

EXTERNAL HEAT COOLANTS
IN VARSITY FOOTBALL PLAYERS

by

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Chapter 1

INTRODUCTION

Heat stress is often a problem for athletes. Seasonal temperature in many parts of the United States including Kansas may exceed the 38°C (100°F) mark, making sports such as football extremely difficult for players in full uniform. Illness from heat exposure has taken its toll on a number of individuals with results varying from sickness to a more severe state, even death. This study was undertaken to examine problems with heat exposure encountered by football players.

The abilities of the human body to maintain its normal core temperature changes, which must occur for human life to function at a proper level, range from vasoconstriction when cold to vasodilation when hot. If the body is not able to remove the heat fast enough, the core temperature will rise. If it gets as high as 40°C (104°F), the chances of life are slim (3). Four methods by which heat may be lost from the body are: 1) convection, 2) conduction, 3) radiation, and 4) evaporation (2). Factors which may influence the maintenance or removal of heat from the body include clothing, humidity, and air passing over the body. Evaporation may remove as much as 50 percent of the total amount of heat from a resting body through the skin surface and respiration (2). Heat loss is proportional to the air speed over

an exposed skin area. High humidity will lessen heat loss from the body through reduced evaporation. The amount of heat loss is important in maintaining body temperature at a level where normal body functions may be carried out. Evaporation is the means by which some of the greatest heat loss may be obtained. Immersing parts of the body into a cool water bath or constant covering of the body parts with ice towels may result in faster cooling and possibly more work potential. Techniques have been developed to help control the core temperature of men working in hot environments such as mines, steel mills, etc. Several different types of coolants can be applied to the body to help heat dissipation. A few ways in which heat can be extracted are: 1) body suits, which conduct water or air through tubes, 2) dry ice jackets, or 3) water cooled helmets which can remove heat from the head.

The elimination of heat from the body is increased by blood flow to the surface of the skin. Exposure to heat during work bouts for a period of 7 to 14 days causes this blood flow to the skin to increase, acclimatizing the person to heat. Acclimatization by an athlete is important by allowing sweat production to occur at a lower skin temperature level and more sweat to be produced per gland (11).

Problems exist with football players exposed to high levels of heat during the early part of the season in some areas of the United States. A high core temperature usually creates the major problem to the athlete because it reduces

his performance ability. In order to maintain a stable core temperature, heat has to be extracted from the body. For effective body temperature regulation, heat loss must equal heat production.

Since football players have only a limited amount of time and are required to be mobile, one practical method to assist in heat dissipation could possibly be accomplished by placing ice towels around the athlete's head, neck, and waist. This method is practical due to the time factor involved and the amount of clothing worn. The heavy padding on the shoulders, head, and hip areas helps to lessen the amount of heat lost from the body during exercise.

The players are required to be available for competition at a moment's notice so the length of time that ice towels can be applied to the athlete may be short. With the short time duration, the industrial type coolants cannot be applied to a football situation. The player's pads cannot be removed thus eliminating the jump suit (circulating cool water through tubes) as a beneficial source of removing heat. The dry ice jacket creates a similar problem due to the necessary removal of clothing and pads to allow the jacket to control the temperature of the body surface. The mobility of the football player limits the extent of industrial type coolants that could be used for removing heat. The industrial situation differs due to the type of job that is done in the hot environment. The industrial worker is in an area for an

extended period of time so that a type of coolant may be applied over a greater length of time. The industrial situation is a more controlled environment in which the body temperature can be lowered from the higher ranges during work. The football player has no such environment which may be altered as in the case of the industrial worker.

Statement of the Problem

The purpose of this study is to determine the body's ability to maintain the core temperature, heart rate (HR), and oxygen uptake ($\dot{V}O_2$) during heat stress situations. More specifically this study is to determine if any significant difference in body temperature can be affected by ice towels while in a heat stress situation of 40°C (104°F) with 40 percent relative humidity. Heat can be extracted from a person wearing a full football uniform by means of ice towels around the head, neck and waist areas.

Limitations

Certain factors which might have an effect on the results of this study should be noted:

- 1) subjects were limited to a small group.
- 2) the total time duration of 75 minutes was relatively short.
- 3) the work bouts produced on the football field were anaerobic in nature as compared to riding a bicycle ergometer at a constant work load

for 5 minutes which may have an aerobic effect on the individual.

Delimitation

The delimiting factor was that the selection of football players was from the 1975 Kansas State Varsity squad.

Definition of Terms

Acclimatization--Continuous repeated exposure to heat during physical activity to bring about a tolerance or an adjustment to the temperature level.

Core Rectal-Temperature--The point or center of the body in which the body temperature stabilizes at a constant resting level (7 cm past anal spincter).

Electrocardiogram-ECG--Graphic tracing of the electrical activity of the heart muscle. Reflection from a trial and ventricular activity are shown on graphs which can be used to determine heart rate.

Heart Rate--Number of ventricular beats per minute.

Heat Stress--Environments ranging from 26°-27°C (78.8°-79.8°F) and higher, the normal threshold for sweating starts at 30°-31°C (86°-87°F), the extreme temperature zone begins at this level.

Ice Shock--An external method of cooling which tends to decrease the venous return with increased resistance to blood flow.

Metabolic Heat--Heat produced by the basal metabolic rate of the body which can combine with heat produced by muscle contraction during activity.

Oxygen Uptake ($\dot{V}O_2$)--is the volume of oxygen extracted from the inspired air, usually expressed in liters per minute.

Respiratory Quotient (RQ)--RQ is the ratio of carbon dioxide volume produced, divided by the oxygen volume utilized, expressed in parts which can be used to demonstrate the amount of fat and carbohydrate metabolism.

Standard Temperature Pressure, Dry (STPD)--The inspired air volume corrected from ambient air and expressed in liters per minute is the STPD value which is used to express the volume of oxygen extracted at 0°C (32°F), 760 mmHg with no water vapor present.

Sweat Rate Loss--The amount of body fluids lost--in grams--during the testing session. Expressed in grams per square meter of surface area per hour.

Chapter 2

REVIEW OF LITERATURE

This chapter reviews research related to heat stress situations. These studies are presented to show various methods in which heat exposure is kept at a lower level in all levels of physical work including industrial, aerospace, and athletic activities. Physiological parameters, which are recorded during the testing, deal primarily with core and skin temperatures, heart rate, sweat rate loss, and oxygen uptake. Two main areas discussed in the review of studies are: 1) general work and aerospace heat stress situations and 2) competition--football players competing in heat stress situations.

Industrial and Aerospace Heat Stress Situations

Various methods of cooling the body may increase the working capacity of the individual when dealing with industrial heat. The body temperature, which may increase during work in this hot environment, may rise as high as 40°C (104°F) or higher. Heat exposed illnesses may cause individual damage to the circulatory system or brain, with even the possibility of death.

Shavartz (23) showed one method of conduction cooling by placing dry ice in pockets of garments. When water ice changes from solid to liquid, it gains 80 kcal/kg of ice

melted. When dry ice changes it gains 137 kcal/kg of gas going from -79°C to 35°C (-110°F to 95°F). Since dry ice gains more energy, it can be used more efficiently than water ice.

Konz and others (12) dealt with an external coolant from a jacket filled with dry ice for industrial workers. One subject was used during the experiment to determine how much heat is extracted from the person's body while in a heat chamber. Readings were taken every 10 minutes from an ECG, rectal probe for core temperature, and blood pressure. They concluded the ice would be more effective if it could be shaped to fit the human body. Petit et al. (19) first reported in the Belgian Mining Journal in 1966, the use of dry ice cooling. The garment was made out of leather and had four pockets in front and four pockets in the back. The pocket sizes were 10 X 10 X 3 cm. The pockets open at the top with approximately 50 holes on the inside surface, 3 mm in diameter, which permitted the carbon dioxide to flow close to the skin. Spherical dry ice, measuring 10 cm in diameter and 3 mm thick, was inserted into each pocket. Eight male subjects walked a treadmill for 20 minutes at six kilometer per hour at a 10 percent grade with and without the dry ice garment, in an environment of 46°C (114.8°F) dry bulb temperature and 50 percent relative humidity. The heart rate was 16 beats slower with the garment on, the oral temperature was 0.5°C (32.9°F) lower, and the skin temperature was 1.8°C

(35.24°F) lower. With a melting rate for the dry ice at 8.8 gm/min. No significant difference was found between the conditions of cooling vs. no cooling for measurement of oxygen consumed, rectal temperature, and sweat loss.

Webb and Annis (26) compared heat coolant systems of a space suit to allow comfort for the astronauts at the same time not over or under cooling them. A treadmill test was administered to the subjects with different speeds and grades to fit the subjects weight in order to achieve the desired metabolic rate. Subjects were weighed before and after the experiment to check oxygen intake, skin and core temperature, heart rate, and water loss. Water-cooled clothes were shown to reduce body heat, as well as slow sweat rate, cool skin temperature and remove metabolic heat.

Shavartz et al. (1974) circulated water through plastic tubes to ten different body regions, (neck, face, upper arm, hands, chest, back, thighs, lower leg and feet.) Three subjects were used in the experiment performing moderate work at 21.3°C (70.34°F) and in heat (49.3°C dry bulb, 31.4°C wet bulb), without any cooling other than that done to the above body regions. The face had the lowest temperature reduction (19 percent), while cooling of the back, chest, or thighs had the highest reductions (66 percent) in total body heat.

Rota and Todaro (21) compared two types of environment on the test subjects. Two series of tests were given

in subsequent days with one hour of acclimatization given before the 20 minutes of testing began. The first series of thermal tests were in a neutral environment with the wall and the air temperature at 25°C (77°F), while the relative humidity was 40 percent and the wind speed 0.8045 kilometers per second (km/s) (0.5 miles per second). The athletes ran on the treadmill for a 20 minute period. The second series of tests were conducted on subjects with the walls and air temperature at 40°C (104°F) with 40 percent relative humidity and a wind speed of 2.4135 km/sec. (1.5 m/s). During the work periods, the following tests were recorded: 1) tympanic temperature; 2) skin temperature (chest, thigh, leg, and lower arm); 3) oxygen intake and carbon dioxide production; 4) heart rate; and 5) body weight before and after the test (nude). The heat loss and skin temperature were closely related between the two groups, both in a neutral environment during the first and tenth minute of work. The difference of temperatures was not significant. Ribisl and Zuti (20) established length of time for heat stress as mentioned earlier.

Athletic Activity-Football players competing in heat stress situation

Murphy (15) states an athlete is effected by dehydration when sweating, coupled with the lack of minerals and salt, and susceptible to cramps, heat exhaustion and heat stroke. In American football during the last 10 years alone,

46 deaths have been recorded due to heat stroke or heat exhaustion. Death from heat exposed illness ranks second only to that of head injuries. Minimal standards should be followed when athletes work in heat environment: 1) provide unlimited fluids during athletic activity; 2) salt tablets should be accompanied by large amounts of water; 3) when conditions warrant, measure heat and humidity so that practice can be altered. Quick replacement of lost body fluids and minerals is essential in hot weather work-outs.

Knochel (11) defines three major manifestations in a medical emergency as heat stroke; profound dysfunction of the central nervous system; a hot, dry skin; and a rectal temperature exceeding 40.6°C (105°F). Gradual heat acclimatization may lessen the chance of heat stress. A man can perform work in a hot climate without discomfort in hot weather. Persons who exercise in plastic suits are more susceptible to fatal heat stroke even with temperatures as low as 26.6°C (80°F). In response to an elevated body temperature hyperventilation occurs with heat stroke. A shift in potassium into cells occurs due to acute respiratory alkalosis. This does not happen in the majority of heat stroke cases. Men training in hot climates may develop a deficiency in body potassium, due to losses in sweat. Three implications of potassium deficiency concerning athletes in training are: 1) can cause postural hypotension; 2) may impair glycogen synthesis in skeletal muscles; and 3) injury may occur to the skeletal muscles.

Fox states (7) from August, 1959 to October, 1962, seven heat stroke deaths were reported in high school players and five in college players. All players wore full football equipment. Five of the players who died were not able to have water during practice but were required to take salt tablets. This study was to quantitate the effects of working in a football uniform with the temperature ranges from 23.33° - 25° C (74° - 77° F) with 31 to 55 percent relative humidity. Subjects ran on a motor driven treadmill at 9.654 kilometer per hour (6 mph) in both the football uniform and scrub suit for a 20 minute period. The final result, marked hyperthermia, while wearing the football uniform over that of the scrub suit, was a result of two factors: 1) the loss of over 50 percent of the evaporation surface area as a result of the additional clothing; and 2) the added weight of the uniform 6.44 kilograms (14.17 pounds) which increased the effective work load.

A serious hazard during strenuous exercise is heat stroke. The committee on Nutritional Misinformation (4) reported that heat stroke was followed by a sudden collapse and loss of consciousness precipitated by physical exertion and inadequate fluid intake. The major factors causing heat strokes are high temperature, high humidity, poor body ventilation, and several hours of water deprivation preceding intense physical activity. Good sound nutrition habits should be included during the practice periods to insure optimal

health for the individuals. Individuals weighing 70 kilograms (154 pounds) lose about 1.419 liters (3 pints) of water each day by expired air, urine, sweat, and stools. With the loss of excessive fluids, sodium is also lost. The dehydration syndrome is characterized by loss of appetite and limited capacity for work. Dehydration causes increase in heart rate and body temperature even with moderate work. With three percent loss in body water, physiological changes impair performance. With five percent loss in body water, heat exhaustion becomes apparent and at seven percent loss of water, hallucinations occur, which is a dangerous sign. A ten percent loss is extremely hazardous and will lead to heat stroke. Without immediate treatment, death will occur. Athletes who try to lose weight by crash caloric restriction, or by drying out for early weigh in, then retain their usual weight for the contest, can cause permanent impairment of health and even death.

Virgin (25) describes the treatment for heat stroke which occurs to athletes who play forceful games during the summer months, is a predetermined treatment. The first part of treatment is a review of the athletes history followed by a physical examination, blood count, and a urine examination. Large doses of fluids and salt is given if there is no evidence of high blood pressure, kidney problem, or blood problems. Salt tablets should be taken depending upon the amount of weight loss after practice. Sodium and potassium

are chemicals which are important in adequate amounts. Fifty athletes were tested over several months with a large number of solutions. It was discovered that salted apple juice with potassium, glucose, sodium, and other constituents were used to replace the loss of body fluids. To prevent heat prostration during game time, four important steps need to be followed, 1) prevent muscle cramping by maintaining the level of sodium in the body fluids, 2) when the temperature is excessive, cool the patient when he comes off the field, 3) to relieve the patient of the physical effects of deep, rapid breathing and rapid heart action, give him oxygen, and 4) replace the body fluids. The four treatments are administered when the athlete arrives at the bench with twenty liters of oxygen immediately given. Then a towel dipped in crushed ice is wrapped around his head and feet. One cup of liquid containing the chemical stated above is given if there is tendency towards cramping.

Olson (18) states the individual should know the importance of treatment to reduce the increased body temperature to decrease heat stress. The inability to keep the body temperature within normal limits involves a situation where the sweating mechanism fails and the elimination of body heat is inadequate. The main issue is to reduce the elevated body temperature as rapidly as possible. An effective means of treatment for heat stroke is the emersion of the persons body in cold water 48.33° - 52.22°C (55 - 70°F). During treatment,

monitor the body temperature, vigorously massage the body segments to combat any vasoconstriction brought on by the cryotherapy to help in heat loss and to stimulate movement of cooled peripheral blood to deeper structures. Severe damage may occur to individuals who are not treated. Damage to the individual ranges from death, vascular permeability resulting in internal hemorrhaging, damage to cellular structure of sweat glands, central nervous system damage, liver cell death, destruction of cardiac muscle, renal tubular damage, and metabolic acidosis resulting from liver dysfunction. Prevention may be the best solution to the problem of heat stroke. One of the most important factors is to remove the need for sweating by sleeping or resting in a cool environment periodically.

Heat injury may be viewed, Goldman (8) adds, as the result of an imbalance between the heat production associated with man's activity and the heat loss allowed in a given environment by the protective clothing and equipment he wears. He requires protection against heavy contact blows in the head, shoulders, kidneys, and groin areas requiring him to wear some form of body armor made from sturdy material. The heat transfer characteristics of a typical football uniform were measured using a heated copper manikin. The moisture permeability index can be determined by the ratio of evaporative cooling allowed by the uniform to that which would occur for an unrestricted wet surface. The football

uniform evaluated consisted of a heavy undershirt, athletic supporter and woolen socks, plastic protective kidney, hip and shoulder pads, a standard football jersey and trousers, cleated shoes, and a plastic helmet. The cooper man simulated a 100 kilogram (220 pound) football player, 1.83 meter (6 foot) tall, with 2.22 square meters of body surface. If 35°C (95°F) is the skin temperature, then 23.89°C (75°F) ambient air temperature, he can only eliminate 30 kcal of heat by radiation and convection. An additional 480 kcal of heat must be lost by evaporation to avoid a rise in core temperature. To obtain this necessary 480 kcal of cooling in a uniform, 800 cc of sweat must be produced for cooling and perhaps twice that amount if the evaporation for cooling takes place on the surface of the uniform rather than at the skin surface. At best, about 180 kcal of evaporative cooling can be obtained, thus the player may have to store in his body 300 kcal per hour of heat. Improving the level of training or competition involved is about all that can be done to improve football clothing a player wears in heat stress situations.

Greenleaf (9) points out that sweat is hypotonic compared to man's blood. To investigate the influence of various levels of serum electrolyte concentration and osmolarity on the control of body temperature during exercise, 8 men were subjected to 3 levels of hydration: 1) hypohydration, 2) adlibitum control; and 3) hyperhydration. The men exercised for 70 minutes in the upright position on a bicycle

ergometer at an average relative oxygen uptake of 49 percent of maximal oxygen uptake. Venous blood samples were taken before exercise, at 35 minutes into exercise, and at 70 minutes, just as completion. Samples were analyzed for sodium, potassium, chloride, osmolarity, pH, total protein, albumin and globulin concentrations. Rectal and mean skin temperatures were taken during rest, exercise, and recovery. The results suggest core temperature is not set by a volume mechanism, but is more directly related to the osmotic concentration. Calculations from sweat loss indicate that between 77-100 percent of the excessive rise in mean body temperature during exercise can be accounted for by reduction in sweating. The high correlation between osmolarity and core temperature is due to variation in sweat rate. Statistical evidence suggests the increased osmolarity acts mainly in two areas: 1) on the hypothalamus and other central temperature centers rather than at peripheral sites and 2) on the sweat glands themselves in the control of sweating during exercise.

Research is being done to help the athlete who has to compete in hot environments for lengthy periods of time. Murphy (15) has researched the effect of weight loss due to sweating on performance level in athletes. The maintenance of fluid volume to combat heat illness was studied by Londeree (13) and others to see if ingestion of fluids before, during, or after work has a significant effect.

Studies concerning the effects of different football uniforms were completed by Fox and others (7) to find the physiological responses to different types of uniforms in heat. Roundy and Cooney (22) studied the effectiveness of rest, abdominal cold packs, and cold showers in relieving fatigue after or between bouts of strenuous exercise. More research is still needed concerning football players in heat stress situation.

The heat stress situation still exists in which the football player has to compete. Deaths and illness have not been eliminated from the sport setting. Lives of athletes may depend on a few minutes of treatment.

Summary

The literature review may be summarized by stating that there is a serious problem concerning football players in a heat stress situation. Prevention is one of the better methods of treatment when dealing with a football player in a potentially dangerous environment. The athlete may continue to participate at a higher level when not affected by the heat stress situation. Since the sport is so popular with thousands of players involved during the hotter months of the year, "ice towels" are a practical method of cooling when dealing with football players in a heat stress situation. Due to the time, location, and the equipment which the football player has to deal with, other methods offer serious disadvantages when comparisons are made.

Chapter III

PROCEDURES

This study was designed to investigate the effects of cold applications on athletic performance in hot environmental temperature of 40°C (104°F) during simulated football conditions. Specifically the study addressed the effect of ice towels--placed on head, neck, and waist--and on the response of heart rate, oxygen consumption, sweat loss, skin and rectal temperatures, and respiratory quotient during a game type situation. This chapter deals with sections on selection of subjects, testing procedures, collection of data, treatment of data and the general procedures used in conducting the research.

Selection of Subjects

The adult males studied were randomly selected from the 1975 varsity football squad at Kansas State University, Manhattan, Kansas. Ten varsity adult male players served as subjects for the study which was conducted in the spring of 1976.

Testing Procedures

Testing was conducted in an environmental control chamber of the Institute for Environmental Research Laboratory located in Seaton Hall on the Kansas State University

campus. Testing periods were designed so the subjects did not have any strenuous physical activity 24 hours prior to testing. The subjects were tested on a bicycle ergometer while wearing complete football uniform. The subjects completed the testing procedures in 75 minutes remaining in the environmental chamber for the complete 75 minutes. The subject pedaled on the bicycle ergometer a few minutes prior to testing to become familiar with the procedures. To maintain a constant work load on all subjects, the bicycle ergometer was set at 750 kpm's while peddling at 50 rpm's.

The uniforms included a helmet made by the Ridell Company with shoulder pads manufactured by the Wilson Sporting Company. Vented jerseys and pants were supplied and manufactured by the Air Capital Sporting, Wichita, Kansas. The football equipment that was utilized weighed 7.18 kilograms (15.8 pounds) and had a Clo value of 1.7.

The environmental conditions were produced by a Sherer-Gillette environmental chamber with a temperature of 40°C (104°F) with 40 percent relative humidity. The humidity controller, manufactured by Yellow Spring Instrument Company, Yellow Spring, Ohio, Model 72, monitored the humidity within the chamber. The wet and dry bulbs were measured by a sling psychrometer manufactured by Cramer Products, Inc., Gardner, Kansas. Temperatures and heart rate were measured every five minutes.

Collection of Data

Each subject was tested in each of two different conditions: once after alternating work and once after alternating work under the same conditions except applying ice towels during rest periods. The order of testing subjects was randomly determined so that five subjects received no treatment and five subjects received treatment. Testing periods consisted of two thirty minute intervals with a fifteen minute rest period in between. The thirty minute intervals were each broken into three work bouts of five minute durations and three rest periods of the same length. Testing started after resting data was recorded. A five minute work period was followed by a five minute resting period. The alternating work--rest periods continued throughout the experiment except for the fifteen minute half time in between the two thirty minute intervals. The experimental condition was the same as the control condition, except during rest, where the helmet was removed and replaced by ice towels on the head, neck, and waist regions. The towels were changed every two minutes until the end of the rest periods in both experimental and control groups with the exact amount of water measured. The accurate amount of water measured is one of the criteria used to calculate the sweat rate loss.

TESTING SEQUENCE

Heart Rate (HR), (ECG) taken 5th minute, skin and rectal temperature taken and recorded every 5th minute along with oxygen uptake ($\dot{V}O_2$).

After resting HR and $\dot{V}O_2$ are taken.

Start work period--750 kpm's.

Time	Work or Rest	Data Taken Every 5th Minute
0- 5	work	HR; skin and rectal; $\dot{V}O_2$
5-10	rest	HR; skin and rectal; $\dot{V}O_2$
10-15	work	HR; skin and rectal; $\dot{V}O_2$
15-20	rest	HR; skin and rectal; $\dot{V}O_2$
20-25	work	HR; skin and rectal; $\dot{V}O_2$
25-30	rest	HR; skin and rectal; $\dot{V}O_2$
15 minute rest		Half time
45-50	work	HR; skin and rectal; $\dot{V}O_2$
50-55	rest	HR; skin and rectal; $\dot{V}O_2$
55-60	work	HR; skin and rectal; $\dot{V}O_2$
60-65	rest	HR; skin and rectal; $\dot{V}O_2$
65-70	work	HR; skin and rectal; $\dot{V}O_2$
70-75	rest	HR; skin and rectal; $\dot{V}O_2$

Figure 1: Testing order: each period was five minutes except half time which was fifteen minutes. Total exposure to heat--75 minutes.

Each subject emptied bowels and bladder and was weighed nude on a Balance beam Gram Scale before and after testing to determine one of the criteria used for calculating sweat rate loss. Samples of the subject's heart

rate and expired air were taken every five minutes with the first sample taken before testing began. A Gra Lab Universal electric timer was utilized to determine when samples were taken. The intervals were marked for easier identification of the time. Samples were taken in order as shown in Table 1.

Table 1

Sample Sequence Times

Minutes Resting Sample		
4- 5		49-50
9-10	30-45	54-55
14-15	Half time	59-60
19-20	-no samples-	64-65
24-25		69-70
29-30		74-75

In order to measure heart rate, a bioplar lead was used to record the electrocardiogram (ECG). Thirty R spikes from the ECG ventricular contractions were timed. The subject was prepared for testing by placing the negative electrode at the top of the sternum with the ground and positive electrode being placed at the bottom of the sternum. All hair was removed from the skin surface, cleaned with alcohol to remove excess dirt and oil and to remove the horny layer of tissue prior to placing the electrodes on the skin so a good contact could be made. To insure better contact, disc adhesive with an adhesive back was placed on the electrodes. New skin, manufactured by the Natcom

Company, was used as a liquid adhesive. It was painted onto the skin surface. New skin was allowed to become tacky before the electrodes were attached. "Dermical," a tape produced by Johnson and Johnson Company, was placed over the electrodes to help hold them firmly into place.

Skin surface temperatures were monitored using a Model 46 TUC Tele-Thermometer serial 1880⁰ manufactured by Yellow Springs Instrument Company. Skin thermometers were used (Model #409) with three skin temperatures being recorded. The areas where recordings were taken were: the right bicep, the abdominal area below right pectoralis major muscle, and the right calf area, six inches below the knee. The skin surfaces were prepared identically to the ECG electrode areas. The electrodes were placed on the skin surface and "New Skin" was painted on both sides of the electrode with "Dermical" tape securing the electrodes into place. Additional tape was placed over the wire to insure contact throughout the experiment.

Rectal temperatures were measured by inserting a rectal probe seven centimeters past the anal sphincter. This was accomplished by applying on the probe before insertion H-R Lubricating Jelly-Sterile manufactured by Holland-Rantos Company. Placement of the football uniform was carefully done to avoid disruption of electrodes before the subject entered the environmental chamber.

With a Parkinson Cowen ventilometer and a Collins triple J valve mouthpiece attachment, ventilated air was measured using open-circuit procedures described in Consolazio, Johnson and Pecora (5). The ventilometer calibration had been checked prior to and during the study by using a 125 liter tissot tank. The ventilometer was placed outside the environmental chamber. This was connected to the Collins triple J valve inside the chamber with a 3.05 meter (10 feet) hose. The dead air space within this hose consists of 9.65 liters; modification of testing procedures was made for this much dead air space. The triple J valve is constructed so the expired air goes into the sampling bag. When the sample bags were filled, they were placed on an oxygen analyzer for analysis of oxygen content. The oxygen analyzer had previously been calibrated for analysis. With the findings of the oxygen analyzer, the bags were placed on the carbon dioxide analyzer. The barometric pressures, gas, wet and dry bulb temperatures and pressure of water were then converted to Standard Temperature Pressure, Dry (STPD) value. To insure accurate readings, the analyzers were calibrated every two or three readings. The samples of ventilated air were extracted by the use of the Neptune Pressure Dya pump, Model 4K, and analyzed on the Beckman Oxygen Analyzer, Model E2, for percentage of oxygen. The Beckman Medical Gas Analyzer, Model 2B-1, was used to analyze carbon dioxide. To insure completed exhaled air, athletic tape was placed on the

nose to prevent the nose clip from sliding off due to perspiration.

All testing sessions, both experimental and controlled, were administrated in the same step by step procedures to insure accurate measurements. The preset heating and humidity elements were switched on the environmental chamber eight hours prior to testing.

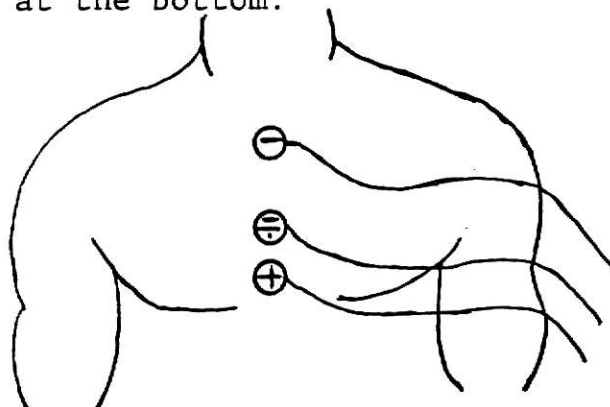
The skin and rectal temperature recorder was placed inside the chamber so quick connection could be made with electrodes after the subject entered the environmental chamber. The ECG machine was placed on a table outside of the chamber with extra long wires leading into the chamber to connect the electrodes. The bicycle ergometer was placed to one side of the chamber with the triple J valve suspended from the ceiling for easy accessibility to the subjects. The ECG recording machine was turned on to insure accurate reading during testing one half hour before the subject entered the environmental chamber and all other equipment was double checked for readiness.

Two one-liter (one quart) water bottles were placed in the chamber along with one 18.95 liter (5 gallons) water can containing ice water and towels. Dry towels were also placed in the chamber to be used at liberty by the subject during the rest periods.

Testing Protocol

Upon entrance to the testing area, the subject was asked to read and sign an informed consent form. After signing of said form, the subject was then asked to urinate and defecate if possible before pre-testing was started. Prior to the placing of the electrodes, hair was removed by a razor at all electrode locations. To help insure better records, the skin surface was lightly rubbed with a towel treated with alcohol to remove the horny layer of epidermal tissue. Another treatment of alcohol on cotton was applied to remove other forms of dirt and tissue. New skin was applied to the skin surface before placement of the electrodes. The new skin spread out one inch beyond the edge of the electrode with no new skin being placed over the center part of the electrode. Initial body weight was then taken while subject stood nude upon a Balance beam Gram Scale in order to insure accurate weight.

Electrodes used for the ECG were placed on the sternum with the negative electrode being placed at the top followed by the ground electrode at mid sternum and the positive electrode at the bottom.



Dermical tape was placed over electrodes to enhance the adhesiveness of the electrode placement. The same process was used for the skin surface electrodes. The placement of the three skin electrodes were in three areas: on the right bicept, on the right abdomen under the pectoral, and on the right calf. After electrode placement, the rectal probe was inserted with H-R Jell applied. The football equipment was then carefully placed on the subject to avoid disruption of the electrode placements.

With the pre-test condition being fulfilled, the subject entered the chamber. Before mounting the bicycle ergometer, the height of the seat was adjusted to fit his leg length during peddling. Adjustment of the triple J valve to fit the height of the subjects mouth during peddling was accomplished. The ECG, skin and rectal electrodes were then hooked to their respected recorders and tested for improper connections.

Upon completion of testing procedures, the subject's electrodes were then disconnected to allow the subject to leave the chamber. Returning to the dressing area the subject then removed all clothing and electrodes to resume a state of complete nudity for weighing out. After the weight was recorded the subject then showered and was free to leave.

The water bottles were then removed from the chamber and the contents measured to determine the amount consumed by the subject during testing. The recorders were turned off and

were cleaned if necessary. Electrodes were also cleaned and prepared for the following test session. The general area was then rearranged for the next testing session.

The air samples were analyzed to determine the carbon dioxide and oxygen percent in the air. The analyzed bags were then vacuumed and a cap placed on the valve to prepare then for the next time of use.

Treatment of Data

The means-standard deviation, standard error of the ten subjects were computed on both rest and working conditions for the parameter of the heart rate, oxygen consumption, respiratory quotient, skin temperatures, rectal temperature, and sweat rate loss. To determine a significant difference between conditions existed, a Repeated Measure Analysis of Variance was used. Comparisons were made of the means for each variable on the different experimental conditions. The criterion for statistical significance set at the .05 level of probability.

Chapter IV

RESULTS AND DISCUSSION

This study investigated one method of cooling on the response of heart rate, oxygen consumption, respiratory quotient, skin temperature, and sweat rate loss during a 75 minute heat stress situation. The results and discussion are presented in this chapter. The statistics presented here includes: 1) means and standard deviations of each of the data, 2) ANOVA of the data to determine the statistical significance of the treatment.

RESULTS

Heart Rate

The heart rate data are presented in Table 2 and the comparison between non-treatment and treatment are shown graphically in Figures 2-3. A summary of the raw data including the means and standard deviations for working heart rate indicated there were no statistically significant differences between treatment groups. Resting heart rates showed similar trends to the work heart rate.

Table 2

REPEATED MEASURE ANALYSIS OF VARIANCE FOR HEART RATES

Means During the Working Period

Source	df	ss	ms	F
Subject	9	11939.44	1326.60	2.0
Treat	1	.00	.00	0.0
Error A	9	5132.41	570.27	
Trial	5	6944.91	1388.98	41.76
Treat x Trial	5	260.98	52.20	1.57
Error B	88	2926.98	33.26	

Means During the Resting Period

Subject	9	5901.29	655.70	0.34
Treat	1	78.96	78.96	0.04
Error A	9	17372.42	1930.27	
Trial	6	5383.78	897.30	11.67
Treat x Trial	6	1057.37	176.23	2.29
Error B	105	8077.01	76.92	

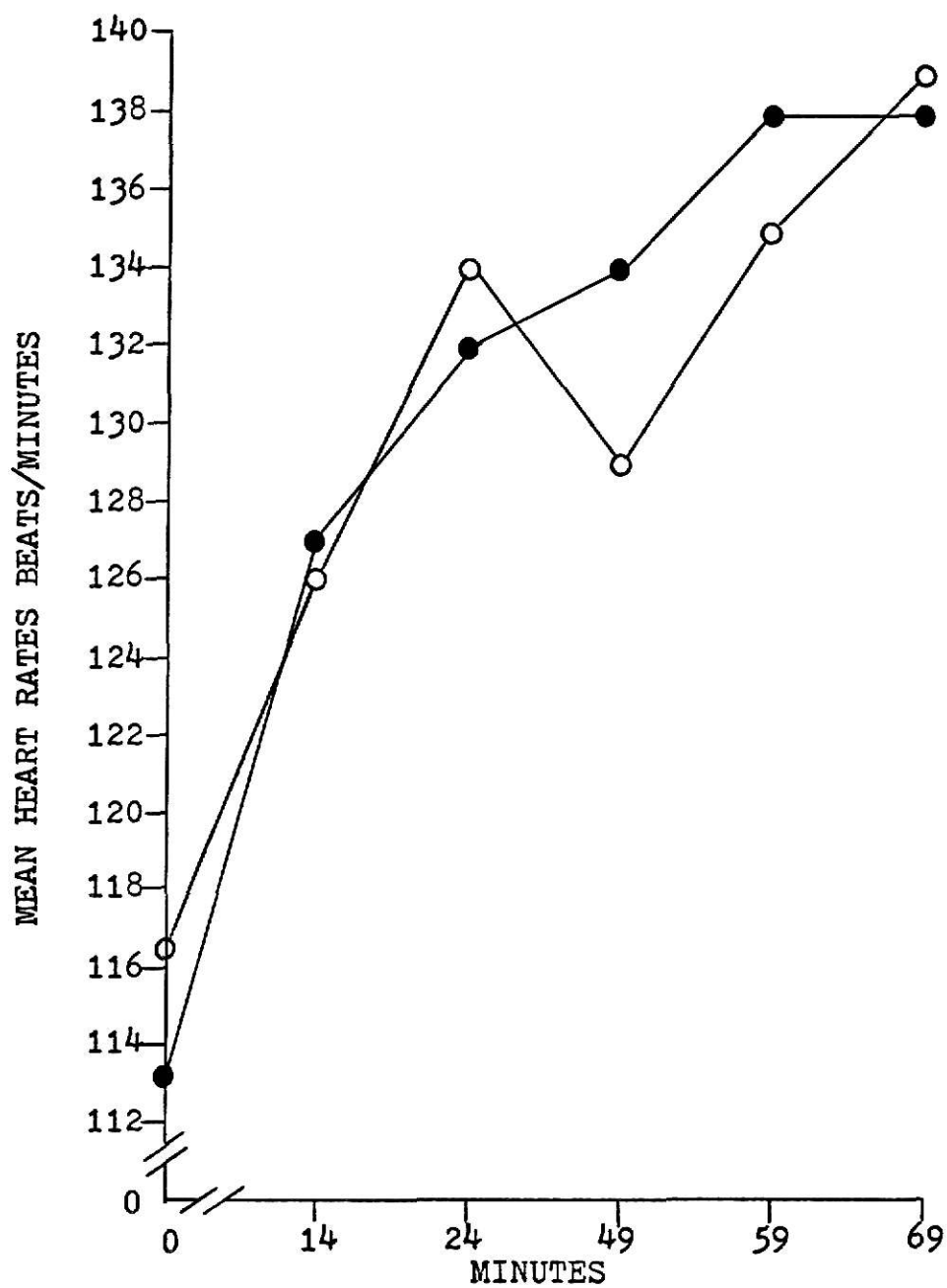


Figure 2. Heart Rates--Working

●—● Without Ice Towels
○—○ With Ice Towels

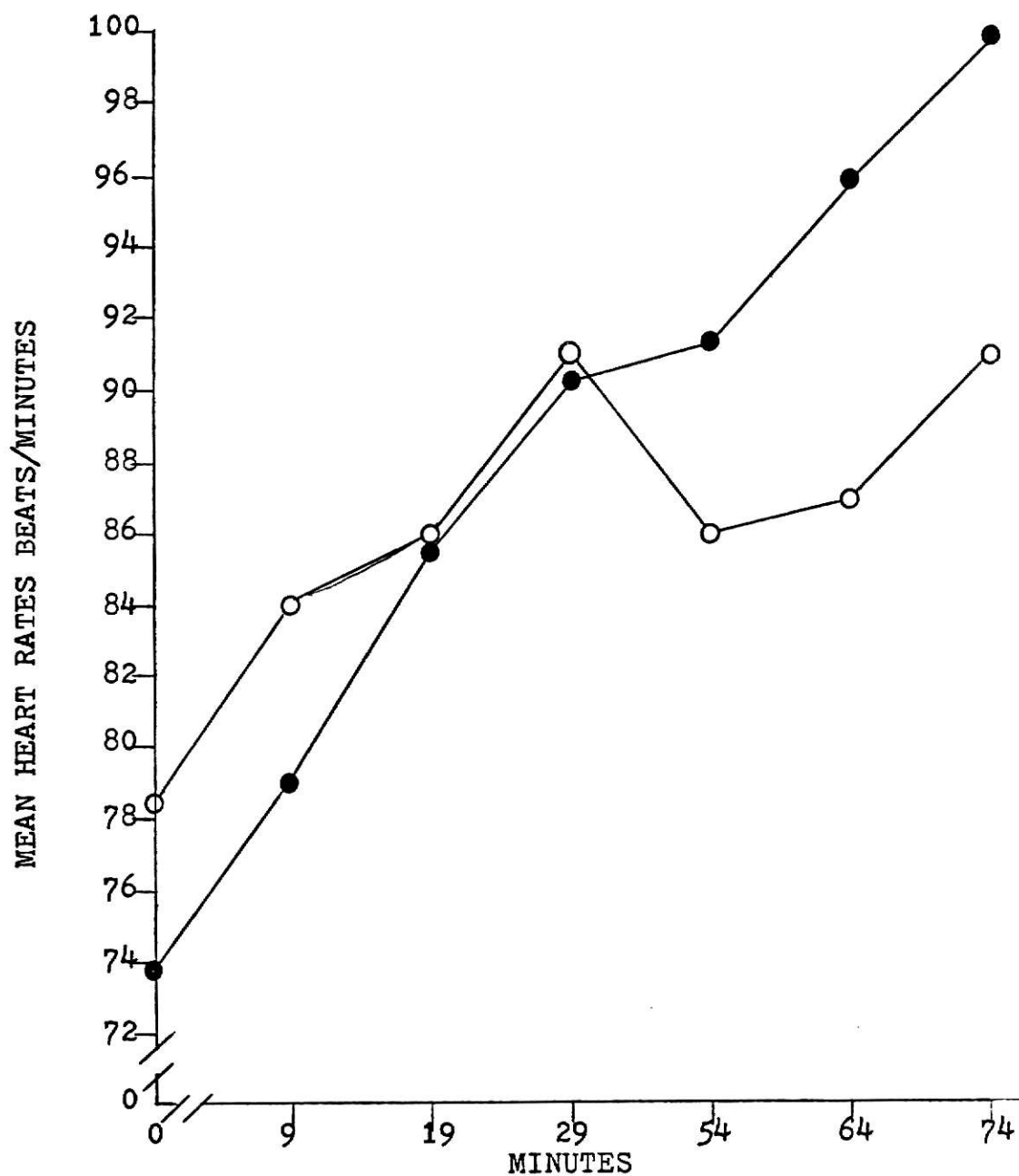


Figure 3. Heart Rates--Resting

●—● Without Ice Towels
○—○ With Ice Towels

Skin Temperatures

The skin temperatures, which included: the other portion of the arm, the rib cage below the nipple on the abdomen, and the outer portion of middle calf are summarized in Tables 3-5. The comparison between non-treatment and treatment data affects are shown graphically in Figures 4-9. The summary of the working raw data for the means and standard deviation of skin temperatures shows no statistically significant difference between treatment and non-treatment groups. Resting skin temperatures had similar responses to those of working skin temperatures. The skin temperatures remain parallel to each other during work and rest periods.

Table 3
 REPEATED MEASURE ANALYSIS OF
 VARIANCE FOR SKIN TEMPERATURES--ARM
 Means During the Working Period

Source	df	ss	ms	f
Subject	9	11.64	1.29	0.94
Treat	1	3.89	3.89	2.82
Error A	9	12.42	1.38	
Trial	5	6.41	1.28	2.79
Treat x Trial	5	2.44	0.49	1.06
Error B	97	40.44	0.46	

Means During the Resting Period

Subject	9	2.57	0.29	0.23
Treat	1	0.03	0.03	0.03
Error A	9	11.07	1.23	
Trial	6	41.26	6.88	17.83
Treat x Trial	6	6.53	1.09	2.82
Error B	105	40.51	0.39	

Table 4
 REPEATED MEASURE ANALYSIS OF
 VARIANCE FOR SKIN TEMPERATURES--ABDOMINAL
 Means During the Working Period

Source	df	ss	ms	F
Subject	9	54.61	6.07	6.43
Treat	1	0.01	0.01	0.01
Error A	9	8.49	0.94	
Trial	5	13.87	2.77	3.09
Treat x Trial	5	5.47	1.09	1.22
Error B	97	79.07	0.90	

Means During the Resting Period

Subject	9	47.45	5.27	3.44
Treat	1	7.19	7.19	4.70
Error A	9	13.78	1.53	
Trial	6	8.24	1.37	2.59
Treat x Trial	6	14.99	2.50	4.71
Error B	105	55.74	0.53	

Table 5
 REPEATED MEASURE ANALYSIS OF
 VARIANCE FOR SKIN TEMPERATURES--CALF
 Means During the Working Period

Source	df	ss	ms	F
Subject	9	11.69	1.30	0.68
Treat	1	1.11	1.11	0.58
Error A	9	17.29	1.92	
Trial	5	12.77	2.55	12.81
Treat x Trial	5	0.44	0.09	0.45
Error B	97	17.55	0.20	

Means During the Resting Period

Subject	9	26.43	2.94	2.12
Treat	1	0.23	0.23	0.16
Error A	9	12.48	1.39	
Trial	6	58.74	9.79	14.81
Treat x Trial	6	11.50	1.92	2.90
Error B	105	69.40	0.66	

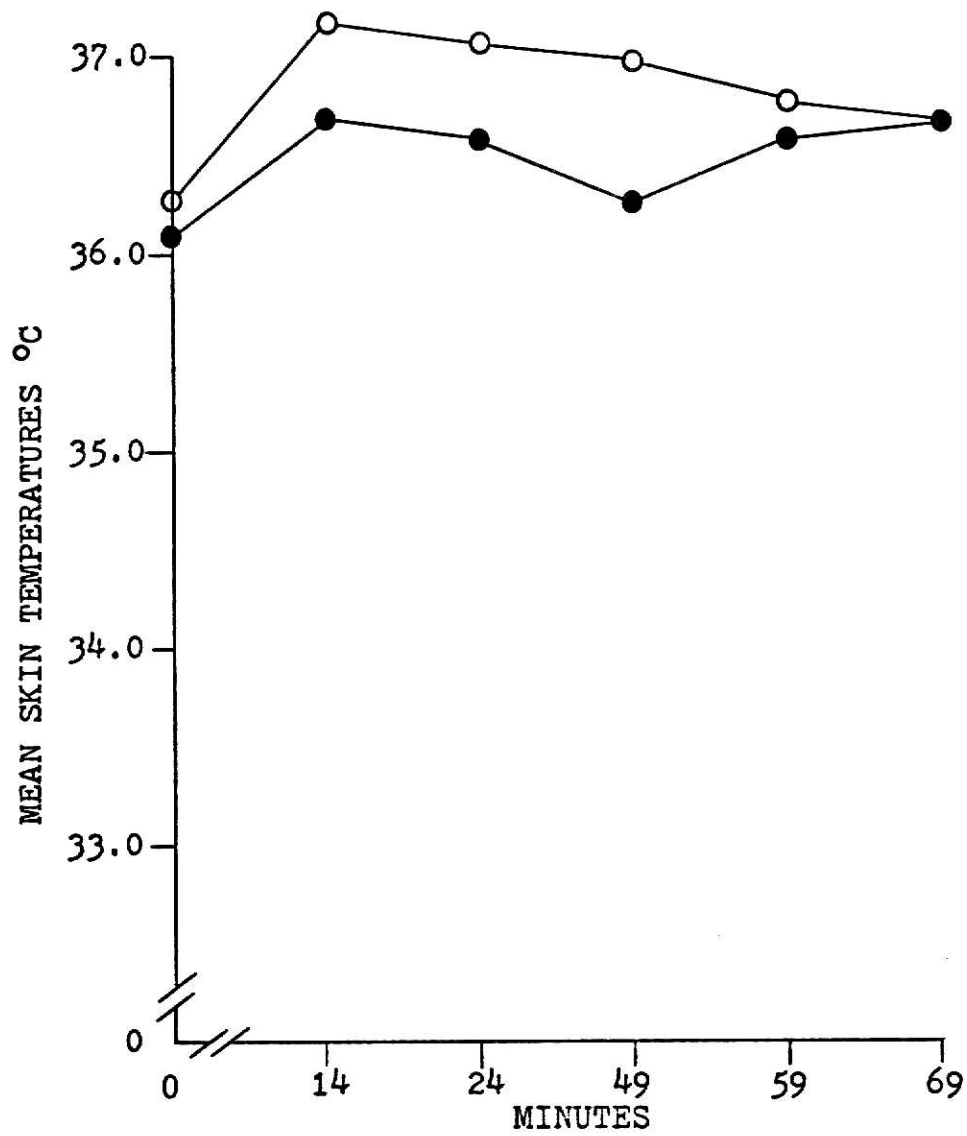


Figure 4. Mean Skin Temperatures--Arm Working °C

●—● Without Ice Towels
○—○ With Ice Towels

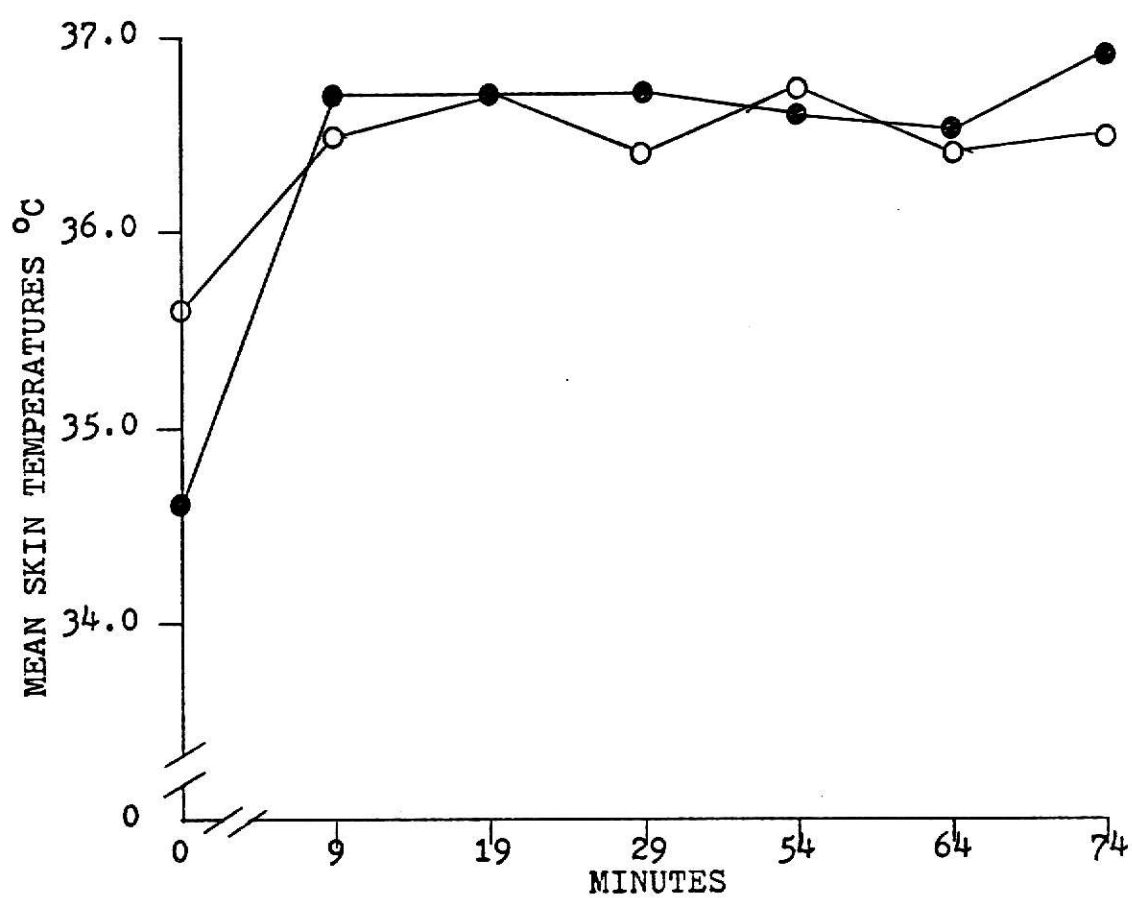


Figure 5. Mean Skin Temperatures--Arm Resting °C

●—● Without Ice Towels
○—○ With Ice Towels

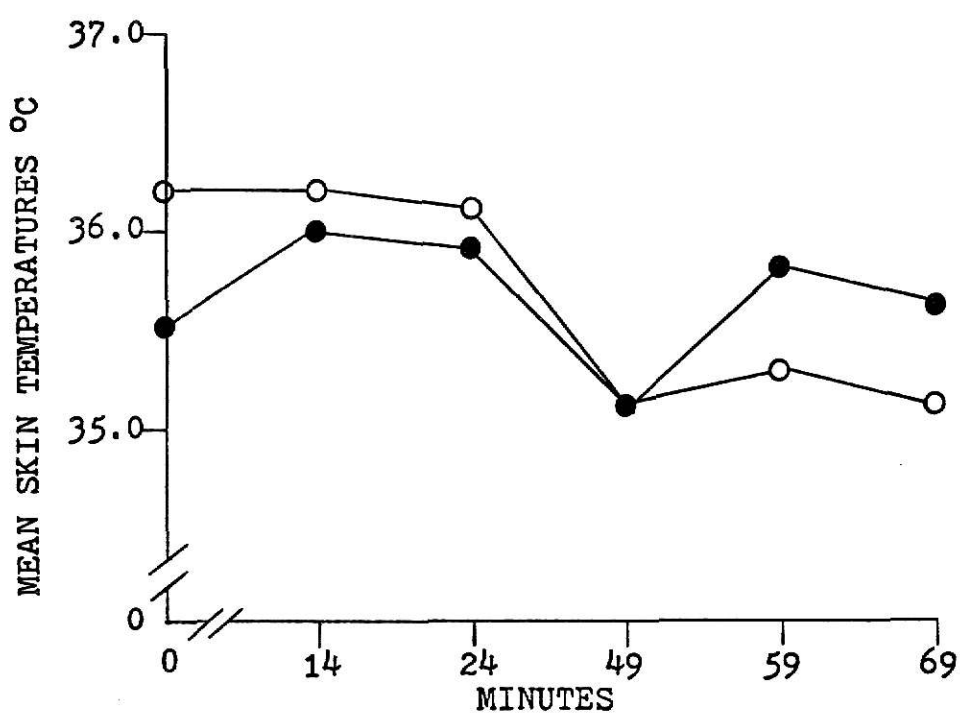


Figure 6. Mean Skin Temperatures--
Abdominal Working °C

●—● Without Ice Towels
○—○ With Ice Towels

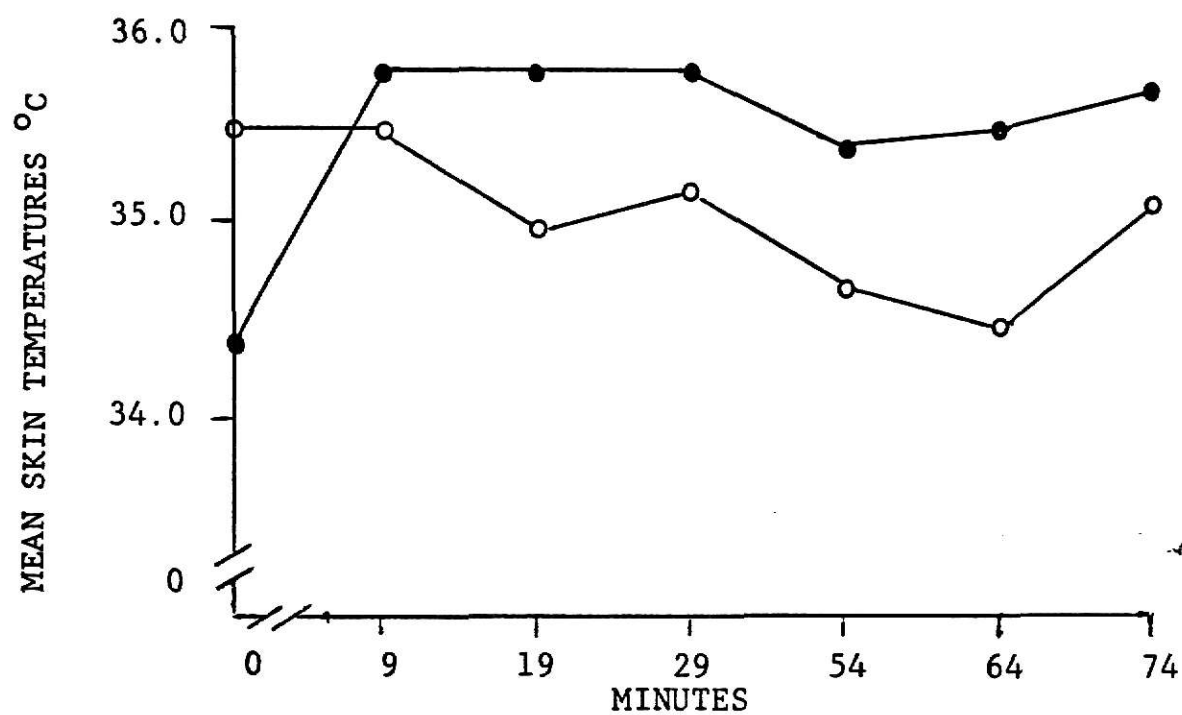


Figure 7. Mean Skin Temperatures--
Abdominal Resting °C

●—● Without Ice Towels
○—○ With Ice Towels

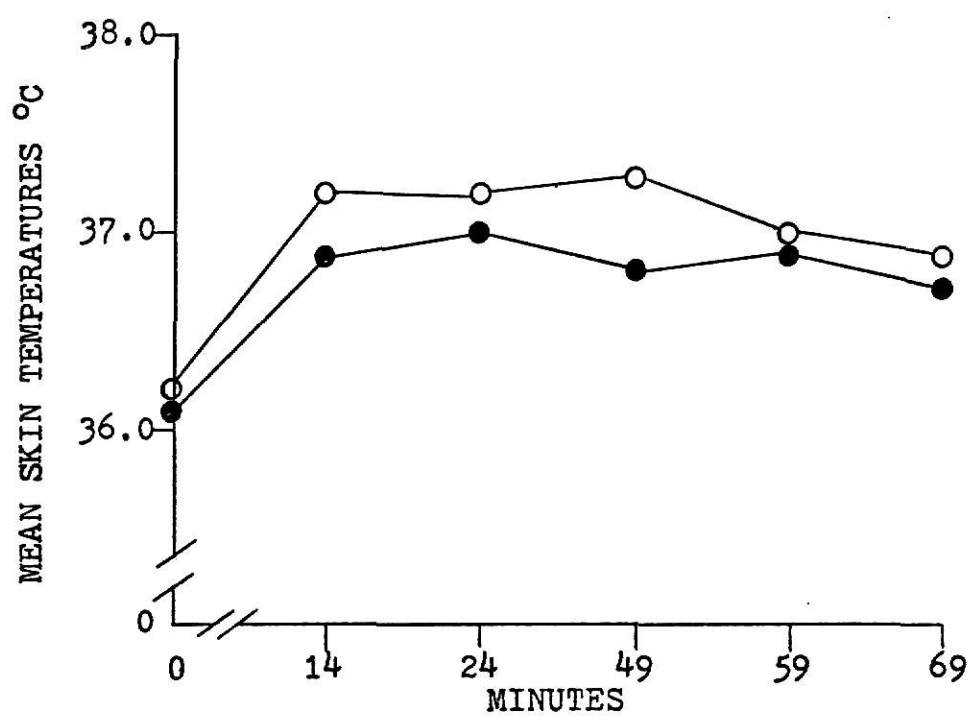


Figure 8. Mean Skin Temperatures--Calf Working °C

●—● Without Ice Towels

○—○ With Ice Towels

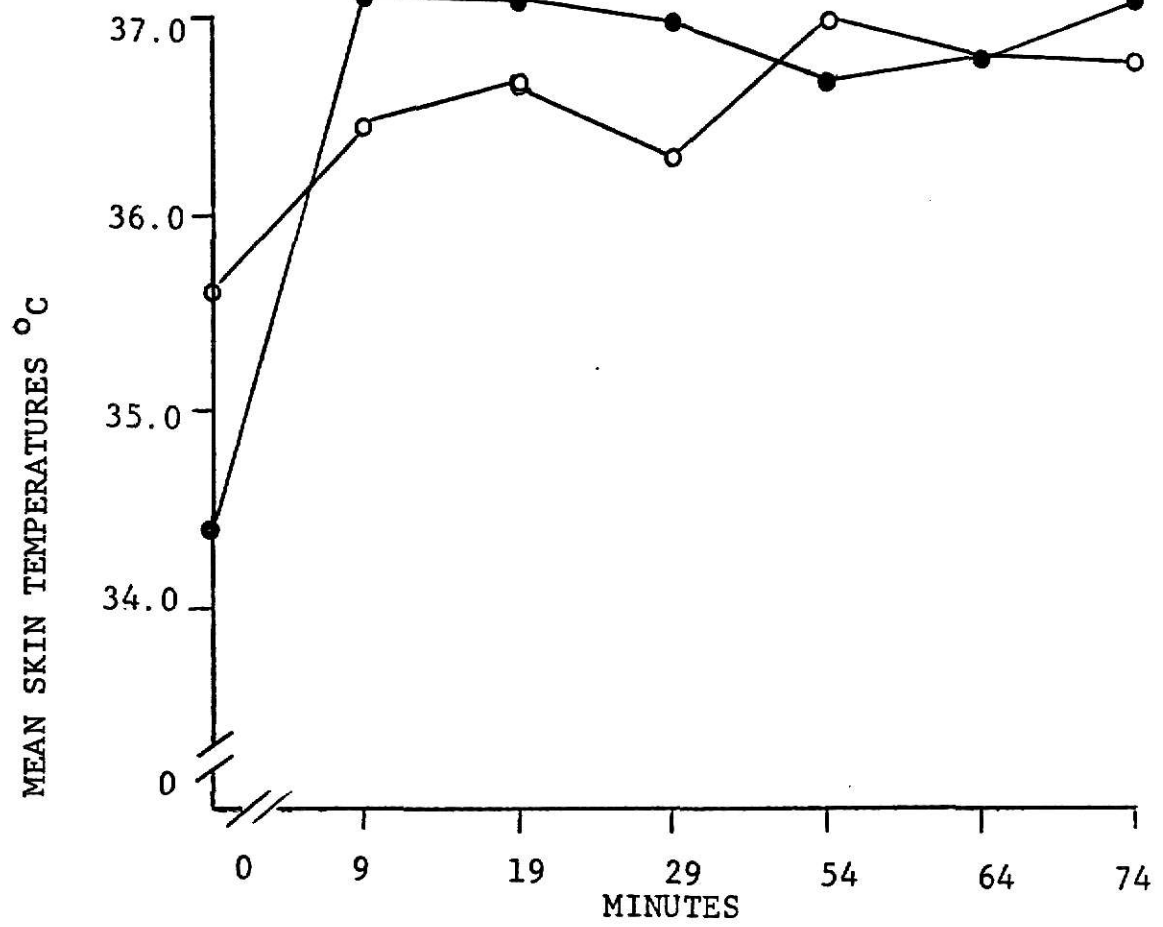


Figure 9. Mean Skin Temperatures--Calf Resting °C

●—● Without Ice Towels
○—○ With Ice Towels

Rectal Temperatures

In Figures 10-11, the rectal temperature comparison between non-treatment and treatment are shown graphically and these data are also presented in Table 6. A summary of the raw data for the means and standard deviation for working rectal temperatures showed similar trends to those of the work rectal temperatures. The rectal temperatures of the two groups remains parallel and continue to rise during the 75 minute exposure. However the rectal temperature only reached a maximum of 38.0°C (100.4°F) which indicated that no severe heat stress occurred.

Table 6
 REPEATED MEASURE ANALYSIS OF VARIANCE
 FOR RECTAL TEMPERATURES
 Means During the Working Period

Source	df	ss	ms	F
Subject	9	3.01	0.33	0.29
Treat	1	1.88	1.88	1.63
Error A	9	10.34	1.15	
Trial	5	5.49	1.10	37.91
Treat x Trial	5	0.08	0.02	0.56
Error B	97	2.55	0.03	

Means During the Resting Period

Subject	9	3.18	0.35	0.25
Treat	1	1.38	1.38	0.99
Error A	9	12.57	1.40	
Trial	6	7.02	1.16	27.04
Treat x Trial	6	0.15	0.02	0.57
Error B	105	4.54	0.04	

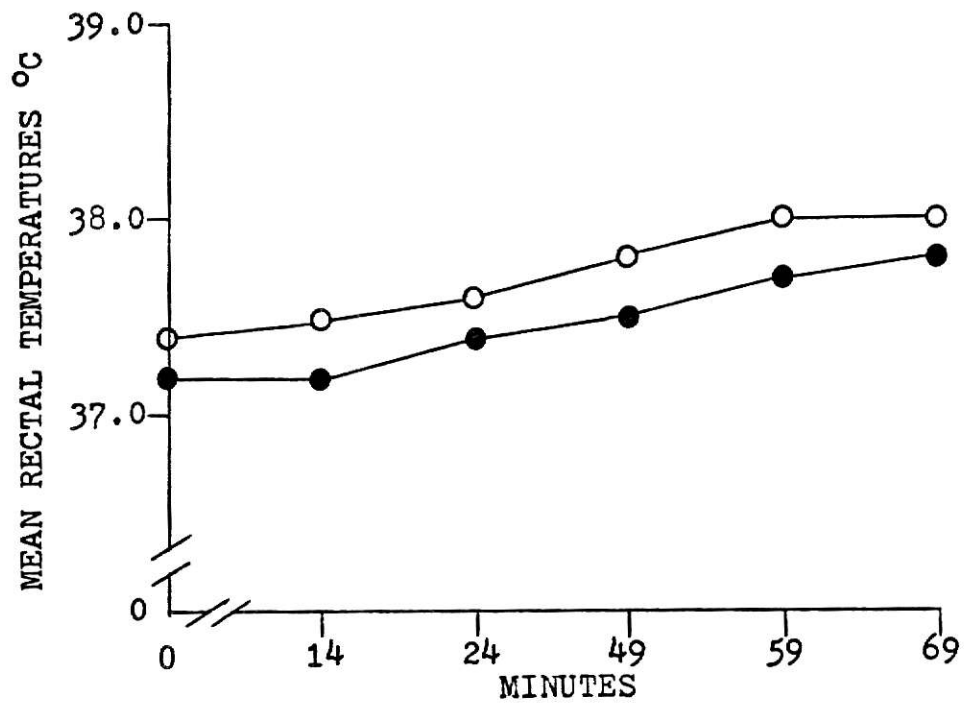


Figure 10. Mean Rectal Temperatures--Working °C

●—● Without Ice Towels
○—○ With Ice Towels

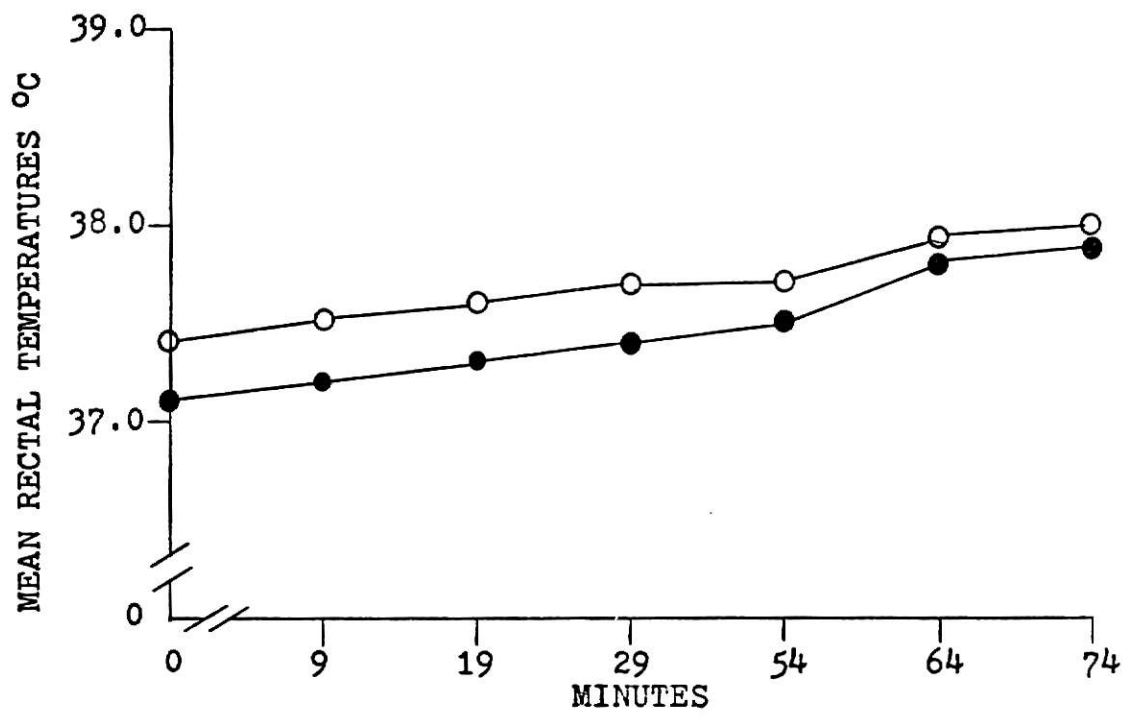


Figure 11. Mean Rectal Temperatures--Resting °C

●—● Without Ice Towels
○—○ With Ice Towels

Oxygen Uptake

The oxygen uptake ($\dot{V}O_2$) expressed as milliliter per kilogram per minute (ml/kg/min) are presented for the exercise portion in Table 7 and the comparison between non-treatment and treatment are shown graphically in Figures 12-13. A summary of the raw data for the means and standard deviation for the oxygen uptake showed no significant difference between the groups. The resting oxygen uptake readings show similar trends as the working oxygen uptake. The working oxygen uptake data trended higher towards the end of the testing session, while the resting oxygen uptake remains constant throughout the testing sessions.

Table 7
 REPEATED MEASURE ANALYSIS OF VARIANCE
 FOR OXYGEN UPTAKE
 Means During the Working Period

Source	df	ss	ms	F
Subject	9	45.55	5.06	0.70
Treat	1	9.02	9.02	1.25
Error A	9	65.09	7.23	
Trial	5	9.59	1.92	2.50
Treat x Trial	5	7.25	1.45	1.90
Error B	97	67.40	0.77	

Means During the Resting Period

Subject	9	5.96	0.66	0.48
Treat	1	7.34	7.34	5.30
Error A	9	12.21	1.38	
Trial	6	2.21	0.37	2.67
Treat x Trial	6	1.06	0.18	1.28
Error B	105	14.46	0.14	

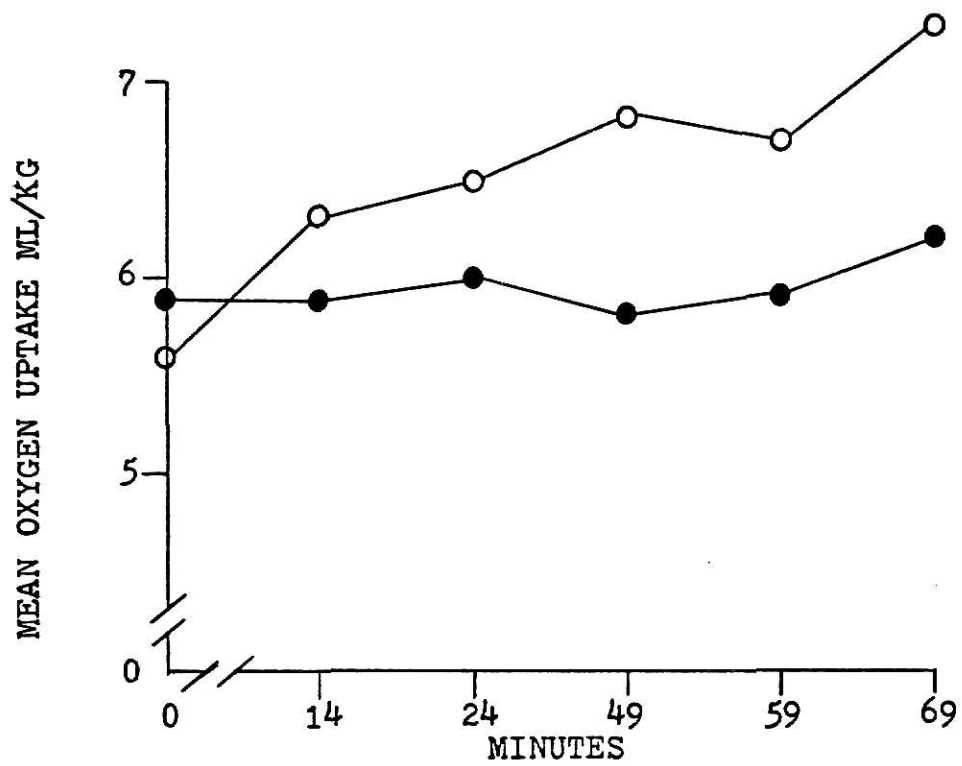


Figure 12. Mean Oxygen Uptake--Working

●—● Without Ice Towels
○—○ With Ice Towels

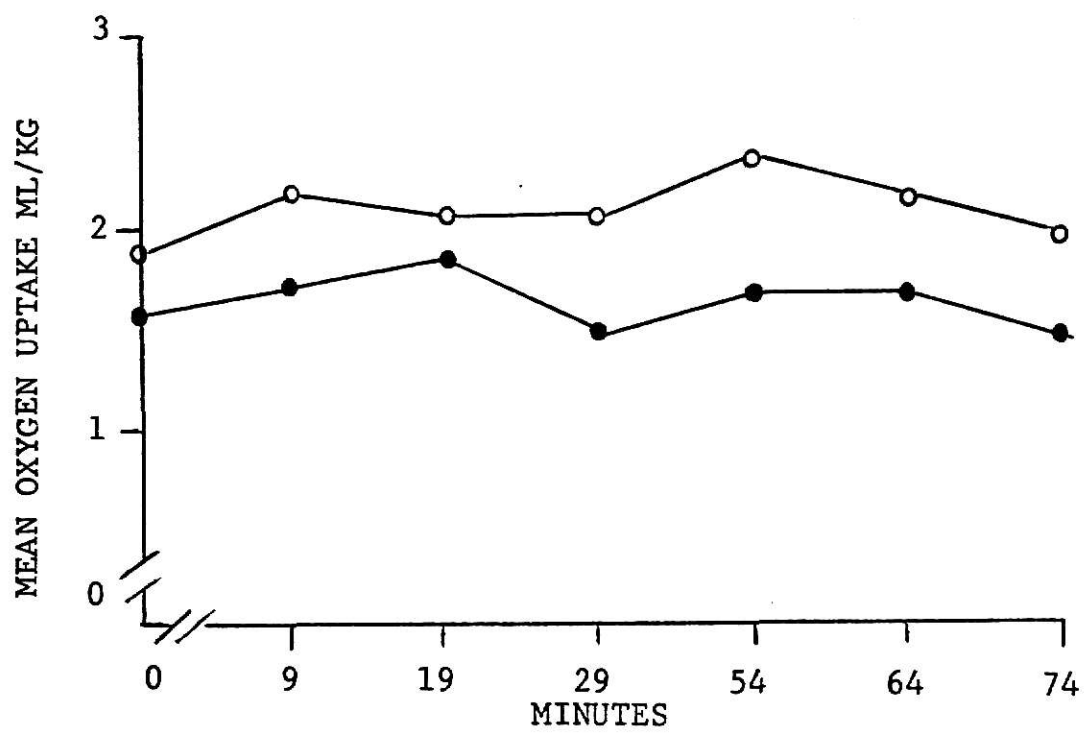


Figure 13. Mean Oxygen Uptake--Resting

●—● Without Ice Towels
○—○ With Ice Towels

Respiratory Quotient

The respiratory quotient (R.Q.) data are presented in Table 8 and the comparison between non-treatment and treatment are shown graphically in Figures 14-15. A summary of the raw data for the means and standard deviation for working respiratory quotient showed no significant difference between treatment groups. The resting respiratory quotient showed similar trends as the work respiratory quotient but remained lower and at a more consistent level.

Table 8
 REPEATED MEASURE ANALYSIS OF
 VARIANCE FOR RESPIRATORY QUOTIENT
 Means During the Working Period

Source	df	ss	ms	F
Subject	9	0.45	0.05	1.75
Treat	1	0.14	0.01	0.99
Error A	9	0.26	0.03	
Trial	5	0.01	0.00	1.11
Treat x Trial	5	0.01	0.00	1.73
Error B	97	0.15	0.00	

Means During the Resting Period

Subject	9	0.93	0.10	10.47
Treat	1	0.24	0.24	23.82
Error A	9	0.09	0.01	
Trial	6	0.05	0.01	0.78
Treat x Trial	6	0.01	0.00	0.09
Error B	105	1.04	0.01	

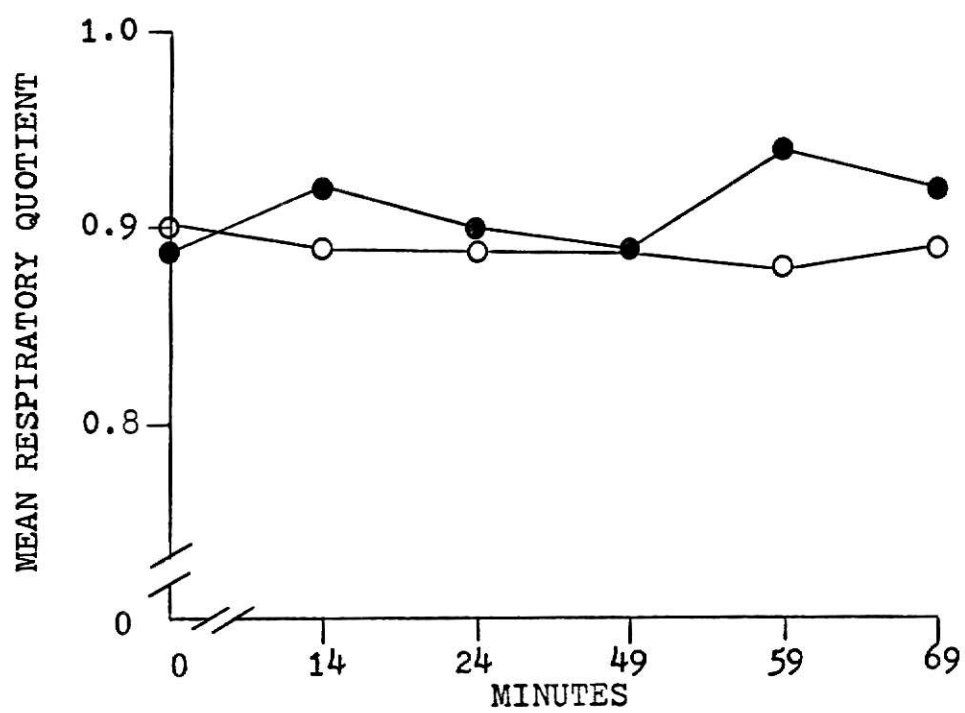


Figure 14. Mean Respiratory Quotient--Working

●—● Without Ice Towels
○—○ With Ice Towels

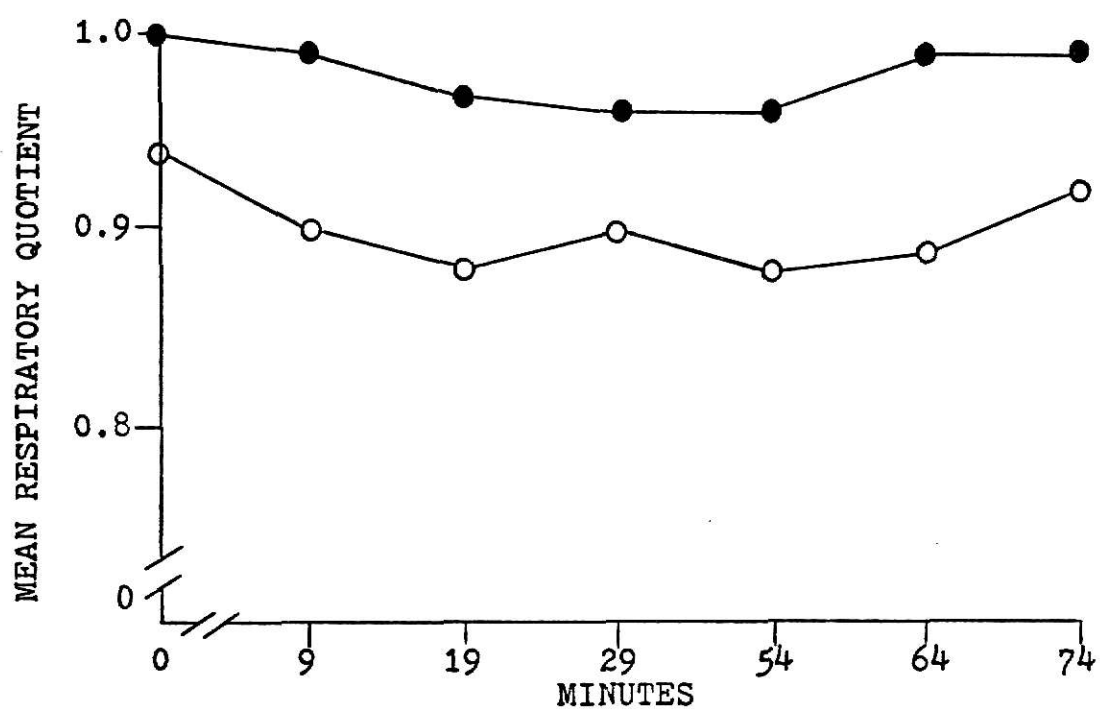


Figure 15. Mean Respiratory Quotient--Resting

●—● Without Ice Towels
○—○ With Ice Towels

DISCUSSION

Similar studies that have investigated methods of cooling have shown a significant effect on some physiological parameters (11, 22). However, this present study shows no statistically significant difference between treatment and non-treatment for heart rate, oxygen uptake, and body temperatures. Careful examination of the data showed that those parameters did not even trend toward significance. A consistent rise in heart rates was found from the beginning of the testing to the conclusion of the testing session for both groups. The heart rates during the first session started at 114-117 beats per minute and steadily rose to 138-139 beats per minute at the conclusion of the testing session. This response is well established and is attributed to fatigue and increased body heat (22). This study cannot isolate which had the greatest effect, but the fatigue would have decreased the efficiency and increased the heart rate. An increase in temperature would result in the increased heart rate during the testing (10) due to metabolic changes and the body's attempt to dissipate the accumulated heat. Testing sessions were scheduled one week apart, this eliminated the effects of any "residual fatigue" which might have affected the performance data. The subject might experience leg fatigue if the treatment was given the following day since they were not use to exercising on a bicycle ergometer.

This week between heat exposures helped assure no acclimatization would begin. The start of acclimatization might have effected the test results so the one week period between the tests, conducted in late winter, were enough to insure acclimatization from occurring.

The ice towel (0° - 7°C) (32° - 44.6°F) treatment or "Ice shock" could have caused vasoconstriction of the skin surface causing a greater demand upon the heart for circulatory response (22). Since the ice towels are extremely cold the resulting effect is to shunt the blood flow away from the surface which makes it more difficult for heat to leave the body. Olson (18) used cool towels with temperatures between 13° - 26°C (55.4° - 78.8°F), and his data showed a significant effect. The vasoconstriction at these cool temperatures is not as severe as the extremely cold ice towels and resulted in more flow to the skin for more effective cooling.

In this study most of the body is covered by the football uniform which also prevents cooling by evaporation. What evaporation that does occur, is not very effective in cooling the subject (8) because the sweating is at the surface of the uniform. As a result, more heat then remains within the body of the subject causing a rise in the core temperature. The core of the body can store only so much heat before the effects are reflected in performance. It has been shown that heat storage is increased with the addition of the football equipment (8, 7).

The surface area of the body that was covered by the ice towel treatment was relatively small compared to the total skin area. This area may not have been large enough to cool the body effectively. What available skin existed, was being covered by ice towels, which could have caused a reduction in evaporation because of vasoconstriction and further limit cooling. If a greater skin surface area or larger muscle mass were covered by ice towels this may have resulted in more effective cooling (18). If the heat load had been reduced, it could have lowered the heart rate; but it is unknown as to what changes have occurred in oxygen uptake during work. However, based on the level of fatigue changing with the increase in heat (11), it would be expected that the level of fatigue would reduce with the reduction of heat.

Half time rest had a slight cooling effect on skin temperatures with a slight drop for both treatment and non-treatment groups; this has been shown by Roundy and Cooney (22). Since the athlete has slightly lower temperature readings after this simulated half time rest period the possibility of removing the athlete from the hot environment to an air conditioned environment (i.e. locker room) might lower the temperature readings even more. Although this present study did not investigate other aspects of cooling such as the air condition environment, it might be expected to be more advantageous in reducing heat stress. If

the football equipment was removed during the fifteen minute time span more evaporative surface area would be available, and cooling should be increased by this means. The possibility of cool towels to cover all the exposed skin surface to help remove heat from the body might even lower the core temperature further by allowing the blood to flow from the core to the skin surface to further remove the heat.

The respiratory quotients were lower in the resting phase of the test when compared to the working phase, which is due to the nature of muscle activity (1). This will establish that the higher the level of physical activity, the higher the respiratory quotient and these data are consistent with previous studies.

These data indicate that this particular ice towel treatment method did not effectively remove the heat and the physiological data were not altered to any great extent during the testing. A written response was given by the subject on the mental feeling which was produced by the effects of the treatment to the non-treatment situations. The subject may have "felt better," however, this was not a psychological study and this phenomenon was not examined here.

Chapter V

CONCLUSIONS AND RECOMMENDATIONS

The purpose of this study was to determine the effects of the ice towels on the body's ability to maintain the core temperature, heart rate, and oxygen uptake during heat stress situations. More specifically this was to determine if any treatment significantly effected these variables during exposure to 40°C (104°F) with 40 percent relative humidity while wearing a full football uniform. The subjects were exposed twice; once with the treatment of ice towels around the head, neck, and waist areas and once with no ice towels.

The results of the data showed that the ice towels do not significantly decrease the core temperature, heart rate, and oxygen consumption during the 75 minute testing session. This leads to the conclusion that the subjects received no physiological advantage in coping with this heat stress by using the ice towels as a cooling method. The subjects may have "felt better" but there were no significant physiological benefits.

The following recommendations for further research were based on the results and conclusions; further investigation should include:

1. The effects of a half time in which the individuals are placed into an air conditioned

environment away from a heat stress environment.

2. The effects of cool towels (7° - 13° C) (44.6° - 55.4° F) as opposed to the ice towels.
3. The effects of covering additional skin surface with cool or cold towels.
4. The effect of increased work load on the athletes during the work bout.

The following recommendations were based on the results and conclusions of this study. The player and coach needs to be aware that previous research has showed heat stress to be a real danger. This study investigated only one method that proved to have no significant effect. Therefore, coaches and players should not believe that any particular method of reducing heat stress is effective unless it has been carefully tested. This study showed no indication of potential heat stress problems during any testing session. Any athletic event conducted in a heat stress situation could be potentially dangerous and care should be taken to protect all competitors from heat stress.

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APPENDICES

APPENDIX A

Sample

Subject Participation Consent Form

Exercise Physiology Research
Department of Health, Physical
Education, and Recreation
Kansas State University
Manhattan, Kansas

Date _____

I _____ have voluntarily consented to have the personnel of the Department of Health, Physical Education and Recreation to study methods of external heat coolants during the bicycle ergometer test for research. I realize that I will be in the environment chamber for one hour and fifteen minutes for two testing periods. I acknowledge that throughout the testing procedures the heart rate and the core temperature will be taken every third minute and fourth minute respectfully. While maximum oxygen uptake will be taken between the fourth and fifth minute during work and rest periods. The vital capacity, respiration rate, skin temperature, and rectal temperature shall be taken and recorded. I understand that I shall be required to breath into a mouth-piece apparatus so the expired gases may be collected and analyzed during the test.

I waive any possibility of personal damage which may occur during my participation in this study and accept the responsibility for my actions. I am not effected by limiting

physical conditions or disability, or with contagious disease, especially with respect to my heart, to my present day knowledge.

The personnel conducting the study shall have additional information concerning myself for use in this study.

I realize that I may drop out of this study at any time.

Subject's Signature Date _____

APPENDIX B

Subject Information

Name _____ Date _____ Day _____

Informed Consent Form _____

Weight In:

Subject. Weight Out:

Sweat Loss:

Room Temperature _____

Wet Bulb: _____

Dry Bulb: _____

Comments:

Water Intake During Testing _____

APPENDIX C

VENTILATION VOLUME

Subject _____ Date: _____ Day: _____ Time: _____

Clock Time	V Air.	Clock Time	V Air.
	Litres/min		Litres/min
Resting	Finish _____ Start _____ _____	16-15	Finish _____ Start _____ _____
		elapsed 30 min.	
41-40	Finish _____ Start _____ _____	11-10	Finish _____ Start _____ _____
elapsed 5 min.		elapsed 35 min.	
36-35	Finish _____ Start _____ _____	6-5	Finish _____ Start _____ _____
elapsed 10 min.		elapsed 40 min.	
31-30	Finish _____ Start _____ _____	1-0	Finish _____ Start _____ _____
elapsed 15 min.		elapsed 45 min.	
26-25	Finish _____ Start _____ _____	Recovery 0-5	Finish _____ Start _____ _____
elapsed 20 min.			
21-20	Finish _____ Start _____ _____	Recovery 6-10	Finish _____ Start _____ _____
elapsed 25 min.			

COMMENTS.

APPENDIX D

HEART RATE & SKIN TEMP--RECTAL

Subject: _____ Day: _____ Date: _____ Time: _____

Time	HR	Time	Skin Temp	Rectal
Rest 3rd min		Rest 4-5 min		
Work 3rd min		Work 4-5 min		
Rest 3rd min		Rest 4-5 min		
Work 3rd min		Work 4-5 min		
Rest 3rd min		Rest 4-5 min		
Work 3rd min		Work 4-5 min		
Rest 3rd min		Rest 4-5 min		
Half time		Half time		
Work 3rd min		Work 4-5 min		
Rest 3rd min		Rest 4-5 min		
Work 3rd min		Work 4-5 min		
Rest 3rd min		Rest 4-5 min		
Work 3rd min		Work 4-5 min		
Rest 3rd min		Rest 4-5 min		

EXTERNAL HEAT COOLANTS
IN VARSITY FOOTBALL PLAYERS

by

Stephens E. Long

B.S., Kansas State University, 1975

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Health, Physical Education and Recreation

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1977

The purpose of this study was to determine the effects of the ice towels on the body's ability to maintain the core temperature, heart rate, and oxygen uptake during heat stress situation. More specifically this was to determine if treatment significantly effected any of these variables during exposure to 40°C (104°F) with 40 percent relative humidity while wearing a full football uniform. Ten varsity adult male players served as subjects for this investigation on the basis that they were on the 1975 varsity football squad at Kansas State University. The subjects were tested on a bicycle ergometer while wearing a complete football uniform during the 75 minute testing session while remaining in the environmental chamber. Each subject was tested in two different conditions: once after alternating work and once after alternating work under the same conditions except applying ice towels during rest periods. Testing periods consisted of two thirty-minute intervals with a fifteen minute rest period in between. The thirty-minute intervals were each broken into three work bouts of five minute durations and three rest periods of the same length. A Repeated Measure Analysis of Variance was used to determine a significant difference between conditions existing on core temperature, heart rate, and oxygen consumption. The results of the data show that ice towels do not significantly decrease the core temperature, heart rate, and oxygen consumption during the 75 minute testing session. This leads to

the conclusion that the subject received no physiological advantage in coping with the heat stress by using the ice towels as a cooling method.