ALCOHOL, CARDIORESPIRATORY FUNCTION AND WORK PERFORMANCE

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ABSTRACT

Twelve males (six moderate drinkers and six abstainers) were studied for the influence of varying dosages of alcohol on cardiorespiratory function and work performance. The subjects underwent three separate maximal exercise tests which consisted of progressive workloads on the bicycle ergometer. Prior to each work bout the subject consumed either a placebo (0.0 ml.kg^{-1}), small (0.44 ml.kg^{-1}), or a moderate (0.88 ml.kg^{-1}) dose of a 95 per cent ethanol solution. Analysis of the results indicated that the ingestion of a small or moderate amount of alcohol had no significant effect on heart rate, blood pressure, ventilation, oxygen uptake or work performance.

Key words: Alcohol, Heart rate, Blood pressure, Ventilation, Oxygen uptake, Work performance.

INTRODUCTION

The effect of alcohol on physical work capacity has been studied in an attempt to determine the influence of alcohol consumption on athletic performance. It has been claimed that alcohol may serve as an ergogenic aid and therefore enhance physical performance (Golding, 1972). The American College of Sports Medicine (1982) supporting an opposite view has concluded that alcohol offers no beneficial effect on work capacity. Despite conclusive evidence that alcohol, when taken in large doses (Blood Alcohol Level $\geq 0.15 \text{ mg.ml}^{-1}$), is detrimental to physical performance, debate has been waged in scientific literature about the physiological response following the intake of small amounts of alcohol (Blood Alcohol Level $\leq 0.15 \text{ mg.ml}^{-1}$). While the degree to which work capacity is affected by alcohol depends upon the blood alcohol concentration, it may also depend upon one's adaptation to the use of alcohol. Previous studies on the physiological effects of alcohol on work performance have been limited, for the most part, to the investigation of subjects whose drinking behaviour ranged from the classification of light to heavy. The absence of the non-drinker in such studies is obvious. While certain physiological responses among abstainers are presumed to be different from those of drinkers (Grollman, 1980; Klatsky et al, 1977), no studies have been published on the physiological effect of alcohol on abstainers during exercise. Therefore, it may be argued that the absence of the non-drinker in earlier studies is a major shortcoming in acknowledging responses that are most representative of alcohol's true effect on physical performance.

Because previous studies concerning the physiological effects of alcohol during exercise neglected to include subjects who were nonsensitised to the use of alcohol, and disagreement as to the physiological action of alcohol in small amounts, it was the purpose of this study to determine the acute effects of small and moderate doses of alcohol on maximal cardiorespiratory function and work performance in abstainers and moderate drinkers.

METHODS

The alcohol used in the present experiment was in the form of a 95% aqueous solution. The subjects in this investigation were 12 males of whom six were abstainers and six were moderate drinkers. The abstainers were described as those who did not drink alcohol at all. The moderate drinkers were described as those who drank alcohol at least once a month, typically several times but usually with no more than three or four drinks on each occasion. (The definitions of the drinking behaviours listed above were adopted from the Secretary of Health Education and Welfare, 1972). The mean physical characteristics of the subjects are listed in Table I. All subjects were physically active and signed informed consents.

Each subject reported to the laboratory following a four-hour fast for three different experimental sessions, approximately one week apart. The alcohol administered was in accord with body weight in dosages of 0 ml. (placebo), .44 ml (small dose), and .88 ml (moderate dose) per kg body weight. The dosages were systematically assigned and diluted to a 20% mixture with unsweetened grapefruit juice so as to provide the most rapid entrance rate into the bloodstream (Himwich, 1969).

Exercise Test

The mechanically-braked Monark cycle ergometer was

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TABLE I
Physical characteristics of abstainers and moderate drinkers.

	Abstainers (N=6)	Moderate Drinkers (N=6)
Age (yr)	22.3 ± 3.7	22.5 ± 3.2
Weight (kg)	77.1 ± 11.5	79.1 ± 17.1
Height (cm)	71.5 ± 2.4	70.8 ± 1.9
Skinfold (mm)	53.7 ± 32.3	55.5 ± 15.7

utilised with the subject performing exercise bouts of three minute durations against progressively increasing workloads of 360, 720 and 1,080 kpm.min⁻¹. Thereafter, the resistance was increased by 180 kpm.min⁻¹ every three minutes until a pedal rate of 60 revolutions per minute could not be sustained.

Physiological Measurements

The variables measured were heart rate, blood pressure, minute ventilation, oxygen uptake and work performance. Heart rate was obtained from electrocardiographic recordings which utilised a cardiac coupler, and recorded with a NARCO Biosystem DMP-4A recorder. Blood pressure was measured by the indirect method with a sphygmomanometer and hollow cuff. Diastolic blood pressure was recorded by a disappearance of the Korotkow sounds. Because of the difficulty in measuring blood pressure during exercise when utilising the indirect method, one trained laboratory technician was assigned the task of recording blood pressure to help control interindividual differences.

Inspired minute gas volume was measured with a Parkinson-Cowan CD4 dry gas meter and recorded with a NARCO Biosystem DMP 4A recorder. The dry gas meter was calibrated against a 120-litre Tissot gasometer. Oxygen uptake was determined by the open circuit method utilising meteorological balloons and a Daniels valve. Expired gas fractions were determined with a Beckman model E-2O₂ analyser and LB1 CO₂ analyser. The Beckman analysers were calibrated with standardised gases previously measured by the Scholander (1947) method. Expired gas samples from each test were checked by the Scholander method as a validation of the electronic gas analyser. Work performance was given as the maximal workload obtained at a pedal frequency of 60 rpm and the total time worked. The ergometer was calibrated weekly to ensure equal work intensity between experimental conditions. Blood alcohol levels were determined in triplicate by the enzymatic method of Boninchsen and Theorall (1947).

General Procedure

One hour prior to the beginning of the performance test, the subject entered the laboratory in a fasted and rested condition. The subject's weight, height and skinfold measures were then recorded. Using a Lange Skinfold Caliper, the subject's total skinfold measures were obtained using the following sites: (1) triceps, (2) chest, (3) subscapular, (4) mid axillary, (5) abdomen, and (6) iliac crest. Preparation for drinking consisted of a nose clip placed over the subject's nose to help disguise the assigned experimental liquid. The subject then ingested the experimental liquid in five equal parts over a 10 minute period. After a 30 minute absorption period, fingertip blood samples were collected for determining blood alcohol levels. After completion of the absorption period, work bouts on the ergometer were initiated. Measures of heart rate, blood pressure, oxygen uptake and ventilation were recorded each minute after a heart rate of 150 beats min⁻¹ was reached. Only the last minute collection at a pedal frequency of 60 rpm was used for analysis purposes.

Data Analysis

A 2 x 3 repeated measures ANOVA was utilised to analyse the descriptive statistics for the variables measured (Edwards, 1972). When appropriate, the Newman Keuls procedure was used to locate the source of significant differences (Bruning et al, 1977). For all main effects and interactions, an α level of 0.05 was adopted.

RESULTS AND DISCUSSION

Descriptive statistics for blood alcohol levels and variables measured during maximal work after administration of the varying alcohol dosages among the groups are presented in Table II. Mean blood ethanol concentration 30 minutes after ingestion of the placebo, small and moderate dosages were similar for both groups. Although no difference was reflected in the ethanol metabolism between groups, the process of alcohol adaptation with use was observed by the abstainers reflecting greater difficulty during ingestion of the experimental liquids. There was no significant difference in mean maximal heart rates when comparing pre and post alcohol ingestion. These findings were in agreement with Bobo (1972) who reported no difference in maximal heart rate after ingesting alcohol in doses of 0.2, 0.4, and 0.6 ml per pound body weight; these dosages were shown to produce blood alcohol levels of 0.0, 0.05, and 0.10 mg.ml⁻¹ respectively (Williams, 1972). In an earlier report, Blomqvist et al, (1970) using a large dose of ethanol concluded no difference in maximal heart rate at a mean ethanol concentration of .16 mg.ml⁻¹.

Ethanol had no effect on mean systolic or diastolic pressure during maximal work. The non-significant

TABLE II

Mean and standard deviations for abstainers and moderate drinkers during maximal exercise in connection with three dosages of alcohol.

Abstainers (N=6)	Alcohol Dosage (ml.kg ⁻¹)		
	0.0	0.44	0.88
Experimental Variables			
Blood Alcohol Level as mg.ml ⁻¹	.004 ± .005	.048 ± .016	.101 ± 0.26
Heart Rate as beats min ⁻¹	179 ± 15.65	177 ± 13.74	179 ± 13.15
Systolic Blood Pressure as mmHg	196 ± 44.46	171 ± 16.47	175 ± 9.57
Diastolic Blood Pressure as mmHg	87 ± 11.66	94 ± 5.08	87 ± 7.72
Ventilation as (STPD) l.min ⁻¹	99.8 ± 15.27	93.4 ± 12.69	97.7 ± 7.79
Oxygen Uptake as ml.kg.min ⁻¹	46.73 ± 5.34	44.73 ± 7.06	46.98 ± 8.91
Workload as kpm.min ⁻¹	1470 ± 123.69	1440 ± 103.92	1440 ± 103.92
Time Worked as sec.	866 ± 92.66	824 ± 129.63	824 ± .03

Moderate Drinkers (N=6)	Alcohol Dosage (ml.kg ⁻¹)		
	0.0	0.44	0.88
Experimental Variables			
Blood Alcohol Level as mg.ml ⁻¹	.002 ± .001	.050 ± .013	.106 ± .021
Heart Rate as beats min ⁻¹	180 ± 9.16	180 ± 13.85	180 ± 11.83
Systolic Blood Pressure as mmHg	180 ± 23.83	174 ± 22.31	182 ± 22.35
Diastolic Blood Pressure as mmHg	86 ± 6.04	83 ± 7.52	80 ± 1.37
Ventilation as (STPD) l.min ⁻¹	113.1 ± 25.65	113.1 ± 25.8	105 ± 16.23
Oxygen Uptake as ml.kg.min ⁻¹	48.13 ± 8.93	46.95 ± 8.80	45.18 ± 7.05
Workload as kpm.min ⁻¹	1470 ± 241.86	1440 ± 207.84	1440 ± 254.55
Time Worked as sec.	865 ± 221.63	830 ± 195.86	819 ± 240.54

change in maximal heart rate and blood pressure during exercise suggest that alcohol exerts on significant acute depressure on cardiac performance.

There were no significant differences in ventilation during maximal work. Bobo found that ethanol concentrations of .0, .05, and .10 mg.ml⁻¹ had no effect on ventilation during maximal work. These results are in disagreement with the findings of Blomqvist et al, who reported that maximal ventilation was significantly lower following alcohol ingestion. The discrepancy in the results of the studies may be explained by the higher blood ethanol concentration in the procedures employed by Blomqvist and associates.

Alcohol consumption had no significant effect on maximum aerobic capacity. The data from earlier studies investigating the effect of alcohol on maximum aerobic capacity in man (Blomqvist et al, 1970; Bobo, 1972) lends support with little or no significant alteration in maximum oxygen uptake.

Work performance as a measure of the maximum workload obtained between experimental treatments was not affected after ingestion of alcohol. Work performance as a measure of total time worked was slightly shorter for the ethanol treatment, but the difference was not significant. This finding is in agreement with Blomqvist and associates who reported no difference in maximal work time after the ingestion of alcohol. The ingestion of moderate amounts of alcohol has been shown to cause a decrease in blood supply to working muscle (Leighninger et al, 1961), which suggests a decrease in muscular efficiency during work. The pattern response of alcohol on oxygen uptake and work performance indicates that alcohol in small and moderate dosages exerts no debilitating effects on mechanical efficiency.

The present study demonstrates that administration of small and moderate dosages of alcohol provokes no noteworthy alteration in heart rate, blood pressure, ventilation, oxygen uptake, or work performance during maximal work. It was also concluded that previous investigators observing similar cardiorespiratory functions after ingestion of alcohol were not committing any biased effects while excluding non-drinkers.

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BOOK REVIEW

Title: PEDIATRIC SPORTS MEDICINE FOR THE PRACTITIONER
Author: Oded Bar-Or, Professor of Pediatrics, McMaster University
Publisher: Springer-Verlag, New York, Berlin, Heidelberg, Tokyo
Price: \$38.10

This single author book is a marriage of paediatrics, medicine, and physiology. It is a happy marriage. The informative text is easy to assimilate.

Commencing with the normal child's reaction to exercise it deals with conditioning and training related to the individual body structures. Working capacity in healthy and sedentary individuals is discussed along with the use of exercise as a diagnostic implement. The deleterious effect of exercise is mentioned with advice regarding its prevention.

The following chapters which deal with the various bodily systems are full of information which must be of particular value to the paediatrician who though clinically knowledgeable in his own discipline may not have had the experience of dealing with children involved in sport. Throughout this section of the book the value of exercise as a diagnostic measure, and in therapeutics is emphasised. Included is a chapter on exercise in different climatic conditions which must be valuable to the young itinerant athlete.

The book is concluded with a number of appendices of practical use to the worker in this field of study.

Following each chapter are many references to the work of world wide authors. It has been a pleasure to study this publication which should be on the book shelf of the paediatrician, the family physician, and the sports scientist.

H. Noel Bleasdale