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The Effects of Ethanol on Thermoregulatory Mechanisms in Men Exercising in Two Different Environmental Temperatures

by

ROBERT JAMES GURNEY

A THESIS

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Abstract

The effects of ethanol ingestion on thermoregulatory mechanisms was investigated in eleven male volunteers. The eleven were selected from a group of twenty because of their higher levels of physical fitness. All subjects participated in two test sessions, one of which ethanol was ingested. Each subject undertook intermittent exercise on a bicycle ergometer for a period of 3 hours and 10 minutes. Five subjects performed the tests in room temperatures (22 ± 2° C), while 6 subjects were tested in cold (-5 ± 2° C).

At intervals during the tests, subjects ingested orange juice mixed with ethanol (94.1%) (2.5ml/kg), or orange juice alone. The ethanol ingestion resulted in eliciting peak blood alcohol levels above 80mg/100ml (legal definition of intoxication). Measurements of heart rate (HR), oxygen uptake (VO_2), respiratory quotient (RQ), skin temperatures (Tsk) and rectal temperature (Tr) were recorded periodically throughout the experiments. An assessment of perceived thermal comfort and environmental conditions were obtained through the use of questionaires completed by each subject.

The findings of this study indicated that ethanol ingestion lead to an increase in body heat loss, as reflected by a greater drop in body temperatures. Ethanol also appeared to alter subjects perception of their thermal environment.

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I. Introduction

The inqestion of alcohol has long been recognized as a contributing cause of accidental hypothermia. For example, Reinke in 1875 in his "Observations on body temperature in drunkards", cited by Weyman et al (1974) described seventeen cases of hypothermia associated with alcoholic intoxication. Observations of Weyman et al (1974) tend to indicate that hypothermia is common among the Alcoholic Bowery Population of New York City. An example given by Cottle (personal communication, 1978) described an extreme case of a man who was severely hypothermic an was brought to the University of Alberta Hospital. This man was found to be intoxicated and had evidently gone to sleep in a "snowbank" on a cold winter night. When the victim was admitted to the Hospital, he was not only hypothermic but had also suffered considerable cold injury. Similar incidents of accidental hypothermia appear occassionally in various newspaper accounts during the winter season. In recent years, writers of articles concerning cold weather activities, for example Merry (1981) warn against the drinking of alcoholic beverages in cold temperatures; indicating it causes cutaneous vasodilation thus predisposing one to the development of hypothermia.

The ingestion of moderate amounts of ethanol may be considered benefical during cold exposure. For example, Schulze in 1947 (cited by Andersen et al, 1963) suggests that a vasodilatory action resulting from ethanol may protect against frostbite. Blair (1964) suggests that ethanol enhances one's tolerance to hypothermia once it has occurred although, as pointed out by Gupta (1960), there may be a compensatory vasoconstriction when the effect of ethanol wears off.

That ethanol causes a cutaneous vasodilatory action in subjects under normal conditions in the absence of cold, appears widely recognized among various authors. Experimental work of Fewings et al (1966) indicates an increase in cutaneous blood flow of subjects, who ingested (orally) moderate amounts of ethyl alcohol, while resting in room temperatures. While under similar physical and environmental conditions, Gillespie (1967) reports an increase in cutaneous blood flow in subjects, following the ingestion of "whiskey" (2ml/kg body wt).

When ethanol has been ingested in tests carried out in cold environments, body temperature changes reflecting alterations in body heat content appears to be conflicting in various reports. Numerous studies in the past have been unable to confirm a substantial increase in body heat loss, as a result of ethanol ingestion in either cold air (Andersen et al, 1963; Kuehn et al, 1978) or cold water (Martin et al, (1977); Fox et al, 1979). However, that ethanol may hasten the onset of hypothermia was recently reported by Graham and Baulk (1980). Their findings indicate a greater decrease in body core (rectal) temperature of subjects immersed to their necks in cold water (13° C), preceded by the ingestion of (40%) alcohol (2.5ml/kg body wt).

When ethanol has been ingested in conjunction with exercise and cold exposure, the results of physiological measurements reflecting body heat loss seem consistent among various studies. Haight and Keatinge (1970) report an impairment in the maintenance of body temperature in subjects resting in cold (14.4°C) preceded by intense exercise and ethanol ingestion (0.34g/kg body wt). Further work by Haight and Keatinge (1973), under similar conditions supports their previous findings. In keeping with these findings, Graham and Dalton (1980) and later Graham (1981) reported a decline in body temperature of subjects who ingested alcohol (2.5ml/kg body wt) prior to intermittent bicycle work in cold ambient temperatures.

Although many studies in the past suggest that ethanol may cause impairment of normal thermoregulation, the mechanisms involved seem to be uncertain. Although ethanol is classified as a hypnotic or sedative drug, Ritchie (1975) indicates that ethanol has a depressant effect on the central nervous system. Such an action by ethanol may possibly cause alterations in thermoregulatory mechanisms. However, direct experimental evidence to this mechanism of action appears limited.

Alterations of one's "perception" of "Thermal Comfort" and consequent loss of a volitional action may be a means by which ethanol increases a person's susceptibility to hypothermia. That ethanol impairs one's perception of a cold stress has been suggested by various authors, including, Martin et al (1977) and Graham and Baulk (1980). These authors concluded that their subjects perceived a cold stress as being less severe after ingesting ethanol. Graham (1981) reported that subject's scores on tests of "Perceived Thermal Comfort" (as described by Fanger, 1970) tended to be reduced (felt warmer) after ingesting ethanol, despite colder body temperatures. Similar observations of an altered perception of a cold sensation was found in a study by Gurney (unpublished 1981), in which subjects rated the severity of pain experienced during hand immersion in cold water (2° C). When the subjects ingested (94.1%) ethanol (1.5ml/kg body wt) they reported the pain elicited by holding their hand in cold water to be less severe, in contrast to a non-alcohol condition. Such findings suggest that the lack of perceiving a painful or warning stimulus and the absence of a volitional response may be a major contributing factor to the adverse effects of ingesting alcoholic beverages while participating in cold weather activities.

Statement of the Problem

In view of the contradictory and limited evidence, the present study was undertaken to investigate the effects of ethanol on thermoregulatory mechanisms and the perception of "thermal comfort" in man during intermittent exercise in warm and cold temperatures. When people engage in outdoor activities, the drinking of alcoholic beverages appears to be a common practice among the participants. In general, most authors agree that ethanol ingestion in combination with cold exposure may be dangerous to one's safety. Fox et al (1979) suggest that accidents in the cold are more likely to occur when ethanol is involved, due to its adverse effects on coordination and cerebral functions.

This study attempts to ascertain the effects of ethanol ingestion on thermoregulatory mechanisms of men exercising in both warm or cold environments.

II. Review of Related Literature

The effects of ethanol ingestion on physiological mechanisms of man have been studied in detail for over one hundred years. Early work from Higgins (1917) suggests that ethanol has little or no effect on measures related to body thermoregulation. However, more recent studies tend to add uncertainty as to the effects of ethanol on thermoregulatory mechanisms. This review has been limited to selected physiological functions of man in response to ethanol ingestion. Thermoregulatory changes associated with ethanol are further discussed in relationship to the effects of environmental temperature (warm or cold) and man's physical state (rest or exercise).

Thermoregulatory functions reviewed include:

1. Heart Rate.
2. Metabolic Rate, including oxygen consumption (VO2) and respiratory quotient (RQ).
3. Body Temperature Regulation, measured by changes in skin and core temperatures.
4. Perception of environmental conditions and of "Perceived Thermal Comfort".

Heart Rate

There appears to be a lack of agreement among the many studies which have investigated the effects of ethanol on heart rate. Writers of textbooks, for example Ritchie (1975) in a well accepted textbook of Pharmacology states; "that heart rate may increase following ethanol ingestion, and this may be due to muscular activity or reflex stimulation." Experimental evidence to this action of ethanol appears somewhat limited. In studies of human subjects resting in room temperatures, Higgins (1917) and Grollman (1930 and 1942) found a consistent, but only transient and slight increase in heart rate following the ingestion of moderate amounts of ethanol. However, reports from Horwitz et al (1949) and Perman (1961) indicate no changes in heart rate's of subjects drinking ethanol while at rest in room temperatures. In order to help clarify such actions of ethanol, Wallgren and Barry (1970) suggest, "that one must consider the effects of ethanol on nervous regulation of heart rate, including its central nervous components, and local effects on the myocardium".

When man is exposed to cold (air) temperatures, it appears well recognized that the cold elicits an increase in heart rate. For example, Raven et al (1970) reported that subject's (resting) heart rates were higher in cold (5° C) in contrast to warm (28° C) conditions. Similar effects were observed by Godin (1977) in subjects performing exercise (75 percent VO2 Max.) in cold (4° C) compared to warm (40° C).

When ethanol is ingested and exercise is undertaken there is an apparent lack of agreement among the various studies that investigated the effects of alcohol on heart rate in either warm or cold air temperatures. That ethanol causes an increase in heart rate above that required by exercise has been suggested by Hebbelinck (1962), Blomqvist et al (1970) and Graham (1981). However, Garlind et al (1960), Riff et al (1969) and Graham (1981) report no changes in heart rate associated with the ingestion of ethanol. The variation in the findings of the many studies may be due to differences in the procedures used, including; exercise intensity, amount of ethanol ingested and blood alcohol levels obtained. This variation can be seen in the studies summarized in Table 2-1.

Table 2-1

The Effects of Ethanol on Heart Rate in Conjunction With Exercise

Author	Subjects	Ethanol Used	Amt. of Ethanol Ingested	Exercise Intensity	Exercise Duration (min)	Environ. Temp. (°C)	Mean Peak BAL's	Mean Change in HR: (beats/min)
Garlind et al, 1960	9 males (non-fasted)	96%	0.32-0.64 g/kg body wt.	Submax.	1. 5 2. 20 3. 60 (Intermittent)	Not Given	0.50-0.65 g/l	No change
Hebbelinck, 1962	19 males (fasted)	94%	0.6 g/kg body wt.	163.5 watts	5	Not Given	0.30-0.60 g/l	increase of 23
Riff et al, 1969	17 (fasted)	Whiskey 90 Proof	81 ml	100 watts	5	Not Given	110.5 mg/100ml	No change
Blomquist et al, 1970	8 males (non-fasted)	90 Proof	150 ml	1. Submax 2. Max.	1. 12 2. 2.5-5	Not Given	1. 165 mg/100ml 2. 156 mg/100ml	1. Increase Approx. 15 2. No change
Graham, 1981	6 males (fasted)	Vodka 40%	2.5 ml/kg body wt.	40% VO2 Max.	180 Intermittent	-5	13.05 mM/l	Increase 15-22 (80-110 min)
Graham, 1981	18 males (fasted)	Vodka 40%	2.5 ml/kg body wt.	40% VO2 Max.	180 Intermittent	1. +5 2. -5 3. -15	1. 10.24 mM/l 2. 12.22 mM/l 3. 13.22 mM/l	No change

<u>Note</u>: Studies not indicating Environ. Temp. were likely, 22°C.

Metabolic Rate

Pawan (1972) has suggested that, "over 90 percent of the absorbed alcohol is metabolized in the body, yielding about 7 kcal/g on complete oxidation to carbon dioxide and water, with a concomittant fall in respiratory quotient." The remainder is excreted in urine, expired air and sweat. It is well accepted that alcohol is mainly metabolized in the liver, and to a lesser extent in other tissues, including; kidney, muscle, lung, intestine and possibly the brain. The main pathways of ethanol metabolism are illustrated in Appendix 1.

Whether or not ethanol stimulates metabolic rate appears uncertain in reports from various authors in the past. Some authors, for example, Barnes et al (1965) suggest that the ingestion of ethanol does not alter metabolic rate's of subjects (fasted) resting in room temperatures. In contradiction, others for example, Perman (1962) found increases in oxygen uptake of subjects (not fasted) drinking ethanol, while under resting conditions in room temperature. The conflicting results as to the effects of ethanol on metabolic rate may be due to differences in the subjects metabolic state (ie. being fasted or not fasted at the onset of the experiment). In an attempt to determine the effects of food and ethanol ingestion on oxygen uptake; Stock et al (1973) found small increases in VO2 of subjects (fasted) drinking whiskey, and large increases in VO2 when both food and whiskey were consummed together. They concluded that the increases in oxygen uptake are likely due to the interaction between the metabolism of ethanol and residual "Specific Dynamic Action" (SDA) of food. In a more recent study, Rosenberg and Durnin (1978) attempted to clarify the uncertainty related to the effects of ethanol and the interaction between food and ethanol on metabolic rate. In their experiment subjects either ingested; ethanol (0.3 - 0.4g/kg body wt) (150 kcal), food (600 kcal) plus ethanol or, food plus a fruit drink. The results of this study indicate a significantly higher VO2 after ethanol alone, and an increase in VO2 of 23% after food (with fruit drink) and a 27% increase after food and ethanol. These findings suggest that ethanol alone and ethanol in combination with food elicit higher metabolic rates in contrast to food alone.

When one is exposed to cold (air) temperatures, it is well recognized that oxygen uptake increases, should the cold stimuli be enough to elicit shivering. When their subjects were exposed to cold air, Raven et al (1970) and Lamke et al (1972) found increases in VO2 above those in a controlled condition. Similar results were reported by Pugh (1967), Claremont et al (1975) and Schvartz (1977), who all found increases in VO2 of subjects undertaking exercise in cold temperatures. The increase in VO2 was likely mediated through a shivering response to cold, as indicated in authorative textbooks, such as that of Astrand and Rodahl (1977). Although direct experimental evidence to support such a response appears to be limited; Hong and Nadel (1979) found a greater amount of electromyographic activity of subjects exercising in cold air (10° C). Such a response suggests that a possible shivering action may occur in cold, even during exercise.

The effects of ethanol ingestion combined with exercise in either warm or cold environments has presented some uncertainty among the findings of various studies. Although the metabolism of ethanol appears to be unaffected by exercise (Pawan, 1968), a common agreement among various authors seems to indicate no changes in measures of metabolic rate during exercise as a result of prior ethanol ingestion. A summary of such studies are illustrated in Table 2-2. Some authors, including Graham (1981) reported that VO2 of subjects were not altered significantly as a result of ethanol ingestion. Whereas Blomqvist et al (1970) reported a slight increase in VO2 of subjects exercising (submaximal), preceded by ethanol ingestion. The diverse findings may be due to the effects of food consumption on VO2 in subjects non-fasted. Such an action of food may have been a contributing factor in the findings reported by Blomqvist and co-workers (1970).

Table 2-2

The Effects of Ethanol on Metabolic Measures in Conjunction with Exercise

Author	Subjects	Ethanol Used	Amt. of Ethanol Ingested	Exercise Intensity	Exercise Duration (min)	Environ. Temp. (°C)	Mean Peak BAL's	Mean Change in VO2	Mean Change in RQ
Garlind et al. 1960	9 males (non-fasted)	96%	0.32-0.64 g/kg body wt.	Submax.	1. 5 2. 20 3. 60 (Intermittent)	Not Given	0.50-0.65 g/l	No change	No change
Blomquist et al. 1970	8 males (non-fasted)	90 Proof	150 ml	1. Submax 2. Max.	1. 12 2. 2.5-5	Not Given	1. 165 mg/100ml 2. 156 mg/100ml	1. Increase 0.05-0.15 l/min. 2. No change	1. No change 2. No change
Barnes et al. 1965	9 males (fasted)	Whiskey	100 ml/65 kg body wt.	Walking 4 mph	2-20 min bouts	Not Given	58 mg/100ml	No change	No change
Graham, 1981	6 males (fasted)	Vodka 40%	2.5 ml/kg body wt.	40% VO2 Max.	180 Intermittent	-5	13.05 mM/l	No change	No change
Graham, 1981	18 males (fasted)	Vodka 40%	2.5 ml/kg body wt.	40% VO2 Max.	180 Intermittent	1. +5 2. -5 3. -15	1. 10.24 mM/l 2. 12.22 mM/l 3. 13.22 mM/l	No change	No change

<u>Note</u>: Studies not indicating Environ. Temp. were likely, 22°C.

Body Temperature Regulation

The function of the thermoregulatory system serves to maintain a relatively stable internal body temperature. Under normal conditions, the system acts in such a way as to keep the body core temperature at approximately 37 degrees C. Basic control mechanisms involved in thermoregulation have been described in various textbooks and reviews, including that of Astrand and Rodahl (1977). The mechanisms function basically as follows: Thermal receptors located both at deep body sites or core, and in the skin respond to thermal stimuli (heat or cold). Their output acts via thermoregulatory centers in the hypothalamic region of the central nervous system; to activate effectors including those which function to either increase the rate of heat production or those which function to facilitate heat loss. While studies of the function at the neural level in the central nervous system are limited to experimentation using laboratory animals, many studies of the effector mechanisms have been possible in man. These include studies of cutaneous blood flow and of sweating as mechanisms subserving heat loss, and of metabolic rate as a reflection of the rate of heat production. The action of such autonomic or reflex responses are closely linked to behavioral or conscious actions wherein one reacts volitionally to avoid conditions of either a cold stress or a heat stress.

Although it appears widely accepted that the ingestion of ethanol causes cutaneous vasodilation, the predictability of such a response is uncertain, as reflected by the inconsistency in the reports from different authors. In studies of subjects partially immersed in cold water, following the drinking of ethanol, Martin et al (1977) and Fox et al (1979) found no evidence of changes in body temperatures following ethanol ingestion. However, Keatinge and Evans (1960) and, Graham and Baulk (1980) reported an increase in body heat loss as reflected by lower body temperatures, in subjects ingesting alcohol followed by cold water immersion.

In studies of subjects exposed to cold air under laboratory conditions (15 to 20° C), Andersen et al (1963) reports that ethanol had no effect on body temperatures. However, under field conditions, a report by Gupta (1960) suggests that ethanol was associated with an increase in heat loss as reflected by lower body core temperatures. The conditions of these studies involving alcohol ingestion in cold environments are summarized in Table 2-3. The conflicting results may be due to the different methods incorporated in each experiment, for example; the amount and type of ethanol ingested varied among the studies, as did blood alcohol levels, the environmental temperature and exposure time.

Table 2-3

The Effects of Ethanol on Body Temperatures in Cold Water and Air

Author	Subjects	Ethanol Used	Amt of Ethanol Ingested	Text conditions (water/Air)	Exposure Time	Environ Temp (°C)	Mean Peak BAL s	Mean Change in Tsk	Mean Change in Tr
Martin et al. 1977	8 males 5 females	Pure Ethanol	Not Given	Water	20 min	13	102 5 mg/100ml	No change	Decrease 0 23°C
Fox et al. 1979	10 males	95%	1 15 ml/kg body wt	water	45 min	10	84 8 mg/100ml	No change	No change
Graham and Baulk, 1980	4 males	40%	2 5 ml/kg body wt	1 water 2 Air	1 24 min 2 24 min	1 13 2 22 5	1 14 9 mM/l 2 20 5 mM/l	1 Lower 2 Lower	1 Decrease 0 3°C 2 Continued Decrease
Keatinge and Evans, 1960	10	Absolute Alcohol	75 ml	water	30 min	15	Not Given	—	Decrease 0 11°C
Andersen et al. 1963	6 males	Gin	1 1 g/kg body wt 2 1 5 g/kg body wt	Air	1 8 hrs 2 8 hrs	1 20 2 15	Not Given	No change	No change
Gupta, 1960 (Field Study)	20	Rum	2 oz	Air	180 min	2	Not Given	Increase 3°C	Decrease 0 7°C

<u>Note</u>. Subjects of the above studies were tested under resting conditions

When ethanol has been ingested in conjunction with exercise in cold air temperatures, the findings of laboratory and field studies indicate that ethanol causes a greater increase in body heat loss. Such reports were based upon measures indicating lower body core temperatures. Details of these studies are presented in Table 2-4.

Table 2-4

The Effects of Ethanol on Body Temperatures, in Conjunction With Exercise

Author	Subjects	Ethanol Used	Amt. of Ethanol Ingested	Exercise Intensity	Exercise Duration (min)	Environ. Temp. (°C)	Mean Peak BAL's	Mean Change in Tsk	Mean Change in Tr
Haight and Keatinge, 1970 (Abstract)	6	Ethanol	0.34 g/kg body wt.	71% VO2 Max.	1. To Exhaustion 2. Rest (23-37) 3. Rest (30)	1. Not Given 2. 19.7 3. 14.4	Not Given	————	3. Decrease 2.3°C
Haight and Keatinge, 1973	14 males	Ethanol	28 ml	71% VO2 Max.	1. 120 min. 2. Rest (30-50)	1. Rm. Temp. 2. 19.5	Not Given	————	2. Decrease 2.5°C
Graham and Dalton, 1980	6 males	40%	2.5 ml/kg body wt.	40% VO2 Max.	120 Intermittent	-5	13.8 mM/l	Decrease 4.6°C	Decrease 0.4°C
Graham, 1981	6 males	40%	2.5 ml/kg body wt.	40% VO2 Max.	180 Intermittent	-5	13.05 mM/l	Decrease 1-2°C	Decrease 0.5°C
Graham, 1981	18 males (3 groups)	40%	2.5 ml/kg body wt.	40% VO2 Max.	180 Intermittent	1. +5 2. -5 3. -15	1. 10.24 mM/l 2. 12.22 mM/l 3. 13.22 mM/l	1. Decrease 0.5-1.0°C 2. Decrease 1-2°C 3. Decrease 0.5-1.0°C	1. Decrease 0.5°C 2. Decrease 0.2-0.5°C 3. Decrease 0.2-0.5°C
Simper et al, 1982 (Field Study)	6 (males and females)	Not Given	0.75 ml/kg body wt.	Not Given	5.5 hrs (2 hrs rest)	-2 to +5°C	82 mg/100ml	————	Decrease

__Note__. Studies not indicating Environ. Temp. were likely 22°C

Perception of Thermal Comfort

When a person drinks ethanol, his perception of thermal comfort may be altered, possibly due to the adverse effects of ethanol on the central nervous system. Although experimental evidence appears to be lacking in this area of research, Graham (1981) and others indicate that subjects reported feeling warmer after ethanol, despite body temperature measures being colder. In addition to this, subjects of various studies have reported feeling less discomfort after ethanol while immersed in cold water (Martin et al, 1977) and exposed to cold air (Andersen et al, 1963).

A person's behavioral or volitional action to avoid thermal stress by seeking comfortable or thermoneutral conditions, may in effect remove him from conditions which would otherwize precipitate hypothermia. Should ethanol ingestion impair his ability to evaluate whether or not conditions are what otherwize would be comfortable, it will result in his not taking corrective action necessary to avoid becoming hypothermic.

Gagge et al (1969) defines "Thermal Comfort" as, "a complex subjective sensation usually associated with physiological and psychological factors". They suggest that "warm discomfort" is associated with changes in physiological mechanisms, such as; when sweating and an increase in blood flow are activated to produce heat loss. Conversely, "cold discomfort" arises predominately from vasoconstiction and a subsequent decline in skin temperature. In a study of subjects (resting) exposed to environmental temperatures of 12° and 48° C, Gagge et al (1969) found that subjects' (clothed) sense of discomfort increases at an ambient temperature below 28° C. They suggest that "cold discomfort" correlates best with the lowering of average skin temperature and "warm discomfort" with increased sweating.

Summary Statement

Many of the aspects of man's thermoregulatory responses to ethanol ingestion in conjunction with exposure to various environmental and physical conditions have been studied. However, from the studies reviewed, there is an apparent uncertainty as to the effects of ethanol on physiological functions. The conflicting opinions among various authors may be due to the diversity of experimental methods employed.

III. Methods and Procedures

Subjects

Twelve male subjects volunteered to participate in tests involving ethanol drinking and intermittent exercise. However, only eleven subjects completed the tests, because one subject (J.W) was unable to participate in the warm temperature tests. The eleven male caucasians were students of The University of Alberta, and ranged in ages from 19 to 30 years. They were selected from twenty initial volunteers on the basis of their having higher levels of physical fitness. All subjects were light to moderate drinkers of alcoholic beverages, as defined by Cahalan et al (1969). The tests undertaken by the subjects were carried out during the months of June and July, 1982. Physical characteristics of the twelve subjects are summarized in Appendix 3-C.

All subjects were informed to the possible risks involved in the experiments prior to the test sessions. Subjects gave an informed consent to the experiments, which had been approved by a Faculty that deals with ethical considerations. The subjects were briefed as to the experimental procedures, however this did not include the content of questionaires involving the assessment of the thermal environment. All subjects were requested not to drink alcoholic beverages nor take part in strenuous exercise for the twenty-four hours prior to each test session. They were also requested not to eat any food for a period of three hours prior to the onset of each test.

Physical Fitness Assessment

The twenty volunteers performed tests to determine body composition and aerobic capacity. Percent body fat was measured by means of body skinfolds, as described by Durnin and Womersley (1974); and by an underwater weighing technique described by MacNab and Quinney, (1980). Maximum oxygen uptake (VO2 Max) was determined by a progressive bicycle ergometer test, modified from Astrand and Rodahl (1977).

Experimental Protocol

The protocol was designed so as to simulate the common practice of people drinking alcoholic beverages at intervals while participating in physical activities in the out-of-doors. All experiments were carried out in a controlled environmental chamber, set at a temperature of 22° ± 2° C (warm group) and -5° ± 2° C (cold group).

On the day of testing, the subjects ingested either: Unsweetened orange juice and ethanol (3:1), (2.5ml of 94.1% matured grain alcohol/kg body wt), (alcohol test), or an equivelent amount of unsweetened orange juice, (control test). Which of these was ingested in the first of the two test sessions was determined by flipping a coin. The subjects were not informed to which drink they would be consumming, however they could recognize the alcohol drink by taste. All subjects wore similar clothing (a sweat suit), so as to have the same amount of insulation for both tests.

In each of the two testing sessions the subjects performed intermittent work on a bicycle ergometer (Uniwork, Quinton Instruments) for 190 minutes. This included 20 minutes work (at a workload estimated to produce 50% VO2 Max.) followed by 10 minutes of rest and repeated six times, with a final rest period of 20 minutes. Prior to the first exercise bout and following all exercise sessions in the procedures, the subjects were instructed to complete a questionaire. The questions concerned their perception of environmental conditions and of their thermal comfort. During the first four rest periods following the first four exercise bouts, the subjects were instructed to drink the contents of one glass containing one-fourth of the total amount to be ingested. Blood alcohol levels were estimated by analysis of expired air (by use of a Breathalyzer, Model 900, Stephenson Corp) prior to the initial exercise bout and at the beginning of the second and subsequent rest periods, before the drink was ingested. Heart rate (HR), oxygen uptake (VO2), respiratory quotient (RQ), skin temperatures (Tsk) and rectal temperature (Tr) were determined at ten minute intervals throughout the experimental sequence.

Following the tests in which ethanol was ingested, subjects were required to remain in the laboratory until blood alcohol levels had fallen to a value less than 40mg/100ml.

The experimental protocol in this study is similar to those of methods described by Graham (1981). However, unlike Graham's methods, subjects of the present report ingested the ethanol drink over a longer period of time. The lengthening of time in which ethanol was ingested was designed for the examination of physiological measures at various blood alcohol levels.

Instrumentation

The questionaires involving perception of environmental conditions and of "perceived thermal comfort", were a modification of those described by, Bedford (1958) and Fanger (1970), (Q1); and of Gumnar and Lindbald (1969), (Q2). Heart rate measures were monitored by means of a cardiotachometer (Cardionics AB, Stockholm. Sweden). Oxygen uptake and respiratory quotient were determined by analysis of expired air, using an automated metabolic measurement device (Metabolic Measurement Cart, Beckman Instruments Inc.). Mean skin temperature was determined from measurements made at four sites using thermocouples (Type "T") attached to the skin by means of surgical tape. These were attached (before the sweat suit was put on) at sites (described by Mitchell and Wyndham, 1969) over the pectoralis, deltoid, quadraceps and gastrocnemius muscles. Rectal temperature was determined by using a rectal thermocouple, self inserted 10cm beyond the anal sphincter. Temperatures were read using an analog meter (BAT-4, Bailey

Instruments) with the aid of a digital volt meter. Mean skin temperature was determined by a weighting formula as described by Mitchell and Wyndham (1969). Mean body temperature was calculated based on a formula described by Folk (1974); and skin conductance was determined by using a formula described by Robinson (1949), (see Appendices 4-A and 4-B).

Statistical Analysis

Data obtained were subjected to a three-way analysis of variance (ANOVA). This ANOVA was applied separately to the first half (Time 0 to 90 min.) and second half (Time 100 to 190 min.) of the experimental sequence. This method was used in order to separate measurements obtained at low and high blood alcohol levels. A Student-Newman-Kuels test was used in evaluating significance of differences between the means (control vs alcohol) at each time period. Statistical significance was accepted at the 95 percent confidence interval, ($P \leq 0.05$).

IV. Results

Blood Alcohol Levels

Blood alcohol levels (BAL's) of all subjects followed a similar response pattern throughout the tests, as can be seen in Figure 4-1. Subjects BAL's increased progressively after the ingestion of each drink of ethanol. Peak BAL's were reached at 140 minutes of the test sessions, which was 20 to 30 minutes after the last ethanol drink was ingested. A gradual decline of BAL's was evident following the peak period, however they did not decrease to levels of zero.

Heart Rate

The mean heart rates of subjects showed progressive increases with each bout of exercise, as can be seen in Figure 4-2. Heart rate at rest periods also increased over time, however this action was not as pronounced as in the exercise condition. Subjects of the warm temperature group demonstrated higher mean heart rates than those subjects who were working in cold. This difference became greater during each bout of exercise.

Subjects of both temperature groups showed higher mean heart rates after alcohol ingestion, and differences from control values became greater as blood alcohol levels increased. Mean heart rates of the warm temperature group (alcohol treatment) were significantly higher ($P \leq 0.05$) than controlled conditions, by 8.2, 7.6 and 14.4 beats/min. at times 150, 180 and 190 min., respectively. Subjects ingesting alcohol in cold temperatures had higher ($P \leq 0.05$) heart rates above control values by 7.4 beats/min. at 170 min. During the final rest period (170 to 190 min) mean heart rates of the controlled conditions tended to decline at a faster rate than those in the alcohol condition.

Oxygen Uptake

During times of low blood alcohol levels (0 to 60 min) no differences were found in the rate of oxygen uptake (VO2) of both temperature groups. However, as BAL's increased a diversity among the VO2 means can be seen in Figure 4-3. Subjects of one temperature group never showed a consistent difference of VO2 means with the other group, however VO2 was higher in the warm temperature group at 140 and 150 min.

Mean VO2 of subjects ingesting alcohol (warm temperatures) were significantly higher ($P \leq 0.05$) than controlled conditions by 2.3, 4.0 and 2.0 $ml \bullet kg^{-1} \bullet min^{-1}$ at the times of 90, 110 and 120 min. respectively. From 130 to 190 min. mean VO2 of the same subjects was higher with alcohol, however the differences from controlled conditions were not statiscally significant. In the cold temperature group, mean VO2 was significantly higher in the alcohol condition than in controlled, by 2.2 $ml \bullet kg^{-1} \bullet min^{-1}$ at both 70 and 90 min. time periods. When blood alcohol levels were high (130 to 140 min), mean VO2 after alcohol was lower than control (cold temperature group), but these differences were not considered significant ($P \le 0.05$). During the final rest period, mean VO2 of both temperature groups tended to decline towards initial test levels.

Respiratory Quotient

There was no apparent consistency in the pattern of mean respiratory quotient (RQ) of both temperature groups, as can be seen in Figure 4-4. However, mean RQ of both temperature groups were lower in the second and third exercise bouts, as compared to the initial and subsequent exercise sessions. Subjects in warm temperature had lower mean RQ responses with alcohol between 100 and 190 min., and the means were significantly ($P \le 0.05$) different from control by 0.13 and 0.15 at 110 and 130 min., respectively. When blood alcohol levels were high (120 to 190 min), mean RQ responses of subjects in cold were higher with alcohol, however this was not significantly different from the control means.

Skin Temperature

The effects of ethanol ingestion on mean skin temperature (Tsk) of subjects exercising in warm and cold temperatures are illustrated in Figure 4-5. Mean Tsk of both temperature groups increased during each exercise bout, however this response appears to be prolonged in cold, at the second and third exercise bouts. A decline in Tsk from the onset of the tests can be seen in the cold temperature group, between 0 and 110 min. Mean Tsk of the warm temperature group followed a relatively stable pattern throughout the experimental sessions.

When blood alcohol levels were highest (140 min), Tsk of the alcohol treatment (warm temperature group) was lower than control ($P \le 0.05$) by 0.3 degrees C. Mean Tsk of subjects (cold temperature group) in the alcohol treatment, was lower than their control levels at 50, 60, 70, 80, 90 and 140 min. by 0.9, 0.6, 0.2, 0.7, 0.2, and 0.6 degrees C, respectively. During the final rest period (170 to 190 min), mean Tsk (cold group) declined below the initial resting levels, while Tsk of subjects in warm temperature only declined to initial resting levels.

Rectal Temperature

Mean rectal temperatures (Tr) of both temperature groups demonstrated a somewhat irregular response pattern during the testing sessions of both subject groups, as can be seen in Figure 4-6. In both temperature groups, mean Tr increased during each exercise bout, however this response became less pronounced when blood alcohol levels were high. Mean Tr was higher in the alcohol condition of subjects in warm temperature, during the first 120 minutes of the tests. However, as blood alcohol levels approached peak periods a sudden decline in Tr became evident at 150 minutes. This drop in Tr after alcohol was significantly lower ($P \le 0.05$) than control levels, by 0.3, 0.2, and 0.3 degrees C at 150, 170 and 190 min., respectively.

As blood alcohol levels became higher, a greater deviation of (cold temperature group) mean Tr from control levels was evident. This decrease in Tr was significantly different from control ($P \leq 0.05$) by 0.2 to 0.3 degrees C at the measurement times of; 100 to 190 minutes. During the last rest period mean Tr of both temperature groups declined, with the greater decrease being in the alcohol treatment of both temperature groups.

Mean Body Temperatures

As can be seen in Figure 4-7, mean body temperature (Tmean) of the warm temperature group was similar in both the alcohol and controlled conditions. However, when blood alcohol levels became high, Tmean for the alcohol condition was slightly lower than control, but this difference was not significant ($P \leq 0.05$). Subjects ingesting alcohol in cold temperatures showed lower Tmean responses than the controlled conditions, following the initial rest period. These reduced body temperatures were significantly different ($P \leq 0.05$) from control by 0.3 to 0.4 degrees C at each of the following times; 50, 80, 140, 160, 170, 180 and 190 minutes. During the final rest period of the tests, Tmean responses of subjects in both temperature conditions followed similar patterns as in the responses of rectal temperatures.

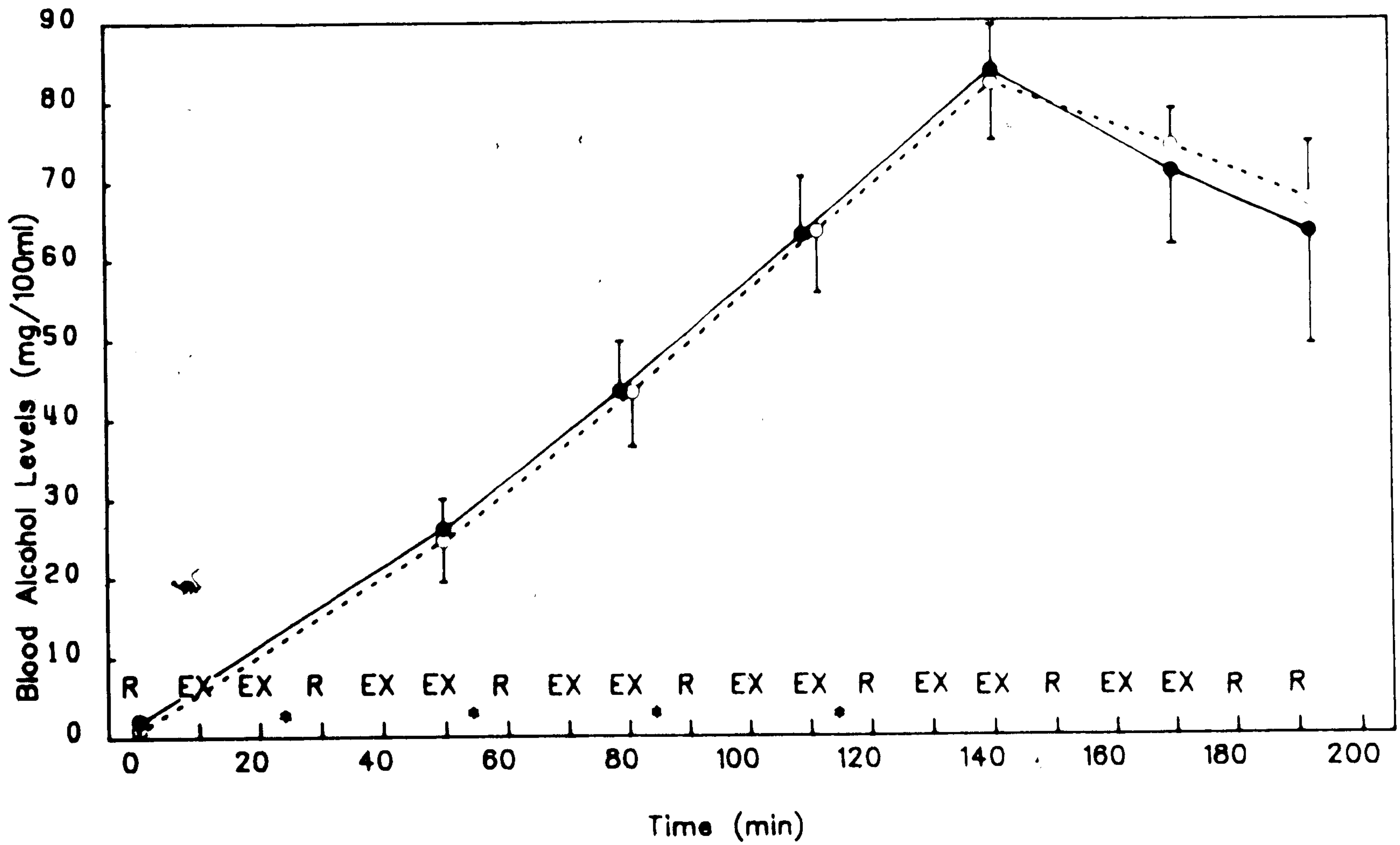

Figure 4-1 Mean blood alcohol levels of subjects working in warm and cold temperatures. The open circles represent the mean values for subjects in warm(n=5), while the closed circles are means for subjects in cold(n=6). The vertical bars represent the standard deviation. Ex and R indicate the exercise and rest periods. "*" indicates time of ethanol ingestion.

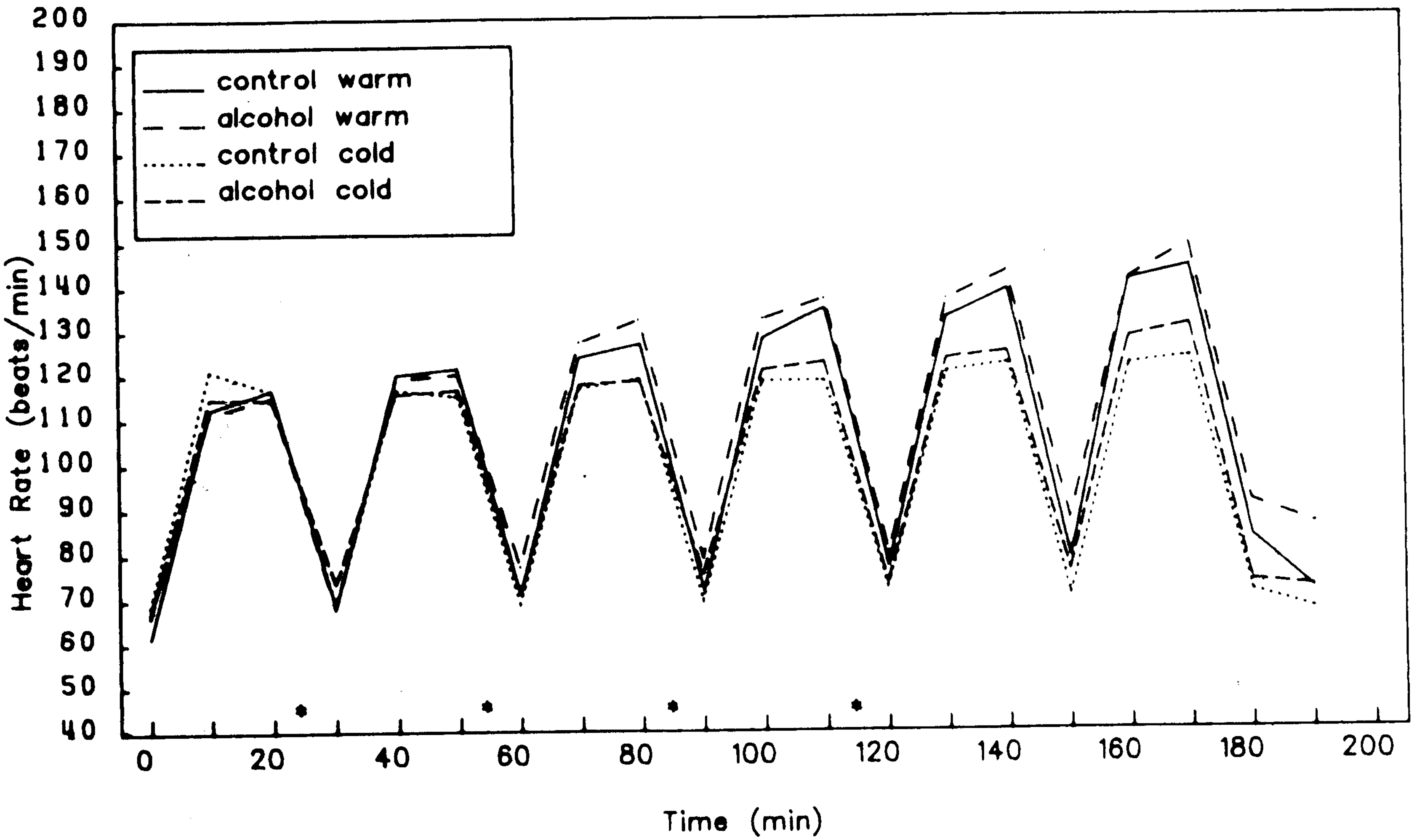

Figure 4-2 Heart rate responses of subjects in warm and cold temperatures * indicates time of ethanol ingestion

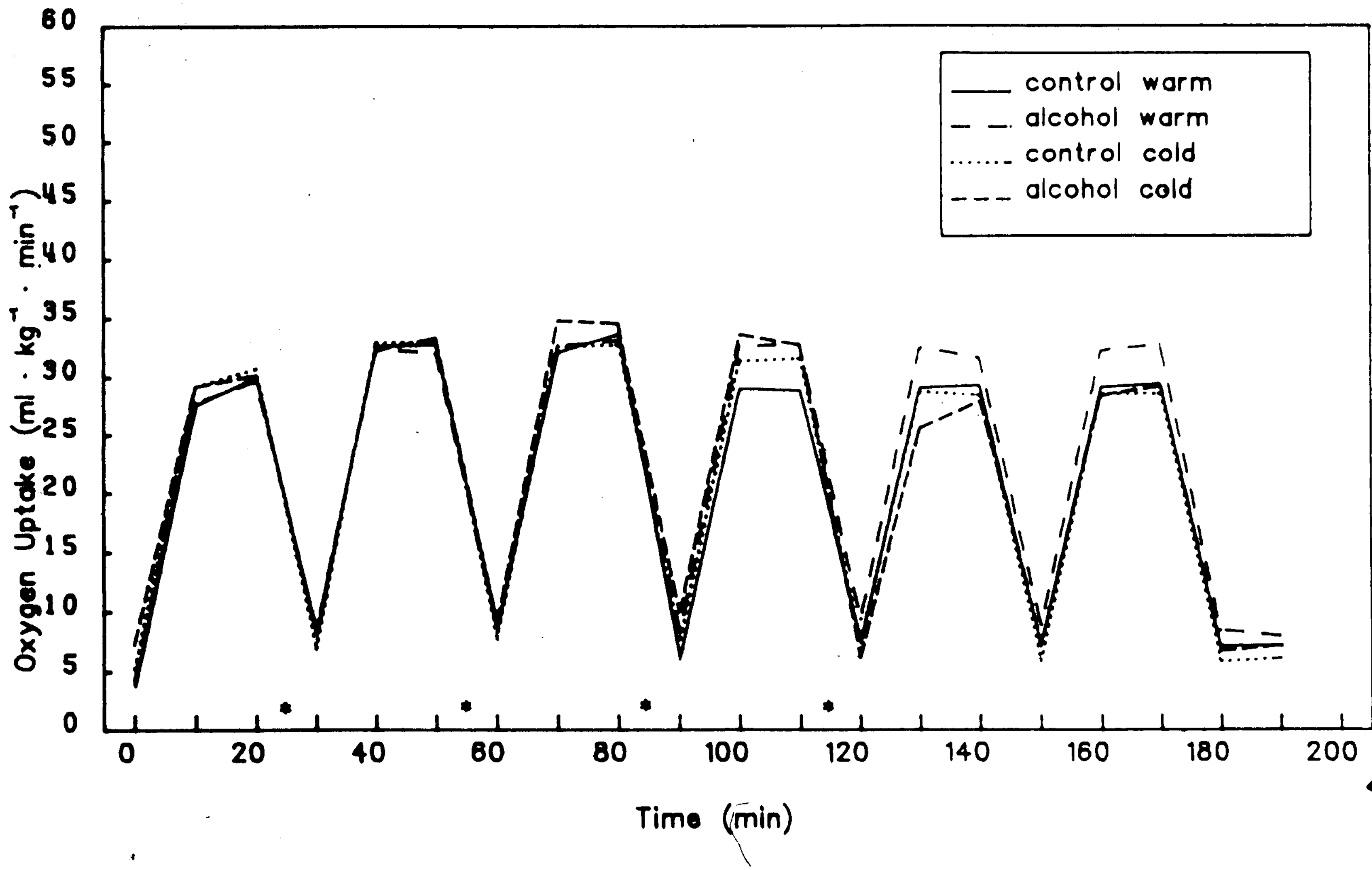

Figure 4-3. Oxygen uptake responses of subjects in warm and cold temperatures   * indicates time of ethanol ingestion

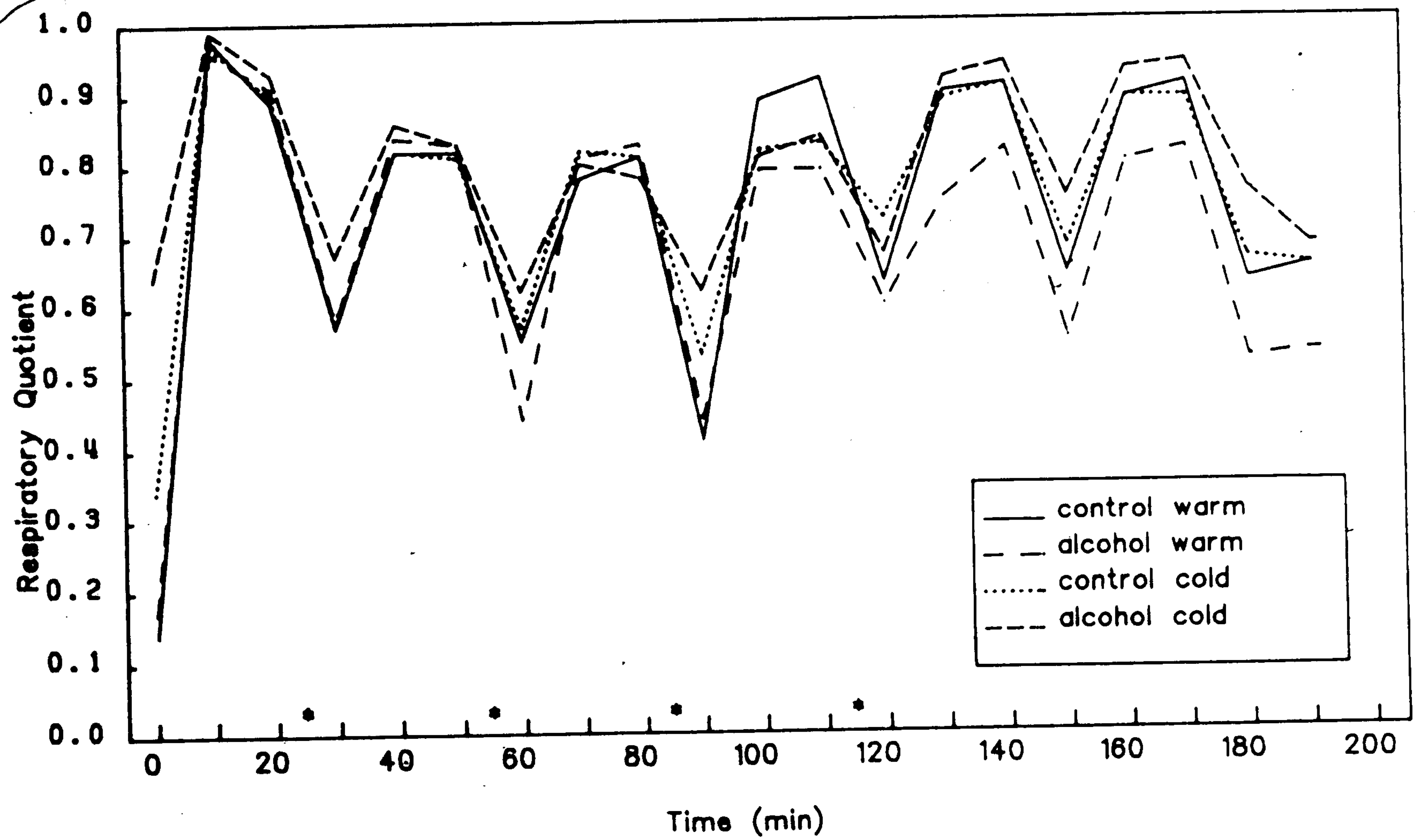

Figure 4-4. Respiratory quotient responses of subjects in warm and cold temperatures "*" indicates time of ethanol ingestion.

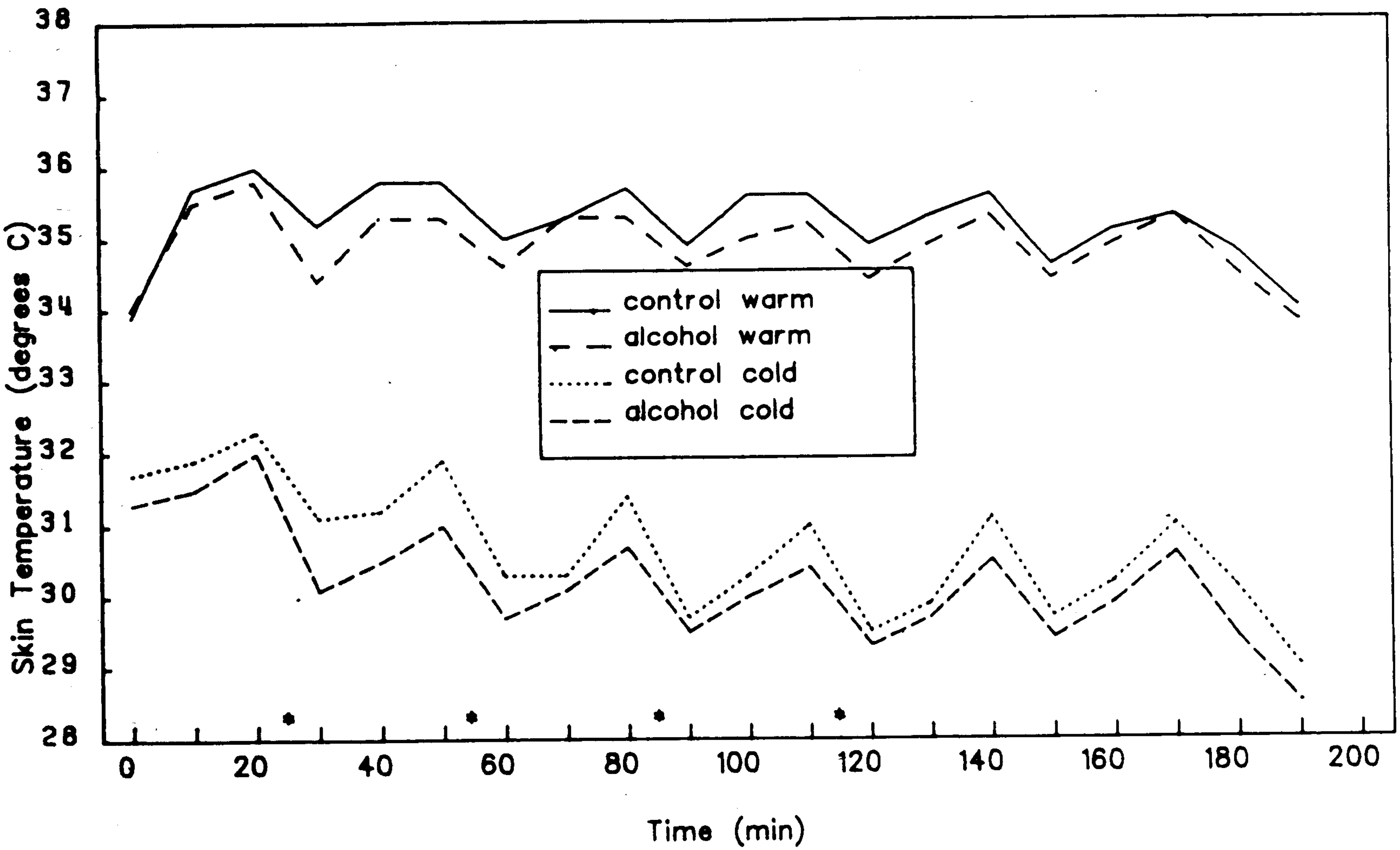

Figure 4-5. Skin temperature responses of subjects in warm and cold temperatures. "*" indicates time of ethanol ingestion.

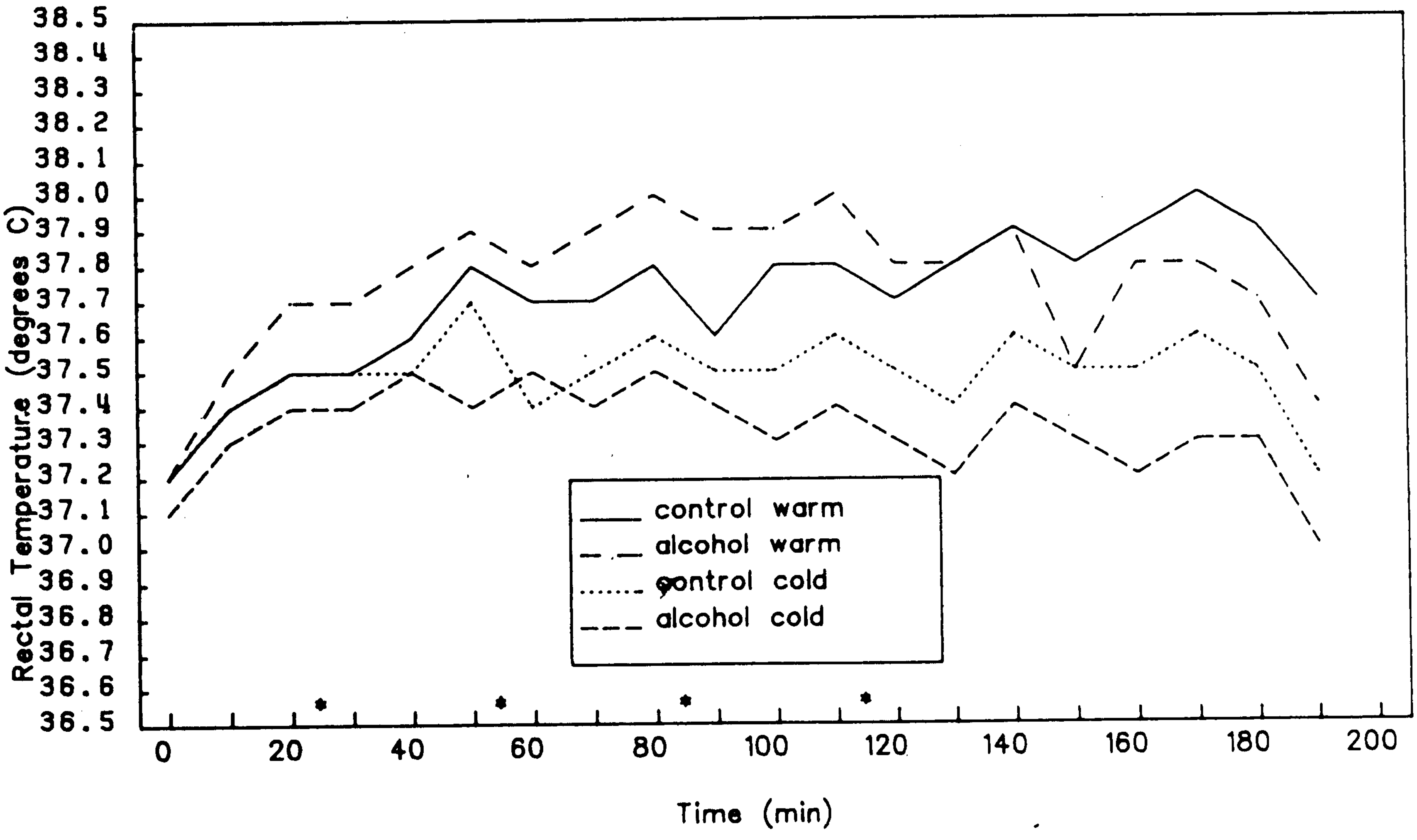

Figure 4-6. Rectal temperature responses of subjects in warm and cold temperatures. *** indicates time of ethanol ingestion.

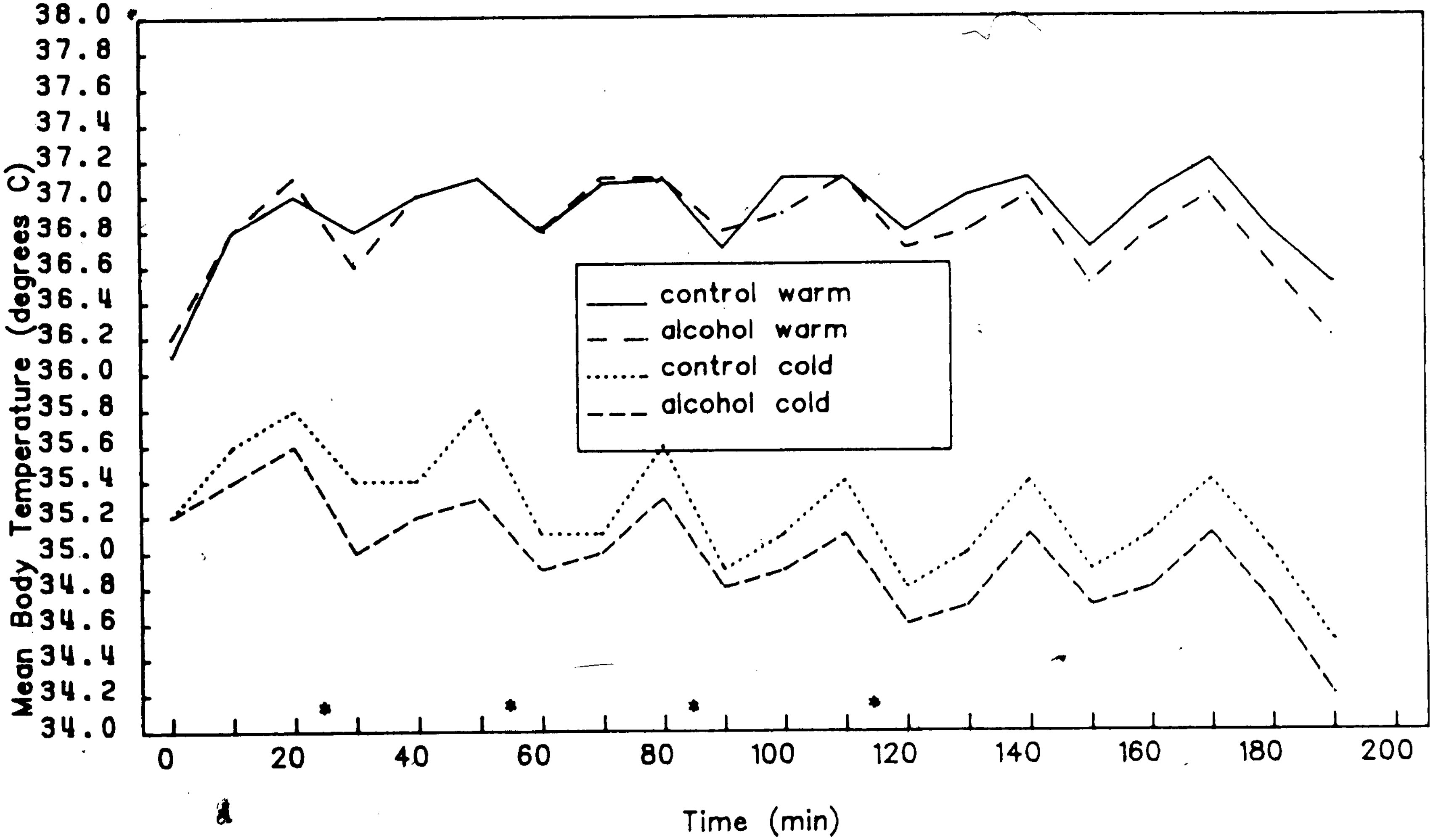

Figure 4-7. Mean body temperatures of subjects in warm and cold temperatures "*" indicates time of ethanol ingestion.

Body Heat Content

Net heat loss of subjects working in warm temperature was similar in both the alcohol and controlled conditions, at measurment times 20 to 140 minutes. However, of the same subjects net heat loss was significantly less ($P \leq 0.05$) in the alcohol condition, compared to the controlled conditions at 170 minutes, as can be seen in Table 4-1. Total heat loss was significantly greater ($P \leq 0.05$) when subjects ingested alcohol in warm temperatures at measurement times of 80, 110, 140 and 170 minutes. Skin conductance of subjects in warm temperatures were significantly less with alcohol when blood alcohol levels were low (50 and 80 min). However, of the same subjects, skin conductance was greater in the alcohol condition when BAL's were high. The differences were statistically significant ($P \leq 0.05$) from control levels at 170 minutes.

The results of body heat content of subjects working working in cold are illustrated in Table 4-2. Net heat loss was significantly ($P \leq 0.05$) less after alcohol ingestion at 50 and 80 minutes. However, net heat loss became greater in subjects ingesting alcohol (140 min), above controlled conditions, but the differences were not statistically significant. Total heat loss was greater after alcohol ingestion, as compared to controlled conditons at each measurment time, and the differences were found to be significant ($P \leq 0.05$) at 170 minutes. Skin conductance was similar or lower in the alcohol condition, compared to the controlled tests, when blood alcohol levels were low. However, as blood alcohol levels became higher, skin conductance was greater in the alcohol condition, but was not statistically different from controlled levels.

Table 4-1

Estimates of Body Heat Loss (Warm Temperature Group)

Measure	Treatment	20 min	50 min	80 min	110 min	140 min	170 min
Net Heat Loss (kcal)	Control	52.10 (9.6)	57.37 (12.4)	59.23 (9.3)	55.99 (11.3)	59.07 (8.8)	60.04 (15.6)
	Alcohol	53.20 (11.6)	52.94 (9.2)	56.84 (9.6)	53.90 (5.1)	49.25 (9.7)	48.25* (11.0)
Total Heat Loss (kcal)	Control	102.78 (9.4)	369.64 (29.3)	518.47 (293.9)	771.99 (101.6)	1004.85 (94.7)	1231.85 (107.0)
	Alcohol	98.79 (9.0)	359.60 (18.8)	626.38* (45.4)	869.61* (73.6)	1085.59* (78.0)	1391.29* (166.2)
Skin Conductance (kcal/m^2/°C/hr)	Control	45.30 (28.0)	111.43 (67.8)	180.00 (56.9)	195.57 (53.5)	259.26 (90.3)	280.84 (133.7)
	Alcohol	33.96 (18.6)	89.44* (32.6)	137.20* (47.7)	185.82 (70.8)	272.32 (143.2)	357.00* (176.0)
Blood Alcohol Level (mg/100ml)		----	25.4	42.6	62.4	81.8	74.4

<u>Note</u>: The numbers represent the mean for all subjects, n=5. The numbers in brackets indicate the standard deviation

* - Value significantly different from control ($P \leq 0.05$)

Heat loss and skin conductance are based on changes from the zero.

Net heat loss - estimated from a formula described by Folk (1974)

Total heat loss - estimated from a formula described by Graham in a personal comment (1982)

Skin Conductance - estimated from a formula described by Robinson (1949)

Table 4-2

Estimates of Body Heat Loss (Cold Temperature Group)

Measure	Treatment	20 min	50 min	80 min	110 min	140 min	170 min
Net Heat Loss (kcal)	Control	47.27	41.23	35.11	28.23	22.60	30.88
		(82.2)	(37.9)	(28.4)	(17.2)	(15.5)	(21.4)
	Alcohol	28.24*	25.61*	20.07*	21.02	28.70	24.58
		(18.4)	(15.2)	(20.3)	(11.6)	(18.4)	(23.2)
Total Heat Loss (kcal)	Control	120.65	409.21	687.97	935.42	1065.10	1304.99
		(27.7)	(54.2)	(96.6)	(104.6)	(130.8)	(201.9)
	Alcohol	135.91	438.96	736.53	978.21	1093.85	1408.32*
		(21.7)	(60.3)	(92.2)	(170.9)	(145.5)	(229.7)
Skin Conductance (kcal/m²/°C/hr)	Control	12.68	38.95	60.20	77.00	91.31	109.08
		(3.7)	(9.4)	(10.8)	(15.2)	(22.7)	(29.0)
	Alcohol	13.36	37.15	57.99	78.66	91.88	114.60
		(2.0)	(8.1)	(12.4)	(10.8)	(16.4)	(28.0)
Blood Alcohol Level (mg/100ml)		----	25.0	43.3	63.3	82.8	71.3

Note: The numbers represent the mean for all subjects, n=6.

Table description is the same as Table 4-1.

Perceptual Responses

The results of questions concerning subjects perception of their thermal environment differ in the mean scores of controlled versus alcohol conditions, as can be seen in Tables 4-3 to 4-11. Subjects ingesting alcohol in warm temperatures perceived the environmental temperature as being higher than responses given in controlled tests. The differences between the mean responses were significant ($P \leq 0.05$) at 58, 178 and 190 minutes (Table 4-3). Subjects of the same temperature group indicated that they desired cooler environmental temperatures after they ingested alcohol, and this response was significantly different from control conditions at 58 minutes (Table 4-4). There were no significant differences found in the questions reflecting "perceived thermal comfort" of subjects in the warm temperature group (Table 4-5 to 4-8). However, mean scores of subjects indicate that they felt warmer in the alcohol tests. Less feelings of discomfort was reported by subjects ingesting alcohol ($P \leq 0.05$), in contrast to controlled conditions at 118 minutes (Table 4-9). This response of subjects feeling less discomfort after alcohol was consistent throughout the experiment except for the final rest period, where more discomfort was indicated. Subjects of the warm temperature tests perceived a slight temperature increase or decrease, or there was no change at all. There were no significant differences found between the alcohol and controlled conditions, (Table 4-10). The same subjects indicated that less time had elapsed since the start of the test when alcohol was ingested, and this response was significantly different ($P \leq 0.05$) from control conditions at 55 and 88 minutes (Table 4-[illegible]).

There were no significant ($P \leq 0.05$) differences apparent between the alcohol and control conditions of subjects perception of environmental temperatures, during the tests conducted in cold temperatures (Table 4-3). The same subjects did not differ in responses (alcohol vs control) to their desire for changes in environmental temperatures (Table 4-4). Subjects working in cold temperatures indicated that they felt warmer after alcohol was ingested, and this response was significantly ($P \leq 0.05$) different from the controlled condition at 58 minutes (Table 4-5). The same subjects reported warmer feelings of their hands in the alcohol tests ($P \leq 0.05$) at times of 88, 148 and 178 minutes (Table 4-6). However, no statistical differences were found of subjects assessment of their feet or face, when controlled tests were compared to alcohol conditions (Tables 4-7 and 4-8). However, the higher scores tended to suggest that warmer sensations of subjects face's were associated with alcohol ingestion. The subjects of the cold temperature group reported feeling less discomfort from the cold stimuli when alcohol was ingested, but the differences from controlled tests were not statistically significant (Table 4-9). The subjects in cold temperatures did not differ in their responses, (controlled versus alcohol conditions) as to their assessment of changes in environmental temperature (Table 4-10); nor was there any differences found in their assessment of elapsed time (Table 4-11).

Table 4-3

The effects of ethanol on subjects perception of the environmental temperature (°C)

Environ. Condition	Treatment	0 min	28 min	58 min	88 min	118 min	148 min	178 min	190 min
	Control	12.2 (8.4)	13.2 (8.2)	12.8 (7.7)	15.9 (3.3)	17.2 (3.3)	16.2 (3.0)	16.2 (3.8)	13.4 (3.8)
WARM (21°C)	Alcohol	18.0 (2.6)	16.4 (1.5)	17.0* (2.1)	17.8 (2.3)	18.8 (2.4)	18.8 (2.4)	19.2* (3.0)	18.4* (3.8)
	BAL (mg/100ml)	———	———	25.4	42.6	62.4	81.8	74.4	66.0
	Control	-1.7 (5.4)	0.2 (7.3)	-0.5 (7.9)	0.5 (6.8)	-0.8 (6.2)	-1.0 (7.3)	-0.7 (9.7)	-4.2 (7.4)
COLD (-5°C)	Alcohol	1.2 (5.6)	2.5 (6.0)	1.3 (6.5)	-1.2 (4.2)	0.3 (4.7)	-1.7 (6.6)	-1.7 (5.9)	-3.0 (5.6)
	BAL (mg/100ml)	———	———	25.0	43.3	63.3	82.8	71.3	63.7

Note: The numbers represent the mean for all subjects (n=5, warm) (n=6, cold) and the numbers in the brackets represent the standard deviation

* - Value significantly different from control ($P \leq 0.05$)

Question subjects were asked: What do you think the temperature is? (°C)

Table 4 4

The effects of ethanol on subjects desire for a change in environmental temperature

Environ Condition	Treatment	0 min	28 min	58 min	88 min	118 min	148 min	178 min	190 min
	Control	2 8 (0 5)	3 4 (0 9)	3 4 (0 5)	4 0 (1 0)	4 4 (0 9)	4 2 (1 1)	4 2 (1 1)	3 6 (0 9)
WARM (21°C)	Alcohol	3 4 (0 5)	3 8 (0 4)	4 2* (0 4)	3 8 (1 1)	4 2 (0 8)	3 8 (1 1)	4 0 (0 7)	3 6 (0 9)
	BAL (mg/100ml)	______	______	25 4	42 6	62 4	81 8	74 4	66 0
	Control	1 3 (0 5)	2 3 (0 8)	1 7 (0 5)	2 0 (0 6)	1 7 (0 5)	1 5 (0 5)	1 5 (0 8)	1 0 (0 0)
COLD (-5°C)	Alcohol	1 0 (0 0)	2 0 (0 6)	2 2 (0 8)	2 3 (0 8)	1 7 (0 5)	1 8 (0 8)	1 7 (0 8)	1 0 (0 0)
	BAL (mg/100ml)	______	______	25 0	43 3	63 3	82 8	71 3	63 7

Table description is the same as Table 4-3

Question subjects were asked How would you like the temperature to be?

Answer Key

1 Warmer
2 Slightly warmer
3 Just as it is
4 Slightly cooler
5 Cooler

Table 4-5

The effects of ethanol on subjects perception of thermal comfort of their body

Environ Condition	Treatment	0 min	28 min	58 min	88 min	118 min	148 min	178 min	190 min
	Control	-0.4 (0.5)	1.4 (0.5)	1.8 (0.4)	2.4 (0.5)	2.6 (0.5)	2.6 (0.5)	2.6 (0.5)	1.0 (0.7)
WARM (21°C)	Alcohol	0.4 (0.5)	1.2 (0.4)	1.4 (0.9)	1.6 (1.1)	1.6 (1.1)	2.0 (0.7)	1.8 (0.8)	0.8 (0.8)
	BAL (mg/100ml)	———	———	25.4	42.6	62.4	81.8	74.4	66.0
	Control	-1.7 (1.0)	0.0 (1.5)	0.0 (1.3)	0.7 (1.8)	0.0 (1.9)	0.0 (2.4)	0.3 (1.9)	-2.8 (0.4)
COLD (-5°C)	Alcohol	-1.7 (0.8)	0.2 (1.0)	0.5 (1.5)	1.0* (1.3)	0.0 (1.7)	0.2 (2.1)	0.0 (2.3)	-2.2 (1.0)
	BAL (mg/100ml)	———	———	25.0	43.3	63.3	82.8	71.3	63.7

Table description is the same as Table 4-3

Question subjects were asked: How do you feel?

Answer Key:

-3 Cold
-2 Cool
-1 Slightly Cool
0 Neutral
+1 Slightly Warm
+2 Warm
+3 Hot

Table 4-6

The effects of ethanol on subjects perception of thermal comfort of their hands

Environ Condition	Treatment	0 min	28 min	58 min	88 min	118 min	148 min	178 min	190 min
	Control	0.2 (1.1)	1.0 (0.7)	1.6 (0.5)	1.8 (1.1)	2.4 (0.5)	2.6 (0.5)	2.6 (0.5)	0.8 (1.1)
WARM (21°C)	Alcohol	0.4 (0.5)	0.8 (0.8)	1.2 (1.1)	1.4 (1.3)	1.8 (0.8)	2.0 (0.7)	2.0 (0.7)	0.6 (0.9)
	BAL (mg/100ml)	———	———	25.4	42.6	62.4	81.8	74.4	66.0
	Control	-1.2 (1.3)	-0.3 (1.4)	0.0 (0.6)	-0.7 (1.4)	-0.7 (0.8)	-1.0 (1.7)	-1.0 (1.5)	-2.5 (0.8)
COLD (-5°C)	Alcohol	-1.7 (1.2)	-0.2 (1.0)	0.5 (0.8)	1.0* (0.9)	0.7 (1.2)	0.5* (2.0)	0.5* (2.3)	-2.2 (0.8)
	BAL (mg/100ml)	———	———	25.0	43.3	63.3	82.8	71.3	63.7

Table description is the same as the Table 4-3.

Question subjects were asked: How do your hands feel?

<u>Answer Key</u>

-3 Cold
-2 Cool
-1 Slightly Cool
0 Neutral
+1 Slightly Warm
+2 Warm
+3 Hot

Table 4-7

The effects of ethanol on subjects perception of thermal comfort of their feet

Environ. Condition	Treatment	0 min	28 min	58 min	88 min	118 min	148 min	178 min	190 min
WARM (21°C)	Control	0.2 (1.1)	0.4 (1.1)	0.8 (1.3)	1.6 (1.7)	1.8 (1.3)	2.0 (1.0)	2.4 (0.9)	1.0 (1.4)
	Alcohol	0.0 (0.7)	0.4 (1.1)	1.0 (1.4)	1.2 (1.1)	1.4 (0.5)	1.06 (0.9)	1.8 (0.8)	0.8 (0.8)
	BAL (mg/100ml)	———	———	25.4	42.6	62.4	81.8	74.4	66.0
COLD (-5°C)	Control	0.3 (0.8)	-0.7 (1.2)	-2.2 (1.0)	-2.7 (0.5)	-2.7 (0.5)	-2.8 (0.4)	-2.2 (1.0)	-2.8 (0.4)
	Alcohol	-0.3 (1.0)	-0.5 (1.2)	-1.7 (0.8)	-2.2 (0.8)	-2.3 (0.8)	-2.3 (1.2)	-2.5 (0.5)	-3.0 (0.0)
	BAL (mg/100ml)	———	———	25.0	43.3	63.3	82.8	71.3	63.7

Table description is the same as Table 4-3.

Question subjects were asked: How do your feet feel?

Answer Key.

-3 Cold
-2 Cool
-1 Slightly Cool
0 Neutral
+1 Slightly Warm
+2 Warm
+3 Hot

Table 4-8

The effects of ethamol on subjects perception of thermal comfort of their face

Environ. Condition	Treatment	0 min	28 min	58 min	88 min	118 min	148 min	178 min	190 min
WARM (21°C)	Control	0.4 (0.9)	1.8 (0.8)	2.2 (0.5)	2.6 (0.5)	2.8 (0.4)	2.8 (0.4)	2.8 (0.4)	1.0 (1.0)
	Alcohol	0.2 (0.4)	1.2 (0.8)	1.6 (0.9)	1.8 (1.1)	2.2 (0.8)	2.2 (0.8)	2.2 (0.8)	1.0 (1.0)
	BAL (mg/100ml)	———	———	25.4	42.6	62.4	81.8	74.4	66.0
COLD (-5°C)	Control	-0.7 (1.0)	0.5 (0.8)	0.2 (1.2)	-0.3 (1.6)	-0.2 (1.2)	0.2 (1.5)	0.5 (1.0)	-1.7 (1.2)
	Alcohol	-0.8 (0.4)	0.2 (0.8)	0.2 (1.0)	0.5 (0.5)	0.3 (1.4)	0.5 (1.4)	0.5 (1.9)	-1.3 (1.4)
	BAL (mg/100ml)	———	———	25.0	43.3	63.3	82.8	71.3	63.7

Table description is the same as Table 4-3

Question subjects were asked: How does your face feel?

Answer Key:

-3 Cold
-2 Cool
-1 Slightly Cool
0 Neutral
+1 Slightly Warm
+2 Warm
+3 Hot

Table 4-9

The effects of ethanol on subjects feelings of discomfort

Environ. Condition	Treatment	0 min	28 min	58 min	88 min	118 min	148 min	178 min	190 min
WARM (21°C)	Control	0.8 (1.8)	1.6 (1.5)	2.2 (2.0)	2.6 (1.5)	4.4 (0.5)	4.2 (2.5)	5.4 (1.3)	0.8 (0.8)
	Alcohol	0.0 (0.0)	0.8 (0.8)	1.4 (1.3)	2.0 (1.6)	2.0* (1.6)	3.0 (1.7)	3.4 (2.1)	1.6 (1.8)
	BAL (mg/100ml)	———	———	25.4	42.6	62.4	81.8	74.4	66.0
COLD (-5°C)	Control	1.5 (1.8)	1.7 (1.6)	2.0 (2.3)	2.3 (2.5)	2.7 (2.3)	3.0 (2.4)	3.5 (1.8)	4.2 (2.1)
	Alcohol	1.2 (1.8)	1.3 (1.8)	1.3 (1.9)	1.8 (1.2)	1.7 (1.5)	2.5 (3.0)	2.8 (3.3)	2.8 (2.9)
	BAL (mg/100ml)	———	———	25.0	43.3	63.3	82.8	71.3	63.7

Table description is the same as Table 4-3

Question subjects were asked: Are you experiencing any discomfort?

Answer Key

0 None at all
1 Very, Very Weak
2 Very Weak
3 Fairly Weak
4 Neither Weak nor Strong
5 Fairly Strong
6 Strong
7 Very Strong
8 Very, Very Strong
9 Maximal

Table 4-10

The effects of ethanol on subjects assessment of any change in Environmental Temperature

Environ. Condition	Treatment	28 min	58 min	88 min	118 min	148 min	178 min	190 min
	Control	5.2 (1.5)	5.0 (1.2)	4.4 (2.1)	3.4 (2.1)	4.4 (2.4)	4.0 (2.2)	4.4 (2.1)
WARM (21°C)	Alcohol	5.6 (0.9)	5.6 (1.1)	5.4 (0.9)	5.0 (1.2)	4.6 (1.1)	4.0 (1.2)	5.0 (0.7)
	BAL (mg/100ml)	———	25.4	42.6	62.4	81.8	74.4	66.0
	Control	4.7 (1.0)	5.3 (1.4)	4.8 (1.2)	4.7 (1.5)	5.0 (1.7)	5.7 (1.6)	6.7 (1.4)
COLD (-5°C)	Alcohol	4.8 (1.3)	5.2 (1.3)	5.3 (1.6)	3.5 (1.4)	6.0 (1.8)	4.8 (2.2)	6.0 (2.7)
	BAL (mg/100ml)	———	25.0	43.3	63.3	82.8	71.3	63.7

Table description is the same as Table 4-3

Question subjects were asked: Indicate how much the temperature has changed since you entered the room?

Answer Key

1 Large Increase
2 Moderate Increase
3 Slight Increase
4 Barely Noticable Increase
5 None at All
6 Barely Noticable Decrease
7 Slight Decrease
8 Moderate Decrease
9 Large Decrease

Table 4-11

The effects of ethanol on subjects assessment of elapsed time (minutes)

Environ. Condition	Treatment	28 min	58 min	88 min	118 min	148 min	178 min	190 min
	Control	22.3 (7.3)	51.9 (13.4)	80.9 (21.6)	114.0 (18.4)	137.2 (23.8)	168.0 (27.2)	185.8 (27.5)
WARM (21°C)	Alcohol	23.0 (5.6)	43.8* (9.0)	68.8* (9.2)	98.2 (14.4)	140.6 (23.2)	157.6 (29.0)	181.3 (27.6)
	BAL (mg/100ml)	——	25.4	42.6	62.4	81.8	74.4	66.0
	Control	28.0 (13.8)	54.8 (11.1)	82.2 (12.8)	109.2 (19.3)	136.7 (21.8)	170.3 (20.2)	192.5 (28.6)
COLD (-5°C)	Alcohol	21.5 (5.2)	50.5 (9.7)	78.7 (14.2)	110.0 (17.9)	138.7 (30.0)	156.0 (22.1)	179.5 (21.5)
	BAL (mg/100ml)	——	25.0	43.3	63.3	82.8	71.3	63.7

Table description is the same as Table 4-3

Question subjects were asked: Indicate the amount of time (min) you think has elasped since you entered the room?

V. Discussion

The findings of this study suggest that ethanol ingestion alters normal thermoregulatory functions of subjects exercising in both warm and cold environmental temperatures. These changes appeared more pronounced when blood alcohol levels of subjects were high. The questionaires that assessed subjects perception of their thermal environment indicated changes from controlled states to alcohol conditions. The alterations in perception suggested that alcohol ingestion impaired subjects interpretation of their thermal state or condition.

The higher heart rates found in subjects of the warm temperature group, may be due to an increase in blood circulation, as affected by warmer temperatures and the effects of exercise. The higher heart rates associated with ethanol ingestion are in agreement with reports of Hebbelinck (1962), Blomqvist et al (1970) and Graham (1981), but in contrast to the findings of Garlind et al (1960), Riff et al (1969) and Graham (1981). Although this action of ethanol appears to be uncertain in the literature reviewed, an increase in blood flow following alcohol ingestion (Gillespie, 1967) may have been influential in the changes in heart rate. The apparent lack of experimental work in cardiovascular and neurological mechanisms associated with heart rate, may be the limiting factors causing uncertainty to this action of ethanol.

The present study showed no differences in mean oxygen uptake (VO2) of subjects in warm versus those in cold temperatures. This finding appears to be in contradiction to the common agreement of various authors, for example Schvartz et al (1977), who indicates that VO2 was higher in subjects exercising in cold compared to warm temperatures. The contrast in results between the present study and those studies of others may be due to differences in exercise intensity and/or duration, or the lack of a shivering response by subjects in cold temperatures. The findings of higher VO2 responses with ethanol ingestion of subjects in both temperature groups, are in agreement with the reports of Blomqvist et al (1970), but in contrast to the findings of Garlind et al (1960) and Barnes et al (1965). Similiar results were found in the cold temperature group of the present study, which supports the findings of work by Risbo et al (1981), but not with Graham's (1981) reports. Risbo and co-workers suggest that higher VO2 responses may be the result of the specific dynamic effect of ethanol. In the present study VO2 declined below control levels in cold temperatures when blood alcohol levels were high, and this response is supported by similar findings found in reports by Graham (1981). This apparent lack of a reflex response to cold, as reflected by reduced VO2 levels after alcohol ingestion, suggests that ethanol may inhibit a response (ie. shivering) normally seen in a non-alcohol condition.

Writers of authoratative textbooks, for example Mathews and Fox (1976), suggest that the respiratory quotient (RQ) of ethanol is 0.67 on complete oxidation, while that of other energy sources are higher, for example; carbohydrates, proteins and fats. Therefore, one would expect lower RQ levels with the ingestion of alcohol, if alcohol had taken the place of other energy sources. The present study appears to support such a response, as was demonstrated by subjects who ingested alcohol while exercising in warm temperatures. However, this action of alcohol was not apparent in the RQ responses of subjects working in cold temperatures, which is in agreement with the findings of Graham (1981).

The similarities found in net heat loss levels of subjects (control and alcohol) in warm temperatures appears to be due to limited differences found in (control and alcohol) mean body temperatures. However, higher VO2 responses with alcohol may have contributed to the higher total heat loss found in the same subjects. Higher skin conductance for the alcohol treatments suggests that a greater vasodilatory response (above that produced by exercise) may of been associated with the ingestion of alcohol. These findings suggest that alcohol may have been maintaining a high heat conductance through the periphery, despite reduced skin and rectal temperatures.

Previous studies on human subjects exposed to warm temperatures (Andersen et al, 1963; Kuehn et al, 1978 and Livingston et al, 1980) indicate no significant changes in body temperatures, as a result of ethanol. However, studies of rats resting in room temperatures and injected with ethanol (Lomax et al, 1981 and Myers, 1981) have demonstrated a decrease in body core temperatures. Myers suggested that ethanol acts acutely as any other anesthetic agent to impair all thermoregulatory functions. He concluded that the physiological mechanisms for the dissipation of body heat as well as those for heat production are incapacitated by ethanol.

The greater heat loss found in subjects ingesting alcohol in cold temperatures is in agreement with the findings of Haight and Keatinge (1973), Graham and Dalton (1980) and Graham (1981). The results of subjects skin and rectal temperatures were also similar to the reports from these workers. Graham (1981) suggests that the increased heat loss with ethanol is the combined result of a lack of a rise in rectal temperature and a greater decline in skin temperature. Although heat loss was greater with ethanol, skin temperature was cooler and skin conductance lower (20 to 110 minutes only). From this response, Graham (1981) has suggested that ethanol may not have been maintaining peripheral vasodilation relative to the control state. However, when BAL's were high (140 and 170 min) skin conductance was higher with ethanol, which Robinson (1949) suggests reflects an increase in cutaneous blood flow.

The results of the questionaires reflecting subjects perception of their thermal environment indicate differences when controlled conditions were compared to tests involving alcohol ingestion. Subject's feelings of less discomfort after alcohol ingestion is in agreement with previous reports (Graham, 198·) of subjects exposed to cold temperatures. Despite the colder body temperatures found of subjects ingesting alcohol, they indicated feeling warmer than controlled tests. Although studies of the past appear limited in studying perceptual responses of subjects ingesting alcohol during exercise; the present study suggests that normal perception of subjects thermal environment was impaired during tests with alcohol.

The results of measures of perception may have been influenced by subjects learning the experimental procedures after the first test session. Also, many of the subjects communicated with each other as to the test procedures.

VI. Summary

The effects of ethanol ingestion on thermoregulatory mechanisms of men undertaking moderate exercise in warm and cold temperatures has been investigated. Previous authors have reported conflicting results, as to the effects of ethanol on subjects either exposed to or immersed in warm and/or cold temperatures. The results of this study tend to support the findings of previous reports involving similar experimental conditions. The results indicate that an increased heat loss may be associated with the ingestion of moderate amounts of ethanol.

Although none of the subjects working in cold temperatures demonstrated clear signs of hypothermia, reduced body temperatures were evident when blood alcohol levels were high. Subjects of both temperature groups, perceived their thermal environment and that of thermal comfort as being less stressful after alcohol ingestion, compared to the controlled conditions. The impairment of subjects perceptual senses may have prevented their undertaking of adequate precautions, if their situation became more stressful. This alteration in subjects perception may be an influential factor in cases of accidental hypothermia. Thus, it is the opinion of this author, that based upon the findings of this study, ethanol ingestion is not recommended for people who participate in outdoor activities.

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VIII. Appendices

Appendix

Figure 1. Pathways of alcohol (ethanol) metabolism in man.

ADM, alcohol dehydrogenase; MEOS, microsomal ethanol oxidizing system; SER, smooth endoplasmic reticulum.

From Pawan (1972)

Appendix 2

Assessment of percent body fat [illegible]

Skinfold measurements as described by Durnin and Womersley (1974)

Equipment: Harpenden skinfold calipers.

Skinfold measurement sites: triceps, biceps, subscapular and supra-iliac.

All measurements were recorded (mm) and each site was measured three times. Percent body fat was determined from the total of the average values obtained at the four skinfold sites. Percent body fat was estimated from the chart on the following page.

Skinfolds (mm)	Males (age in years)				Females (age in years)			
	[illegible] 29	30 39	40 49	50	16 29	30 39	40 49	50
120	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	39 6	[illegible]	[illegible]
125	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
130	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
135	[illegible]	[illegible]	[illegible]	42 4	40 8	[illegible]	[illegible]	[illegible]
140	[illegible]	[illegible]	[illegible]	43 0	[illegible]	[illegible]	[illegible]	[illegible]
145	[illegible]	[illegible]	[illegible]	43 6	[illegible]	[illegible]	[illegible]	[illegible]
150	[illegible]	[illegible]	40 2	[illegible]	[illegible]	42 6	45 0	48 2
155	[illegible]	[illegible]	[illegible]	44 6	42 8	[illegible]	45 4	[illegible]
160	[illegible]	34 3	41 3	45 1	43 3	43 6	45 8	49 2
165	[illegible]	34 6	41 6	45 6	43 7	44 0	46 2	49 6
170	34 5	34 8	42 0	46 1	44 1	44 4	46 6	50 0
175	34 9			—	—	44 8	47 0	50 4
180	35 3		—	—	—	45 2	47 4	50 8
185	35 6	—		—	—	45 6	47 8	51 2
190	35 9	—		—	—	45 9	48 2	51 6
195			—	—	—	46 2	48 5	52 0
200		—	—	—	—	46 5	48 8	52 4
205		—	—	—	—	—	49 1	52 7
210	—	—	—	—	—	—	49 4	53 0

In two-thirds of the instances the error was within ± 3 5% of the body-weight as fat for the women and ± 5% for the men

The equivalent fat content, as a percentage of bodyweight, for a range of values for the sum of four skinfolds (biceps, triceps subscapular and supra-iliac) of males and females of different ages

* By J V G A Durnin and J Womersley "Body fat assessed from total body density and its estimation from skinfold thickness measurements on 481 men and women aged from 16 to 72 years" *British Journal of Nutrition*, 32 77-97, 1974

Appendix 2-B.

Assessment of percent body fat - Densitometry

From MacNab and Quinney (1980).

MEASUREMENTS SUBJECT ______

(1) Wt. in air ______ (lbs.)

(2) Vital capacity (V.C.) ______ (litres) x 61.02 = ______ (cu. in.)

(3) Residual Volume 25% (Males) / 30% (Females) of V.C. = ______ (cu. in.)

(4) Vol. Gastro-intestinal track (VGI) = 7.01 (cu. in.)

(5) Wt. in water (full inspiration) = ______ (lbs.)

Wt. in water = [Chart Reading x belt wt. / 75] - belt weight (lbs) = ______

CALCULATIONS:

(6) Total body air (T.B.A.) = V.C. ______ (cu. in.) (from 2 above)
+ R.V. ______ (cu. in.) (from 3 above)
+ RGI 7.01 (cu. in.)
= ______ x 0.0362 = (lbs.)

(7) True wt. in water = weight in water (from 5 above) ______ (lbs.)
+ total body air (from 6 above) ______ (lbs.)
= ______ (lbs.)

(8) Body Volume = wt. in air (1) ______ - true wt. in water (7) ______
= ______ (lbs.)

(9) Body Density = [wt. in air (1) ______ / Body volume (8) ______] X density of H_2O ______ = ______

(10) % Fat = [4.570 / Body Density - 4.142] x 100
= ______ %

(11) Lbs. fat = [______ (% fat) x ______ (wt. in air)] - 100
= ______ (lbs.)

(12) Lbs. fat free wt. = ______ wt. in air (1) - Lbs. fat (11) ______
= ______ (lbs. fat free wt.)

Appendix 2-C.

Assessment of maximum oxygen uptake (VO2 max)

Modified Astrand Test (bicycle - continuous)

Equipment:

1. Bicycle ergometer (Uniwork, Quinton Instruments).
2. Cardiotachometer (Cardionics AB, Stockholm)
3. Metabolic Measurement Cart (Beckman Instruments Inc.)

Protocol:

1. Weigh subject (kg).
2. Adjust bicycle seat to appropriate height.
3. Attach electrodes (for heart rate) on subject.
4. Adjust breathing valve and nose clip.
5. All subjects pedalled at a workload of 400kpm/min (60 RPM) for a period of 4 minutes (warm-up).
6. Workload was increased by 100 kpm/min every minute following the warm-up.
7. Subjects pedalled to exhaustion.
8. During the tests, the expired air w[illegible]nalysed for oxygen and carbon dioxide content by th[illegible]an MMC at 30 second intervals. The criterion for attaining VO2 max. is an asymptote or an increase of less than 80 ml/min. in the oxygen uptake measurements.

Appendix 3-A.

Data Sheet Used For Experiments

Subject: Wt. (kg): Temp. Group: Workload (kpm):

Ethanol Ingestion (ml): Orange Juice (ml): Date: Time:

Time (min)	Ex/ Rest	HR (b/min) Con/ Alc		VO_2 (ml/kg/min) Con/ Alc		Tr (°C) Con/Alc		Skin Temp. (°C) Pect C/A	Delt C/A	Thigh C/A	Gast C/A	RQ C/A	BAL (mg/100ml) Con/ Al.
0													
10													
20													
30													
40													
50													
60													
70													
80													
90													
100													
110													
120													
130													
140													
150													
160													
170													
180													
190													

Appendix 3-B.

Questionaires used to assess "perceptual" measures of subjects.

Q1a: Please indicate what you think the current room temperature is by putting a vertical mark through the scale below.

-30 -20 -10 0 10 20 30 40

(°C)

Q1b: What do you think of the temperature in here? Would you like it to be:

1 __ Warmer
2 __ Slightly Warmer
3 __ Just as it is
4 __ Slightly Cooler
5 __ Cooler

Q1c: How do you feel?

__ -3 Cold
__ -2 Cool
__ -1 Slightly Cool
__ 0 Neutral
__ +1 Slightly Warm
__ +2 Warm
__ +3 Hot

Q1d: How are your hands?

__ -3
__ -2
__ -1
__ 0
__ +1
__ +2
__ +3

Q1e: How are your feet?

__ -3
__ -2
__ -1
__ 0
__ +1
__ +2
__ +3

Q1f: How does your face feel?

__ -3
__ -2
__ -1
__ 0
__ +1
__ +2
__ +3

Q1g: Are you experiencing any discomfort?

0 Not at all

1 Very, Very Weak (Hardly noticable)

2 Very Weak

3 Fairly Weak

4 Neither weak nor strong

5 Fairly strong

6__ Strong

7__ Very strong

8__ Very, very strong

9__ Maximal

Q2a: Please indicated how muc the temperature has changed since you entered the room?

1__ Large increase

2__ Moderate increase

3__ Slight increase

4__ Barely noticable increase

5__ None at all

6__ Barely noticable decrease

7__ Slight decrease

8__ Moderate decrease

9__ Large decrease

Q2b: Please indicate the amount of time you think has elapsed since you entered the room? Please answer in minutes.

Appendix 3-C.

Subject Characteristics Table

(Warm and Cold Temperature Conditions)

Subject	Age	Wt. (kg)	Ht. (cm)	VO2 Max (ml•kg •min)	Body Surface Area (m^2)	Percent Body Fat Skinfolds	Percent Body Fat Densitometry
N.C.	21	72	179	61.3	1.9	[illegible]	8.1
G.M.	27	69.6	171	64.8	1.8	10.5	8.6
A.M.	28	73.9	184	65.1	1.96	12.9	16.2
J.B.	28	69	172	68.4	1.82	8.1	[illegible]
R.T.	29	69.5	173	62.9	1.82	8.1	[illegible]
J.W.	26	80.2	174.5	61.5	1.96	[illegible]	[illegible]
Mean (warm)	26.5	70.8	175.8	64.5	1.86	[illegible]	[illegible]
R.S.	25	70.7	172	62.2	1.82	12.9	[illegible]
B.D.	19	70.1	173	63.6	1.82	12.5	5.6
P.H.	23	69.2	165	67.6	1.76	8.1	6.1
D.B.	30	72.5	173.5	61.2	1.88	[illegible]	[illegible]
A.A.	21	93.4	193.5	68.2	2.22	8.1	14.2
J.G.	28	74.1	178.5	60.2	1.8[illegible]	[illegible]	8.6
Mean (cold)	24.3	75.0	175.9	63.8	1.9[illegible]	[illegible]	[illegible]

Appendix 4-A

Formulas used in determining Mean Skin Temperature, Mean Body Temperature and Thermal Conductance of Tissues

Mean Skin Temperature (Tsk): From Mitchell and Wyndham (1969).

Tsk (°C) = 0.3(Pectoralis+Deltoid) + 0.2(Quadracep+Gastrocnemius)

Mean Body Temperature (Tmean): From Folk (1974).

Tmean (°C) = 0.33 x Tsk + 0.67 x Tr

Thermal Conductance of Tissues: From Robinson (1949).

Equation: $C = \frac{Ms}{A(Tr-Tsk)}$ expressed in (kcal/m²/°C/hr)

Where C is the coefficient of heat conductance of tissues, Ms is the metabolic heat loss through the skin (total heat loss), A is the body surface area in square meters, Tr is the rectal temperature and Tsk is skin temperature. Robinson (1949) suggests that the rate of conductance is dependent on the rate of cutaneous blood flow.

Appendix 4-B.

Calculations for Net and Total Heat Loss.

Net Heat Gain or Loss (kcal): (From Folk, 1974)

= Mass (kg) x Specific Heat (0.83) x Body Temperature Change (°C).

Total Heat Gain or Loss (kcal): described by Graham (personal comment, 1982).

Total heat gain or loss = 75% of VO2 (l/min) x 4.825 ± Net heat gain or loss.

The value "75%" represents the mechanical efficiency of work (ME) (Astrand and Rodahl, 1977) as the ratio of external work performed, to the extra energy production. Astrand and Rodahl suggest, "that when a person exercises on a bicycle ergometer the ME rises to, 20 to 25 percent; ie. 75 to 80 percent of the energy is dissipated as heat."

The value 4.825 represents an estimated number of kilo calories yielded per one litre of oxygen, as suggested by Mathews and Fox (1976).

Example:

VO2 (l/min) = 2.1

Net heat gain or loss = 57.17 kcal

75% of VO2 (l/min) x 4.825 x ± net heat gain or loss

= 1.58 x 4.825 x 20 (minutes of time) - 57.17

= 7.60 x 20 - 57.17

= 151.99 - 57.17

= 94.82 kcal

or if Net heat loss were (negative) -57.77, then:

7.60 x 20 + 57.77

= 151.99 + 57.77

= 209.76 kcal

Appendix 4-C

Student-Newman-Kuels Test

Formula: $$S_{\bar{x}} = \sqrt{\frac{\text{MS Within}}{n}}$$

Where $S_{\bar{x}}$ represents the "critical difference". Ms represents "Mean Squares Within" from Analysis of Variance (ANOVA) Tables, and n indicates the "number of distinct cases used", from ANOVA Tables.

Example:

Ms within = 27.839; number of distinct cases = 11; degrees of freedom (df) = 81.

$$S_{\bar{x}} = \sqrt{\frac{\text{MS Within}}{n}}$$

$$S_{\bar{x}} = \sqrt{\frac{27.839}{11}}$$

$$S_{\bar{x}} = \sqrt{2.53}$$

$$S_{\bar{x}} = 1.59$$

Locate the df value in Student-Newman-Kuels Tables (for eg. Moorehouse and Stull [illegible] 376-378) at the 0.05 level. The value from these Tables = 2.81. Then multiply $S_{\bar{x}}$ by this value (2.81), which equals 4.47. Therefore, if two means obtained are different by 4.47, the the means are significantly different ($P \leq 0.05$).

Appendix 5.

Analysis of Variance Tables.

Heart Rate

Oxygen Uptake

Respiratory Quotient

Mean Skin Temperature

Rectal Temperature

Mean Body Temperature

Net Heat Loss

Total Heat Loss

Skin Conductance

Questionaires of Perceptual Measures

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FILE RESEARCH (CREATION DATE = 09/15/82) CONDUCTED BY BOB GURNEY

Analysis of Variance (ANOVA) Summary Table (Heart Rate 0 to 90 minutes)

BETWEEN SUBJECT FACTORS ARE:

A - V3 : 1 , 2

WITHIN SUBJECT FACTORS ARE:

B - GROUP : 1 CONTROL , 2 ALCOHOL

C - TEST : 1 TIME1 , 2 TIME2 , 3 TIME3 , 4 TIME4 , 5 TIME5
6 TIME6 , 7 TIME7 , 8 TIME8 , 9 TIME9 , 10 TIME10

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
A	284 318	1	284 318	0 267	0.618
S-WITHIN	9598.000	9	1066 444		
B	92 045	1	92 045	0 814	0.391
AB	44.318	1	44 318	0 392	0.547
BS-WITHIN	1018.000	9	113 111		
C	124765.563	9	13862 840	271 952	0 001
AC	1385 114	9	153 901	3 019	0 004
CS-WITHIN	4129.000	81	50 975		
BC	467.727	9	51 970	1 867	0 069
ABC	203 864	9	22 652	0 814	0 605
BCS-WITHIN	2255.000	81	27.839		

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FILE RESEARCH (CREATION DATE = 09/15/82) CONDUCTED BY BOB GURNEY

* * * * * * Analysis of Variance (ANOVA) Summary Table (Heart Rate: 100 to 190 minutes)

BETWEEN SUBJECT FACTORS ARE:

A - V3 : 1 , 2

WITHIN SUBJECT FACTORS ARE:

B - GROUP : 1 CONTROL , 2 ALCOHOL

C - TEST : 1 TIME11 , 2 TIME12 , 3 TIME13 , 4 TIME14 , 5 TIME15 , 6 TIME16 , 7 TIME17 , 8 TIME18 , 9 TIME19 , 10 TIME20

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
A	9576.137	1	9576.137	7.431	0.023
S-WITHIN	11598.000	9	1288.667		
B	1184.659	1	1184.659	3.053	0.115
AB	23.523	1	23.523	0.061	0.811
BS-WITHIN	3492.000	9	388.000		
C	153054.875	9	17006.094	218.372	0.001
AC	881.591	9	97.955	1.258	0.273
CS-WITHIN	6308.000	81	77.877		
BC	252.273	9	28.030	1.318	0.240
ABC	221.250	9	24.583	1.156	0.334
BCS-WITHIN	1722.000	81	21.259		

FILE RESEARCH (CREATION DATE = 09/15/82) CONDUCTED BY BOB GURNEY

* * * * * * Analysis of Variance (ANOVA) Summary Table (Oxygen Uptake: 0 to 90 minutes)

BETWEEN SUBJECT FACTORS ARE:

A - V3 : 1 , 2

WITHIN SUBJECT FACTORS ARE:

B - GROUP : 1 CONTROL , 2 ALCOHOL

C - TEST : 1 TIME1 , 2 TIME2 , 3 TIME3 , 4 TIME4 , 5 TIME5 ,
6 TIME6 , 7 TIME7 , 8 TIME8 , 9 TIME9 , 10 TIME10

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
A	29.169	1	29.169	0.253	0.627
S-WITHIN	1039.313	9	115.479		
B	19.858	1	19.858	2.126	0.179
AB	10.078	1	10.078	1.079	0.326
BS-WITHIN	84.063	9	9.340		
C	31713.516	9	3523.724	1052.488	0.001
AC	41.761	9	4.640	1.386	0.208
CS-WITHIN	271.188	81	3.348		
BC	38.544	9	4.283	2.337	0.021
ABC	12.933	9	1.437	0.784	0.632
BCS-WITHIN	148.438	81	1.833		

FILE RESEARCH (CREATION DATE = 08/15/82) CONDUCTED BY BOB GURNEY

* * Analysis of Variance (ANOVA) Summary Table (Oxygen Uptake: 100 to 190 minutes)

BETWEEN SUBJECT FACTORS ARE:

A - V3 : 1 . 2

WITHIN SUBJECT FACTORS ARE:

B - GROUP : 1 CONTROL . 2 ALCOHOL

C - TEST : 1 TIME11 . 2 TIME12 . 3 TIME13 . 4 TIME14 . 5 TIME15 .
6 TIME16 . 7 TIME17 . 8 TIME18 . 9 TIME19 . 10 TIME20

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
A	90.533	1	90.533	0.960	0.353
S-WITHIN	848.688	9.	94.299		
B	104.126	1.	104.126	2.246	0.168
AB	73.189	1.	73.189	1.579	0.241
BS-WITHIN	417.250	9.	46.361		
C	27604.816	9.	3067.202	367.588	0.001
AC	133.125	9.	14.792	1.773	0.086
CS-WITHIN	675.875	81.	8.344		
BC	40.398	9.	4.489	0.921	0.512
ABC	48.899	9.	5.433	1.114	0.362
BCS-WITHIN	394.938	81.	4.876		

F:

* Analysis of Variance (ANOVA) Summary Table (Respiratory Quotient: 0 to 90 minutes)

BETWEEN SUBJECT FACTORS ARE:

A - V3 : 1 , 2

WITHIN SUBJECT FACTORS ARE:

B - GROUP : 1 CONTROL , 2 ALCOHOL

C - TEST : 1 TIME1 , 2 TIME2 , 3 TIME3 , 4 TIME4 , 5 TIME5 ,
6 TIME6 , 7 TIME7 , 8 TIME8 , 9 TIME9 , 10 TIME10

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
A	0.227	1.	0.227	0.956	0.354
S-WITHIN	2.134	9.	0.237		
B	0.057	1.	0.057	4.317	0.068
AB	0.045	1.	0.045	3.419	0.098
BS-WITHIN	0.119	9.	0.012		
C	8.441	9.	0.938	142.214	0.001
AC	0.590	9.	0.066	9.942	0.001
CS-WITHIN	0.534	81.	0.007		
BC	0.148	9.	0.016	1.661	0.112
ABC	0.116	9.	0.013	1.299	0.251
BCS-WITHIN	0.802	81.	0.010		

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FILE RESEARCH (CREATION DATE = 08/15/82) CONDUCTED BY BOB GURNEY

* * * * Analysis of Variance (ANOVA) Summary Table (Respiratory Quotient: 100 to 190 minutes)

BETWEEN SUBJECT FACTORS ARE:

A - V3 : 1 . 2

WITHIN SUBJECT FACTORS ARE:

B - GROUP : 1 CONTROL . 2 ALCOHOL

C - TEST : 1 TIME11 . 2 TIME12 . 3 TIME13 . 4 TIME14 . 5 TIME15 .
6 TIME16 . 7 TIME17 . 8 TIME18 . 9 TIME19 . 10 TIME20

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY.
A	0.183	1.	0.183	1.698	0.225
S-WITHIN	1.023	9.	0.114		
B	0.066	1.	0.066	0.706	0.423
AB	0.237	1.	0.237	2.542	0.145
BS-WITHIN	0.838	9.	0.093		
C	2.657	9.	0.295	40.074	0.001
AC	0.134	9.	0.015	2.023	0.047
CS-WITHIN	0.567	81.	0.007		
BC	0.020	9.	0.002	0.374	0.945
ABC	0.045	9.	0.005	0.828	0.592
BCS-WITHIN	0.488	81.	0.006		

FILE RESEARCH (CREATION DATE = 08/15/82) CONDUCTED BY BOB GURNEY

Analysis of Variance (ANOVA) Summary Table (Skin Temperature: 0 to 90 minutes)

BETWEEN SUBJECT FACTORS ARE:

A - V3 : 1 . 2

WITHIN SUBJECT FACTORS ARE:

B - GROUP : 1 CONTROL . 2 ALCOHOL

C - TEST : 1 TIME1 . 2 TIME2 . 3 TIME3 . 4 TIME4 . 5 TIME5 .
6 TIME6 . 7 TIME7 . 8 TIME8 . 9 TIME9 . 10 TIME10

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
A	983.608	1.	983.608	82.062	0.001
S-WITHIN	107.875	9.	11.986		
B	10.526	1.	10.526	2.417	0.154
AB	0.831	1.	0.831	0.191	0.673
BS-WITHIN	39.188	9.	4.354		
C	69.013	9.	7.668	23.662	0.001
AC	29.318	9.	3.258	10.052	0.001
CS-WITHIN	26.250	81.	0.324		
BC	3.175	9.	0.353	1.929	0.059
ABC	0.320	9.	0.036	0.194	0.994
BCS-WITHIN	14.813	81.	0.183		

FILE INFRARCH (CREATION DATE = 08/15/82) CONDUCTED BY BOB GURNEY

Analysis of Variance (ANOVA) Summary Table (Skin Temperature: 100 to 190 minutes)

BETWEEN SUBJECT FACTORS ARE:

A - VB : 1 , 2

WITHIN SUBJECT FACTORS ARE:

B - GROUP : 1 CONTROL , 2 ALCOHOL

C - TEST : 1 TIME11 , 2 TIME12 , 3 TIME13 , 4 TIME14 , 5 TIME15 ,
6 TIME16 , 7 TIME17 , 8 TIME18 , 9 TIME19 , 10 TIME20

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
A	1328.778	1.	1328.778	61.152	0.001
S-WITHIN	195.563	9.	21.729		
B	7.479	1.	7.479	1.118	0.318
AB	0.192	1.	0.192	0.029	0.869
BS-WITHIN	60.189	9.	6.688		
C	64.708	9.	7.190	24.329	0.001
AC	3.750	9.	0.417	1.410	0.198
CS-WITHIN	23.936	81.	0.296		
BC	0.554	9.	0.062	0.268	0.982
ABC	1.023	9.	0.114	0.494	0.874
BCS-WITHIN	18.625	81.	0.230		

[illegible]

Analysis of Variance (ANOVA) Summary Table (Rectal Temperature: 0 to 90 minutes)

BETWEEN SUBJECT FACTORS ARE:

A - VS : 1 , 2

WITHIN SUBJECT FACTORS ARE:

B - GROUP : 1 CONTROL , 2 ALCOHOL

C - TEST : 1 TIME1 , 2 TIME2 , 3 TIME3 , 4 TIME4 , 5 TIME5 ,
6 TIME6 , 7 TIME7 , 8 TIME8 , 9 TIME9 , 10 TIME10

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
A	2.983	1.	2.983	1.739	0.220
S-WITHIN	15.438	9.	1.715		
B	0.107	1.	0.107	0.148	0.710
AB	0.724	1.	0.724	1.003	0.343
BS-WITHIN	6.500	9.	0.722		
C	5.391	9.	0.599	32.344	0.001
AC	0.511	9.	0.057	3.068	0.003
CS-WITHIN	1.500	81.	0.019		
BC	0.170	9.	0.019	1.023	0.429
ABC	0.128	9.	0.014	0.767	0.647
BCS-WITHIN	1.500	81.	0.019		

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FILE RESEARCH (CREATION DATE = 09/15/82) CONDUCTED BY BOB GURNEY

Analysis of Variance (ANOVA) Summary Table (Rectal Temperature: 100 to 190 minutes)

BETWEEN SUBJECT FACTORS ARE:

A - V3 : 1 , 2

WITHIN SUBJECT FACTORS ARE:

B - GROUP : 1 CONTROL , 2 ALCOHOL

C - TEST : 1 TIME11 , 2 TIME12 , 3 TIME13 , 4 TIME14 , 5 TIME15 ,
6 TIME16 , 7 TIME17 , 8 TIME18 , 9 TIME19 , 10 TIME20

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
A	9.886	1.	9.886	5.787	0.040
S-WITHIN	15.375	9.	1.708		
B	1.257	1.	1.257	0.948	0.356
AB	0.277	1.	0.277	0.209	0.659
BS-WITHIN	11.938	9.	1.326		
C	2.237	9.	0.249	16.956	0.001
AC	0.192	9.	0.021	1.453	0.180
CS-WITHIN	1.188	81.	0.015		
BC	0.341	9.	0.038	2.231	0.028
ABC	0.277	9.	0.031	1.813	0.078
BCS-WITHIN	1.375	81.	0.017		

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FILE RESEARCH (CREATION DATE = 09/15/82) CONDUCTED BY BOB GURNEY

Analysis of Variance (ANOVA) Summary Table (Mean Body Temperature: 0 to 90 minutes)

BETWEEN SUBJECT FACTORS ARE:

A - V3 : 1 . 2

WITHIN SUBJECT FACTORS ARE:

B - GROUP : 1 CONTROL . 2 ALCOHOL

C - TEST : 1 TIME1 . 2 TIME2 . 3 TIME3 . 4 TIME4 . 5 TIME5 .
6 TIME6 . 7 TIME7 . 8 TIME8 . 9 TIME9 . 10 TIME10

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
A	132.017	1.	132.017	44.006	0.001
S-WITHIN	27.000	9.	3.000		
B	0.533	1	0.533	0.501	0.497
AB	0.788	1.	0.788	0.742	0.411
BS-WITHIN	9.563	9.	1.063		
C	10.696	9.	1.188	20.536	0.001
AC	4.048	9.	0.450	7.773	0.001
CS-WITHIN	4.688	81.	0.058		
BC	0.703	9.	0.078	1.947	0.057
ABC	0.149	9.	0.017	0.413	0.925
BCS-WITHIN	3.250	81.	0.040		

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FILE RESEARCH (CREATION DATE = 09/15/82) CONDUCTED BY BOB GURNEY

Analysis of Variance (ANOVA) Summary Table (Mean Body Temperature: 100 to 190 minutes)

BETWEEN SUBJECT FACTORS ARE:

A - V3 : 1 , 2

WITHIN SUBJECT FACTORS ARE:

B - GROUP : 1 CONTROL , 2 ALCOHOL

C - TEST : 1 TIME11 , 2 TIME12 , 3 TIME13 , 4 TIME14 , 5 TIME15
6 TIME16 , 7 TIME17 , 8 TIME18 , 9 TIME19 , 10 TIME20

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
A	201.243	1.	201.243	45.493	0.001
S-WITHIN	39.813	9.	4.424		
B	2.536	1.	2.536	1.466	0.257
AB	0.213	1.	0.213	0.123	0.734
BS-WITHIN	15.563	9.	1.729		
C	12.891	9.	1.492	35.697	0.001
AC	0.511	9.	0.057	1.416	0.195
CS-WITHIN	3.250	81.	0.040		
BC	0.128	9.	0.014	0.392	0.936
ABC	0.085	9.	0.009	0.261	0.983
BCS-WITHIN	2.938	81.	0.036		

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FILE

Analysis of Variance (ANOVA) Summary Table (Net Heat Loss 20, 50 and 80 min)

BETWEEN SUBJECT FACTORS ARE:

A - V3 : 1 , 2

WITHIN SUBJECT FACTORS ARE:

B - GROUP : 1 CONTROL , 2 ALCOHOL

C - TEST : 1 TIME1 , 2 TIME2 , 3 TIME3

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
A	8181.883	1	8181.883	8.758	0.016
S-WITHIN	8408.375	9	934.264		
B	1396.151	1	1396.151	1.013	0.341
AB	878.629	1	878.629	0.637	0.445
BS-WITHIN	12410.000	9	1378.889		
C	63.324	2	31.662	0.553	0.585
AC	662.429	2	331.214	5.787	0.011
CS-WITHIN	1030.188	18	57.233		
BC	5.305	2	2.653	0.023	0.977
ABC	62.642	2	31.321	0.274	0.763
BCS-WITHIN	2057.875	18	114.326		

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FILE RESEARCH (CREATION DATE = 09/01/83) CONDUCTED BY BOB GURNEY

Analysis of Variance (ANOVA) Summary Table (Net heat Loss: 110, 140 and 170 min)

BETWEEN SUBJECT FACTORS ARE:

A - V3 : 1 , 2

WITHIN SUBJECT FACTORS ARE:

B - GROUP : 1 CONTROL , 2 ALCOHOL

C - TEST : 1 TIME4 , 2 TIME5 , 3 TIME6

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
A	13214.617	1.	13214.617	47.296	0.001
S-WITHIN	2514.625	9.	279.403		
B	439.794	1.	439.794	0.495	0.499
AB	120.511	1.	120.511	0.136	0.721
BS-WITHIN	7992.500	9.	888.055		
C	17.514	2	8.757	0.088	0.917
AC	41.527	2	20.763	0.208	0.814
CS-WITHIN	1800.125	18.	100.007		
BC	143.182	2.	71.591	0.414	0.667
ABC	301.747	2.	150.874	0.872	0.435
BCS-WITHIN	3112.813	18.	172.934		

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FILE RESEARCH (CREATION DATE = 09/01/83) CONDUCTED BY BOB GURNEY

* * Analysis of Variance (ANOVA) Summary Table (Total Heat Loss 20, 50 and 80 min)

BETWEEN SUBJECT FACTORS ARE:

A - V3 : 1 , 2

WITHIN SUBJECT FACTORS ARE:

B - GROUP : 1 CONTROL , 2 ALCOHOL

C - TEST : 1 TIME1 , 2 TIME2 , 3 TIME3

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
A	93507.250	1.	93507.250	5.423	0.045
S-WITHIN	155197.000	9.	17244.109		
B	15970.910	1.	15970.910	2.666	0.137
AB	5.455	1.	5.455	0.001	0.977
BS-WITHIN	53910.000	9.	5990.000		
C	3042709.000	2.	1521354.000	147.453	0.001
AC	36545.457	2.	18272.727	1.771	0.199
CS-WITHIN	185716.000	18.	10317.555		
BC	18114.547	2.	9057.273	1.761	0.200
ABC	7467.273	2.	3733.637	0.726	0.498
BCS-WITHIN	92589.000	18.	5143.832		

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FTIF RESEARCH (CREATION DATE = 09/01/83) CONDUCTED BY BOB GURNEY

Analysis of Variance (ANOVA) Summary Table (Total Heat Loss: 110, 140 and 170 min)

BETWEEN SUBJECT FACTORS ARE:

A - V3 : 1 , 2

WITHIN SUBJECT FACTORS ARE:

B - GROUP : 1 CONTROL , 2 ALCOHOL

C - TEST : 1 TIME4 , 2 TIME5 , 3 TIME6

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
A	84310.875	1.	84310.875	1.345	0.276
S-WITHIN	564160.000	9.	62684.441		
B	119476.375	1.	119476.375	4.080	0.074
AB	12065.453	1.	12065.453	0.412	0.537
BS-WITHIN	263568.000	9.	29285.332		
C	2198383.000	2.	1099191.000	101.269	0.001
AC	34074.547	2.	17037.273	1.570	0.235
CS-WITHIN	195376.000	18.	10854.219		
BC	17918.180	2.	8959.090	1.322	0.291
ABC	5.455	2.	2.727	0.000	0.999
BCS-WITHIN	122000.000	18.	6777.777		

THREE WAY ANOVA 09/01/83 PAGE 3

FILE RESEARCH (CREATION DATE = 09/01/83) CONDUCTED BY BOB GURNEY

* * * * Analysis of Variance (ANOVA) Summary Table (Skin Conductance: 20, 50 and 80 min) * * *

BETWEEN SUBJECT FACTORS ARE:

A - V3 : 1 , 2

WITHIN SUBJECT FACTORS ARE:

B - GROUP : 1 CONTROL , 2 ALCOHOL

C - TEST : 1 TIME1 , 2 TIME2 , 3 TIME3

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
A	64612.633	1.	64612.633	14.907	0.004
S-WITHIN	39010.313	9.	4334.477		
B	2870.263	1.	2870.263	10.656	0.010
AB	2409.396	1.	2409.396	8.945	0.015
BS-WITHIN	2424.250	9.	269.361		
C	74336.375	2.	37168.188	107.442	0.001
AC	14494.645	2.	7247.320	20.950	0.001
CS-WITHIN	6226.875	18.	345.938		
BC	819.055	2.	409.528	1.928	0.174
ABC	590.604	2.	295.302	1.390	0.275
BCS-WITHIN	3824.000	18.	212.444		

THREE WAY ANOVA 09/01/83 PAGE 8

FILE RESEARCH (CREATION DATE = 09/01/83) CONDUCTED BY BOB GURNEY

Analysis of Variance (ANOVA) Summary Table (Skin Conductance: 110, 140 and 170 min)

BETWEEN SUBJECT FACTORS ARE:

A - V3 : 1 , 2

WITHIN SUBJECT FACTORS ARE:

B - GROUP : 1 CONTROL , 2 ALCOHOL

C - TEST : 1 TIME4 , 2 TIME5 , 3 TIME6

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
A	443948.875	1.	443948.875	17.908	0.002
S-WITHIN	223117.000	9.	24790.777		
B	3459.546	1.	3459.546	0.482	0.505
AB	2338.977	1.	2338.977	0.326	0.582
BS-WITHIN	64631.000	9.	7181.219		
C	71998.938	2.	35999.469	14.696	0.001
AC	24945.340	2.	12472.668	5.092	0.018
CS-WITHIN	44094.000	18.	2449.667		
BC	5981.250	2.	2990.625	2.302	0.129
ABC	4857.270	2.	2428.635	1.869	0.183
BCS-WITHIN	23385.000	18.	1299.167		

[illegible]

Analysis of Variance (ANOVA) Summary Table (Subjects assessment of environmental temperature (Q1a): 0 to 88 minutes)

BETWEEN SUBJECT FACTORS ARE:

A - V3 : 1 , 2

WITHIN SUBJECT FACTORS ARE:

B - GROUP : 1 CONTROL , 2 ALCOHOL

C - TEST : 1 TIME1 , 2 TIME2 , 3 TIME3 , 4 TIME4

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
A	4988.500	1.	4988.500	24.104	0.001
S-WITHIN	1862.645	9.	206.960		
B	142.336	1.	142.336	4.094	0.074
AB	32.518	1.	32.518	0.935	0.359
BS-WITHIN	312.941	9.	34.771		
C	9.403	3.	3.134	0.405	0.751
AC	40.632	3.	13.544	1.748	0.181
CS-WITHIN	209.156	27.	7.747		
BC	50.766	3.	16.922	4.210	0.014
ABC	5.492	3.	1.831	0.455	0.716
BCS-WITHIN	108.527	27.	4.020		

THREE WAY ANOVA 09/18/82 PAGE 8

FILE RESEARCH (CREATION DATE = 09/18/82) CONDUCTED BY BOB GURNEY

Analysis of Variance (ANOVA) Summary Table (Subjects assessment of environmental temperature (Q1a): 118 to 190 minutes)

BETWEEN SUBJECT FACTORS ARE:

A - V3 : 1 , 2

WITHIN SUBJECT FACTORS ARE:

B - GROUP : 1 CONTROL , 2 ALCOHOL

C - TEST : 1 TIME5 , 2 TIME6 , 3 TIME7 , 4 TIME8

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
A	7759.344	1.	7759.344	45.710	0.001
S-WITHIN	1527.770	9.	169.752		
B	56.438	1.	56.438	1.391	0.269
AB	45.348	1.	45.348	1.117	0.318
BS-WITHIN	365.270	9.	40.585		
C	90.334	3.	30.111	4.091	0.016
AC	4.153	3.	1.384	0.188	0.904
CS-WITHIN	198.730	27.	7.360		
BC	16.408	3.	5.469	1.470	0.245
ABC	11.317	3.	3.772	1.014	0.402
BCS-WITHIN	100.434	27.	3.720		

Analysis of Variance (ANOVA) Summary Table (Subjects desire for a change in environmental temperature (Q1b):0 to 88 minutes)

BETWEEN SUBJECT FACTORS ARE:

A - VS : 1 , 2

WITHIN SUBJECT FACTORS ARE:

B - GROUP : 1 CONTROL , 2 ALCOHOL

C - TEST : 1 TIME1 , 2 TIME2 , 3 TIME3 , 4 TIME4

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
A	66.500	1.	66.500	49.040	0.001
S-WITHIN	12.204	9.	1.356		
B	1.064	1.	1.064	2.733	0.133
AB	0.700	1.	0.700	1.799	0.213
BS-WITHIN	3.504	9.	0.389		
C	10.647	3.	3.549	8.701	0.001
AC	0.828	3.	0.276	0.677	0.574
CS-WITHIN	11.012	27.	0.408		
BC	1.368	3.	0.456	1.971	0.142
ABC	1.731	3.	0.577	2.495	0.081
BCS-WITHIN	6.246	27.	0.231		

Analysis of Variance (ANOVA) Summary Table (Subjects desire for a change in environmental temperature (Q1b):118 to 190 minutes)

BETWEEN SUBJECT FACTORS ARE:

A - V3 : 1 , 2

WITHIN SUBJECT FACTORS ARE:

B - GROUP : 1 CONTROL , 2 ALCOHOL

C - TEST : 1 TIME5 , 2 TIME6 , 3 TIME7 , 4 TIME8

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
A	138.646	1.	138.646	52.864	0.001
S-WITHIN	23.604	9.	2.623		
B	0.031	1.	0.031	0.046	0.836
AB	0.576	1.	0.576	0.859	0.378
BS-WITHIN	6.038	9.	0.671		
C	5.931	3.	1.977	6.247	0.002
AC	0.295	3.	0.098	0.311	0.817
CS-WITHIN	8.546	27.	0.317		
BC	0.032	3.	0.011	0.064	0.978
ABC	0.395	3.	0.132	0.800	0.505
BCS-WITHIN	4.446	27.	0.165		

Analysis of Variance (ANOVA) Summary Table (Perception of body thermal comfort (Q1c): 0 to 88 minutes)

BETWEEN SUBJECT FACTORS ARE:

A - V3 : 1 , 2

WITHIN SUBJECT FACTORS ARE:

B - GROUP : 1 CONTROL , 2 ALCOHOL

C - TEST : 1 TIME1 , 2 TIME2 , 3 TIME3 , 4 TIME4

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
A	50.188	1.	50.188	11.430	0.008
S-WITHIN	39.517	9.	4.391		
B	1.024	1.	1.024	0.583	0.465
AB	2.933	1.	2.933	1.669	0.229
BS-WITHIN	15.817	9.	1.757		
C	50.858	3.	16.953	26.951	0.001
AC	1.312	3.	0.437	0.695	0.563
CS-WITHIN	16.983	27.	0.629		
BC	0.888	3.	0.296	0.623	0.606
ABC	7.524	3.	2.508	5.284	0.005
BCS-WITHIN	12.817	27.	0.475		

THREE WAY ANOVA 09/23/82 PAGE 8

FILE RESEARCH (CREATION DATE = 09/23/82) CONDUCTED BY BOB GURNEY

Analysis of Variance (ANOVA) Summary Table (Perception of body thermal comfort (Q1c) 118 to 190 minutes)

BETWEEN SUBJECT FACTORS ARE:

A - V3 : 1 , 2

WITHIN SUBJECT FACTORS ARE:

B - GROUP : 1 CONTROL , 2 ALCOHOL

C - TEST : 1 TIME5 , 2 TIME6 , 3 TIME7 , 4 TIME8

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
A	129.631	1.	129.631	12.900	0.006
S-WITHIN	90.438	9.	10.049		
B	1.503	1.	1.503	0.580	0.466
AB	3.276	1.	3.276	1.263	0.290
BS-WITHIN	23.338	9.	2.593		
C	61.968	3.	20.656	27.013	0.001
AC	6.831	3.	2.277	2.978	0.049
CS-WITHIN	20.646	27.	0.765		
BC	2.165	3.	0.722	1.232	0.317
ABC	0.210	3.	0.070	0.120	0.948
BCS-WITHIN	15.813	27.	0.586		

THREE WAY ANOVA 09/23/82 PAGE 3

FILE RESEARCH (CREATION DATE = 09/23/82) CONDUCTED BY BOB GURNEY

Analysis of Variance (ANOVA) Summary Table (Perception of hand thermal comfort (Q1d): 0 to 88 minutes)

BETWEEN SUBJECT FACTORS ARE:

A - V3 : 1 , 2

WITHIN SUBJECT FACTORS ARE:

B - GROUP : 1 CONTROL , 2 ALCOHOL

C - TEST : 1 TIME1 , 2 TIME2 , 3 TIME3 , 4 TIME4

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
A	40.503	1.	40.503	24.568	0.001
S-WITHIN	14.838	9.	1.649		
B	0.364	1.	0.364	0.144	0.713
AB	2.364	1.	2.364	0.937	0.358
BS-WITHIN	22.704	9.	2.523		
C	29.113	3.	9.704	12.161	0.001
AC	1.204	3.	0.401	0.503	0.683
CS-WITHIN	21.546	27.	0.798		
BC	1.962	3.	0.654	0.935	0.437
ABC	5.416	3.	1.805	2.582	0.074
BCS-WITHIN	18.879	27.	0.699		

THREE WAY ANOVA 09/23/82 PAGE 8

FILE RESEARCH (CREATION DATE = 09/23/82) CONDUCTED BY BOB GURNEY

Analysis of Variance (ANOVA) Summary Table (Perception of hand thermal comfort (Q1d): 18 to 190 minutes)

BETWEEN SUBJECT FACTORS ARE:

A - V3 : 1 , 2

WITHIN SUBJECT FACTORS ARE:

B - GROUP : 1 CONTROL , 2 ALCOHOL

C - TEST : 1 TIME5 , 2 TIME6 , 3 TIME7 , 4 TIME8

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
A	142.801	1.	142.801	32.117	0.001
S-WITHIN	40.017	9.	4.446		
B	2.424	1.	2.424	0.639	0.445
AB	15.152	1.	15.152	3.991	0.077
BS-WITHIN	34.167	9.	3.796		
C	56.014	3.	18.671	30.833	0.001
AC	2.377	3.	0.792	1.309	0.292
CS-WITHIN	16.350	27.	0.606		
BC	0.542	3.	0.181	0.308	0.820
ABC	2.361	3.	0.787	1.339	0.282
BCS-WITHIN	15.867	27.	0.588		

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FILE RESEARCH (CREATION DATE = 09/23/82) CONDUCTED BY BOB GURNEY

Analysis of Variance (ANOVA) Summary Table (Perception of feet thermal comfort (Q1e) 0 to 88 minutes)

BETWEEN SUBJECT FACTORS ARE:

A - V3 : 1 , 2

WITHIN SUBJECT FACTORS ARE:

B - GROUP : 1 CONTROL , 2 ALCOHOL

C - TEST : 1 TIME1 , 2 TIME2 , 3 TIME3 , 4 TIME4

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
A	81.200	1	81 200	16 702	0 003
S-WITHIN	43.754	9	4 862		
B	0.003	1	0 003	0 003	0 960
AB	0.276	1	0 276	0 214	0 654
BS-WITHIN	11.587	9	1 287		
C	5.404	3	1 801	3 022	0 047
AC	46.859	3	15 620	26 201	0 001
CS-WITHIN	16.096	27	0 596		
BC	1.741	3	0 580	1 264	0 307
ABC	1.286	[illegible]	0 429	0 934	0 438
BCS-WITHIN	12.396	27	0 459		

Analysis of Variance (ANOVA) Summary Table (Perception of feet thermal comfort (O1e) 118 to 190 minutes)

BETWEEN SUBJECT FACTORS ARE:

A - V3 : 1 , 2

WITHIN SUBJECT FACTORS ARE:

B - GROUP : 1 CONTROL , 2 ALCOHOL

C - TEST : 1 TIME5 , 2 TIME6 , 3 TIME7 , 4 TIME8

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
A	381.824	1.	381 824	217 952	0 001
S-WITHIN	15.767	9.	1 752		
B	0.547	1.	0 547	0.344	0 572
AB	1.274	1.	1 274	0.801	0.394
BS-WITHIN	14.317	9	1.591		
C	9 148	3.	3 049	8 637	0 001
AC	1.330	3	0 443	1 256	0 309
CS-WITHIN	9.533	27	0 353		
BC	0.844	3	0 281	0.613	0.612
ABC	0.662	3	0 221	0 481	0 698
BCS-WITHIN	12.383	27.	0 459		

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FILE RESEARCH (CREATION DATE = 09/23/82) CONDUCTED BY BOB GURNEY

Analysis of Variance (ANOVA) Summary Table (Perception of face thermal comfort (Q1f) 0 to 88 minutes)

BETWEEN SUBJECT FACTORS ARE:

A - V3 : 1 , 2

WITHIN SUBJECT FACTORS ARE:

B - GROUP : 1 CONTROL , 2 ALCOHOL

C - TEST : 1 TIME1 , 2 TIME2 , 3 TIME3 , 4 TIME4

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
A	50.188	1	50.188	21.492	0.001
S-WITHIN	21.017	9	2.335		
B	1.188	1	1.188	0.890	0.370
AB	2.188	1	2.188	1.639	0.233
BS-WITHIN	12.017	9	1.335		
C	26.348	3	8.783	15.722	0.001
AC	4.076	3	1.359	2.432	0.087
CS-WITHIN	15.083	27	0.559		
BC	0.676	3	0.225	0.580	0.633
ABC	2.039	3	0.680	1.751	0.180
BCS-WITHIN	10.483	27	0.388		

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FILE ·RESEARCH (CREATION DATE = 09/23/82) CONDUCTED BY BOB GURNEY

Analysis of Variance (ANOVA) Summary Table (Perception of face thermal comfort (Q1f) 118 to 190 minutes)

BETWEEN SUBJECT FACTORS ARE:

A - V3 : 1 , 2

WITHIN SUBJECT FACTORS ARE:

B - GROUP : 1 CONTROL , 2 ALCOHOL

C - TEST : 1 TIME5 , 2 TIME6 , 3 TIME7 , 4 TIME8

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
A	112.509	1.	112.509	19.622	0.002
S-WITHIN	51.604	9.	5.734		
B	0.137	1.	0.137	0.044	0.839
AB	3.000	1.	3.000	0.957	0.353
BS-WITHIN	28.204	9.	3.134		
C	45.180	3.	15.060	62.758	0.001
AC	0.862	3.	0.287	1.197	0.330
CS-WITHIN	6.479	27.	0.240		
BC	0.616	3.	0.205	0.639	0.596
ABC	0.480	3.	0.160	0.498	0.687
BCS-WITHIN	8.679	27.	0.321		

THREE WAY ANOVA 09/23/82 PAGE 3

FILE RESEARCH (CREATION DATE = 09/23/82) CONDUCTED BY BOB GURNEY

Analysis of Variance (ANOVA) Summary Table (Subjects rating of Discomfort (Q1g): 0 to 88 minutes)

BETWEEN SUBJECT FACTORS ARE:

A - V3 : 1 , 2

WITHIN SUBJECT FACTORS ARE:

B - GROUP : 1 CONTROL , 2 ALCOHOL

C - TEST : 1 TIME1 , 2 TIME2 , 3 TIME3 , 4 TIME4

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
A	1.064	1.	1.064	0.104	0.754
S-WITHIN	92.004	9.	10.223		
B	7.964	1.	7.964	1.663	0.229
AB	0.464	1.	0.464	0.097	0.763
BS-WITHIN	43.104	9.	4.789		
C	20.759	3.	6.920	4.251	0.014
AC	4.531	3.	1.510	0.928	0.441
CS-WITHIN	43.946	27.	1.628		
BC	0.122	3.	0.041	0.035	0.991
ABC	0.168	3.	0.056	0.048	0.986
BCS-WITHIN	31.446	27.	1.165		

THREE WAY ANOVA 09/23/82 PAGE 8

CONDUCTED BY BOB GURNEY

Analysis of Variance (ANOVA) Summary Table (Subjects rating of Discomfort (Q1g): 118 to 190 minutes)

BETWEEN SUBJECT FACTORS ARE:

A - V3 : 1 , 2

WITHIN SUBJECT FACTORS ARE:

B - GROUP : 1 CONTROL , 2 ALCOHOL

C - TEST : 1 TIME5 , 2 TIME6 , 3 TIME7 , 4 TIME8

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
A	0.909	1.	0.909	0.045	0.837
S-WITHIN	183.204	9.	20.356		
B	23.485	1.	23.485	6.496	0.031
AB	0.576	1.	0.576	0.159	0.699
BS-WITHIN	32.538	9.	3.615		
C	25.462	3.	8.487	3.587	0.027
AC	46.007	3.	15.336	6.482	0.002
CS-WITHIN	63.879	27.	2.366		
BC	6.304	3.	2.101	0.996	0.410
ABC	11.395	3.	3.798	1.801	0.171
BCS-WITHIN	56.946	27.	2.109		

Analysis of Variance (ANOVA) Summary Table (Subjects assessment of changes in environmental temperature (Q2a): 28 to 90 minutes)

BETWEEN SUBJECT FACTORS ARE:

A - V3 : 1 , 2

WITHIN SUBJECT FACTORS ARE:

B - GROUP : 1 CONTROL , 2 ALCOHOL

C - TEST : 1 TIME1 , 2 TIME2 , 3 TIME3 , 4 TIME4

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
A	0.547	1.	0.547	0.121	0.736
S-WITHIN	40.817	9.	4.535		
B	2.934	1.	2.934	1.063	0.332
AB	6.206	1.	6.206	2.228	0.170
BS-WITHIN	25.067	9.	2.785		
C	16.393	3.	5.464	4.835	0.008
AC	2.028	3.	0.676	0.598	0.622
CS-WITHIN	30.517	27.	1.130		
BC	1.084	3.	0.361	0.223	0.880
ABC	5.449	3.	1.816	1.121	0.358
BCS-WITHIN	43.733	27.	1.620		

THREE WAY ANOVA 09/23/82 PAGE 8

[illegible]

Analysis of Variance (ANOVA) Summary Table (Subjects assessment of changes in environmental temperature (Q2a): 118 to 180 minutes)

BETWEEN SUBJECT FACTORS ARE:

A - V3 : 1 , 2

WITHIN SUBJECT FACTORS ARE:

B - GROUP : 1 CONTROL , 2 ALCOHOL

C - TEST : 1 TIME5 , 2 TIME6 , 3 TIME7 , 4 TIME8

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
A	20.564	1.	20.564	5.524	0.043
S-WITHIN	33.504	9.	3.723		
B	0.031	1.	0.031	0.006	0.941
AB	0.576	1.	0.576	0.108	0.750
BS-WITHIN	48.037	9.	5.337		
C	425.601	3.	141.867	71.580	0.001
AC	7.965	3.	2.655	1.340	0.282
CS-WITHIN	53.512	27.	1.982		
BC	2.886	3.	0.962	0.499	0.686
ABC	3.432	3.	1.144	0.594	0.625
BCS-WITHIN	52.046	27.	1.928		

THREE WAY ANOVA 09/23/82 PAGE 3

FILE RESEARCH (CREATION DATE = 09/23/82) CONDUCTED BY BOB GURNEY

Analysis of Variance (ANOVA) Summary Table (Subjects assessment of elapsed time (O2b): 28 to 88 minutes)

BETWEEN SUBJECT FACTORS ARE:

A - V3 : 1 , 2

WITHIN SUBJECT FACTORS ARE:

B - GROUP : 1 CONTROL , 2 ALCOHOL

C - TEST : 1 TIME1 , 2 TIME2 , 3 TIME3 , 4 TIME4

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
A	347.727	1.	347.727	0.426	0.530
S-WITHIN	7341.125	9.	815.680		
B	811.705	1.	811.705	2.338	0.161
AB	161.932	1.	161.932	0.466	0.512
BS-WITHIN	3125.000	9.	347.222		
C	85482.250	3.	28494.082	562.640	0.001
AC	38.182	3.	12.727	0.251	0.860
CS-WITHIN	1367.375	27.	50.644		
BC	82.159	3.	27.386	0.525	0.669
ABC	406.364	3.	135.454	2.596	0.073
BCS-WITHIN	1409.000	27.	52.185		

THREE WAY ANOVA 09/23/82 PAGE 8

FILE RESEARCH (CREATION DATE = 09/23/82) CONDUCTED BY BOB GURNEY

Analysis of Variance (ANOVA) Summary Table (Subjects assessment of elapsed time (Q2b): 118 to 190 minutes)

BETWEEN SUBJECT FACTORS ARE:

A - V3 : 1 , 2

WITHIN SUBJECT FACTORS ARE:

B - GROUP : 1 CONTROL , 2 ALCOHOL

C - TEST : 1 TIME5 , 2 TIME6 , 3 TIME7 , 4 TIME8

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	PROBABILITY
A	3.409	1.	3.409	0.002	0.963
S-WITHIN	13220.000	9.	1468.889		
B	462.273	1.	462.273	0.427	0.530
AB	65.455	1.	65.455	0.061	0.811
BS-WITHIN	9734.000	9.	1081.555		
C	453131.250	3.	151043.750	589.503	0.001
AC	38.182	3.	12.727	0.050	0.985
CS-WITHIN	6918.000	27.	256.222		
BC	829.432	3.	276.477	1.740	0.182
ABC	56.932	3.	18.977	0.119	0.948
BCS-WITHIN	4289.000	27.	158.852		

Appendix 6.

Results Tables.

Heart Rate

Oxygen Uptake

Respiratory Quotient

Skin Temperature

Rectal Temperature

Mean Body Temperature

Results Table
(Warm Temperature)

Time of Measurement (min)	Heart Rate (beats/min) Control		Alcohol		BAL (mg/100ml)
0	61.6	(4.6)	67.2	(4.0)	0.0
10	112.4	(9.2)	111.2	(6.2)	
20	117.0	(9.5)	115.2	(6.3)	
30	68.4	(5.6)	68.0	(5.9)	
40	120.2	(9.1)	119.2	(8.6)	
50	121.6	(8.7)	120.2	(8.7)	25.4
60	71.2	(7.2)	77.4	(10.8)	
70	124.0	(12.0)	127.4	(9.4)	
80	127.0	(12.0)	132.4	(3.3)	42.6
90	71.6	(7.8)	79.0	(14.8)	
100	128.2	(12.5)	132.4	(10.9)	
110	134.8	(11.6)	137.0	(10.7)	62.4
120	77.0	(5.7)	80.2	(6.5)	
130	132.6	(10.3)	136.8	(9.7)	
140	139.0	(9.4)	143.0	(9.1)	81.8
150	79.0	(6.8)	87.2*	(5.0)	
160	141.0	(10.1)	141.4	(9.6)	
170	144.0	(9.7)	148.8	(10.4)	74.4
180	83.2	(4.1)	90.8*	(6.6)	
190	71.6	(4.5)	86.0*	(10.1)	66.0

Note: The values represent the mean for all subjects (n=5) and the numbers in the brackets represent the Standard Deviation.

* - Signifies that the value was statistically ($P \leq 0.05$) different from control.

Results Table
(Cold Temperature)

Time of Measurement (min)	Heart Rate (beats/min) Control	Alcohol	BAL (mg/100ml)
0	68.7 (6.5)	66.3 (4.4)	0.0
10	121.0 (13.1)	114.8 (14.9)	
20	116.7 (10.9)	114.5 (13.2)	
30	68.8 (11.6)	73.7 (8.1)	
40	116.8 (12.4)	115.8 (8.5)	
50	115.2 (11.2)	116.8 (10.0)	25.0
60	68.8 (7.6)	71.3 (9.6)	
70	117.0 (12.2)	117.8 (9.9)	
80	119.0 (13.3)	118.5 (9.2)	43.3
90	69.2 (7.6)	75.5 (9.1)	
100	118.3 (12.2)	120.8 (8.9)	
110	118.3 (15.1)	122.5 (11.6)	63.3
120	72.2 (8.3)	73.3 (7.1)	
130	120.2 (16.3)	123.2 (12.8)	
140	122.0 (19.3)	124.8 (13.6)	82.8
150	70.5 (10.2)	75.8 (6.7)	
160	121.7 (19.2)	128.0 (15.1)	
170	123.3 (19.6)	130.7*(14.5)	71.3
180	71.0 (6.6)	73.3 (9.3)	
190	67.0 (6.4)	72.0 (10.6)	63.7

Note: The values represent the mean for all subjects (n=6) and the numbers in the brackets represent the Standard Deviation.

* - Signifies that the value was statistically ($P \leq 0.05$) different from control.

Results Table
(Warm Temperature)

Time of Measurement (min)	Oxygen Uptake (VO2)(ml•kg⁻¹•min⁻¹) Control	Alcohol	BAL (mg/100ml)
0	3.8 (1.5)	4.2 (2.1)	0.0
10	27.6 (1.1)	27.8 (1.2)	
20	30.0 (0.9)	29.7 (1.4)	
30	8.1 (0.6)	8.5 (1.9)	
40	32.7 (2.2)	32.4 (1.7)	
50	32.8 (2.8)	32.0 (1.5)	25.4
60	8.7 (1.6)	8.4 (1.1)	
70	32.1 (3.4)	32.7 (0.9)	
80	33.7 (2.8)	33.1 (1.9)	42.6
90	6.0 (1.4)	8.3*(0.9)	
100	29.0 (2.0)	32.6 (2.0)	
110	28.8 (2.1)	32.8*(2.0)	62.4
120	7.4 (2.0)	9.4*(2.0)	
130	29.1 (1.9)	32.5 (2.1)	
140	29.3 (2.1)	31.6 (1.7)	81.8
150	7.1 (1.1)	8.9 (1.4)	
160	29.1 (1.7)	32.2 (2.5)	
170	29.4 (1.8)	32.7 (2.5)	74.4
180	7.1 (1.6)	8.4 (1.5)	
190	7.2 (1.3)	7.9 (0.8)	66.0

Note: The values represent the mean for all subjects (n=5) and the numbers in the brackets represent the Standard Deviation.

* - Signifies that the value was statistically ($P \leq 0.05$) different from control.

Results Table
(Cold Temperature)

Time of Measurement (min)	Oxygen Uptake (VO2) (ml•kg^{-1}•min^{-1}) Control		Alcohol		BAL (mg/100ml)
0	5.2	(3.3)	7.3	(2.8)	0.0
10	29.2	(3.5)	29.2	(3.1)	
20	30.8	(3.0)	30.2	(3.2)	
30	6.9	(2.7)	8.2	(2.4)	
40	33.0	(4.0)	32.3	(3.7)	
50	33.0	(4.1)	33.4	(4.7)	25.0
60	7.7	(3.2)	9.1	(2.6)	
70	32.6	(5.5)	34.8*	(4.8)	
80	32.7	(4.1)	34.5	(4.4)	43.3
90	7.7	(2.4)	9.9*	(2.1)	
100	31.4	(4.3)	33.6	(3.6)	
110	31.6	(4.0)	32.7	(4.2)	63.3
120	7.5	(1.8)	6.1	(2.5)	
130	28.7	(4.4)	25.6	(10.2)	
140	28.4	(4.9)	27.9	(5.3)	82.8
150	5.8	(2.2)	7.3	(2.2)	
160	28.5	(5.3)	28.4	(5.8)	
170	28.5	(5.4)	29.2	(6.4)	71.3
180	5.8	(2.5)	6.7	(2.3)	
190	6.1	(2.6)	7.2	(2.2)	63.7

Note: The values represent the mean for all subjects (n=6) and the numbers in the brackets represent the Standard Deviation.

* - Signifies that the value was statistically ($P \leq 0.05$) different from control.

Results Table
(Warm Temperature)

Time of Measurement (min)	Respiratory Quotient (RQ) Control	Alcohol	BAL (mg/100ml)
0	0.14 (0.07)	0.17 (0.11)	0.0
10	0.98 (0.09)	0.96 (0.05)	
20	0.89 (0.08)	0.91 (0.06)	
30	0.57 (0.10)	0.58 (0.13)	
40	0.82 (0.08)	0.84 (0.05)	
50	0.82 (0.09)	0.83 (0.06)	25.4
60	0.55 (0.15)	0.44 (0.12)	
70	0.78 (0.12)	0.81 (0.05)	
80	0.81 (0.10)	0.83 (0.04)	42.6
90	0.41 (0.25)	0.44 (0.17)	
100	0.89 (0.05)	0.79 (0.06)	
110	0.92 (0.08)	0.79*(0.06)	62.4
120	0.63 (0.15)	0.60 (0.15)	
130	0.90 (0.08)	0.75*(0.08)	
140	0.91 (0.07)	0.82 (0.06)	81.8
150	0.64 (0.04)	0.55 (0.05)	
160	0.89 (0.06)	0.80 (0.09)	
170	0.91 (0.06)	0.82 (0.09)	74.4
180	0.63 (0.04)	0.52 (0.07)	
190	0.65 (0.06)	0.53*(0.10)	66.0

<u>Note</u>: The values represent the mean for all subjects (n=5) and the numbers in the brackets represent the Standard Deviation.

* - Signifies that the value was statistically ($P \leq 0.05$) different from control.

Results Table
(Cold Temperature)

Time of Measurement (min)	Respiratory Quotient (RQ) Control	Respiratory Quotient (RQ) Alcohol	BAL (mg/100ml)
0	0.34 (0.17)	0.64 (0.32)	0.0
10	0.97 (0.13)	0.99 (0.14)	
20	0.90 (0.14)	0.93 (0.16)	
30	0.57 (0.15)	0.67 (0.11)	
40	0.82 (0.14)	0.86 (0.17)	
50	0.81 (0.13)	0.83 (0.17)	25.0
60	0.57 (0.12)	0.62 (0.15)	
70	0.82 (0.12)	0.80 (0.16)	
80	0.81 (0.13)	0.78 (0.17)	43.3
90	0.53 (0.18)	0.62 (0.19)	
100	0.82 (0.10)	0.81 (0.14)	
110	0.83 (0.08)	0.84 (0.13)	63.3
120	0.72 (0.17)	0.67 (0.10)	
130	0.89 (0.10)	0.92 (0.14)	
140	0.91 (0.11)	0.94 (0.19)	82.8
150	0.68 (0.16)	0.75 (0.22)	
160	0.89 (0.13)	0.93 (0.20)	
170	0.89 (0.12)	0.94 (0.22)	71.3
180	0.66 (0.10)	0.76 (0.22)	
190	0.65 (0.13)	0.68 (0.21)	63.7

Note: The values represent the mean for all subjects (n=6) and the numbers in the brackets represent the Standard Deviation.

* - Signifies that the value was statistically ($P \leq 0.05$) different from control.

Results Table
(Warm Temperature)

Time of Measurement (min)	Skin Temperature (°C) Control	Alcohol	BAL (mg/100ml)
0	33.9 (0.63)	34.0 (0.69)	0.0
10	35.7 (0.31)	35.5 (0.65)	
20	36.0 (0.49)	35.8 (0.48)	
30	35.2 (0.69)	34.4 (1.08)	
40	35.8 (0.61)	35.3 (0.88)	
50	35.8 (0.59)	35.3 (1.03)	25.4
60	35.0 (0.52)	34.6 (0.84)	
70	35.3 (0.88)	35.3 (0.69)	
80	35.7 (0.32)	35.3 (0.68)	42.6
90	34.9 (0.62)	34.6 (1.31)	
100	35.6 (0.43)	35.0 (1.01)	
110	35.6 (0.67)	35.2 (0.73)	62.4
120	34.9 (0.51)	34.4 (0.98)	
130	35.3 (0.53)	34.9 (1.00)	
140	35.6 (0.60)	35.3* (0.80)	81.8
150	34.6 (1.10)	34.4 (1.15)	
160	35.1 (0.89)	35.0 (0.97)	
170	35.3 (1.07)	35.3 (0.86)	74.4
180	34.8 (0.95)	34.5 (0.66)	
190	34.0 (1.10)	33.8 (0.80)	66.0

Note: The values represent the mean for all subjects (n=5) and the numbers in the brackets represent the Standard Deviation.

* - Signifies that the value was statistically ($P \leq 0.05$) different from control.

Results Table
(Cold Temperature)

Time of Measurement (min)	Skin Temperature (°C) Control	Alcohol	BAL (mg/100ml)
0	31.7 (0.66)	31.3 (0.58)	0.0
10	31.9 (0.73)	31.5 (0.92)	
20	32.3 (0.98)	32.0 (1.33)	
30	31.1 (1.21)	30.1 (1.17)	
40	31.2 (1.11)	30.5 (1.09)	
50	31.9 (1.33)	31.0*(1.50)	25.0
60	30.3 (1.37)	29.7*(1.08)	
70	30.3 (1.37)	30.1*(1.23)	
80	31.4 (1.32)	30.7*(1.36)	43.3
90	29.7 (1.85)	29.5*(1.16)	
100	30.3 (1.21)	30.0 (1.19)	
110	31.0 (1.36)	30.4 (1.26)	63.3
120	29.5 (2.01)	29.3 (1.31)	
130	29.9 (1.60)	29.7 (1.55)	
140	31.1 (1.43)	30.5*(1.60)	82.8
150	29.7 (1.79)	29.4 (1.58)	
160	30.2 (1.26)	29.9 (1.54)	
170	31.0 (1.32)	30.6 (1.68)	71.3
180	30.1 (1.43)	29.4 (1.65)	
190	29.0 (1.91)	28.5 (1.88)	63.7

<u>Note</u>: The values represent the mean for all subjects (n=6) and the numbers in the brackets represent the Standard Deviation.

* - Signifies that the value was statistically ($P \leq 0.05$) different from control.

Results Table
(Warm Temperature)

Time of Measurement (min)	Rectal Temperature (°C) Control	Alcohol	BAL (mg/100ml)
0	37.2 (0.29)	37.2 (0.31)	0.0
10	37.4 (0.38)	37.5 (0.37)	
20	37.5 (0.43)	37.7 (0.37)	
30	37.5 (0.45)	37.7 (0.37)	
40	37.6 (0.50)	37.8 (0.37)	
50	37.8 (0.44)	37.9 (0.37)	25.4
60	37.7 (0.58)	37.8 (0.28)	
70	37.7 (0.54)	37.9 (0.36)	
80	37.8 (0.49)	38.0 (0.38)	42.6
90	37.6 (0.50)	37.9 (0.32)	
100	37.8 (0.48)	37.9 (0.45)	
110	37.8 (0.44)	38.0 (0.37)	62.4
120	37.7 (0.47)	37.8 (0.30)	
130	37.8 (0.45)	37.8 (0.37)	
140	37.9 (0.43)	37.9 (0.37)	81.8
150	37.8 (0.48)	37.5*(0.49)	
160	37.9 (0.43)	37.8 (0.38)	
170	38.0 (0.38)	37.8*(0.48)	74.4
180	37.9 (0.46)	37.7 (0.39)	
190	37.7 (0.45)	37.4*(0.51)	66.0

<u>Note</u>: The values represent the mean for all subjects (n=5) and the numbers in the brackets represent the Standard Deviation.

* - Signifies that the value was statistically ($P \leq 0.05$) different from control.

Results Table
(Cold Temperature)

Time of Measurement (min)	Rectal Temperature (°C) Control	Alcohol	BAL (mg/100ml)
0	37.2 (0.20)	37.1 (0.17)	0.0
10	37.4 (0.28)	37.3 (0.26)	
20	37.5 (0.35)	37.4 (0.27)	
30	37.5 (0.41)	37.4 (0.28)	
40	37.5 (0.42)	37.5 (0.27)	
50	37.7 (0.37)	37.4 (0.39)	25.0
60	37.4 (0.42)	37.5 (0.33)	
70	37.5 (0.32)	37.4 (0.45)	
80	37.6 (0.28)	37.5 (0.46)	43.3
90	37.5 (0.31)	37.4 (0.42)	
100	37.5 (0.32)	37.3*(0.34)	
110	37.6 (0.32)	37.4*(0.36)	63.3
120	37.5 (0.37)	37.3*(0.43)	
130	37.4 (0.30)	37.2*(0.38)	
140	37.6 (0.36)	37.4*(0.42)	82.8
150	37.5 (0.34)	37.3*(0.48)	
160	37.5 (0.29)	37.2*(0.42)	
170	37.6 (0.28)	37.3*(0.48)	71.3
180	37.5 (0.33)	37.3*(0.47)	
190	37.2 (0.40)	37.0*(0.55)	63.7

<u>Note</u>: The values represent the mean for all subjects (n=6) and the numbers in the brackets represent the Standard Deviation.

* - Signifies that the value was statistically ($P \leq 0.05$) different from control.

Results Table
(Warm Temperature)

Time of Measurement (min)	Mean Body Temperature (°C) Control	Mean Body Temperature (°C) Alcohol	BAL (mg/100ml)
0	36.1 (0.28)	36.2 (0.35)	0.0
10	36.8 (0.30)	36.8 (0.31)	
20	37.0 (0.36)	37.1 (0.27)	
30	36.8 (0.41)	36.6 (0.35)	
40	37.0 (0.44)	37.0 (0.31)	
50	37.1 (0.39)	37.1 (0.36)	25.4
60	36.8 (0.46)	36.7 (0.29)	
70	36.9 (0.79)	37.0 (0.29)	
80	37.1 (0.38)	37.1 (0.31)	42.6
90	36.7 (0.51)	36.8 (0.51)	
100	37.1 (0.37)	36.9 (0.32)	
110	37.1 (0.38)	37.1 (0.29)	62.4
120	36.8 (0.38)	36.7 (0.28)	
130	37.0 (0.39)	36.8 (0.23)	
140	37.1 (0.35)	37.0 (0.20)	81.8
150	36.7 (0.56)	36.5 (0.12)	
160	37.0 (0.50)	36.8 (0.26)	
170	37.1 (0.51)	37.0 (0.27)	74.4
180	36.8 (0.53)	36.6 (0.22)	
190	36.5 (0.53)	36.2 (0.33)	66.0

__Note__: The values represent the mean for all subjects (n=5) and the numbers in the brackets represent the Standard Deviation.

* - Signifies that the value was statistically ($P \leq 0.05$) different from control.

Results Table
(Cold Temperature)

Time of Measurement (min)	Mean Body Temperature (°C) Control	Alcohol	BAL (mg/100ml)
0	35.2 (0.19)	35.2 (0.28)	0.0
10	35.6 (0.38)	35.4 (0.45)	
20	35.8 (0.47)	35.6 (0.59)	
30	35.4 (0.51)	35.0 (0.56)	
40	35.4 (0.56)	35.2 (0.50)	
50	35.7 (0.60)	35.3*(0.76)	25.0
60	35.1 (0.58)	34.9 (0.57)	
70	35.1 (0.62)	35.0 (0.65)	
80	35.6 (0.58)	35.3*(0.73)	43.3
90	34.9 (0.71)	34.8 (0.65)	
100	35.1 (0.48)	34.9 (0.58)	
110	35.4 (0.49)	35.1 (0.64)	63.3
120	34.8 (0.83)	34.6 (0.71)	
130	35.0 (0.68)	34.7 (0.72)	
140	35.4 (0.63)	35.1*(0.80)	82.8
150	34.9 (0.72)	34.7 (0.82)	
160	35.1 (0.58)	34.8*(0.75)	
170	35.4 (0.61)	35.1*(0.80)	71.3
180	35.0 (0.63)	34.7*(0.84)	
190	34.5 (0.81)	34.2*(0.94)	63.7

<u>Note</u>: The values represent the mean for all subjects (n=6) and the numbers in the brackets represent the Standard Deviation.

* - Signifies that the value was statistically (P≤0.05) different from control.

Appendix 7.

Subject Consent Form.

I ______________________________ am willing to act as a subject in two exercise tests to be carried out by Mr. R. Gurney in the Department of Physical Edcuation at the University of Alberta. During their tests I agree to drink a certain amount of grain alcohol mixed with orange juice knowing the tests are intended to determine the effects of ethanol on physiological response to exercise. I know I am free to withdraw from the tests at anytime I wish and agree to withdraw at the request of Mr. Gurney should he wish to terminate the test at anytime. At the conclusion of the tests I agree to remain in the laboratory until measurement of my blood alcohol indicate 40 to 50 mg/100 ml.

In agreeing to take part I waive the University of Alberta of any and all legal claims in connection with their tests.

DATE: ____________________ SUBJECT: ______________________

(Signature)

SUPERVISING STAFF MEMBER: ____________________

(Signature)