%	3.60%	3.50%	3.50%	3.45%
18	17.00%	16.50%	16.60%	16.80%	16.40%	16.40%	3.30%	3.60%	3.60%	3.40%	3.65%	3.60%
19	17.65%	17.00%	17.00%	16.80%	16.95%	16.70%	3.30%	3.25%	3.20%	3.30%	3.25%	3.40%
20	17.55%	16.90%	17.30%	16.80%	16.80%	17.10%	3.00%	3.35%	3.00%	3.40%	3.40%	3.50%

SUBJECT	GAS TEMPERATURE (C)						WATER VAPOR PRESSURE (mm/Hg)					
	T 1	T 2	T 3	T 4	T 5	T 6	T 1	T 2	T 3	T 4	T 5	T 6
1	22.3	23.0	23.9	24.0	24.4	24.8	20.2	21.1	22.2	22.4	22.9	23.5
2	24.0	24.0	24.0	24.1	24.2	24.0	22.4	22.4	22.4	22.5	22.6	22.4
3	23.8	24.2	24.5	24.8	25.0	25.0	22.1	22.6	23.1	23.5	23.8	23.8
4	26.0	23.8	23.9	24.0	24.0	24.0	25.2	22.1	22.3	22.4	22.4	22.4
5	25.5	26.2	26.5	26.8	26.8	27.0	24.5	25.5	26.0	26.4	26.4	26.7
6	26.0	26.5	26.8	26.9	26.9	27.0	25.2	26.0	26.4	26.6	26.6	26.7
7	26.0	26.1	26.8	26.9	26.9	27.0	25.2	25.4	26.4	26.6	26.6	26.7
8	24.0	24.2	24.8	24.9	24.9	25.0	22.4	22.6	23.5	23.6	23.6	23.8
9	25.0	25.0	25.3	25.3	25.5	25.3	23.8	23.8	24.2	24.2	24.5	24.2
10	26.1	27.0	26.8		26.8	26.9	25.4	26.7	26.4		26.4	26.6
11	25.4	26.2	26.9	27.0	27.1	27.0	24.3	25.5	26.6	26.7	26.9	26.7
12	25.0	25.4	26.1	26.6	26.7	26.8	23.8	24.3	25.4	26.1	26.3	26.4
13	24.2	24.9	25.0	25.2	25.2	25.2	22.6	23.6	23.8	24.0	24.0	24.0
14	25.8	26.2	26.5	26.5	26.8	26.9	24.9	25.5	26.0	26.0	26.4	26.6
15	25.0	25.1	26.0	26.0	26.1	26.1	23.8	23.9	25.2	25.2	25.4	25.4
16	25.8	26.4	26.8	27.0	27.0	27.1	24.9	25.8	26.4	26.7	26.7	26.9
17	24.0	24.9	25.0	25.1	25.2	25.5	22.4	23.6	23.8	23.9	24.0	24.5
18	24.9	25.1	25.2	25.6	25.5	25.8	23.6	23.9	24.0	24.6	24.5	24.9
19	25.1	25.2	25.5	25.6	25.9	26.0	23.9	24.0	24.5	24.6	25.1	25.2
20	26.4	27.1	27.6	28.0	28.0	28.1	25.8	26.9	27.7	28.3	28.3	28.5

APPENDIX A, DATA AT 30 DEGREES CENTIGRADE

SUBJECT	FINAL RECTAL TEMPERATURE	RECTAL TEMPERATURE T 1	T 2	T 3	T 4	T 5	T 6	SYSTOLIC BLOOD PRESSURE T 1	T 2	T 3	T 4	T 5	T 6
1	36.4	36.9	36.7	36.5	36.4	36.4	36.4	109	111	97	105	101	104
2	37.1	37.7	37.4	37.3	37.2	37.1	37.1	127	130	112	129	126	135
3	36.9	37.4	37.0	36.7	36.9	36.9	36.9	101	111	109	106	111	106
4	37.2	37.7	37.5	37.3	37.3	37.3	37.2	123	113	112	133	111	116
5	36.8	37.8	37.4	37.1	37.0	36.8	36.8	110	104	106	111	106	108
6	36.9	37.4	37.1	36.9	36.8	36.9	36.9	93	106	105	104	101	130
7	36.9	37.4	37.0	36.8	36.8	36.9	36.9	94	102	96	95	105	99
8	37.2	37.7	37.2	37.1	37.2	37.2	37.2	120	113	117	113	117	126
9	37.0	37.5	37.2	37.1	37.0	37.1	37.0	99	95	89	102	103	106
10	37.1	37.4	37.3	37.1	37.0	37.0	37.1	110	110	113	122	105	112
11	36.9	37.4	36.7	37.0	36.9	36.8	36.9	118	114	103	108	108	114
12	37.1	37.5	37.4	37.3	37.2	37.1	37.1	111	113	108	106	114	115
13	37.0	37.7	37.2	37.1	37.1	37.0	37.0	108	104	104	100	105	110
14	37.0	37.2	37.2	37.0	37.0	37.0	37.0	100	104	106	101	112	111
15	37.0	37.1	36.8	36.8	36.9	36.8	37.0	104	98	99	108	101	104
16	36.9	37.3	37.2	37.0	36.9	36.9	36.9	107	111	99	106	118	109
17	36.9	37.3	37.1	37.0	37.0	36.9	36.9	102	107	100	105	104	104
18	36.6	37.2	37.1	37.0	36.9	36.9	36.8	117	108	104	102	101	106
19	37.5	37.5	37.5	37.4	37.4	37.4	37.5	108	98	97	106	109	109
20	36.8	37.3	36.9	36.6	36.7	36.7	36.8	94	101	108	97	99	95

SUBJECT	MEAN H.R.	HEART RATE T 1	T 2	T 3	T 4	T 5	T 6	DIASTOLIC BLOOD PRESSURE T 1	T 2	T 3	T 4	T 5	T 6
1	62	75	63	65	75	56	56	77	64	71	65	73	69
2	58	57	60	64	59	57	58	86	73	80	76	76	84
3	60	62	64	68	62	58	60	58	63	67	64	68	73
4	56	60	63	54	63	52	54	69	71	67	65	67	73
5	68	68	75	71	75	58	70	70	69	66	68	70	69
6	67	63	63	70	68	64	70	79	63	73	76	66	63
7	39	44	40	40	40	38	38	38	47	58	54	56	47
8	55	60	48	50	52	58	56	77	74	70	70	77	68
9	70	77	66	70	65	70	75	65	52	55	64	63	65
10	55	60	66	62	62	52	52	70	60	63	75	64	79
11	41	56	58	43	40	43	41	71	74	69	63	68	69
12	43	47	45	50	44	41	44	66	64	63	61	72	71
13	61	60	59	62	59	65	60	75	75	68	70	77	73
14	66	60	64	68	68	68	62	72	71	74	74	76	76
15	51	75	58	60	50	48	54	74	64	67	72	72	68
16	71	70	74	72	73	70	70	73	77	66	72	77	76
17	57	54	58	60	63	53	56	66	74	71	64	67	61
18	73	79	88	68	76	65	77	81	82	82	77	64	81
19	64	68	79	67	65	63	65	76	63	71	76	69	75
20	59	63	59	75	60	58	60	68	71	67	62	73	72

APPENDIX A, DATA AT 30 DEGREES CENTIGRADE

SUBJECT	FINAL MEAN SKIN TEMPERATURE	MEAN SKIN TEMPERATURE (C) T 1	T 2	T 3	T 4	T 5	T 6	FOREHEAD (C) T 1	T 2	T 3	T 4	T 5	T 6
1	32.6	30.4	31.7	32.9	32.5	33.0	32.6	31.2	34.2	34.4	34.2	34.4	33.6
2	34.2	32.6	33.5	33.6	33.8	34.0	34.2	34.0	34.7	34.7	35.2	35.1	35.4
3	34.1	31.9	33.7	34.0	34.2	34.3	34.1	33.0	35.1	35.1	35.2	35.3	34.8
4	33.5	31.7	33.0	33.4	33.5	33.3	33.5	32.0	34.6	34.6	34.2	34.4	34.8
5	34.4	33.8	34.7	34.9	34.7	34.4	34.4	34.4	35.0	34.7	34.7	34.8	34.4
6	33.6	32.4	32.9	33.6	33.5	33.5	33.6	33.8	34.4	34.5	34.7	34.9	34.8
7	33.7	33.5	33.9	34.1	33.7	33.9	33.7	34.2	34.4	35.1	33.3	34.6	35.1
8	33.6	31.6	32.0	33.0	33.3	33.4	33.6	32.7	33.8	33.9	33.9	33.9	34.3
9	33.9	33.3	33.5	33.8	33.4	33.8	33.9	34.2	34.8	35.0	35.0	35.1	35.3
10	33.9	33.7	33.6	33.9	34.2	34.3	33.9	34.4	35.0	35.0	35.3	34.8	34.8
11	33.0	32.3	33.2	33.5	33.5	33.2	33.0	32.6	34.2	34.6	34.3	33.9	34.0
12	32.7	31.8	32.3	32.7	32.6	32.7	32.7	31.6	33.5	32.3	33.7	33.6	33.8
13	33.4	32.7	33.2	33.3	33.4	33.2	33.4	33.0	33.1	33.2	33.9	33.4	33.6
14	32.2	31.7	32.2	32.3	32.2	32.0	32.2	32.1	32.8	32.7	32.5	32.3	32.5
15	33.1	31.6	32.3	32.7	32.9	33.3	33.1	33.5	33.5	34.1	34.4	34.4	34.0
16	32.7	32.2	32.4	32.8	32.5	32.4	32.7	33.8	34.0	34.7	33.9	34.1	33.9
17	32.8	31.6	32.5	32.8	32.9	32.8	32.8	33.0	33.4	34.4	34.5	33.7	33.9
18	32.1	32.8	33.5	32.1	32.1	31.9	32.1	33.9	34.3	34.8	32.5	32.6	32.5
19	32.9	32.1	32.6	32.8	32.9	32.9	32.9	33.6	34.0	34.1	34.4	34.0	34.3
20	33.0	32.3	32.8	33.0	33.1	33.1	33.0	34.0	34.2	34.4	33.9	34.5	34.2

SUBJECT	CHEST (C) T 1	T 2	T 3	T 4	T 5	T 6	UPPER ARM (C) T 1	T 2	T 3	T 4	T 5	T 6
1	32.4	33.4	34.1	34.1	34.5	34.2	30.0	30.6	31.3	31.9	31.8	31.6
2	32.6	34.3	34.9	34.9	35.2	35.5	32.3	32.4	32.8	33.2	33.2	33.2
3	33.4	34.7	35.0	35.1	35.2	34.9	31.7	33.1	33.6	34.0	33.9	33.5
4	34.6	35.0	35.1	35.3	34.7	35.5	31.9	33.1	33.6	33.7	33.7	33.6
5	34.7	35.6	35.4	35.4	35.2	35.2	32.9	33.7	34.8	34.6	34.7	34.9
6	33.8	34.3	34.9	34.8	34.5	34.8	32.2	32.7	33.5	33.4	33.6	33.8
7	34.6	35.4	35.4	34.8	34.9	34.9	32.9	33.5	33.5	33.5	33.9	33.8
8	33.6	32.8	34.5	34.8	34.9	34.9	30.6	31.7	32.2	32.5	32.5	32.8
9	34.7	35.0	35.4	34.2	35.0	35.0	32.0	32.5	33.2	33.8	34.0	34.0
10	34.2	34.9	35.4	35.3	35.4	35.3	32.6	33.2	33.5	34.2	34.1	34.0
11	32.0	33.5	34.0	34.2	33.8	34.0	32.3	32.6	33.0	33.1	32.9	32.5
12	32.8	33.3	33.7	33.8	34.2	33.9	31.7	31.8	32.6	32.3	32.4	32.3
13	33.8	34.4	34.4	34.8	34.5	34.9	31.2	32.5	32.5	32.7	33.0	33.1
14	32.4	33.0	32.9	32.8	32.4	32.7	31.2	31.8	31.8	31.7	31.7	31.9
15	33.8	33.9	34.2	34.7	35.1	34.5	31.0	31.4	32.3	32.4	33.2	33.1
16	32.8	33.3	34.0	33.4	33.6	33.7	30.3	31.3	32.2	31.7	31.8	32.9
17	32.6	33.6	33.8	33.9	33.7	33.9	30.4	31.6	32.2	33.0	32.5	31.9
18	33.2	34.0	32.2	32.3	32.2	32.4	33.1	33.0	32.1	32.7	32.3	32.4
19	34.0	34.6	34.8	35.0	35.0	34.9	31.1	32.3	32.3	32.6	32.3	32.5
20	33.4	33.9	34.3	34.6	34.9	34.8	31.4	31.7	32.4	32.4	32.1	32.1

APPENDIX A, DATA AT 30 DEGREES CENTIGRADE

SUBJECT	CALF (C) T1	T2	T3	T4	T5	T6	BIG TOE (C) T1	T2	T3	T4	T5	T6
1	31.4	31.8	32.4	32.3	32.7	32.4	23.0	27.3	28.9	29.0	28.9	28.9
2	33.5	32.9	32.7	33.0	32.8	33.3	29.4	32.5	31.9	31.2	31.9	31.5
3	31.2	32.5	32.6	32.9	33.4	33.3	27.2	32.6	32.8	33.1	33.1	33.2
4	31.1	31.4	31.6	31.5	31.8	31.8	21.6	27.7	29.4	28.9	28.9	27.8
5	34.2	34.4	34.7	33.7	33.6	33.2	32.2	34.0	34.1	34.1	32.4	32.4
6	32.0	32.3	32.9	33.4	33.0	32.6	28.5	28.4	29.6	29.9	30.2	29.6
7	32.7	33.1	32.9	32.9	32.9	32.4	33.0	32.4	31.8	31.6	31.8	30.7
8	31.0	31.6	32.0	32.2	32.5	32.3	24.5	28.5	29.6	29.8	30.0	30.0
9	32.9	32.1	32.6	32.7	32.2	32.9	31.6	32.7	31.8	30.6	31.3	30.4
10	33.2	33.4	32.6	33.2	33.4	32.2	29.0	30.4	30.3	31.1	29.8	30.4
11	32.6	33.0	33.2	33.1	32.6	32.5	32.5	33.0	33.0	33.0	32.4	30.8
12	31.5	31.4	32.0	31.8	32.0	32.3	30.4	30.4	30.4	30.7	29.8	29.8
13	32.8	32.2	32.7	32.4	32.2	32.1	31.1	30.0	30.5	30.4	29.7	29.8
14	31.1	31.4	31.7	31.6	31.3	31.1	31.6	31.8	31.7	31.5	31.2	31.3
15	30.8	31.5	31.5	32.0	32.4	32.2	24.3	28.1	28.6	28.3	29.0	28.8
16	31.7	31.4	31.5	31.9	32.1	32.1	31.8	30.8	29.3	29.1	28.4	28.1
17	30.8	31.8	32.3	32.2	32.1	32.0	32.3	30.3	29.2	29.1	29.9	30.4
18	33.0	33.3	31.8	31.7	31.5	31.6	30.0	30.8	30.5	30.6	30.4	31.0
19	32.8	32.0	31.8	31.7	31.7	31.6	24.8	27.1	28.2	28.0	28.2	28.3
20	31.2	31.9	32.1	31.7	31.6	31.5	31.9	32.1	30.9	30.5	30.2	30.3

SUBJECT	FINGER (C) T1	T2	T3	T4	T5	T6	THIGH (C) T1	T2	T3	T4	T5	T6
1	26.1	29.0	33.1	29.3	29.5	29.1	29.7	30.6	33.1	31.8	33.0	32.4
2	34.0	34.0	33.4	33.0	32.7	33.3	32.3	33.0	32.8	33.4	33.8	34.0
3	31.1	34.0	34.2	34.4	34.4	34.6	31.5	32.8	33.4	33.4	33.5	33.4
4	26.4	33.2	33.0	33.5	32.6	32.6	31.4	31.9	32.4	32.6	32.7	33.0
5	34.7	34.3	34.5	34.3	33.5	34.0	32.7	34.2	34.8	34.7	34.2	34.3
6	31.5	31.8	32.3	31.7	32.2	31.8	31.3	32.4	33.3	32.6	33.2	33.6
7	33.3	33.8	33.9	33.4	32.9	32.9	32.3	32.5	33.3	33.3	33.5	33.0
8	31.3	31.2	31.9	32.0	31.7	31.4	31.3	32.1	32.8	33.3	33.2	34.1
9	34.0	33.8	34.0	34.2	33.7	34.2	32.3	32.2	32.6	32.6	32.8	33.0
10	32.7	32.8	33.3	32.7	32.9	32.8	33.8	32.3	33.2	33.8	34.8	33.7
11	33.2	33.6	33.0	33.2	33.0	32.5	32.0	32.7	32.9	33.0	32.9	32.7
12	31.7	32.3	32.6	32.4	31.7	32.1	31.0	31.5	32.3	31.5	31.7	31.8
13	32.4	32.7	32.1	31.4	31.0	30.9	32.3	33.6	33.6	33.6	33.5	33.6
14	31.8	32.6	32.1	32.2	32.0	32.2	31.0	31.5	32.1	31.9	32.3	32.3
15	30.2	31.9	31.8	31.4	33.2	31.6	30.8	31.8	32.2	32.3	32.1	32.6
16	33.1	32.6	32.6	31.9	31.6	32.4	32.1	32.0	32.6	32.5	32.1	32.4
17	30.9	31.9	32.0	32.5	32.5	32.7	30.7	32.1	32.7	32.4	32.3	32.4
18	32.7	33.3	32.0	31.7	32.1	32.4	32.4	33.7	31.7	32.1	31.5	32.0
19	30.9	30.9	31.8	31.2	30.9	30.0	31.4	31.4	31.8	31.8	32.0	32.1
20	32.1	33.4	32.9	33.2	32.9	32.8	31.4	32.0	32.1	32.3	32.3	32.2

APPENDIX A, DATA AT 33 DEGREES CENTIGRADE

SUBJECT	MEAN $\dot{V}O2$ (ml/kg/min)	$\dot{V}O2$ (ml/kg/min) (STPD) T 1	T 2	T 3	T 4	T 5	T 6	$\dot{V}E$ (ATPS) T 1	T 2	T 3	T 4	T 5	T 6
1	3.00	2.90	2.83	3.12	3.08	2.97	2.95	59.5	54.5	51.9	52.1	48.0	48.2
2	4.09	3.80	3.77	3.65	4.02	4.19	4.05	81.7	81.5	72.5	87.2	93.4	91.9
3	3.57	3.55	3.41	3.61	3.42	3.51	3.79	81.1	73.9	80.4	74.3	76.1	79.9
4	4.32	4.56	4.26	4.46	4.45	4.50	4.00	76.2	61.9	62.1	60.1	65.8	60.6
5	3.40	3.44	3.24	3.03	3.11	3.52	3.55	77.1	76.1	73.5	73.7	81.6	82.7
6	3.40	3.26	3.40	3.28	3.22	3.49	3.48	73.3	73.2	64.1	71.7	71.8	63.8
7	4.62	5.44	4.97	4.75	4.52	4.60	4.74	89.6	89.6	69.0	68.1	69.3	72.1
8	3.83	3.49	3.51	3.81	3.59	4.00	3.88	48.3	55.5	48.7	45.3	51.8	52.6
9	3.88	4.32	4.43	4.06	3.60	3.91	4.14	85.5	83.2	59.3	46.9	49.9	66.0
10	3.41	3.87	3.22	3.29	3.51	3.28	3.45	79.7	69.1	66.8	69.4	65.9	67.1
11	3.71	3.37	3.62	3.38	3.64	3.93	3.54	66.7	93.1	67.3	72.8	67.4	62.4
12	4.20	4.01	3.94	4.03	4.21	4.19	4.20	78.7	82.8	81.1	60.9	81.5	80.7
13	3.46	3.30	3.44	3.46	3.47	3.54	3.42	65.5	59.4	59.6	59.8	61.0	56.5
14	4.40	3.96	4.31	4.43	4.35	4.36	4.50	54.6	64.4	65.7	63.3	65.0	66.3
15	3.47	3.71	3.36	3.37	3.22	3.46	3.74	59.3	48.1	47.4	45.1	50.9	53.5
16	3.58	3.35	3.57	3.55	3.46	3.80	3.47	57.9	69.1	71.6	66.9	71.5	66.8
17	3.30	3.05	3.31	3.17	3.35	3.24	3.30	53.3	51.6	52.9	53.8	53.7	54.7
18	3.59	3.30	3.53	4.12	3.72	3.56	3.49	53.4	58.2	68.5	57.2	57.6	53.9
19	4.46	4.44	4.54	4.31	4.50	4.40	4.47	81.6	60.2	57.9	61.9	65.0	65.2
20	4.02	3.85	3.97	4.24	3.90	4.18	3.98	61.4	71.1	72.0	58.2	58.1	58.0

SUBJECT	MEAN COMFORT	COMFORT INDEX T 1	T 2	T 3	T 4	T 5	T 6	BARO. PRESSURE	WEIGHT (KG)
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	726	70.56
2	1.3	1.5	1.5	1.0	1.0	1.5	1.5	725	80.91
3	1.5	2.0	1.5	1.5	1.5	1.5	1.5	717	73.28
4	2.0	1.0	1.0	1.0	2.0	2.0	2.0	718	53.89
5	1.8	2.0	2.0	2.0	1.5	1.5	2.5	716	86.74
6	1.0	1.0	1.0	1.0	1.0	1.0	1.0	719	63.11
7	2.7	1.0	1.0	2.0	2.0	3.0	3.0	719	62.14
8	2.0	1.0	2.0	2.0	2.0	2.0	2.0	721	56.13
9	1.7	2.0	1.0	1.5	1.5	1.5	2.0	719	46.78
10	1.0	2.0	1.0	1.0	1.0	1.0	1.0	716	75.61
11	3.0	1.0	1.5	2.0	2.5	3.0	3.5	713	78.78
12	2.0	2.0	2.0	2.0	2.0	2.0	2.0	717	90.46
13	1.0	1.0	1.0	1.0	1.0	1.0	1.0	709	79.01
14	1.7	1.0	2.0	2.0	2.0	1.5	1.5	716	57.24
15	1.0	1.0	1.0	1.0	1.0	1.0	1.0	723	65.86
16	2.3	1.5	2.0	2.0	2.0	2.5	2.5	717	74.01
17	1.3	1.0	1.0	1.0	1.0	1.5	1.5	715	67.57
18	1.0	1.0	1.0	1.0	1.0	1.0	1.0	723	60.58
19	1.7	2.0	1.5	1.5	1.5	1.5	2.0	719	54.41
20	1.0	2.0	1.5	1.5	1.0	1.0	1.0	713	55.76

APPENDIX A, DATA AT 33 DEGREES CENTIGRADE

SUBJECT	FE O2 (ATPS)						FE CO2 (ATPS)					
	T 1	T 2	T 3	T 4	T 5	T 6	T 1	T 2	T 3	T 4	T 5	T 6
1	16.95%	16.70%	16.10%	16.20%	16.00%	16.00%	3.70%	3.90%	4.10%	3.90%	4.00%	4.10%
2	16.60%	16.65%	16.30%	16.65%	16.80%	16.90%	3.90%	3.65%	3.85%	3.70%	3.40%	3.20%
3	17.20%	17.00%	17.10%	17.00%	17.00%	16.90%	3.50%	3.60%	3.50%	3.55%	3.55%	3.55%
4	17.20%	16.70%	16.50%	16.35%	16.70%	16.80%	3.30%	3.40%	3.55%	3.70%	3.40%	3.50%
5	16.50%	16.70%	16.80%	16.70%	16.50%	16.60%	3.70%	3.40%	3.40%	3.45%	3.60%	3.60%
6	17.70%	17.70%	17.25%	17.65%	17.40%	17.00%	2.70%	2.80%	2.90%	2.80%	2.90%	3.10%
7	16.40%	16.40%	15.90%	16.05%	16.05%	16.10%	4.50%	4.40%	4.55%	4.50%	4.50%	4.40%
8	16.35%	16.50%	15.95%	15.90%	16.00%	16.20%	3.70%	3.60%	3.95%	3.90%	3.90%	3.80%
9	18.05%	17.90%	17.20%	16.80%	16.70%	17.45%	3.05%	3.15%	3.25%	3.40%	3.55%	3.30%
10	16.70%	16.50%	16.60%	16.55%	16.60%	16.45%	3.70%	3.65%	3.80%	3.60%	3.60%	3.70%
11	17.20%	17.30%	17.20%	17.20%	17.15%	17.25%	3.40%	3.40%	3.40%	3.45%	3.40%	3.30%
12	15.70%	16.00%	15.80%	15.60%	15.65%	15.60%	4.10%	4.00%	4.05%	4.00%	4.00%	4.00%
13	16.90%	16.60%	16.60%	16.60%	16.60%	16.45%	3.70%	3.80%	3.70%	3.70%	3.75%	3.70%
14	16.30%	16.60%	16.55%	16.45%	16.55%	16.50%	3.65%	3.50%	3.60%	3.70%	3.60%	3.60%
15	16.35%	15.80%	15.70%	15.70%	15.90%	15.80%	3.50%	3.90%	4.00%	3.90%	3.90%	3.80%
16	16.10%	16.55%	16.70%	16.50%	16.40%	16.50%	3.60%	3.50%	3.50%	3.70%	3.70%	3.60%
17	16.50%	16.00%	16.30%	16.15%	16.25%	16.25%	3.60%	3.80%	3.60%	3.60%	3.70%	3.70%
18	16.70%	16.80%	16.80%	16.50%	16.70%	16.50%	3.50%	3.30%	3.40%	3.50%	3.40%	3.55%
19	17.45%	16.30%	16.40%	16.45%	16.75%	16.70%	3.40%	3.70%	3.60%	3.60%	3.40%	3.40%
20	16.90%	17.30%	17.10%	16.65%	16.35%	16.50%	3.50%	3.30%	3.40%	3.50%	3.70%	3.80%

SUBJECT	GAS TEMPERATURE (C)						WATER VAPOR PRESSURE (mm/Hg)					
	T 1	T 2	T 3	T 4	T 5	T 6	T 1	T 2	T 3	T 4	T 5	T 6
1	25.2	25.2	26.0	26.2	26.3	26.8	24.0	24.0	25.2	25.5	25.7	26.4
2	25.0	26.0	26.2	26.4	26.5	26.6	23.8	25.2	25.5	25.8	25.9	26.1
3	23.2	24.1	24.8	25.0	25.1	25.2	21.3	22.5	23.5	23.8	23.9	24.0
4	25.0	26.2	26.8	27.0	27.2	27.3	23.8	25.5	26.4	26.7	27.1	27.2
5	25.0	26.2	27.0	27.5	27.4	27.7	23.8	25.5	26.7	27.5	27.4	27.8
6	26.6	26.9	27.0	27.1	27.1	27.1	26.1	26.6	26.7	26.9	26.9	26.9
7	26.8	27.0	27.2	27.4	27.5	27.7	26.4	26.7	27.1	27.4	27.5	27.8
8	24.9	25.8	26.2	26.5	26.9	27.0	23.6	24.9	25.5	26.0	26.6	26.7
9	26.6	27.1	27.0	27.1	27.1	27.1	26.1	26.9	26.7	26.9	26.9	26.9
10	24.0	25.0	25.6	25.6	26.1	26.3	22.4	23.8	24.6	24.6	25.4	25.7
11	24.9	25.6	25.9	26.0	26.0	26.0	23.6	24.6	25.1	25.2	25.2	25.2
12	25.8	26.1	26.7	26.8	27.0	26.9	24.9	25.4	26.3	26.4	26.7	26.6
13	26.2	27.0	27.7	27.5	27.2	27.4	25.5	26.7	27.9	27.5	27.1	27.4
14	22.2	23.8	24.0	24.3	24.9	25.0	20.1	22.1	22.4	22.8	23.6	23.8
15	24.5	25.0	25.3	25.5	25.8	26.0	23.1	23.8	24.2	24.5	24.9	25.2
16	26.5	26.9	27.0	27.0	27.1	27.2	26.0	26.6	26.7	26.7	26.9	27.1
17	25.8	26.1	26.3	26.9	26.9	27.0	24.9	25.4	26.4	26.6	25.6	26.7
18	24.5	25.1	25.3	25.5	25.6	25.8	23.0	23.9	24.2	24.5	24.6	24.9
19	24.0	24.8	25.0	25.1	25.2	25.2	22.4	23.5	23.8	23.9	24.0	24.0
20	23.7	24.0	24.9	24.9	25.0	25.0	22.0	22.4	23.6	23.6	23.8	23.8

APPENDIX A, DATA AT 33 DEGREES CENTIGRADE

SUBJECT	FINAL RECTAL TEMPERATURE	RECTAL TEMPERATURE T 1	T 2	T 3	T 4	T 5	T 6	SYSTOLIC BLOOD PRESSURE T 1	T 2	T 3	T 4	T 5	T 6
1	36.8	37.3	37.0	36.8	36.8	36.8	36.8	97	102	101	104	96	107
2	37.2	37.5	37.3	37.3	37.2	37.2	37.2	138	119	121	125	127	125
3	37.1	37.4	36.9	36.8	36.9	36.9	37.1	102	101	97	108	104	106
4	37.1	37.3	36.9	36.8	36.8	36.9	37.1	97	109	103	105	101	100
5	36.8	36.9	36.7	36.7	36.7	36.7	36.8	111	110	110	108	117	101
6	37.3	37.5	37.3	37.2	37.3	37.3	37.3	120	111	113	111	114	118
7	37.2	37.3	37.1	37.2	37.3	37.2	37.2	119	112	121	114	116	117
8	36.8	37.0	36.8	36.5	36.7	36.8	36.8	108	116	115	112	110	110
9	37.4	37.5	37.3	37.3	37.3	37.5	37.4	98	93	108	99	100	106
10	37.2	37.7	37.3	37.2	37.1	37.0	37.2	105	98	84	102	92	107
11	37.3	37.5	37.5	37.4	37.4	37.3	37.3	128	123	118	130	122	135
12	37.0	37.6	37.2	37.1	36.9	36.9	37.0	117	109	111	118	113	131
13	37.7	37.6	37.6	37.7	37.7	37.7	37.7	113	112	115	116	121	123
14	37.1	37.5	37.2	36.9	36.9	37.0	37.1	120	110	109	124	111	111
15	37.2	37.1	37.0	36.8	36.8	37.0	37.2	120	107	105	109	100	103
16	37.1	37.3	37.1	37.0	36.9	37.0	37.1	107	113	112	94	102	117
17	36.5	36.8	36.6	36.5	36.5	36.5	36.5	106	101	108	99	102	107
18	37.0	37.2	36.9	36.8	36.9	36.9	37.0	110	105	123	123	112	117
19	37.7	37.8	37.5	37.5	37.5	37.6	37.7	123	117	109	120	115	114
20	36.8	37.3	37.1	36.8	36.7	36.7	36.8	85	95	98	112	95	106

SUBJECT	MEAN H.R.	HEART RATE T 1	T 2	T 3	T 4	T 5	T 6	DIASTOLIC BLOOD PRESSURE T 1	T 2	T 3	T 4	T 5	T 6
1	76	65	67	75	79	75	75	85	72	72	71	75	70
2	72	71	75	66	53	75	88	61	76	79	83	76	82
3	66	63	67	64	68	60	71	60	48	50	60	57	55
4	58	55	65	71	58	59	58	58	64	67	54	61	56
5	61	58	58	60	63	60	60	68	62	66	58	55	57
6	67	70	63	65	65	68	68	75	75	76	75	69	73
7	47	45	55	49	47	47	48	57	53	53	51	52	50
8	61	63	65	63	68	58	58	84	72	69	70	66	63
9	71	65	70	75	67	68	79	64	63	66	70	70	62
10	62	65	65	63	63	65	58	60	60	48	55	58	55
11	49	50	58	51	50	52	45	67	64	69	69	70	68
12	46	43	45	65	43	47	48	64	69	69	60	66	87
13	69	60	65	65	68	75	65	81	71	65	73	80	89
14	72	75	70	63	68	70	78	92	86	80	84	83	64
15	63	70	75	63	68	68	54	70	62	60	61	63	67
16	87	75	75	78	83	94	83	71	73	67	74	68	82
17	53	56	53	50	52	50	58	67	64	67	69	65	75
18	82	68	75	80	83	73	83	80	80	81	84	62	75
19	75	67	70	88	83	72	71	80	77	68	78	79	73
20	61	68	68	70	68	56	60	56	68	54	56	63	53

APPENDIX A, DATA AT 33 DEGREES CENTIGRADE

SUBJECT	FINAL MEAN SKIN TEMPERATURE	MEAN SKIN TEMPERATURE (C) T 1	T 2	T 3	T 4	T 5	T 6
1	35.0	31.9	34.2	34.9	34.9	35.2	35.0
2	34.7	32.6	34.1	34.3	34.5	34.8	34.7
3	35.4	32.2	34.0	34.8	35.2	35.3	35.4
4	35.2	31.8	34.1	34.8	35.0	35.3	35.2
5	35.7	33.2	34.6	35.1	35.3	35.4	35.7
6	35.7	31.8	33.7	34.5	34.9	35.2	35.7
7	35.5	33.6	34.8	35.3	35.5	35.5	35.5
8	35.2	31.9	33.7	34.4	34.9	35.1	35.2
9	35.6	32.6	34.4	35.0	35.0	35.3	35.6
10	35.5	33.1	34.5	35.1	35.4	35.4	35.5
11	34.7	32.4	33.6	34.2	34.5	34.3	34.7
12	34.4	32.4	34.1	34.3	34.7	34.6	34.4
13	35.5	33.8	34.5	35.1	35.3	35.4	35.5
14	35.6	32.4	34.7	35.3	35.4	35.5	35.6
15	35.4	32.9	34.6	35.2	35.2	35.4	35.4
16	35.5	32.9	34.4	35.2	35.4	35.5	35.5
17	35.1	32.5	33.9	34.5	34.7	34.9	35.1
18	35.2	32.3	34.1	34.5	34.9	35.3	35.2
19	35.5	32.0	34.6	35.1	35.5	35.4	35.5
20	35.1	31.6	34.2	34.5	34.9	35.1	35.1

SUBJECT	FOREHEAD (C) T 1	T 2	T 3	T 4	T 5	T 6
1	33.3	35.0	35.4	35.5	35.6	35.7
2	33.5	35.2	34.8	34.3	35.0	34.9
3	34.6	35.2	35.6	35.9	36.0	36.0
4	33.6	35.0	35.2	35.5	35.4	35.4
5	32.5	35.0	35.1	35.7	35.2	35.8
6	34.0	34.6	35.5	35.7	36.0	36.3
7	34.4	35.3	36.0	36.0	35.9	35.8
8	33.3	34.1	34.8	35.2	35.2	35.2
9	34.6	35.4	35.8	35.9	36.1	36.0
10	33.3	35.1	35.5	35.7	35.8	35.9
11	32.7	34.0	34.2	34.1	34.2	34.9
12	33.6	34.7	35.0	35.0	35.0	34.7
13	34.6	35.3	35.8	35.7	36.0	36.1
14	33.3	35.4	35.7	35.8	35.9	35.8
15	34.4	34.6	35.8	36.0	36.1	36.1
16	34.1	35.1	35.8	35.7	35.7	35.6
17	33.9	35.1	35.3	35.5	35.5	35.6
18	33.1	34.9	35.1	35.1	35.7	35.7
19	34.3	35.9	36.1	36.3	36.3	36.3
20	34.0	35.4	35.5	35.8	36.0	35.9

SUBJECT	CHEST (C) T 1	T 2	T 3	T 4	T 5	T 6
1	33.1	34.7	35.2	35.2	35.5	35.4
2	33.3	34.8	35.1	35.0	35.4	35.0
3	33.7	34.7	35.6	35.9	35.9	36.0
4	33.8	35.3	35.5	35.4	35.8	35.6
5	34.2	35.4	35.8	35.8	36.0	36.2
6	33.2	35.3	35.5	35.8	35.9	36.3
7	34.7	36.0	36.4	36.5	36.5	36.6
8	33.1	34.6	35.1	35.5	35.7	35.8
9	34.4	35.9	36.1	36.2	36.4	36.5
10	34.4	35.2	35.6	36.0	36.1	36.1
11	32.5	34.3	34.7	35.3	34.7	35.2
12	33.2	34.8	35.0	35.6	35.1	35.1
13	34.9	35.2	35.7	35.8	35.7	35.5
14	34.2	35.4	35.6	35.6	35.8	36.0
15	34.3	35.3	35.8	35.9	36.2	36.1
16	33.8	35.1	35.9	36.0	36.0	36.1
17	33.7	34.5	35.0	35.0	35.4	35.6
18	32.8	34.3	34.5	35.0	35.7	35.5
19	34.3	36.1	36.1	36.5	36.6	36.5
20	34.0	35.3	35.5	35.8	35.9	36.1

SUBJECT	UPPER ARM (C) T 1	T 2	T 3	T 4	T 5	T 6
1	31.3	33.7	34.8	35.0	35.2	35.1
2	31.2	33.1	33.8	34.2	34.7	34.7
3	30.8	32.6	33.9	34.5	34.6	34.9
4	31.7	33.8	34.5	35.5	35.4	35.7
5	31.8	33.8	34.7	35.2	35.4	35.6
6	31.9	33.3	33.9	34.4	34.4	35.2
7	32.5	34.0	34.8	35.5	35.5	35.3
8	30.9	33.0	33.9	34.4	34.9	35.2
9	32.1	33.8	34.5	35.0	35.4	35.9
10	32.2	33.8	34.5	35.2	35.3	35.5
11	31.8	33.3	34.2	34.4	34.6	34.6
12	32.5	34.4	34.5	34.9	34.9	35.2
13	33.6	33.9	34.6	35.2	35.5	35.6
14	32.4	34.5	35.0	35.3	35.6	35.5
15	31.7	34.0	35.0	34.9	35.0	35.4
16	30.8	32.8	35.2	35.7	35.7	35.6
17	31.6	33.4	34.1	34.6	34.8	35.0
18	31.5	33.6	34.9	35.3	35.3	35.2
19	31.6	34.0	34.8	35.2	35.2	35.3
20	31.4	33.8	34.4	34.9	35.1	35.2

APPENDIX A, DATA AT 33 DEGREES CENTIGRADE

SUBJECT	CALF (C) T 1	T 2	T 3	T 4	T 5	T 6	BIG TOE (C) T 1	T 2	T 3	T 4	T 5	T 6
1	31.7	33.6	34.1	34.2	34.4	34.4	26.7	32.4	34.0	34.0	34.2	34.0
2	32.5	33.4	33.8	34.2	34.4	34.2	32.5	33.9	33.8	34.1	34.1	34.7
3	33.1	33.7	34.5	34.9	35.1	34.9	24.8	34.1	34.5	34.8	35.3	34.9
4	31.8	33.4	34.2	34.4	34.9	34.5	24.3	30.7	33.3	33.0	33.5	33.8
5	32.8	34.0	34.6	34.9	34.7	35.0	32.7	34.7	34.7	34.7	35.3	35.2
6	31.6	33.3	34.4	34.5	35.3	35.6	24.5	29.4	31.4	32.7	32.8	33.7
7	33.7	34.4	34.5	34.3	34.5	34.6	33.6	33.6	34.4	34.4	34.6	34.8
8	32.4	33.3	33.8	34.3	34.5	34.5	25.1	32.5	33.7	34.0	34.3	34.5
9	32.3	33.7	33.9	33.8	34.1	34.3	25.2	31.6	34.1	33.8	33.6	34.7
10	33.4	34.6	35.1	35.2	35.1	35.1	31.6	33.8	34.9	33.8	33.0	33.6
11	32.6	32.9	33.8	34.2	34.0	34.4	32.1	33.2	34.3	34.6	34.2	33.8
12	32.1	33.3	33.8	33.7	34.0	33.6	31.4	32.9	33.5	34.0	33.9	33.4
13	32.3	33.8	34.4	34.6	34.6	35.0	33.7	34.6	35.1	34.7	34.7	35.3
14	33.2	34.9	35.2	35.4	35.1	35.2	24.1	31.4	33.8	33.8	34.1	34.5
15	32.7	34.4	34.9	35.0	35.0	35.1	30.0	33.3	33.2	32.4	32.7	31.9
16	32.1	33.8	34.4	34.8	34.8	34.9	33.1	34.6	33.7	34.4	35.4	34.6
17	32.7	33.4	33.6	34.1	34.1	34.5	28.1	33.3	34.4	34.4	34.0	34.6
18	31.4	33.1	33.9	34.4	34.9	34.6	30.1	33.5	33.8	34.7	34.8	34.8
19	32.2	33.9	34.3	35.5	34.4	34.3	23.4	30.1	32.2	32.4	32.9	33.8
20	30.4	32.9	33.4	33.7	33.9	33.8	23.8	32.9	32.5	33.7	33.5	33.5

SUBJECT	FINGER (C) T 1	T 2	T 3	T 4	T 5	T 6	THIGH (C) T 1	T 2	T 3	T 4	T 5	T 6
1	31.0	33.8	34.4	34.0	34.2	34.2	31.9	34.3	35.1	34.9	35.5	35.1
2	32.1	34.1	34.5	34.7	34.4	34.9	32.1	33.6	33.6	34.1	34.2	34.2
3	32.9	34.4	34.8	35.0	35.5	35.5	31.3	33.3	34.1	34.5	34.6	34.8
4	28.8	34.0	34.6	34.6	34.7	35.0	31.2	33.5	34.6	35.2	35.5	35.0
5	33.4	34.7	35.1	35.1	35.2	35.5	32.8	33.9	34.6	35.1	35.1	35.6
6	32.4	31.5	32.4	33.5	33.4	34.5	31.2	33.4	34.6	35.0	35.6	35.8
7	33.1	34.1	35.3	35.1	35.3	35.0	32.4	33.9	34.2	34.7	34.6	34.6
8	32.4	33.8	34.5	34.8	35.0	35.1	31.9	33.2	34.2	34.8	34.8	34.8
9	31.8	33.9	34.8	34.5	34.6	35.4	32.1	33.5	34.1	34.1	34.4	34.8
10	32.5	34.7	35.3	34.8	34.7	35.3	31.8	33.9	34.6	35.1	35.4	35.2
11	33.1	34.3	34.5	34.7	34.7	34.8	32.1	33.0	33.4	33.5	33.5	34.3
12	31.9	33.8	34.0	33.8	34.5	34.5	31.3	33.2	33.2	34.2	34.2	33.1
13	34.0	34.7	34.8	35.2	35.3	35.8	32.5	33.9	34.6	35.2	35.3	35.7
14	29.5	34.6	35.1	35.3	35.2	35.2	31.8	34.5	35.5	35.8	35.4	35.5
15	31.9	34.1	34.5	33.7	34.3	34.7	32.1	34.3	35.0	35.3	35.4	35.7
16	33.2	34.6	34.6	35.2	35.3	35.2	32.5	34.3	35.1	34.9	35.0	35.0
17	33.0	33.7	34.7	34.9	34.3	34.9	32.0	33.5	34.4	34.3	34.9	34.6
18	32.6	34.3	34.7	34.9	34.9	35.1	33.0	34.5	34.5	34.8	34.9	34.9
19	27.9	33.6	34.7	34.7	34.5	35.2	31.4	34.3	34.9	35.0	35.0	34.6
20	30.8	34.1	33.9	34.5	34.8	34.4	30.4	33.5	34.0	34.4	34.7	34.5

APPENDIX A, DATA AT 36 DEGREES CENTIGRADE

SUBJECT	MEAN $\dot{V}O_2$ (ml/kg/min)	$\dot{V}O_2$ (ml/kg/min) (STPD) T 1	T 2	T 3	T 4	T 5	T 6	$\dot{V}E$ (ATPS) T 1	T 2	T 3	T 4	T 5	T 6
1	2.77	2.72	2.70	2.63	2.71	2.73	2.86	51.4	49.7	47.4	48.7	47.4	48.5
2	3.93	3.68	3.75	3.66	3.94	3.56	4.30	69.2	76.4	71.7	76.2	77.4	91.3
3	3.90	3.75	3.71	3.91	3.80	4.01	3.89	74.9	72.4	70.8	74.8	79.2	78.9
4	4.82	4.40	4.62	4.74	4.63	5.22	4.62	65.5	63.8	62.7	61.0	67.1	57.8
5	3.63	3.49	3.81	3.53	3.62	3.37	3.91	38.8	79.3	77.1	80.3	71.4	80.9
6	3.53	3.64	3.20	3.20	3.52	3.50	3.56	66.9	59.6	57.2	66.4	66.9	66.2
7	5.12	5.97	5.99	5.71	5.49	4.93	4.93	84.4	94.9	87.5	86.3	80.2	70.9
8	4.45	4.38	4.28	4.31	4.34	4.38	4.64	45.6	36.9	45.9	47.1	44.0	48.3
9	4.25	4.66	4.48	4.28	4.13	4.37	4.23	79.8	60.4	56.1	54.4	65.4	54.4
10	3.59	3.56	3.40	3.46	3.55	3.58	3.64	89.7	73.4	63.0	65.8	63.9	63.6
11	3.44	3.46	3.40	3.57	3.50	3.66	3.16	84.2	72.3	75.9	78.9	78.0	67.0
12	3.77	4.26	4.04	3.71	4.21	3.67	3.45	88.5	82.6	78.5	85.4	77.8	74.1
13	3.64	3.18	3.53	3.69	3.73	3.67	3.52	59.1	66.9	68.7	69.7	69.7	71.3
14	4.42	4.12	4.44	4.67	4.53	4.30	4.41	63.7	65.7	64.8	69.2	65.7	64.2
15	3.63	LOST	3.96	3.74	3.33	3.57	4.00	64.2	69.0	65.9	54.2	54.2	63.6
16	3.16	3.16	3.22	LOST	3.19	3.25	3.04	58.6	63.6	lost	58.9	61.3	56.6
17	3.31	3.28	3.04	3.25	3.38	3.22	3.33	50.4	47.5	51.8	54.5	53.1	56.7
18	3.52	3.40	3.43	3.64	3.43	3.70	3.41	57.9	58.8	61.4	63.7	62.0	60.5
19	4.03	4.20	4.13	4.08	4.04	4.07	3.97	54.2	52.5	53.1	52.7	52.8	53.0
20	3.71	3.54	4.08	3.81	3.62	3.97	3.53	63.7	64.6	63.9	52.3	62.9	59.4

SUBJECT	MEAN COMFORT	COMFORT INDEX T 1	T 2	T 3	T 4	T 5	T 6	BARO. PRESSURE	WEIGHT (KG)
1	2.0	1.0	1.0	2.0	2.0	2.0	2.0	719	69.11
2	2.0	1.5	1.5	1.5	2.0	2.0	2.0	718	81.24
3	3.0	2.0	2.0	2.5	3.0	3.0	3.0	716	73.07
4	2.0	1.0	1.0	2.0	2.0	2.0	2.0	714	53.89
5	3.3	1.5	2.0	2.0	3.0	3.5	3.5	723	86.51
6	1.7	1.0	1.0	1.0	1.0	2.0	2.0	716	62.94
7	3.0	1.0	1.0	2.0	2.5	3.0	3.5	716	60.61
8	2.5	1.0	2.0	2.0	2.5	2.5	2.5	716	55.63
9	3.0	2.0	2.0	2.0	2.5	3.0	3.5	717	46.80
10	1.0	1.0	1.0	1.0	1.0	1.0	1.0	725	76.49
11	2.0	1.5	2.0	2.0	2.0	2.0	2.0	718	82.36
12	2.0	2.0	2.0	2.0	2.0	2.0	2.0	719	89.13
13	1.5	1.0	1.0	1.0	1.5	1.5	1.5	720	80.50
14	2.0	1.0	2.0	2.0	2.0	2.0	2.0	716	57.40
15	1.0	1.0	1.0	1.0	1.0	1.0	1.0	717	63.83
16	2.5	2.0	2.0	2.0	2.5	3.0	3.0	722	73.50
17	4.2	3.0	3.0	4.0	4.5	4.0	6.0	719	66.73
18	2.2	1.0	1.0	1.5	2.0	2.0	2.5	721	60.51
19	1.5	1.0	1.5	1.5	1.5	1.5	1.5	720	54.15
20	3.3	2.0	2.0	4.0	4.0	3.0	3.0	716	56.85

APPENDIX A, DATA AT 36 DEGREES CENTIGRADE

SUBJECT	FE O2 (ATPS) T 1	T 2	T 3	T 4	T 5	T 6	FE CO2 (ATPS) T 1	T 2	T 3	T 4	T 5	T 6
1	16.75%	16.60%	16.50%	16.50%	16.35%	16.25%	3.50%	3.70%	3.80%	3.70%	3.80%	3.80%
2	15.90%	16.30%	16.15%	16.05%	16.60%	16.50%	4.35%	3.90%	3.90%	4.10%	3.60%	3.65%
3	16.80%	16.70%	16.40%	16.70%	16.70%	16.80%	3.30%	3.30%	3.40%	3.40%	3.40%	3.35%
4	16.80%	16.50%	16.30%	16.30%	16.15%	16.05%	3.50%	3.60%	3.70%	3.60%	3.85%	3.80%
5	16.50%	16.20%	16.45%	16.50%	16.30%	16.20%	3.70%	3.90%	3.60%	3.60%	3.70%	3.70%
6	17.05%	17.10%	16.90%	17.10%	17.15%	17.05%	3.10%	3.00%	3.30%	3.10%	3.05%	3.10%
7	15.95%	16.45%	16.30%	16.40%	16.60%	16.10%	4.40%	4.00%	4.05%	4.00%	3.60%	3.70%
8	14.90%	14.40%	15.00%	15.10%	14.80%	14.90%	4.40%	4.60%	4.40%	4.30%	4.35%	4.30%
9	17.70%	16.90%	16.80%	16.80%	16.40%	16.70%	3.10%	3.50%	3.50%	3.55%	3.80%	3.60%
10	17.45%	16.90%	16.15%	16.25%	16.10%	16.00%	3.10%	3.40%	3.90%	3.85%	3.80%	3.80%
11	17.00%	16.50%	16.45%	16.70%	16.45%	16.45%	3.30%	3.40%	3.60%	3.40%	3.60%	3.50%
12	16.00%	16.40%	16.10%	15.90%	16.10%	16.15%	4.10%	3.80%	3.90%	4.00%	3.90%	3.90%
13	16.00%	16.10%	16.00%	16.00%	16.10%	16.40%	4.00%	3.80%	3.85%	3.90%	3.70%	3.50%
14	16.70%	16.50%	16.20%	16.60%	16.60%	16.40%	3.35%	3.50%	3.70%	3.50%	3.50%	3.60%
15	lost	16.70%	16.75%	16.40%	16.10%	16.30%	lost	3.50%	3.40%	3.70%	3.80%	3.70%
16	16.50%	16.70%	lost	16.40%	16.50%	16.50%	3.40%	3.50%	lost	3.70%	3.60%	3.40%
17	16.00%	16.05%	16.15%	16.20%	16.30%	16.40%	3.90%	3.85%	3.75%	3.70%	3.60%	3.70%
18	16.90%	16.90%	16.85%	17.20%	16.80%	17.05%	3.35%	3.40%	3.35%	3.10%	3.40%	3.10%
19	16.20%	16.10%	16.20%	16.20%	16.15%	16.30%	3.60%	3.75%	3.70%	3.70%	3.80%	3.60%
20	17.25%	16.75%	17.00%	16.40%	16.75%	17.00%	3.30%	3.70%	3.35%	3.70%	3.60%	3.35%

SUBJECT	GAS TEMPERATURE (C) T 1	T 2	T 3	T 4	T 5	T 6	WATER VAPOR PRESSURE (mm/Hg) T 1	T 2	T 3	T 4	T 5	T 6
1	25.1	26.0	26.4	26.8	27.0	27.0	23.9	25.2	25.8	26.4	26.7	26.7
2	26.9	27.4	27.5	27.8	28.0	27.8	26.6	27.4	27.5	28.0	28.3	28.0
3	23.9	25.0	25.2	25.5	25.9	26.2	22.3	23.8	24.0	24.5	25.1	25.5
4	23.2	24.0	24.7	24.9	24.9	25.0	21.3	22.4	23.3	23.6	23.6	23.8
5	25.5	25.8	25.9	26.0	26.2	26.8	24.5	24.9	25.1	25.2	25.5	26.4
6	24.9	25.9	26.2	26.8	26.9	27.1	23.6	25.1	25.5	26.4	26.6	26.3
7	24.7	25.8	26.6	26.9	27.1	27.4	23.3	24.9	26.1	26.6	26.9	27.4
8	26.9	27.5	27.6	27.8	27.6	27.8	26.6	27.5	27.7	28.0	27.7	28.0
9	25.2	26.2	26.5	26.9	27.0	27.0	24.0	25.5	26.0	26.6	26.7	26.7
10	25.0	25.8	26.9	26.2	26.5	27.2	23.8	24.9	26.6	25.5	26.0	27.1
11	26.4	27.0	27.2	27.8	27.8	27.9	25.8	26.7	27.1	28.0	28.0	28.3
12	26.2	27.0	27.0	27.2	27.2	27.4	25.5	26.7	26.7	27.1	27.1	27.4
13	26.0	27.0	27.8	27.9	28.0	28.0	25.2	26.7	28.0	28.2	28.3	28.3
14	25.8	26.6	27.0	27.1	27.3	27.3	24.9	26.1	26.7	26.9	27.2	27.2
15	26.0	27.0	27.5	27.8	27.9	27.9	25.2	26.7	27.5	28.0	28.2	28.2
16	24.9	25.3	lo	26.0	26.1	26.2	23.6	24.1	lost	25.2	25.4	25.5
17	26.0	27.0	27.1	27.8	28.0	28.0	25.2	26.7	26.9	28.0	28.3	28.3
18	24.9	25.3	25.9	26.2	26.5	26.6	23.6	24.2	25.1	25.5	26.0	26.1
19	26.6	26.9	27.2	27.4	27.8	27.8	26.1	26.6	27.1	27.4	28.0	28.0
20	25.0	25.8	26.2	26.6	26.7	26.8	23.8	24.9	25.5	26.1	26.3	26.4

APPENDIX A, DATA AT 36 DEGREES CENTIGRADE

SUBJECT	FINAL RECTAL TEMPERATURE	RECTAL TEMPERATURE T 1	T 2	T 3	T 4	T 5	T 6	SYSTOLIC BLOOD PRESSURE T 1	T 2	T 3	T 4	T 5	T 6
1	37.0	37.2	37.0	36.8	36.8	36.9	37.0	110	107	107	107	111	109
2	37.0	37.2	37.0	36.9	36.9	36.9	37.0	140	120	117	124	126	121
3	37.3	37.2	36.9	37.1	37.2	37.2	37.3	111	105	103	105	104	107
4	37.1	37.1	36.3	36.4	36.8	37.1	37.1	107	103	107	109	121	105
5	37.2	37.3	37.2	37.1	37.2	37.2	37.2	117	117	102	111	103	97
6	37.4	37.3	37.2	37.1	37.1	37.3	37.4	108	102	106	108	105	102
7	37.3	37.4	37.2	37.2	37.3	37.3	37.3	110	102	104	128	103	100
8	37.8	37.7	37.4	37.4	37.7	37.7	37.8	117	124	116	117	128	126
9	37.5	37.3	37.1	37.1	37.2	37.4	37.5	98	93	100	104	104	107
10	37.3	37.3	37.2	37.1	37.2	37.2	37.3	109	108	102	103	100	113
11	37.2	37.6	37.4	37.3	37.2	37.2	37.2	131	140	126	146	133	125
12	37.3	37.7	37.4	37.3	37.3	37.3	37.3	118	114	117	117	117	115
13	37.2	37.2	36.9	36.9	36.9	37.0	37.2	111	115	117	128	123	127
14	36.8	36.8	36.7	36.7	36.8	36.8	36.8	113	107	109	112	111	115
15	37.4	37.2	37.1	37.1	37.1	37.3	37.4	106	111	114	99	112	98
16	37.2	37.2	36.9	36.9	37.0	37.1	37.2	95	101	89	95	95	100
17	37.2	37.2	37.0	36.9	36.8	37.1	37.2	131	127	125	116	116	118
18	37.6	37.6	37.5	37.5	37.5	37.5	37.6	104	114	102	111	104	106
19	37.3	37.3	37.2	37.3	37.3	37.3	37.3	120	112	100	93	101	115
20	37.2	37.4	36.9	36.8	37.0	37.0	37.2	97	99	99	98	103	100

SUBJECT	MEAN H.R.	HEART RATE T 1	T 2	T 3	T 4	T 5	T 6	DIASTOLIC BLOOD PRESSURE T 1	T 2	T 3	T 4	T 5	T 6
1	81	75	63	79	83	71	68	76	77	76	68	68	69
2	58	63	54	70	52	60	63	63	77	71	73	67	60
3	75	63	68	73	75	75	75	61	57	57	49	50	57
4	62	50	60	60	64	60	63	64	57	56	57	67	57
5	74	70	75	76	75	75	72	67	73	63	70	62	66
6	72	68	65	68	71	71	75	65	71	64	65	63	62
7	48	54	59	50	50	43	50	58	55	62	49	51	67
8	78	74	63	79	85	75	74	73	63	63	69	59	53
9	90	70	65	80	94	92	83	70	61	57	55	53	71
10	59	65	60	75	60	60	58	65	62	52	47	42	68
11	63	68	60	60	88	54	47	68	83	78	82	72	58
12	55	56	54	54	50	58	56	50	62	62	54	64	64
13	67	58	60	71	68	68	65	75	80	72	76	84	79
14	62	62	64	71	60	67	59	54	80	77	88	80	70
15	66	65	65	64	71	63	63	75	74	62	65	69	58
16	80	79	84	76	79	80	82	68	72	71	66	67	71
17	69	76	63	68	66	70	71	97	85	83	77	82	77
18	72	51	79	75	65	75	75	73	77	71	66	66	69
19	79	71	73	71	79	75	83	86	75	72	70	91	72
20	61	60	63	68	62	60	61	74	58	53	53	70	60

APPENDIX A, DATA AT 36 DEGREES CENTIGRADE

SUBJECT	FINAL MEAN SKIN TEMPERATURE	MEAN SKIN TEMPERATURE (C) T 1	T 2	T 3	T 4	T 5	T 6	FOREHEAD (C) T 1	T 2	T 3	T 4	T 5	T 6
1	36.2	31.8	34.2	35.4	35.8	35.9	36.2	33.5	35.1	35.8	35.5	36.2	36.4
2	35.3	32.8	34.4	34.8	35.1	35.3	35.3	33.9	34.3	33.8	33.9	34.5	34.5
3	36.1	32.9	35.3	36.0	36.1	36.2	36.1	33.8	35.6	36.2	36.1	36.2	36.4
4	35.9	31.1	33.9	35.0	35.7	36.0	35.9	32.9	34.8	35.4	36.1	36.3	36.2
5	35.7	32.4	34.7	35.5	35.6	35.8	35.7	32.7	34.6	35.2	34.8	35.0	34.7
6	36.1	32.6	34.4	35.5	35.9	35.9	36.1	33.8	35.1	35.9	36.2	36.0	36.2
7	36.1	33.5	35.1	35.6	35.8	35.9	36.1	33.3	35.1	35.4	35.4	35.6	36.0
8	36.2	32.9	35.8	36.4	36.4	36.5	36.2	33.8	36.0	36.7	36.4	36.8	36.4
9	36.5	32.6	35.0	36.0	36.5	36.4	36.5	34.1	35.9	36.2	36.6	36.8	37.1
10	36.1	33.1	34.8	35.5	36.0	36.1	36.1	33.7	35.5	35.6	36.2	36.4	36.4
11	34.9	32.9	33.9	34.2	34.9	34.7	34.9	33.0	33.7	33.4	34.2	34.2	34.6
12	35.7	32.2	35.2	35.1	35.5	35.5	35.7	30.7	35.5	35.0	35.2	35.2	36.0
13	36.4	33.2	35.6	36.5	36.4	36.3	36.4	34.6	36.0	36.6	36.7	36.6	36.4
14	35.5	33.4	34.8	35.3	35.5	35.7	35.5	34.5	35.2	35.7	35.9	36.1	36.1
15	35.2	32.9	34.2	34.0	34.8	35.1	35.2	33.9	34.6	35.1	35.0	35.5	35.3
16	35.6	31.9	34.9	35.5	35.6	35.5	35.6	33.0	35.9	36.1	36.0	36.0	35.9
17	35.5	31.5	34.2	35.1	35.2	35.5	35.5	33.6	34.7	35.7	35.1	35.7	35.5
18	35.3	32.4	34.3	35.2	35.2	35.4	35.3	34.0	35.0	35.6	35.3	35.4	35.5
19	35.4	32.7	34.5	35.1	35.3	35.4	35.4	34.0	35.1	35.5	35.6	35.8	35.7
20	35.7	33.0	34.7	35.2	35.5	35.5	35.7	34.1	35.4	35.9	36.1	36.1	36.2

SUBJECT	CHEST (C) T 1	T 2	T 3	T 4	T 5	T 6	UPPER ARM (C) T 1	T 2	T 3	T 4	T 5	T 6
1	33.4	34.7	35.7	35.9	36.1	36.3	31.3	33.5	35.0	36.6	35.8	36.0
2	32.8	34.8	35.1	35.2	35.7	35.5	32.3	34.4	35.0	35.5	35.9	35.8
3	34.1	35.7	36.3	36.2	36.4	36.5	31.3	34.5	35.7	36.1	36.4	36.3
4	33.7	34.8	35.5	36.1	36.4	36.3	30.7	34.2	35.1	36.0	36.3	36.4
5	34.3	35.3	35.8	35.8	35.8	35.7	32.9	35.0	35.9	36.1	36.3	36.1
6	34.1	35.0	35.9	36.2	36.2	36.2	31.9	33.7	34.5	34.9	35.4	36.0
7	34.4	36.1	36.3	36.4	36.6	36.7	32.6	34.6	35.9	36.3	36.5	36.6
8	34.9	36.4	36.7	36.5	37.0	36.6	31.5	35.3	36.2	36.4	36.9	36.7
9	35.0	35.9	36.6	36.8	36.9	36.9	31.6	34.5	35.9	36.6	36.9	37.0
10	34.3	35.3	35.8	36.2	36.4	36.5	32.5	34.5	34.9	35.6	36.0	36.1
11	33.5	34.5	34.6	35.4	35.1	35.4	31.8	34.1	35.0	35.5	35.6	35.7
12	33.8	35.9	35.7	36.1	35.8	36.2	32.5	35.5	36.1	36.4	36.4	36.3
13	34.3	35.9	36.7	36.7	36.8	36.8	31.9	35.1	36.2	36.7	36.6	36.6
14	34.1	35.0	35.2	35.4	35.7	35.3	32.9	34.3	35.2	35.6	35.7	35.7
15	34.4	34.9	33.3	35.4	35.7	35.7	31.8	33.2	34.5	34.8	34.8	35.2
16	32.4	35.1	35.8	35.7	35.7	35.7	30.4	34.2	35.1	35.6	35.6	35.9
17	33.4	34.7	35.3	35.5	35.7	35.7	30.8	34.0	35.2	35.5	35.7	35.7
18	33.0	34.6	35.5	35.2	35.6	35.4	30.6	33.6	35.2	35.3	35.5	35.5
19	33.9	35.2	35.7	35.9	36.0	35.9	33.8	34.8	35.5	35.4	35.5	35.5
20	34.2	35.1	35.9	36.2	36.0	36.3	31.5	33.8	35.1	35.8	35.9	36.1

APPENDIX A, DATA AT 36 DEGREES CENTIGRADE

SUBJECT	CALF (C) T 1	T 2	T 3	T 4	T 5	T 6	BIG TOE (C) T 1	T 2	T 3	T 4	T 5	T 6
1	31.9	34.1	35.4	35.6	35.9	36.2	26.6	33.3	35.4	35.7	35.7	35.9
2	32.6	34.1	34.7	35.0	35.1	35.2	33.1	34.9	35.3	35.6	35.7	35.9
3	32.3	35.2	35.7	35.7	35.7	35.5	31.9	35.1	36.0	36.4	36.4	36.3
4	30.7	33.4	34.5	35.5	35.0	35.1	23.8	31.3	34.1	34.7	35.0	35.5
5	32.7	33.6	34.6	35.2	35.5	35.5	24.5	34.9	35.8	36.0	36.0	36.0
6	31.6	33.7	35.3	36.0	36.0	36.0	29.8	33.5	35.4	36.0	35.9	36.1
7	32.7	33.9	34.1	35.3	34.4	34.9	33.6	34.7	35.6	35.9	35.9	36.2
8	32.9	35.5	36.1	35.9	35.5	35.2	26.7	34.5	35.6	36.7	36.2	36.3
9	31.9	34.6	35.8	36.2	35.8	36.1	25.4	32.0	33.5	35.6	35.3	34.3
10	33.5	34.4	35.1	35.6	35.6	35.7	30.5	33.9	35.2	35.3	35.6	35.6
11	32.7	33.2	33.6	34.5	34.1	34.0	33.8	34.2	35.0	35.3	35.4	35.3
12	31.6	33.7	34.0	34.6	34.8	34.5	30.7	35.1	35.5	35.9	35.8	35.8
13	32.2	35.2	36.1	35.9	35.6	35.5	29.9	35.4	36.3	36.0	35.9	36.4
14	33.4	34.8	35.4	35.6	35.7	35.5	33.1	34.7	35.5	35.8	35.9	35.6
15	31.6	33.9	34.0	34.2	34.4	34.4	31.8	33.8	34.4	34.5	34.9	34.9
16	30.5	34.1	35.0	35.1	35.1	35.4	31.5	35.3	35.6	35.9	35.7	36.1
17	31.4	33.8	34.9	34.8	35.0	35.0	25.0	33.2	34.6	34.8	34.9	35.2
18	32.9	34.4	34.9	35.0	35.3	35.1	33.7	35.1	35.6	35.8	36.0	35.9
19	32.3	33.6	34.0	34.6	34.7	34.9	26.0	33.6	34.9	35.2	35.2	35.5
20	31.6	34.4	34.1	34.3	34.6	35.1	33.2	34.9	35.1	35.6	35.5	35.8

SUBJECT	FINGER (C) T 1	T 2	T 3	T 4	T 5	T 6	THIGH (C) T 1	T 2	T 3	T 4	T 5	T 6
1	32.1	34.2	35.3	34.8	35.3	35.5	30.4	33.7	35.1	35.6	35.9	36.2
2	33.0	34.8	35.2	35.5	35.8	35.6	32.9	33.8	34.3	34.6	34.5	34.6
3	32.4	35.3	36.0	36.0	36.3	36.4	32.3	35.2	36.0	36.0	36.0	35.6
4	27.1	33.9	35.0	35.6	37.6	35.8	30.1	33.2	34.3	35.2	35.8	35.4
5	32.2	35.0	35.7	35.8	35.9	35.7	31.2	33.8	35.1	35.4	35.8	35.9
6	31.7	34.4	35.4	35.7	35.3	35.8	32.0	34.5	35.8	36.1	35.7	36.2
7	32.9	34.8	35.5	35.8	36.1	35.9	33.1	34.6	35.0	34.8	35.1	35.3
8	32.5	35.7	36.2	36.1	36.1	35.9	32.3	35.5	36.4	36.3	36.1	35.9
9	29.4	34.5	35.7	36.1	35.1	35.1	32.2	34.7	35.9	36.5	36.1	36.5
10	31.4	34.8	35.3	35.8	35.9	35.3	32.4	34.4	35.7	36.2	36.1	36.0
11	33.4	34.4	35.1	35.4	35.3	35.6	32.3	33.0	33.2	33.8	33.5	33.6
12	31.8	35.4	35.7	36.0	35.9	35.9	30.6	34.6	33.9	34.2	34.5	34.9
13	33.9	35.8	36.3	36.2	35.9	36.4	33.2	35.8	36.6	36.0	35.7	35.9
14	33.4	34.7	35.2	35.6	35.6	35.5	32.3	34.7	35.1	35.4	35.5	35.5
15	33.0	33.7	34.0	34.4	34.9	34.9	31.8	33.9	34.2	34.4	34.7	34.8
16	33.4	35.1	35.7	35.5	35.2	35.3	32.6	35.0	35.4	35.3	35.1	35.3
17	27.9	33.6	34.3	34.4	34.5	34.7	31.2	34.0	35.2	35.3	35.7	35.5
18	33.1	34.5	35.0	35.2	35.5	35.5	31.2	33.6	34.4	34.8	34.8	34.9
19	29.7	34.3	34.9	34.7	35.3	35.2	32.7	33.8	34.3	34.5	34.9	34.4
20	33.2	35.0	35.1	35.7	35.5	35.7	32.1	34.2	34.4	34.6	34.9	34.5

APPENDIX B

Calibration of Gas Analyzers

Calibrating the Anarad 411 CO2 Portable Analyzer

1. Allow the analyzer one hour to warm up.

2. Introduce pure nitrogen into the inlet port, which will be drawn in by the instrument pump.

3. Zero the instrument.

4. Introduce a calibrated gas.

5. Correct reading to calibrated value with the SPAN control.

6. Repeat the zero procedure and calibration a second time.

Calibrating the Servomex 570A Protable O2 Analyzer

1. Allow the analyzer one hour to warm up.

2. Introduce pure nitrogen into the calibration port by means of external pressure to the sample bag containing nitrogen.

3. Zero the instrument.

4. Introduce the calibrated gas.

5. Correct reading to calibrated value with the SPAN control.

6. Repeat the zero procedure and calibration a second time.

7. Use room air as a second calibrating gas following the same procedure as the calibrated gas.

APPENDIX C

Comfort Scale

COMFORT SCALE

10. Extremely uncomfortable: I must quit.
9. Extremely uncomfortable: Question if I can go on.
8. Very uncomfortable
7. Uncomfortable - would like to quit.
6. Uncomfortable - but bearable.
5. Not very comfortable: But easily bearable.
4. A little discomfort - some stress.
3. A little discomfort - no stress.
2. Comfortable - no stress.
1. Extremely comfortable: Could sit here indefinitely.

APPENDIX D

Informed Consent

Informed Consent to Participate in a Research Study at the University of Nevada, Las Vegas.

The research project for which you have volunteered is to determine the comfort temperature zone in adults. Prior to starting the study a submaximal bicycle ergometer test will be given to determine your fitness level.

The submaximal bike test is not usually stressfull although it may cause light headedness and even fainting but this is not common and will disappear quickly on lying down. Other risks of injury while climbing onto or off the bicycle are possible but are rare. Sore muscles may occur.

The study requires that you sit in an environmental chamber for 2 hours at each of 7 temperatures. (15,20,25,27,30,33,36 degrees centegrade,59 to 97 degrees fahrenheit). These sessions will be several days apart. The following measurements will be taken every 20-25 minutes: skin temperature of the following sites, forehead, chest, upper arm, thigh, calf, big toe, finger. Core temperature, heart rate (through an EKG), blood pressure, and resting metabolism (consisting of collecting expired breath in a weather ballon), will also be taken. There is no exercise and the only stress should be temperatures at 15,20 & 36 degrees centegrade. You will relax in a reclining chair dressed in gym shorts and a T shirt, you may read, listen to music or relax.

In signing this form you indicate that you have read and understand the information, and any questions have been answered to your satisfaction, You realize you may withdraw from the study at any time.

----------------	------------------	----------
Print name	Signature	Date
----------------	------------------	----------
Witness Print Name	Witness Signature	Date

APPENDIX E

Skin Fold Data Sheet

UNIVERSITY OF NEVADA, LAS VEGAS

4505 Maryland Parkway Las Vegas, Nevada 89154

Department of Health, Physical Education and Recreation

Exercise Physiology Laboratory
(702) 739-3766

Exercise Physiology Laboratory
University of Nevada - Las Vegas

SKINFOLD MEASUREMENTS, PERCENT FAT, and TARGET WEIGHT

NAME_______________________________RECORDER________

Date__________Age_________Weight in pounds________

1. Pectoral (Chest) ________mm

2. Abdomen ________mm

3. Ilium (Hip, Suprailiac) ________mm

4. Mid-Axilla ________mm

5. Scapula (Back) ________mm

6. Tricep ________mm

7. Front Thigh ________mm

8. Gastrocnemius (Calf) ________mm

Percent Fat: sum of _____ = ______%

Percent Fat: sum of _____ = ______%

Target Weight @ ______ = _______lbs.

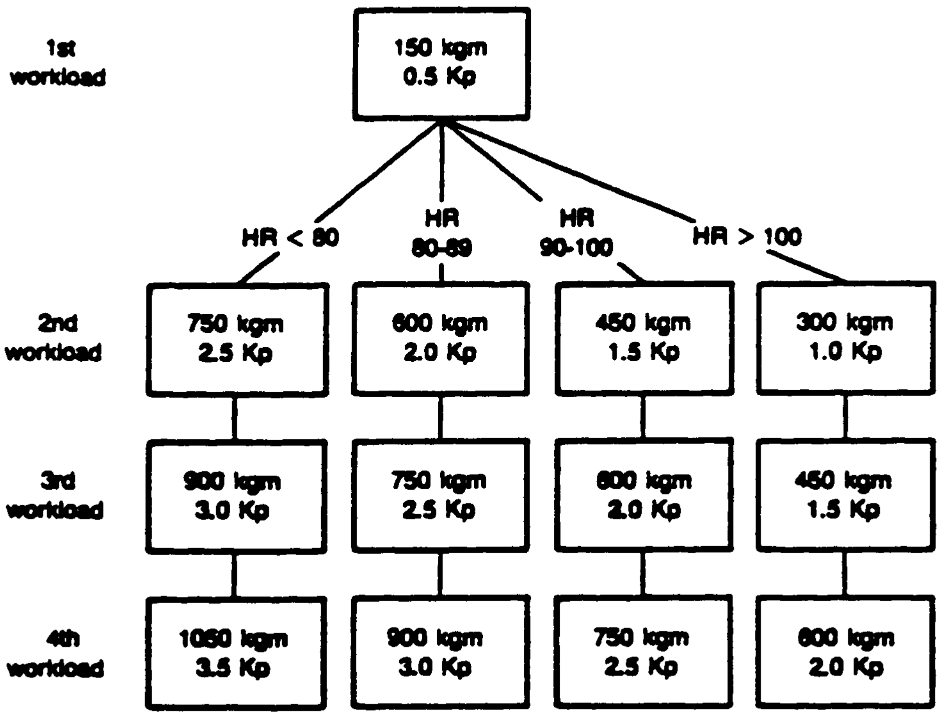
Standing Height ________cms. ________ inchs.

APPENDIX F

YMCA Guide to Setting Workloads

and

Physical Working Capacity Sheets



Directions:

1. Set the first workload at 150 kgm/min (0.5 Kp).
2. If the HR in the third min is
   - less than (<) 80, set the second load at 750 kgm (2.5 Kp);
   - 80 to 89, set the second load at 600 kgm (2.0 Kp);
   - 90 to 100, set the second load at 450 kgm (1.5 Kp);
   - greater than (>) 100, set the second load at 300 kgm (1.0 Kp).
3. Set the third and fourth (if required) loads according to the loads in the columns below the second loads.

Figure 4-18. Guide to setting workloads on bicycle ergometer.

Graph 4-6

Y's WAY TO PHYSICAL FITNESS — TEST BATTERY

MAXIMUM PHYSICAL WORKING CAPACITY PREDICTION.

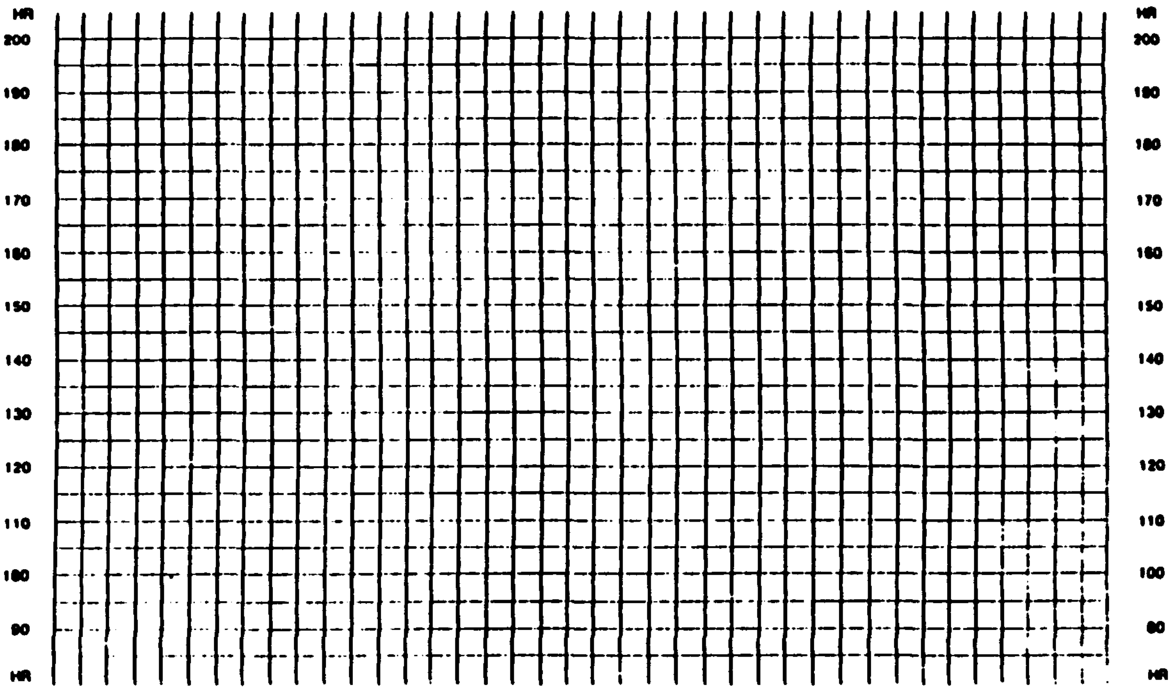
NAME ______________________ AGE ________ WEIGHT __________ LB. ________ KG SEAT HEIGHT __________

PREDICTED MAX. HR ________

	DATE	1st WORKLOAD HR USED	2nd WORKLOAD HR USED	MAX. WORKLOAD	MAX O_2 (L/min)	MAX O_2 (ml/kg)
TEST 1						
TEST 2						
TEST 3						

DIRECTIONS

1. Plot the HR of the 2 workloads versus the work (kgm/min)
2. Determine the subject's max HR line by subtracting subject's age from 220 and draw a line across the graph at this value
3. Draw a line through both points and extend to the max HR line for age
4. Drop a line from this point to the baseline and read the predicted max workload and O_2 uptake



WORKLOAD (kgm/min)	150	300	450	600	750	900	1050	1200	1350	1500	1650	1800	1950	2100
MAX O_2 UPTAKE (L/m)	06	09	12	15	18	21	24	28	32	35	38	42	46	50
KCAL USED (Kcal/m)	30	45	60	75	90	105	120	140	160	175	190	210	230	250
APPROX MET LEVEL (for 132 lbs)	33	47	60	73	87	100	113	127	140	153	167	180	193	207
APPROX MET LEVEL (for 176 lbs)	30	40	50	60	70	80	90	100	110	120	130	140	150	160

PHYSICAL WORKING CAPACITY TEST

(BICYCLE TEST)

NAME_______________________________ DATE.___________________

SEAT HEIGHT:______________ BICYCLE NO.____________

WORKLOAD (KGM)	HEART RATE	
150 KGM	________	2ND MIN.
	________	3RD MIN.
	________	4TH MIN. (IF NEEDED)
________KGM.	________	2ND MIN.
	________	3RD MIN.
	________	4TH MIN. (IF NEEDED)
________KGM.	________	2ND MIN.
	________	3RD MIN.
	________	4TH MIN. (IF NEEDED)
________KGM.	________	2ND MIN.
(IF NEEDED)	________	3RD MIN.
	________	4TH MIN. (IF NEEDED)

APPENDIX G

Pretest Questionnaire

Pretest Questionnaire

Date____________

Name_________________________

1. How long has it been since you ate last?

2. Has it been more than three hours since you exercised?

3. Has it been more than three hours since you have had any alcohol, drugs, or coffee?

4. How many hours did you sleep last night?

5. Do you have any major problems or pressures?

6. How long has it been since your last test?

7. Females, how long until your next period?

APPENDIX H

Data Collection Sheets

THERMONEUTRAL DATA

Test Number__________________ Room Temperature__________________

Name________________________ Age__________ Date______________

Robe Weight________________Kg WT. at start__________Kg PB________

___________RH Outside Temp_______ Wet Bulb_______ Dry Bulb_______

___________RH Inside Temp_______ Wet Bulb_______ Dry Bulb_______

___________RH Enviro.Temp_______ Wet Bulb_______ Dry Bulb_______

Col. Period Col. Time	Resting 10 min	One 10 min	Two 35 min	Three 60 min	Four 85 min	Five 110 min
Heart Rate						
Temp Rec						
SKIN TEMP.						
Forehead						
Chest						
Upper Arm						
Finger						
Thigh						
Calf						
Big Toe						
Blood Pres.						
Comfort						

Weight at Finish____________________Kg

Onset of Shivering Time_____________

Sweat Volume in Glove_______________Ml

Sweat Test Tube #__________________

GAS COLLECTION & ANALYSIS

NAME______________________________ DATE____________________

Period Time	Resting 10 min	One 15-25	Two 40-50	Three 65-75	Four 90-100	Five 110-120
Bag #						
Time						
Volume						
Temp						
Sample #						
% 02						
% C02						

Comments:

Questionnaire:

1. How long has it been since you ate last?
2. Has it been more than three hours since you exercised?
3. Has it been more than three hours since you have had any alohol, drugs, or coffee?
4. How many hours did you sleep last night?
5. Do you have any major problems or pressures?
6. How long has it been since your last test?
7. Females, how long until your next period?

APPENDIX I

Mean Skin Temperature

Determination of Mean Skin Temperature

A Bailey Instruments (Model BAT-12) digital thermocouple and a special skin probe were used to measure skin temperature at seven different sites. The temperature for each site was multiplied by a weighted value which had been used by Hardy and DuBois in 1938. These values were added together to arrive at a Mean Skin Temperature.

Sites and Weighted Value percentages:

1. Forehead = 0.07
2. Chest = 0.35
3. Arm = 0.14
4. Finger = 0.05
5. Thigh = 0.19
6. Calf = 0.13
7. Toe = 0.07

APPENDIX J

Rectal Probe Instructions

Rectal Probe Instructions

Data obtained by the use of the rectal probe is necessary in this study. The rectal probe has been thoroughly sterilized.

To use the rectal probe:

1. Take a cotton ball and apply mineral oil to the end of the probe up to the mark (depth of insertion).
2. The probe is inserted into the rectum up to the insertion mark (10 cms.)
3. Sterilized gauze tied at the insertion mark and attached to a belt made from sterilized gauze will hold the probe in place.
4. The probe may feel uncomfortable initially. This discomfort should not last long.
5. When testing is complete, remove the probe slowly and place it in the disinfection solution located in the changing room.

Any problems or questions should be directed to the laboratory personnel.

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