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The effects of an intoxicating amount of alcohol on maximum oxygen consumption, heart rate, and ratings of perceived exertion

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THE EFFECTS OF AN INTOXICATING AMOUNT OF ALCOHOL ON MAXIMUM OXYGEN CONSUMPTION, HEART RATE, AND RATINGS OF PERCEIVED EXERTION

by

Alan Stuart Zarrow

An Abstract

of a thesis submitted in partial fulfillment
of the requirements for the degree of
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Thesis Advisor: Dr. Edmund J. Burke, Jr.

ABSTRACT

The effects of ingesting 0.55 ml/lb of 100 proof vodka on maximum oxygen consumption, heart rate, and ratings of perceived exertion were studied using 12 male and female graduate and undergraduate physical education majors. Upon entering the test room, all subjects were weighed, then asked to put on a noseclip and to consume two anesthetic throat lozenges. The subjects had 10 minutes in which to consume a drink that consisted of either the alcohol and 50 ml of orange juice or an equivalent amount of water, 50 ml of orange juice, and eight drops of tabasco sauce. After a 30 minute absorption period, the subjects were given a progressive step increment test on the bicycle ergometer and asked to ride until they reached exhaustion or until there was an increase in work load with no increase in $\dot{V}O_2$.

The experiment was repeated on each subject three times, with the alcohol drink being administered once and the control drink being given twice. The assignment of the drinks to each person was random. Each subject was asked not to eat for at least six hours before coming to the test area.

Each exercise bout started with a 10 minute warm-up which was followed by a five minute rest. Succeeding bouts lasted three minutes, with a five minute rest interval.

During the last minute of each bout, a sample of expired gas was collected for oxygen consumption data, and heart rate was monitored. At the end of the bout, a rating of perceived exertion was obtained.

A one-way analysis of variance for repeated measures was used to determine the presence of significant F ratios. The .05 significance level was set.

Results indicated that there were no significant differences between experimental treatments for heart rate, pulmonary ventilation, maximum oxygen consumption l/min and ml/kg/min, and ratings of perceived exertion as measured across all subjects and in males. No significant differences existed between experimental treatments for heart rate, pulmonary ventilation, and ratings of perceived exertion as measured in females. The females did show a significantly lower measure of maximum oxygen consumption, both l/min and ml/kg/min during the maximum work load while under the influence of the alcohol. The results further indicated that the perceived exertion scale could be used as an accurate assessment of a subject's working capacity when complex physiological data collection is impractical.

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A Thesis Presented to the Faculty of
the School of Health, Physical
Education, and Recreation
Ithaca College

In Partial Fulfillment of the
Requirements for the Degree
Master of Science

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by

Alan Stuart Zarrow

May, 1978

Ithaca College
School of Health, Physical Education, and Recreation
Ithaca, New York

CERTIFICATE OF APPROVAL

MASTER OF SCIENCE THESIS

This is to certify that the Master of Science Thesis of

Alan Stuart Zarrow

submitted in partial fulfillment of the requirements for the degree of Master of Science in the School of Health, Physical Education, and Recreation at Ithaca College has been approved.

Thesis Advisor: _

Committee Member: _

Candidate: _

Chairman, Graduate Programs in Physical Education: _

Director of Graduate Studies: _

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter 1

INTRODUCTION

Alcohol is a colorless, odorless liquid, with a burning taste, and is molecularly composed of carbon, hydrogen, and oxygen (11,13,21). It is the main ingredient not only for many of the world's most popular drinks but for perfumes and lacquers as well.

Most alcohols are poisonous, althouth ethanol, or drinking alcohol, is not. Rapid oxidation upon consumption is what makes it safe. Methanol, also called wood alcohol because it is derived from wood distillation, is poisonous and can cause blindness or death. Many alcoholics have been known to intake methanol because of its availability at relatively low costs. Isopropyl, or rubbing alcohol, is also poisonous. Its major benefit to man is its rapid rate of evaporation which causes a cooling sensation when applied to the skin.

When consumed in moderate doses (e.g. three to four drinks of 86 proof whiskey or gin) alcohol can cause dizziness, slur speech, decrease balance, shorten memory, disrupt time perception, and decrease the coordination needed to perform fine motor skills (21). Furthermore, it shortens breath and inhibits the ability of the thalamus to send analgesic relief to body parts.

With the drawbacks so apparent, why do people drink? One reason is its wide-spread social acceptability. It is advertised as pleasant to indulge in during leisure time. People like to drink because it stimulates their appetites. Probably the main reason for alcoholic consumption is that it is a depressant. It numbs the inhibition units of the brain centers allowing shy people to be more outgoing. The relaxing agents appear to enable people to free themselves from the strain of a busy day at the office.

Minors indulge in alcohol at ever-increasing rates. It is estimated that of the young people in junior high school, 63 percent of the males and 54 percent of the females have had a drink. By the time they graduate from high school, 93 percent of the boys and 87 percent of the girls have consumed some alcoholic beverage (21). Approximately 20 percent of the people between the ages of 21 and 24 are considered heavy drinkers (11).

Younger adults drink for a number of reasons. They think that drinking makes them seem more mature. Some indicate that they like the taste. Others indicate that peer pressure and social acceptability is another reason. Finally, unlike marijuana, alcohol is legal (11).

Over a period of time, individuals learn to deal with the negative side effects that alcohol produce so that greater amounts of alcohol can be consumed. This is illustrated by the tolerance effect present with ethanol. Tolerance is the need for ever-increasing doses of the drug in order to achieve the relaxing sensation. Tolerance is an adaptation of the central nervous system (51,44). Although people with a high tolerance level to alcohol perform well-learned skills better than occasional drinkers (21,27), over-all performance goes down as blood-alcohol count (BAC) increases.

An increased intake of alcohol produces side effects not usually experienced in the occasional drinker. Double vision, diplopia, caused by the relaxation of the convergence muscles is one such effect. Irritation of the mucous membranes in the esophogus and the stomach lining, leading to ulcers, is another side effect (8).

Athletes, like the rest of the population, are subject to the lure of alcohol. Target shooters have been known to have a drink before competition in order to relax (16). But what are the effects of alcohol on performance?

Scope of Problem

This study dealt with the effects of a legally intoxicating amount of alcohol on heart rate, pulmonary efficiency, maximum oxygen consumption, and ratings of perceived exertion. The data were collected from 12 male and female physical education majors enrolled in the Spring, 1977 semester at Ithaca College, Ithaca, New York. All were given three maximal workloads on a bicycle ergometer under one of two experimental conditions. The intoxicating amount of alcohol was administered once and the control drink was administered twice. Readings of heart rate, pulmonary ventilation, oxygen consumption, and perceived exertion were taken during the last minute of each work bout on the bicycle ergometer.

Statement of Problem

The purpose of this study was to determine the physiological and psycho-physical effects of a legally intoxicating dose of alcohol during sub-maximal and maximal exercise on a bicycle ergometer.

Major Null Hypotheses

The major null hypotheses for this study were as follows:

1. There will be no significant over-all differences between experimental treatments for the physiological and psycho-physical parameters employed across all subjects.

2. There will be no significant over-all differences between experimental treatments for the physiological and psycho-physical parameters employed in males.

3. There will be no significant over-all dif-

ferences between experimental treatments for the physiological and psycho-physical parameters employed in females.

Minor Null Hypotheses

The minor null hypotheses for this study were as follows:

1. There will be no significant differences between experimental treatments for ratings of sub-maximal perceived exertion in all subjects.
2. There will be no significant differences between experimental treatments for ratings of maximal perceived exertion in all subjects.
3. There will be no significant differences between experimental treatments for sub-maximal heart rate in all subjects.
4. There will be no significant differences between experimental treatments for maximal heart rate in all subjects.
5. There will be no significant differences between experimental treatments for $\dot{V}O_2$ max (l/min) in all subjects.
6. There will be no significant differences between experimental treatments for $\dot{V}O_2$ max (ml/kg/min) in all subjects.
7. There will be no significant differences between experimental treatments for ventilatory equivalent readings in all subjects.
8. There will be no significant differences between experimental treatments for maximum pulmonary ventilation readings in all subjects.
9. There will be no significant differences between experimental treatments for ratings of sub-maximal perceived exertion in females.
10. There will be no significant differences

between experimental treatments for ratings of maximal perceived exertion in females.

11. There will be no significant differences between experimental treatments for sub-maximal heart rate in females.

12. There will be no significant differences between experimental treatments for maximal heart rate in females.

13. There will be no significant differences between experimental treatments for $\dot{V}O_2$ max (l/min) in females.

14. There will be no significant differences between experimental treatments for $\dot{V}O_2$ max (ml/kg/min) in females.

15. There will be no significant differences between experimental treatments for ventilatory equivalent readings in females.

16. There will be no significant differences between experimental treatments for maximum pulmonary ventilation readings in females.

17. There will be no significant differences between experimental treatments for ratings of sub-maximal perceived exertion in males.

18. There will be no significant differences between experimental treatments for ratings of maximal perceived exertion in males.

19. There will be no significant differences between experimental treatments for sub-maximal heart rate in males.

20. There will be no significant differences between experimental treatments for maximal heart rate in males.

21. There will be no significant differences between experimental treatments for $\dot{V}O_2$ max (l/min) in males.

22. There will be no significant differences

between experimental treatments for $\dot{V}O_2$ max (ml/kg/min) in males.

23. There will be no significant differences between experimental treatments for ventilatory equivalent in males.

24. There will be no significant differences between experimental treatments for maximum pulmonary ventilation readings in males.

Assumptions of Study

The following were assumed for this study:

1. The subjects followed the directions given to them on the Informed Consent Form.
2. The subjects could not tell whether they were drinking the alcohol or the control solution.
3. The subjects gave an honest answer when asked to rate their work using the perceived exertion scale.

Definition of Terms

The following were defined for this study:

1. Bicycle Ergometer. A stationary bicycle, powered by the subject's pedaling against an adjustable resistance provided by a friction band.
2. Blood Alcohol Count (BAC). The percentage of alcohol in a person's blood system at the time of the measurement as measured in milligrams percent (21).
3. Heart Rate. The number of ventricular contractions per minute as monitored by a stethoscope.
4. Intoxicating Amount of Alcohol. The amount of alcohol in a drink needed to raise the blood alcohol count of the subject to a level of 0.10 percent (13).
5. Maximum Heart Rate. The highest number of ventricular contractions recorded during the work bout.
6. Maximum Oxygen Consumption ($\dot{V}O_2$ max). The

highest level of oxygen consumption reached during the work bout, as expressed in both liters per minute and milliliters per kilogram of body weight per minute.

7. Maximum Pulmonary Ventilation (Minute Volume). The amount of air expired, in liters per minute, during the work load, when maximum oxygen consumption was elicited, converted to standard temperature and pressure of dry gas.

8. Maximum Perceived Exertion. The highest given rating of perceived exertion during a single work session.

9. Oxygen Consumption. The corrected volume of oxygen extracted from expired air, at sea level, as expressed in liters per minute and millimiters per kilograms of body weight per minute.

10. Perceived Exertion (RPE). The subject's reported feeling of the over-all body response to physical strain, as measured on the Borg 6-20 scale.

11. Sub-Maximal Heart Rate. The heart rate recorded at 150 kpm lower than the highest rating.

12. Sub-Maximal Perceived Exertion. The perceived exertion rating given at 150 kpm lower than the highest rating.

13. Ventilatory Equivalent. The ratio of oxygen used per liter of air consumed.

Delimitations of Study

The delimitations of the study were as follows:

1. The subjects for the study were male and female graduate and undergraduate physical education majors registered in the Spring, 1977 semester at Ithaca College, Ithaca, New York.

2. The intoxicating amount of alcohol was measured as 0.55 ml/lb of body weight of 100 proof vodka.

3. Ratings of perceived exertion were based on the Borg 6-20 scale.

4. Work loads were achieved by riding on a Monark bicycle ergometer.

Limitations of Study

The limitations of the study were as follows:

1. The results of the study apply to the data recorded by means of the progressive step increment test on the bicycle ergometer.

2. No control was made for subjects who may have had more bicycle riding experience outside that which may have been required for formal athletic conditioning.

3. No control was made for subjects who experienced any unusual psychological stress, such as an examination, on the day of their testing for this study.

Chapter 2

REVIEW OF RELATED LITERATURE

The review of literature will relate to three aspects pertinent to this study. A discussion of maximum oxygen consumption and its implications will be followed by an examination of perceived exertion and its implications, and a review of the effects of alcohol on physical performance.

Maximum Oxygen Consumption

Maximum oxygen consumption ($\dot{V}O_2$ max) is the highest corrected volume of oxygen extracted from expired air, as expressed as both liters per minute and milliliters per kilogram of body weight per minute, during a work load of between two and six minutes (2). It is one of the best measurements available for judging a person's ability to adapt to change in work loads under various conditions (10). Maximum oxygen consumption is a function of the person's physical condition, regardless of his age (31).

McArdle and Magel (49) compared the use of two popular methods of gathering $\dot{V}O_2$ max data, namely the bicycle ergometer and the treadmill. They put 23 male college students on a treadmill that was running at 3.4 mph for two minutes at a zero percent increase in grade. Every minute thereafter, the grade was raised one percent. If the subject was not exhausted at the maximum height of 22 percent, the speed was increased. The same 23 subjects were placed on a bicycle ergometer and asked to ride at a pace of 60 rpm with the resistance increasing at the rate of 0.5 kgm every two minutes until they reached exhaustion.

Sub-maximal comparisons were made at 900 kgm/min and at the 10 percent grade. It was found that the percentage of $\dot{V}O_2$ max was greater at the sub-maximal level on the bicycle ergometer and greater at the maximal level on the treadmill. There was no significant difference in heart rate between the two methods.

In another comparison of testing procedure for $\dot{V}O_2$ max, McArdle, Katch, and Pechar (48) tested 15 college students using six of the most common tests. They were the continuous bicycle test; the discontinuous bicycle test; the Balke Treadmill Test; the Mitchell, Sproule, Chapman Test (MSC); the continuous treadmill test; and the discontinuous treadmill test. Results, using an analysis of variance for repeated measures and a .05 level of significance, showed significantly lower levels of $\dot{V}O_2$ max with the bicycle tests. The discontinuous bicycle test results were somewhat higher but not significantly higher in yield of $\dot{V}O_2$ max than the continuous test. A reason given for the lower performance on the bicycle tests as opposed to the treadmill tests was the complaint of local muscular pain in the quadriceps region. The MSC treadmill test not only gave the highest $\dot{V}O_2$ max reading, but also produced the most favorable reaction from the subjects.

Hermansen (40) also made a comparison of the two methods of testing. He used 55 healthy males, ranging in age from 19 to 68 years, and divided them into groups according to age and physical condition. Subjects were asked to ride at 50 rpm at increasing work loads for 10 minutes with samples of expired air taken during the last 30 seconds. The treadmill exercise was performed with a walk at a 10 percent grade at 3.5 mph which was followed by a run at seven miles per hour. All maximal tests started with a warm-up at 50 or 75 percent of a predicted maximum. All sub-maximal work was performed at 25, 50, 75, and 90 percent of maximum. Sub-maximal results showed that heart rate, pulmonary ventilation, and blood lactate levels were higher on the treadmill than on the bicycle. Results at maximal work indicated no differences in all measured variables which were due to fitness levels and conditioning habits. For example, sedentary businessmen showed no difference in oxygen uptake between the two tests though sedentary students had an 11.7 percent increase on the treadmill test (a significant difference.) The author concluded that the maximum levels of heart rate and blood lactate may not be true values since the $\dot{V}O_2$ max values were reached first. His results corresponded with those of Astrand (2) who found no significant differences when riding on the bicycle ergometer or running at either a zero or one percent grade on the treadmill.

Katch and Katch (43) used 75 untrained males to test the linear relationship of work output to $\dot{V}O_2$ max. After a one minute warm-up, the subjects pedalled at 60 rpm against a resistance of 900 kpm/min which was increased by 180 kpm/min until the subject reached exhaustion. Verbal encouragement to continue was given. Work output was measured by a counter activated by a microswitch which was tripped by each full rotation of the bicycle wheel. The work output/$\dot{V}O_2$ relationship showed a correlation that was significant at the .01 level. The relationship continued until the $\dot{V}O_2$ max reading was reached and the work output dropped by 19 percent but the authors did not find this a true measure of $\dot{V}O_2$ max since there was a drop in the productivity.

Girandola and Katch (32) put 45 men on a nine week conditioning program of jogging, sprinting, step running, and calisthenics. They compared their scores on a physical work capacity test to a control group of 45 men. All subjects were pretested one week prior to the start of the program and were posttested within five days after the termination. On a bicycle ergometer, which was chosen because resistance is not effected by any weight loss which may have occurred during the program, subjects were asked to ride at a speed of 60 rpm against a constant load of 1,050 kpm/min. Results of a t test indicated no significant changes in $\dot{V}O_2$ max of the control group which spent the same nine weeks in a general physical education program. Further results showed that there were no significant differences in the $\dot{V}O_2$ max scores of the experimental group. The conditioning program, in this case, had no effect on oxygen consumption.

Perceived Exertion

During exercise, a person receives feedback of a general body feeling and of specific feelings from joints and muscles regarding how hard the work is. These feedback ratings are functions of a person's physical condition at the time of the test. These conditions can include joint and muscle injury as well as respiratory problems (5).

In the early 1960's, Gunnar Borg invented a scale which could be used by all people, businessmen and trained athletes, and which could give a reliable reading of how hard they feel they have been working. The scale, which ranges from six to 20, with every odd number having a verbal association connected to it, was the end result of many trial and error attempts to obtain accurate psychophysical ratings from the subjects. In its final form the scale corresponds to approximately one tenth of the person's heart rate during the work (5,25).

Tarnvall (62) conducted two tests of validity of a heart rate/perceived exertion relationship. In the first test, 69 military conscripts were asked to pedal against a resistance of 1,400 kpm until they reached exhaustion. Their ratings of perceived exertion were based on both the Borg 6-20 scale and a line scale. Another 63 conscripts used Borg's original 1-21 scale and a 1-9 scale. Correlations based on heart rate versus RPE and between methods showed a somewhat high relationship using the 6-20 scale (r=.62) and the line scale (r=.61). A highly significant relationship was seen when comparing ratings on both the 6-20 and the line scales (r=.93). The low correlations between the heart rates and the RPE could have been due to the fact that the starting work load was high.

In a second experiment, Tarnvall (62) used a progressive step increment test. Using the 6-20 scale and the line scale, 43 conscripts achieved a higher correlation of heart rate and RPE (r=.72). His subjects rode at 600 kpm for six minutes and had an increase in resistance of 300 kpm for each additional six minutes until the subjects reached exhaustion.

Skinner, Borg, and Buskirk (20) tested the original Borg HR/RPE correlation (r=.83) on subjects of different body size and exercise habits. Subjects were 26 males, age 17 to 24, who were grouped as either lean and sedentary, lean and active, heavy and sedentary, or heavy and active. Sedentary subjects were those who had a motor fitness test administered to them and were considered unfit by the physical education faculty of their university. The lean and active subjects were long distance runners, and the heavy and active subjects were varsity football players. All subjects rode on a bicycle ergometer, which was used to minimize the effect of the heavy subjects, at 75 kgm/min for four minutes. The resistance was raised 300 kgm/min every four minutes until a self-imposed maximum was reached. Results showed that at all work loads, the light and sedentary group had a higher RPE rating than the active groups. There were no significant differences in perceived exertion ratings between the active groups which indicated that body weight had no significant effect on the ratings.

Testing the hypothesis that perceived exertion is linearly related to increasing work loads as well as heart rate, Gimberale (33) used a series of tests on a population of 12 healthy male college students. One group (n=6) first lifted three weighted boxes of 1,350, 3,350, and 5,350 gm from shoulder height to a shelf 25 cm higher, at a rate of 30 times a minute for six minutes, with an eight minute rest between trials. They were then put on a bicycle ergometer and rode for six minutes at resistances of 300, 600, and 900 kpm/min and at a predicted maximum. The second group (n=6) pushed a wheelbarrow, which weighed either 33, 66, or 96 kg, at a rate of 100 m/min, for six minutes with an eight minute rest between pushes. They were then given the same bicycle test. Heart rates and expired gas samples were taken during the last minute of each bout, and blood lactate samples and RPE ratings were taken at the end of each bout. Results showed the existance of a linear relationship between RPE and blood lactate levels, regardless of the type of work done.

A study by Henriksson, Knuttgen, and Bonde-Petersen (39) investigated the effects of eccentric contractions on RPE. Subjects were six females and 13 males who ranged in age from 18 to 30 and who had various levels of fitness. The Borg 6-20 scale was used for ratings of perceived exertion during the three experiments. In the first experiment the females pedalled at 60 rpm for 10 minutes. In the second and the third experiments the males pedalled for four minutes at 60 rpm and for four minutes at 30 rpm, respectively. During each of these four minute work bouts the subjects were pedalling against 8, 4, and 6 separate resistances of both concentric and eccentric work. Results revealed significantly lower ratings of RPE in eccentric contractions, significantly higher perceived exertion ratings at the slower speed of 30 rpm, and significantly higher ratings of perceived exertion in females.

In the first of his five experiments on the psychological factors effecting RPE, Morgan (52) tested 15 subjects on the bicycle ergometer for the correlation of RPE and work load. After pedalling for one minute at 50 rpm against a resistance of 600 kpm, subjects were asked to rate their work on a scale of 0-25 and they were told that future ratings would be based on that original selection. Subsequent work loads were given in random order of intensity to avoid bias in future ratings. Subjects who made errors in their perception of work were those who were shown to be neurotic or anxious as determined by the Eysenck Personality Inventory and Spielberger's State-Trait Inventory, respectively. Individuals with these symptoms apparently have difficulty with perception.

In the second experiment, nine subjects were asked to pedal at 50 rpm against a resistance of 300, 600, 900, 1.200, and 1,500 kpm for one minute each. This time Borg's 6-20 scale was used for RPE ratings. High negative correlations were found showing a decrease in RPE ratings in extroverted subjects. Extroverts have a high tolerance of pain and would perceive work as being lighter than would an introvert.

The third experiment correlated RPE ratings to state anxiety and neuroticism. Results showed high RPE ratings from those with low anxiety and neuroticism measures.

The fourth experiment showed little relationship between anxiety, neuroticism, and RPE but it was noted that the experimental design differed greatly from experiment number three. Here, the subjects were asked to pedal for 30 minutes against a resistance of 600 kpm at a rate of 50 rpm. A conclusion was drawn that an accurate RPE rating, regardless of the subject, is task specific.

In the final experiment, hypnotic suggestion was used to manipulate the subjects' knowledge of the work level. Subjects were all working at a resistance of 600 kpm, but they were told that they were either cycling uphill, downhill, or on level ground. Perceived exertion ratings were changed periodically in that the heavier the imaginged work load, the higher the perceived exertion rating.

Noble and others (56) tested six male college students in order to determine, in part, what some of the physiological parameters were that effected perceived exertion ratings. All subjects had to have a $\dot{V}O_2$ max of at least 51 ml/kg/min in order to show they could endure the 30 minutes of exercise during each of the five trials. Subjects were asked to ride for 30 minutes at 60 rpm, at levels that would yield 48, 60, and 68 percent of their $\dot{V}O_2$ max based on heart rates that were elicited from pretest data. During the first three trials the required sub-maximal oxygen consumptions were obtained while the room was kept at a constant temperature of 24°C. The fourth trial was conducted with the room temperature at 44°C and the fifth with the room at 54°C with each eliciting 48 percent of $\dot{V}O_2$ max. Results showed significant increases in RPE were achieved when body heat increased in the normal-temperature room. Readings of $\dot{V}O_2$ max were shown to have no relationship to measures of RPE.

Skinner and others (60) authored a study which examined the reliability of Borg's scale. They thought that subjects would think that as work loads increased and heart rates followed suit ratings of RPE should do the same. The eight lean and eight obese male college students used in the study were asked to ride on two separate occasions, on a bicycle ergometer, at progressively increasing resistances of 150 kgm/min every two minutes until they reached exhaustion. They then rode two more times with a resistance of either 300, 450, 600, 750, or 900 kgm/min for four minutes with the resistances randomly selected. No significant differences were found between different test methods. This led to the conclusion that subjects, regardless of body type and order of presentation of stimuli, can perceive small differences in work loads on the bicycle ergometer.

Pandolf and Noble (57) used 15 healthy conditioned athletes to test the effects of pedalling speeds at equivalent power outputs on ratings of perceived exertion. The minimum criteria for the subjects were a weight of between 65 and 85 kg and a $\dot{V}O_2$ max of 51 ml/kg/min. Three different pedal speeds of 40, 60, and 80 rpm were each used against resistances of 550, 775, and 1,075 kgm/min. Perceived exertion was shown to be significantly higher during work at 40 rpm, since the resistance was harder to overcome with a slower speed. The result corresponded to a similar one achieved by Henriksson, Knuttgen, and Bonde-Petersen (39).

Effects of Alcohol on Physical Performance

After an alcoholic drink has been absorbed into the blood and oxidized, the excess ethanol, usually about 10 percent of what was consumed, finally reaches the brain. Among alcohol's major effects are a decrease in memory, a decrease in balance control, and a decrease in the effectiveness of the audio center.

Perhaps alcohol's greatest effect is on fine motor movements. A 65 gm dose of alcohol decreased finger control by 20 percent as measured on an ergograph. The fine finger skill of typing was slowed by three percent (16). Tracing ability was decreased by 20 percent due to the distorting of the muscular-controlling nerves. Movements became shaky and exaggerated (8,11,18).

Haffner and others (35) gave eight male volunteers, who were classified as moderate drinkers, a 30 percent solution of 192 proof ethanol dissolved in fruit juice. Results on a mirror tracing test showed that while under the influence of the drink, subjects attempted more but made more errors. Reduced scores were also present in tests for memory, sorting, and simple coordination.

In a test for both accuracy and perception, Mørland and others (53) gave eight healthy males either a placebo, diazepam, a 20 percent solution of 192 proof ethanol, or diazepam and ethanol. Results indicated that the scores on a mirror tracing test were reduced when the subjects took the ethanol even though they completed the course faster. When given a time evaluation ability test, the subjects with the ethanol indicated that time seemed to go by faster.

In a study involving a critical tracking test (CTT), Klein and Jex (45) found that the subjects classified as heavy drinkers had a better performance than those who were moderate drinkers. The heavy drinkers received 0.60 ml/kg of body weight of a 20 percent solution of 200 proof ethanol, the moderate drinkers received 0.45 ml/kg, and the light drinkers received 0.35 ml/kg. The results substantiated those found by Haffner and others (35) who also used a coordination test. It was noted, though, that while the heavy drinkers did perform better than the other two groups, over-all performance dropped as BAC increased.

After a long period of usage, alcohol can decrease a person's ability to detect pain to an intensity beyond that of social drinkers. Using 29 alcoholics and 50 non-alcoholics, Cutter and others (29) found a significantly greater degree of tolerance to pain in the alcoholics. All subjects received the equivalent of one and one half ounces and three ounces, for a 70 kg man, of 100 proof alcohol. The test used was a subjective pain test in which the subjects had to submerge their non-writing arm up to the elbow with the fingers extended into a pail of ice water for 40 seconds. Scoring was done on a ten-point rating scale in which "1" represented little pain and "10" represented pain great enough to want to withdraw the arm from the water.

Concerning the resting muscle and its reaction to alcohol, Doctor and Perkins (30), after giving their subjects 0.50 ml/kg of a 20 percent solution of 200 proof ethanol, found a significantly higher level of resting muscle tonus. The subjects ranged from social drinkers to abstainers in their assessments of their own drinking habits.

Astrand and Rodahl (2) reported that maximal isometric muscular strength can be improved with moderate degrees of alcohol consumption using untrained subjects. This was due to the depression of the nerve fibers leading to the skeletal muscles.

Using the moving muscle, Williams (63) examined the effects of 190 proof ethanol, measured at 0.20 ml/lb and 0.40 ml/lb on fatigue rate using the forearm flexors. The subjects, 35 male college students, flexed their forearm muscles against a resistant handle at a rate of 30 times per minute for six minutes and were measured for their initial strength, maximal strength, and final strength. There were no significant differences across the dependent variables under any of the experimental conditions.

In contrast to these findings was a study by Hebbelinck (38) who examined the effects of a 20 percent solution of 188 proof ethanol on vertical jump, 80 meter dash time, posture control, and static strength. The subjects, 21 males, were tested when both sober and under the influence of the alcohol, which was measured out at 0.60 ml/kg. Results showed a significant decrease in vertical jump, a significant increase in dash time, and a decrease in posture control as measured by the Rhomborg test. There was no significant change in grip strength scores.

Tests of endurance, which included bicycle riding and push-ups, showed significant decreases in scores when BAC was high in a test conducted by Nelson (54). A total of 30 subjects were randomly divided into six groups. The groups received two or three ounces of 200 proof ethanol or a placebo at time intervals of one day before

90 minutes before, and 24 hours after the test. Speed and reaction time, as judged by start time in a 10-yard dash, decreased. Strength, as measured by a hand dynamometer, decreased the greatest of all the variables.

The research into the effects of alcohol on the circulatory system is not conclusive. Textbooks such as those by Chafetz (8) and Fort (11) say that there is a decrease in heart rate. Doctor and Perkins (30) went beyond that when they found a significant decrease in the heart rate of subjects who were given a 20 percent solution of 200 proof ethanol measured at 0.50 ml/kg.

Hebbelinck (37) gave 21 male subjects 0.60 ml/kg of a 20 percent solution of 188 proof ethanol and asked them to ride for five minutes on a bicycle ergometer at 1,000 kg/m/min. The average heart rate increase was four beats per minute at the end of the 40 minute absorption period, and an average of 23 bpm at the end of the work load. Alcohol's disruption of the hypothalamus was given as a reason for the results but the author cautioned that there were many uncontrolled variables.

In circulatory system experiments using commercially prepared alcoholic drinks, Riff, Jain, and Doyle (58) studied the effects of alcohol for its hemodynamic effects on subjects with no history of cardiac conditions. The subjects, while under the influence of six ounces of 90 proof bourbon, were placed on a bicycle ergometer which was set at a resistance of 100 watts. They had not eaten for six hours before the test nor had they consumed alcohol for 12 hours beforehand. Results indicated that after five minutes of riding there was a significant increase in heart rate but not in stroke volume.

Delgado, Fortuin, and Ross (29) found an increase of 12 percent in the heart rates of subjects with a low dose of alcohol and an increase of eight percent with a high dose. The low dose was 0.70 ml/kg of 86 proof scotch, and the high dose was 1.15 ml/kg.

The hangover is the most widely recognized after-effect of a single bout of moderate drinking. It is characterized by headache caused by the vasodilation of the blood vessels in the brain and fatigue caused by the retarded rate of removal of lactic acid from the cells (8,14,16).

A study by Karvonen, Miettinen, and Ahlman (42) attempted to measure the effects of a hangover on physical work. Thirty males were given 2.49 ml/kg of a 33 percent solution of 200 proof ethanol before bedtime. In the morning, they were allowed one cigarette, if desired, and were then asked to ride a bicycle ergometer set at 1,500 kpm for five minutes. Compared to a control population, the hangover group showed significantly higher heart rates after the second minute of work, but no such differences at any other interval during the test. Results also indicated no significant differences in grip strength and vertical jump ability.

The effect of alcohol on cardio-pulmonary function has been explored in various ways. In testing the combined effect of alcohol and altitude on oxygen consumption, Mazness and others (50) gave their subjects 1.70 ml/kg of 83 proof ethanol, and put them at an altitude of 4,000 meters. After a four minute bout at a sub-maximal work level of 1,000 kpm, pedalling at 60 rpm, a one minute sample of expired air was taken. Total riding time was five minutes. Results showed that there was a significant increase in the oxygen consumption scores of those who had been at that altitude before.

Blomqvist, Saltin, and Mitchell (23) gave eight male subjects, who were classified as moderate drinkers, a 150 ml drink of 86 proof rum, whiskey, or gin. The choice of drink depended on the individual's taste. A maximal work load and two sub-maximal work loads (one at 50 percent and the other at 75 percent) were given on the bicycle ergometer. No significant differences in oxygen consumption scores were found. Sub-maximal results showed a significant increase in oxygen consumption scores in the alcohol group.

Bobo (24) gave 19 male college students a drink which consisted of either 0, 0.20, 0.40, or 0.60 ml/lb of 190 proof ethanol mixed with 10 oz of grape juice. A maximal work load, which started as a 10 minute run on a treadmill at 3 mph up a 10 percent grade and followed by a series of three minute runs at 6.14 mph as grades increased by two percent, was given. Results showed no significant differences in $\dot{V}O_2$ max, heart rate, and lung ventilation.

In 1972, Williams (64) conducted a test with nine college students and faculty members. All subjects had a dose of either 0, 0.20, 0.40, and 0.60 ml/lb of a 20 percent solution of 190 proof ethanol. Results showed that after a maximal work load of three minutes of pedalling at 500, 1,000, and 1,500 kpm on the bicycle ergometer, there were no significant differences in heart rate and oxygen consumption.

Summary

Maximum oxygen consumption is one of the best indicators of one's ability to do strenuous work. Regardless of the person's age, it is a reliable indicator of physical condition. Tests for $\dot{V}O_2$ max are conducted by using either a treadmill or a bicycle ergometer and using either a continuous or a progressive step increment test. Results of several studies have shown that work bouts on the treadmill will give a greater yield of $\dot{V}O_2$ max than work bouts on the bicycle (49,50), while one test indicated that there were no differences in methods (48). Readings of $\dot{V}O_2$ max are significantly effected by the amount of work output (43), but not by short-term physical conditioning programs (32).

Perceived exertion is a psycho-physical assessment of work as rated by the subject with the use of a scale of numbers, ranging from 6-20 and having verbal associations with every odd number, that was invented by Borg (5). Such ratings are not significantly changed in either direction by changes in body weight (20) but can be altered by increased work load (33), decreased pedal speed (39), body temperature (57), and psychological conditions (52).

Alcohol is a colorless, odorless liquid that is the base for many of the world's most popular drinks. Aside from the pleasant, relaxing feeling it gives, alcohol has several side effects. It seems to slow fine movements (16), decrease tracing performance (35,53), hinder the ability of nerves to detect pain (28), increase dash time, decrease balance (38), and decrease physical endurance (47). No significant differences have been found in static or explosive strength after having been "hung over" (42). There were no significant differences in $\dot{V}O_2$ max while under the influence of alcohol (23,24,64).

Chapter 3

METHODS AND PROCEDURES

This chapter contains a discussion on the selection of subjects, the instruments, testing design, and procedures for collection and treatment of data.

Selection and Description of Subjects

A total of 12 volunteer male and female graduate and undergraduate physical education majors who were enrolled in the Spring, 1977 semester at Ithaca College, Ithaca, New York, served as subjects for this study. The six males ranged in age from 21 to 27 years, with a mean age of 23.0 years and a standard deviation of 2.08. They ranged in weight from 134 to 204 pounds, with a mean weight of 165.83 pounds, and a standard deviation of 25.78. The six females ranged in age from 18 to 21 years, with a mean age of 19.67 years, and a standard deviation of 1.11. They ranged in weight from 115 to 141 pounds, with a mean weight of 130.33 pounds and a standard deviation of 7.87.

Of the 12 subjects, four were on athletic teams at Ithaca College within the last year, one was presently involved in training for a team, and none were engaged in training methods that required bicycle riding. All subjects were subjected to all treatments of the experiment.

Testing Instruments

A Detecto Medic scale was used to weigh all subjects when they first came into the testing room. Their weights and a standard amount of alcohol were entered into a Texas Instruments SR-10 calculator in order to determine how much 100 proof Jacquins vodka would be given. A noseclip and two Cēpacol Anesthetic Troches with Benzocaine were used to eliminate the sense of taste.

Heart rate was measured by listening with a stethoscope and counting the ventricular contractions. This was accomplished by placing the stethoscope on the left side of the sternum just below the manubrium.

Work was done on the Monark Bicycle Ergometer to a pace set by a Franz Electric Metronome. Expired gas was collected in a 120 liter Collins Chain Compensated Gasometer and was then drawn by a Beckman Sample Pump to a Beckman F3M3 Oxygen Analyzer and a Beckman LB1 Medical Gas Analyzer for readings of expired oxygen and carbon dioxide, respectively.

Temperature of the expired gas was measured by the mercury thermometer attached to the gasometer. Barometric pressure was measured by a Collins Pulmonary Function Barometer.

Drinks were mixed in a paper cup in the desired proportions. A straw was placed in the cup for easy consumption by the subject. The alcohol, or an equivalent amount of water and eight drops of tabasco sauce, was measured in a Pyrex #3075 100-ml flask and mixed with orange juice. There was a separate flask for the alcoholic and the non-alcoholic drinks. All materials were kept at a constant temperature of 7°C in a refrigerator in an adjacent laboratory.

Testing Design

A single-blind testing design was used for this study. All subjects received all three treatments: once with an intoxicating amount of alcohol and twice with an equivalent amount of water. The decision as to whether to give the alcoholic or non-alcoholic drink was made at random.

For standardization of data, all subjects were asked to report to the testing area at the same time of the day on the same day of three separate weeks. The exact time of testing was determined by the availability of the laboratory, the availability of the tester and the subjects, and the time of day the subject could best go without having eaten for at least six hours.

Testing Environment

The experiment was conducted in the Ithaca College Exercise Physiology Laboratory. Room temperature was kept at between 21 and 24°C. There were no external stimuli, such as music, to distract from the beat of the metronome, but subjects were engaged in conversation with the experimenter or other subjects in order to eliminate boredom.

Testing Procedure

Before taking part in the experiment, all subjects were asked to sign an Informed Consent Form (46). In addition, all subjects were asked to bring proof of being over 18 years of age in order to comply with the New York State liquor law concerning minimum legal age for alcohol consumption (6).

When the subjects entered the test area, they showed their Informed Consent Forms and proof of age, and were then weighed. Afterward, they went over to the bicycle and were asked to adjust the seat and the mouthpiece. They they went back to a seat in the room, sat down, and attached a noseclip. The two throat lozenges were administered.

While the subjects were dissolving the lozenges, the barometric pressure reading was recorded. Then a drink was prepared, in an adjacent laboratory, that consisted of 0.55 ml/lb of either 100 proof vodka or water. The drink containing the water had eight drops of tabasco sauce added to simulate the burning sensation of the vodka. All drinks had 50 ml of orange juice added.

When the lozenges were dissolved, the subjects' heart rates were taken. They were told that they had a maximum of 10 minutes in which to consume their drink, and to expect a burning sensation no matter what type of drink they had. They were relaxed and were asked to use the straw as seen in Figure 1 (p. 28). When they finished the drink, heart rates were again taken. They were then told there would be a 30 minute absorption period to follow. To help maximize the absorption of the alcohol into the blood system, all subjects were asked not to eat for at least six hours before coming to the test area, and were asked not to consume any alcohol the night before or the day of the test.

It was during the absorption period that a final check was made on the apparatus. If there were any other subjects in the room, it was the testing period for them.

At the end of the 30 minutes, the heart rate was taken again. At the appropriate time, each subject went over to the bicycle and was instructed in the use of the perceived exertion scale and then began pedalling in time with the metronome that was set at a rate of 50 rpm. It was up to the subject to decide which foot would be coordinated to the click of the metronome.

The warm-up period consisted of riding for 10 minutes at a resistance of 300 kpm for the females and 450 kpm for the males. During the last minute of the bout, expired air was collected in the gasometer, a reading of heart rate was taken, and a rating of perceived exertion was requested. A five minute rest period was allowed.

In between work bouts, subjects were free to take a drink of water from the fountain located outside the laboratory, and were encouraged to wipe themselves off with the towel that was always available. Subjects were asked to walk around and to stretch in order to prevent cramping.

Each succeeding bout lasted three minutes, with gas samples, heart rate counts, and RPE ratings taken during the last minute. The process continued until the subject could no longer continue or until there was an increase in work load with no increase in oxygen consumption. The gas collection process can be seen in Figure 2 (p. 30).

At the end of the test, all subjects were given a chance to recover. They were asked not to leave the testing area until they were sure they had recovered from the effects of the riding.

After each subject finished on the bicycle, the mouthpiece was changed. The one-way valve was cleaned and the hose was ventilated periodically during the testing period. All instruments were calibrated before the start of each testing session.

Method of Data Collection

Upon completion of each bout, the readings of oxygen and carbon dioxide in the expired gas were made to the nearest hundredth and tenth of a percent, respectively. These data, along with barometric pressure, gas temperature, change of volume in the tank, and the subject's weight were used in an oxygen consumption computer program which gave back minute volume, $\dot{V}O_2$ max l/min and ml/kg/min, ventilatory equivalent, and the original data.

Heart rate was obtained by listening to the ventricular contractions through a stethoscope which was placed on the left side of the sternum, just below the manubrium, during the last minute of each work bout.

Perceived exertion ratings were based on the Borg 6-20 scale. A copy of the scale appears in Appendix A. The instructions for the use of the scale were based on those used by Noble and others (56), and appear in Appendix C. A copy of the scale was placed on the bicycle ergometer, within easy reading distance from the subject who had to make a decision on his perceived exertion as soon as the bout was over. Subjects were not told of the approximate 1:10 ratio of perceived exertion to heart rate until the third trial had been completed.

Treatment of Data

A multivariate analysis of variance was used to determine if significant F ratios existed between treatments across dependent variables. A univariate one-way analysis of variance for repeated measures was used for tests of maximum oxygen consumption, sub-maximal and maximal heart rates, sub-maximal and maximal ratings of perceived exertion, and measures of pulmonary ventilation to determine if significant F ratios existed between experimental conditions. The .05 significance level was employed. When significant F ratios were obtained, the Tukey post-hoc test of significance was used to determine where these differences took place.

Reliability of data was determined by the use of an intraclass correlation technique.

Summary

The test of the effects of alcohol on heart rate, pulmonary efficiency, $\dot{V}O_2$ max, and perceived exertion was conducted in the Exercise Physiology Laboratory at Ithaca College, Ithaca, New York. Each of the 12 subjects was asked to ride on the bicycle ergometer, on three separate occasions, until exhaustion was reached or until there was no increase in $\dot{V}O_2$ with increasing work loads. Before riding, and after having put on a noseclip and dissolving two anesthetic throat lozenges, subjects were given either a drink with 0.55 ml/lb of 100 proof vodka and 50 ml of orange juice or a drink with an equivalent amount of water, 50 ml of orange juice, and eight drops of tabasco sauce. The latter drink was administered twice. Data were recorded using a progressive step increment test.

A multivariate analysis of variance was used to determine if significant F ratios exsited between treatments across dependent variables. A univariate one-way analysis of variance for repeated measures was used to determine if significant F ratios existed between experimental conditions. Reliability of data was determined by use of an intraclass correlation technique.

Chapter 4

ANALYSIS OF DATA

The analysis of data deals, first, with the intraclass correlation performed for reliability of data. This is followed by a discussion on the multivariate analysis of variance and the univariate analysis of variance performed.

Reliability of Data

As listed in Table 1 (p. 34), intraclass correlation coefficients in females revealed acceptable reliability for sub-maximal heart rate (R=.93), sub-maximal RPE (R=.88), maximal RPE (R=.87), $\dot{V}O_2$ max l/min (R=.87), $\dot{V}O_2$ max ml/kg/min (R=.90), and maximum ventilatory equivalent (R=.88). Lower correlations in maximum heart rate (R=.47), and minute volume (R=.51) were found.

In males, reliable correlation coefficients were obtained in maximum heart rate (R=.96), sub-maximal RPE (R=.94), $\dot{V}O_2$ max l/min (R=.88), $\dot{V}O_2$ max ml/kg/min (R=.73), and minute volume (R=.90). Lower correlations were found in sub-maximal heart rate (R=.09), maximal RPE (R=.45), and ventilatory equivalent (R=.31).

Correlation coefficients across all subjects revealed acceptable reliability in sub-maximal heart rate (R=.81), maximal heart rate (R=.77), sub-maximal RPE (R=.76), maximal RPE (R=.73), $\dot{V}O_2$ max l/min (R=.92), $\dot{V}O_2$ max ml/kg/min (R=.80), ventilatory equivalent (R=.72), and minute volume (R=.84).

Table 1

Intraclass Correlations for Reliability of Data

	Females	Males	All Subjects
SUB-MAXIMAL HEART RATE	.93	.09	.81
MAXIMAL HEART RATE	.47	.96	.77
SUB MAXIMAL RPE	.88	.94	.76
MAXIMAL RPE	.87	.45	.73
$\dot{V}O_2$ MAX l/min	.87	.88	.92
$\dot{V}O_2$ MAX ml/kg/min	.90	.73	.80
VENTILATORY EQUIVALENT	.88	.31	.72
$\dot{V}_E$ MAX/STPD	.51	.90	.84

Results of Multivariate Analysis

Table 2 (p. 36) indicates that there were no significant differences between treatments across all subjects. This led to the inability to reject the major null hypothesis. There is no significant over-all difference between experimental treatments for the physical and psycho-physical parameters employed across all subjects.

Table 3 (p. 37) indicates that there were no significant differences between treatments for female subjects. This led to the inability to reject the major null hypothesis. There is no over-all significant difference between experimental treatments for the physical and psycho-physical parameters employed for males.

Table 4 (p. 38) indicates that there were no significant differences between treatments for male subjects. This led to the inability to reject the major null hypothesis. There is no over-all significant difference between experimental treatments for the physical and psycho-physical parameters employed for females.

Results of Univariate Analysis

As seen in Table 5 (p. 39), the univariate ANOVA for repeated measures for all subjects revealed non-significant F ratios for sub-maximal and maximal heart rates, sub-maximal and maximal ratings of perceived exertion, $\dot{V}O_2$ max l/min, $\dot{V}O_2$ max ml/kg/min, ventilatory equivalent, and minute volume. This led to the inability to reject all minor null hypotheses which stated that there would be no significant differences between experimental treatments for each variable across all subjects.

As seen in Table 6 (p. 40), the univariate ANOVA for repeated measures for males revealed non-significant

Table 2

Summary for MANOVA in All Subjects for Eight Physiological Variables

	Approximate F	df	Level of Significance
Subjects	8.1445	8,11,22	$< .05$
Treatments	0.8067	8, 2,22	N.S.

Table 3

Summary for MANOVA in Males for the
Eight Physiological Variables

	Approximate F	df	Level of Significance
Subjects	6.0977	8,5,10	$<.05$
Treatments	0.2754	8,2,10	N.S.

Table 4

Summary for MANOVA in Females for
Eight Physiological Variables

	Approximate F	df	Level of Significance
Subjects	9.7214	8,5,10	< .05
Treatments	0.6170	8,2,10	N.S.

Table 5

Means, Standard Deviations, and Univariate F Ratios in All Subjects for Eight Physiological Variables

Measurements	Without Alcohol 1		Without Alcohol 2		With Alcohol		F	p
	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.		
SUB-MAXIMAL HR	172.3	12.24	175.0	10.67	167.3	13.94	2.947	0.0721
MAXIMAL HR	186.7	8.46	188.7	5.93	184.6	10.86	1.206	0.3187
SUB-MAXIMAL RPE	16.3	1.30	16.4	1.38	16.4	1.68	0.035	0.9665
MAXIMAL RPE	18.6	0.97	18.6	0.97	18.9	1.16	0.187	0.8320
$\dot{V}O_2$ MAX l/min	3.0	0.77	2.9	0.82	2.7	0.84	0.921	0.1688
$\dot{V}O_2$ MAX ml/kg/min	44.9	6.37	44.2	7.34	40.0	7.90	2.430	0.1098
VENTILATORY EQUIVALENT	2.8	0.46	2.8	0.38	2.9	0.45	0.320	0.7336
$\dot{V}_E$ MAX/STPD	62.5	12.86	62.7	10.30	62.6	19.58	0.001	0.9986

Table 6

Means, Standard Deviations, and Univariate F Ratios in Males for the Eight Physiological Variables

Measurements	Without Alcohol 1		Without Alcohol 2		With Alcohol		F	p
	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.		
SUB-MAXIMAL HR	173.3	9.00	176.0	7.16	168.7	15.47	1.148	0.3569
MAXIMAL HR	183.0	6.16	186.0	5.66	181.5	14.50	0.580	0.5816
SUB-MAXIMAL RPE	15.5	2.88	15.3	2.73	17.0	1.90	0.894	0.5578
MAXIMAL RPE	18.7	0.82	18.5	0.84	19.2	0.75	1.000	0.4039
$\dot{V}O_2$ MAX l/min	3.4	0.93	3.4	0.98	3.2	0.87	0.174	0.8430
$\dot{V}O_2$ MAX ml/kg/min	45.0	7.79	45.1	8.43	42.9	9.01	0.157	0.8564
VENTILATORY EQUIV.	2.8	0.44	2.7	0.29	2.8	0.35	0.387	0.6929
$\dot{V}_E$ MAX/STPD	67.8	12.02	68.7	11.10	74.6	20.20	0.775	0.5101

Table 7

Means, Standard Deviations, and Univariate F Ratios in Females for Eight Physiological Variables

Measurements	Without Alcohol 1		Without Alcohol 2		With Alcohol		F	p
	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.		
SUB-MAXIMAL HR	171.3	15.68	174.0	14.03	166.0	13.56	1.573	0.2543
MAXIMAL HR	190.3	9.33	191.3	5.32	187.7	5.13	0.595	0.5739
SUB-MAXIMAL RPE	15.8	1.33	16.2	1.72	15.8	1.33	0.455	0.6513
MAXIMAL RPE	18.8	1.17	19.0	1.10	18.7	1.51	0.383	0.6957
$\dot{V}O_2$ MAX l/min	2.7	0.26	2.6	0.23	2.2	0.35	5.598[a]	0.0231
$\dot{V}O_2$ MAX ml/kg/min	44.9	5.35	43.4	6.77	37.1	5.91	5.441[a]	0.0248
VENTILATORY EQUIVALENT	2.9	0.51	2.9	0.44	3.0	0.55	0.061	0.9412
$\dot{V}_E$ MAX/STPD	57.2	12.31	56.7	4.99	50.7	9.57	1.262	0.3250

[a]Significant at the .05 level

F ratios for sub-maximal and maximal heart rates, sub-maximal and maximal ratings of perceived exertion, $\dot{V}O_2$ max l/min, $\dot{V}O_2$ max ml/kg/min, ventilatory equivalent, and minute volume. This led to the inability to reject all minor null hypotheses which stated that there is no significant difference between experimental treatments for the physical and psycho-physical parameters employed for males.

As seen in Table 7 (p. 41), the univariate ANOVA for repeated measures for females revealed non-significant F ratios for sub-maximal and maximal heart rates, sub-maximal and maximal ratings of perceived exertion, ventilatory equivalent, and minute volume. This led to the inability to reject the minor null hypotheses that there is no significant difference between experimental treatments for sub-maximal and maximal heart rates, sub-maximal and maximal ratings of perceived exertion, ventilatory equivalent, and minute volume in females. Significant F ratios of 5.59 for $\dot{V}O_2$ max l/min and 5.44 for $\dot{V}O_2$ max ml/kg/min led to a rejection of the minor null hypotheses for these variables in females. A post hoc test, using the Tukey method, revealed a significant difference between the first trial without alcohol and the alcohol treatment for $\dot{V}O_2$ max ml/kg/min. The same post-hoc analysis revealed a significant difference between all trials for $\dot{V}O_2$ max l/min.

Summary

Intraclass correlation coefficients showed acceptable reliability in most cases. Low coefficients of reliability were found for male maximum heart rate and minute volume, and female sub-maximal heart rate, maximal ratings of perceived exertion, and ventilatory equivalent. A multivariate analysis of variance revealed no significant differences between treatments in all subjects, in females, and in males. A univariate analysis of variance revealed significant differences in $\dot{V}O_2$ max l/min and $\dot{V}O_2$ max ml/kg/min for female subjects.

Chapter 5

DISCUSSION OF RESULTS

The discussion of results explores the three main factors involved in this study. It begins by examining the results obtained in the test for maximum oxygen consumption. This is followed by the discussion of the results of the tests on heart rate and on ratings of perceived exertion.

Maximum Oxygen Consumption

Results of analyses performed on maximum oxygen consumption data revealed no significant differences between experimental conditions for males and across all subjects. There was a significant difference found in the univariate analysis of data for females in both $\dot{V}O_2$ max l/min and $\dot{V}O_2$ max ml/kg/min. In both of these measurements, the subjects consumed significantly less oxygen when intoxicated.

These results must be interpreted with caution. First, there were no over-all significant differences found for females as a result of the MANOVA performed. This is consistent with MANOVA results for males and across all subjects. Second, there were no significant differences found in the other pulmonary data comparisons. Ventilatory equivalent should have shown a corresponding decrease on oxygen used. Third, with the small number of females employed, any large intra-individual difference in a small percentage of the subjects could effect the entire population result.

The lack of an over-all significant difference is in accord with the results of the studies by Blomqvist, Saltin, and Mitchell (23), Bobo (24), and Williams (64). Both Bobo and Williams, though, used 190 proof ethanol when conducting their experiments. Blomqvist, Saltin, and Mitchell used 86 proof ethanol.

The over-all results of this study are in contrast to those achieved by Mazness and others (50). They did note a significant difference in maximum oxygen consumption.

Differentiation in the results of various studies make it necessary to examine the trends that are observed in this study in order to facilitate future investigations. With respect to $\dot{V}O_2$ max l/min, 58 percent of the subjects showed a decrease in consumption while under the influence of alcohol. The remaining 42 percent either increased or remained the same. An examination of the $\dot{V}O_2$ max ml/kg/min data revealed that 50 percent of the subjects showed a decrease in consumption while the other 50 percent were evenly divided by those whose scores either increased or remained the same.

The great majority of scores in the decreasing direction raises the question of the unique effects of alcohol on female aerobic power. Further investigation in this area is needed.

Heart Rate

The effect of alcohol on heart rate is not a new topic of investigation. The major problem, though, has been in the methodologies employed, as different studies have yielded inconsistent results.

The results of this study, which revealed no significant differences between experimental conditions for heart rate, are in conjunction with those of Bobo (24), and Williams (64). When examining these studies, though, it must be noted that along with the difference in the strength of the alcohol they used, Bobo conducted his study using a treadmill and Williams regulated the resistances of riding across all subjects.

The results achieved in this study differ with those of Riff, Jain, and Doyle (58) who found an increase in heart rate. Their test, though, consisted of only one work bout while under the influence of an amount of alcohol that was the same, in volume, for all subjects, regardless of body weight. Hebbelinck (37) also found an increase in heart rate, using 188 proof ethanol and one standard riding resistance. These results are in contrast to the physiological rule that heart rate, as do other body functions, slows down when alcohol is administered (11,21).

In this study, trends show a decrease in beats per minute in all subjects in both sub-maximal and in maximal work. The results contribute to the inconclusiveness of the effects of alcohol on the working heart. Different dosages of different strengths of ethanol produce their own unique results and generalizations are difficult to draw. The trend of decreasing heart rates in this study and supported by texts (8,11,21) leads to another important question. It must be found whether the heart is working more efficiently when the person is intoxicated or if the body is receiving less blood. The answer may lie in measurements of stroke volume.

It would appear that results of studies conducted on the effect of alcohol on the heart are drink and task specific. Replication of studies with one variable held constant is needed to draw any generalizations.

Perceived Exertion

There appear to have been no studies published concerning the effects of alcohol upon ratings of perceived exertion. It is for this reason that a hypothesis of results must be made on a cumulation of the information appearing in the following paragraphs.

Astrand and Rodahl (2) described alcohol as a depressant that inhibits the nerve fibers leading to the skeletal muscles. This would lead to the hypothesis that a person under the influence of alcohol would feel less pain, as did the subjects in the study by Cutter and others (28). One would then expect that ratings of perceived exertion would not significantly increase and may evenly be significantly lower.

On the other hand, alcohol inhibits the removal of lactic acid which is hypothesized as the cause of pain while working (21). It also slows down the ability of the thalamus to send analgesic relief to the effected body areas. A high degree of pain in a localized area as is brought about by riding on the bicycle ergometer for a long period of time would lead to the hypothesis that ratings of perceived exertion would be significantly greater in the subject that is under the influence of alcohol.

The latter hypothesis was rejected due to the amount of information regarding alcohol's depressant characteristics. It is a nerve fiber relaxer, slowing the messenger units (21). It must also be noted that due to alcohol's inhibition relaxation ability, the subject who would have normally quit at a given time may feel that he is more able to continue (11). The fact that alcohol decreases the ability to perform fine coordinated skills was not a factor to be considered in this study where the only required skill was to ride the bicycle. Thus it was hypothesized that subjects, while under the influence of a legally intoxicating amount of alcohol, would have lower ratings of perceived exertion then when they were sober.

The results of this study showed no significant differences in ratings of perceived exertion across all experimental conditions. It would appear, then, that alcohol would have no effect on RPE scores in either direction. In conjunction with the studies by Gimberale (30) and Skinner and others (60), the ratings tended to increase with an increasing work load.

A point of interest can be made concerning the results of this study. As experimental conditions were changed, both heart rate and RPE scores were not significantly altered. This showed to be a more accurate evaluation of the effect of the alcohol on the population employed than were the maximum oxygen consumption data, which did show a significant decrease among the females. While it is not yet accepted as a completely positive method, these results add to the hope that the RPE scale could be used when assessing work capacity under game conditions where the use of sophisticated physiological data collection devices is impractical.

Uncontrolled Variables

Ratings of perceived exertion and heart rates are both affected by variables that cannot be controlled. This is especially true if, for the sake of practicality, the experimenter uses a subject that has been following a normal daily routine before becoming intoxicated.

Heart rate is affected not only by the amount of work done, but by emotions as well. A subject can enter the test area by coming in either rushed or very nervous, producing a high heart rate. Drops in count, in these instances, cannot be completely attributed to the ingestion of the alcohol. Not all subjects will admit to being afraid of what will transpire during the test, and yet such a condition cannot be assumed when examining the data. Neither can a person's anxiety of events that are expected to happen after the test is over be assumed.

Perceived exertion is affected by localized pain in muscles or joint areas, caused by either lactic acid build-up, injury, or both. Yet, an assumption cannot be made as to how much work a person has done before he came into the test area. Pain from injury can raise the ratings of perceived exertion, but injury can be concealed from the experimenter.

Summary

The results of this study are in conjunction with other studies performed in this area (23,24,64), and in contrast with others (37,50,58), with respect to $\dot{V}O_2$ max and heart rate. There were no studies to compare perceived exertion data to, but the results contradicted the hypothesis that a subject would feel less pain when under the influence of alcohol.

Chapter 6

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

A total of 12 male and female, graduate and undergraduate physical education majors, enrolled in the Spring, 1977 semester at Ithaca College, Ithaca, New York, were the subjects for this study which investigated the effects of a legally intoxicating amount of alcohol on heart rate, maximum oxygen consumption, pulmonary efficiency, and ratings of perceived exertion. All subjects were given three maximum progressive step increment work loads on the bicycle ergometer under one of two experimental conditions. The intoxicating amount of alcohol, consisting of 0.55 ml/lb of 100 proof vodka, mixed with 50 ml of orange juice, was given once. An equivalent amount of water, mixed with 50 ml of orange juice and eight drops of tabasco sauce, was given twice. The order of presentation of drinks from one subject to the next was random. A reading of heart rate, pulmonary ventilation, oxygen consumption, and perceived exertion was taken during the last minute of each step of the work bout.

Each work load consisted of a 10 minute warm-up at either 300 kpm (for females) or 450 kpm (for males,) followed by a five minute rest. Each succeeding work load was at an increase of 150 kpm, lasting for three minutes, and was followed by a five minute rest. Maximum level was reached when the subject could no longer continue or when there was an increase in work load with no increase in oxygen consumption. Sub-maximal readings were those recorded at 150 kpm lower than those achieved at maximum.

Reliability of data was established by means of an intraclass correlation. A multivariate analysis of variance was used to determine if significant F ratios existed between treatments across dependent variables. A univariate one-way analysis of variance for repeated measures was used to determine if significant F ratios existed between experimental conditions. The .05 significance level was employed.

Conclusions

Within the limitations of this study, the following conclusions can be made:

1. The ingestion of a legally intoxicating amount of alcohol has no significant effect on heart rate, pulmonary ventilation, maximum oxygen consumption, and ratings of perceived exertion as measured across all subjects.

2. The ingestion of a legally intoxicating amount of alcohol has no significant effect on heart rate, pulmonary ventilation, maximum oxygen consumption, and ratings of perceived exertion as measured in male subjects.

3. The ingestion of a legally intoxicating amount of alcohol has no significant effect on heart rate, pulmonary ventilation, and ratings of perceived exertion as measured in female subjects.

4. The ingestion of a legally intoxicating amount of alcohol has a significant effect on the maximum oxygen consumption, measured in liters per minute, and maximum oxygen consumption, measured in milliliters per kilogram per minute, as measured in female subjects.

Recommendations for Further Study

Based on the conclusions drawn from this study, the following recommendations for further study were made:

1. A minimum level of maximum oxygen consumption should be set for all subjects participating in the study, as was done in experiments by Noble and others (56) and by Pandolf and Noble (57). This is necessary to assure both pretest consistency between subjects and the knowledge that changes in scores came about due to the treatments.

2. Blood Alcohol Counts (BAC's) should be taken in order to determine the level of intoxication at the time the perceived exertion ratings are given. This is necessary to assure that the entire dose of the alcohol has entered the blood system.

3. In order to determine if the hypothesis that ratings of perceived exertion are influenced by different pedal speeds while under the influence of alcohol, a replication of the studies by Henriksson, Knuttgen, and Bonde-Petersen (39), and Pandolf and Noble (57) should be performed.

APPENDICES

Appendix A

THE BORG 6-20 SCALE OF PERCEIVED EXERTION

6	
7	Very, very light
8	
9	Very light
10	
11	Somewhat light
12	
13	Somewhat hard
14	
15	Hard
16	
17	Very hard
18	
19	Very, very hard
20	

Appendix B

INFORMED CONSENT FORM

NAME:____________________AGE:______WEIGHT:_______SEX:____

PROOF USED TO VERIFY AGE:____________________

Dear _____________,

Thank you for agreeing to participate in this experiment. As per your schedules, I selected the following time for you to report to the Exercise Physiology lab, located in the basement of the Science Building (room S-2.)

____

If there is any problem with your time, please let me know immediately. I can be reached at Centrex extention 732, or you can slip a note in my mailbox in room 10 at the Physical Education Center.

IT IS IMPERATIVE THAT YOU DO NOT EAT AT LEAST 6 HOURS BEFORE COMING TO THE EXPERIMENT

PLEASE ANSWER THE FOLLOWING QUESTIONS:

1. Are you a member of an athletic team at IC?______
2. Are you presently in training?______
3. Does any required part of your training involve bicycle riding?______
4. Do you have any allergic reaction to vodka?______
5. Do you have any allergic reaction to orange juice?______ to tabasco sauce?______
6. Do you have an allergic reaction to Cēpacol?_____
7. Are you hypoglycemic?______

You are about to engage in an experiment that involves both the consumption of an intoxicating amount of alcohol (100 proof vodka) and working at maximum output on the bicycle ergometer. Your heart rate will be monitored, samples of expired gas will be taken, and you will be asked to give an honest rating of how hard you felt you worked.

It would be advisable to wear light clothing to participate. A towel will be provided.

Before taking part in the experiment, you will have to sign this piece of paper stating that you are aware of the conditions of participation. The sheet will be countersigned by me stating that the information you have given will be kept in the strictest of confidence.

Please bring this sheet with you, along with your proof of age, to the lab the first time you come.

Thank you very much.

________________________   ___/___/___

Signed   Date

________________________   ___/___/___

Alan S. Zarrow   Date

Appendix C

STANDARD DIRECTIONS

The following directions were read to all subjects at the appropriate time during the experiment:

> Hi, and thank you for coming. You are about to engage in an experiment to see how alcohol will effect certain physiological factors while you ride on the bicycle ergometer. Please go over to the bike, sit down, then adjust the saddle height so that there will be a slight bend in your knee when you touch the pedal with the balls of your feet. Adjust the mouth piece in front of you. I will record your saddle height for future reference.
>
> Before we go any further, I would like you to hop up on the scale. All alcohol intake measurements are based on how much you weigh.
>
> Go over to any seat in the room. Attach the noseclip firmly, but comfortably. The noseclip will remain on for most of the experiment.
>
> These are two commercially available anesthetic throat lozenges. Please take them and suck on them slowly, working them around in your mouth. The purpose of these, along with the noseclip, is to prevent you from tasting the liquid that you will be ingesting.

As the subject was about to ingest his drink, the following directions were given:

> You will have a maximum time of 10 minutes in which to consume your drink. As soon as you are finished, I will start a stopwatch for your 30 minute absorption period. There will be a slight burning sensation as the drink is being swallowed, no matter what type of drink you have. Heart rate will be taken before you drink, after you finish the drink, and at the end of the absorption period.

At the end of the absorption period, the subjects were told the following:

> The 30 minutes have now expired. Please get onto the bicycle and make sure that everything is comfortable. After a 10 minute warm-up period, you will be given a five minute rest. Heart rate will be measured at various times during the test. During the last minute of each work bout, you will be asked to breathe into

the mouthpiece so a sample of expired gas can be collected. A series of bouts will be necessary in order to get your working capacity up to maximum. Now, start pedalling in time with the metronome. Start on either foot, and make sure that the same foot pedals each time a click is heard.

Attached to the bike, placed directly in front of you, is a scale of numbers which is used to translate your feelings of exertion into quantitative measures. Your task, when asked to do so, is to select a number that corresponds to your over-all perception of your body feeling. There are no right and wrong numbers. Use any number that you feel is appropriate.

At the end of the test, do not leave the lab until you have completely cooled down and have recovered from fatigue.

Once again, thanks.

Appendix D

RAW SCORES FOR SUBMAXIMAL HEART RATES

Subject	Sex	Without Alcohol 1	Without Alcohol 2	With Alcohol
1	F	184	184	160
2	M	168	172	168
3	F	176	172	184
4	M	164	180	148
5	F	188	184	180
6	M	164	176	156
7	F	144	148	148
8	M	184	184	188
9	F	168	184	160
10	M	180	164	168
11	F	168	172	164
12	M	180	180	184

Appendix E

RAW SCORES FOR MAXIMUM HEART RATES

Subject	Sex	Without Alcohol 1	Without Alcohol 2	With Alcohol
1	F	190	200	184
2	M	172	176	176
3	F	180	184	190
4	M	186	186	164
5	F	208	192	196
6	M	180	184	169
7	F	188	192	184
8	M	188	188	200
9	F	188	192	186
10	M	184	190	184
11	F	188	188	184
12	M	188	192	196

Appendix F

RAW SCORES FOR SUBMAXIMAL RPE

Subject	Sex	Without Alcohol 1	Without Alcohol 2	With Alcohol
1	F	17	16	15
2	M	18	16	17
3	F	17	17	17
4	M	17	17	16
5	F	15	15	15
6	M	18	18	19
7	F	14	14	15
8	M	15	17	19
9	F	17	19	18
10	M	16	15	14
11	F	15	16	15
12	M	17	17	17

Appendix G

RAW SCORES FOR MAXIMUM RPE

Subject	Sex	Without Alcohol 1	Without Alcohol 2	With Alcohol
1	F	20	20	20
2	M	19	17	19
3	F	20	19	20
4	M	19	19	19
5	F	17	17	17
6	M	19	19	20
7	F	19	19	17
8	M	17	18	20
9	F	19	20	20
10	M	19	19	18
11	F	18	19	18
12	M	19	19	19

Appendix H

RAW SCORES FOR $\dot{V}O_2$ MAX 1/min

Subject	Sex	Without Alcohol 1	Without Alcohol 2	With Alcohol
1	F	2.45	2.12	1.66
2	M	4.35	3.47	2.80
3	F	2.66	2.62	1.94
4	M	4.38	5.21	3.56
5	F	3.06	2.95	2.04
6	M	3.94	3.59	4.69
7	F	2.83	2.87	2.47
8	M	3.04	2.78	3.46
9	F	2.59	2.22	2.42
10	M	2.63	2.58	2.62
11	F	2.33	2.56	2.51
12	M	2.19	2.73	2.28

Appendix I

RAW SCORES FOR $\dot{V}O_2$ MAX ml/kg/min

Subject	Sex	Without Alcohol 1	Without Alcohol 2	With Alcohol
1	F	38.22	33.14	27.27
2	M	53.14	44.09	34.27
3	F	50.82	50.17	37.08
4	M	51.50	61.32	41.20
5	F	49.91	48.00	33.17
6	M	42.44	38.67	50.58
7	F	47.49	48.26	41.55
8	M	49.87	45.69	56.79
9	F	43.75	37.64	40.88
10	M	39.86	39.15	39.83
11	F	39.41	43.39	42.41
12	M	33.24	41.38	34.60

Appendix J

RAW SCORES FOR MAXIMUM VENTILATORY EQUIVALENT

Subject	Sex	Without Alcohol 1	Without Alcohol 2	With Alcohol
1	F	3.53	3.16	3.00
2	M	3.34	2.79	3.31
3	F	2.37	2.43	3.53
4	M	2.12	2.71	2.47
5	F	3.02	3.50	3.28
6	M	2.79	2.68	2.92
7	F	3.56	3.29	3.52
8	M	2.61	3.05	3.09
9	F	2.59	2.81	2.14
10	M	3.19	2.80	2.78
11	F	2.64	2.50	2.62
12	M	2.62	2.16	2.42

Appendix K

RAW SCORES FOR $\dot{V}_E$ MAX/STPD

Subject	Sex	Without Alcohol 1	Without Alcohol 2	With Alcohol
1	F	075.2	056.9	043.2
2	M	086.8	076.8	080.7
3	F	048.9	052.9	044.9
4	M	069.4	080.9	062.1
5	F	070.1	062.0	057.8
6	M	068.4	072.0	102.3
7	F	049.2	051.0	047.4
8	M	069.5	069.5	090.7
9	F	046.3	054.3	043.8
10	M	063.2	063.0	063.2
11	F	053.3	063.3	066.8
12	M	049.5	049.8	048.1

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