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SOME EFFECTS OF ALCOHOL AND SIMULATED ALTITUDE ON COMPLEX PERFORMANCE SCORES AND BREATHALYZER READINGS

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16. Abstract

This study assessed possible interactive effects of alcohol and a simulated altitude of 12,500 ft. Each of 17 men was trained on the various tasks that comprise the Multiple Task Performance Battery and then performed over a 2-week period in four experimental sessions, viz, ground level (1,300 ft), with and without alcohol, and altitude (12,500 ft), with and without alcohol. Subjects breathed appropriate gas mixtures through oxygen masks at both ground level and altitude. Subjects performed for 3 hours in the morning, had a 1-hour lunch break, and performed again for 3 hours in the afternoon. Alcohol doses were 2.2 mL of 100-proof vodka per kilogram of body weight mixed with three parts of a selected juice. Each 1-hour test block included five 10-minute performance periods with varying workloads and a 10-minute period for controlled breathalyzer measurements. Results showed no differential effect of simulated altitude on breathalyzer readings (peaks averaged .078% at 12,500 ft and .077% at ground level). The best performance occurred at ground level under placebo conditions; the 12,500-ft simulated altitude produced some decrement for the placebo condition scores. Alcohol at ground level resulted in significantly impaired performance during the morning sessions; the addition of altitude to the alcohol condition further depressed performance scores, but to about the same extent that placebo scores were depressed by altitude. Thus, there was no interactive effect of alcohol and altitude on either breathalyzer readings or performance scores. However, the general decrement produced by altitude (with or without alcohol) serves to reduce further whatever margin of safety remains in performance skills following alcohol ingestion.

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INTRODUCTION

A previous study (3) from this laboratory assessed performance at a tracking task under placebo vs. alcohol conditions at ground level and at 12,000 ft simulated in an altitude chamber. Results were complex due to the design of the study, which involved a "typical" drinking schedule from evening until midnight. Performance tests were conducted prior to drinking (evening), immediately following drinking (midnight), and 8 hours after drinking ceased (morning), for placebo and alcohol; the midnight session was excluded from a third, sleep control condition. Overall, ground vs. altitude scores did not differ statistically, but the ingestion of alcohol significantly impaired (midnight) performance scores. There was no alcohol/altitude interaction in effects on performance, a finding that runs counter to prevalent beliefs. The complexity of the findings resides in a performance decrease (compared to ground level) in the altitude chamber, only at midnight, under both placebo and alcohol conditions. That effect did not occur during any of the three evening and three morning sessions. It would seem that fatigue and sleepiness may have interacted with the altitude condition at midnight to produce an increased decrement in performance scores regardless of whether or not alcohol had been ingested.

The present study was designed to provide the possibility of replication of the ground vs. altitude results noted above without the complexity of fatigue and sleepiness introduced by testing after midnight. In addition, the present study provided for breathalyzer measures under both ground level and altitude conditions; in the previous study such measures were taken at ground level just before the chamber ascent.

METHOD

Subjects. A total of 17 men between the ages of 21 and 35 years completed the experiment. Three other men had difficulty handling the alcohol condition and did not complete the study. All men had been selected on the basis on their self-reported drinking habits and their stated ability to be able to handle the equivalent of four or five drinks in a short period of time. Subjects were unaware of the order of presentation of the experimental conditions (alcohol vs. placebo; ground vs. altitude) and, in addition, were told that they would be receiving "some" alcohol in every drink.

Altitude. Subjects breathed appropriate gas mixtures through oxygen masks to simulate both ground level (approximately 1,300 ft) and altitude (approximately 12,500 ft). The masks were worn both in training and in experimental sessions.

Alcohol. Subjects drank equal volumes of either a placebo or alcoholic drink at the start of each session. Alcohol doses were 2.2 mL of 100-proof vodka per kilogram of body weight mixed with three parts of either tomato or orange juice, as selected by the subjects. The placebo drink contained a few drops of rum extract floated on top of ice cubes primarily to produce the odor of an alcoholic beverage. Subjects consumed each drink in a 20-min period.

Breathalyzer. Breath alcohol levels were assessed by means of an Omicron Intoxilyzer. Practice at using the device was provided the subjects during performance training. Subjects learned to take a deep breath, remove the oxygen mask, and breathe into the breath-recording device.

Performance Measures. Performance under all conditions was assessed by using the Civil Aeromedical Institute (CAMI) Multiple Task Performance Battery (MTPB). The MTPB measures complex workload performance and time-sharing skills by presenting different tasks in various combinations to produce low, moderate, and heavy workload conditions. The MTPB apparatus comprises five testing panels that contain the displays and response controls for the tasks. Descriptions of the seven tasks used in this study are as follows:

1. Red Warning Lights. This task involved the monitoring of five red lights (red lights were normally off). The subject was instructed to push the light button whenever a light changed from its normal state. Response times were recorded.

2. Green Warning Lights. This task involved the monitoring of five green lights (green lights were normally on). The subject was instructed to push the light button whenever a light changed from its normal state. Response times were recorded.

3. Meters. Four meters, located at the top of the testing panels, were monitored for changes in needle indicator position. Normally the indicator moved randomly to the left and right with the movement centering around "0." Presentation of a signal deflected the continually moving indicator to a different center point, to either the left or the right of "0," and subjects were required to push the button on the same side as the direction of deflection. Response times were recorded.

4. Mental Arithmetic. A screen display presented three numbers, each containing two digits. The subject had to mentally add the first two numbers, subtract a third number from the sum of the first two, and enter the answer on a keyboard on the testing panel. Accuracy and response time were recorded.

5. Two-Dimensional Compensatory Tracking. The tracking task was displayed on an oscilloscope screen lined with two cross-hairs. A dot of light moved around the screen driven by a forcing function. The subject was instructed to keep the dot in the center of the screen by means of a joystick. Performance was scored by using analog circuitry that integrated absolute error and error squared for each dimension. The error-squared measure was converted to vector root-mean-square (RMS) error, and vector RMS error measures derived from horizontal and vertical RMS error scores were used as an index of tracking performance.

6. Problem Solving. This task required the subject to use a trial-and-error search procedure to discover the correct sequence in which to press the five response buttons in order to solve the problem. Three "feedback" lights indicated when any response button was pressed (orange light), when an incorrect button was pressed (red light), and when the correct sequence had been entered (blue light after completion of sequence). Whenever an incorrect button was

pushed, the subject was required to reenter the correct portion of the sequence already discovered before the search could continue. Twenty seconds after the solution of a problem, subjects were required to reenter the solution (confirmation phase). Speed of the solution phase, speed of the confirmation phase, proportion of redundant responses made during the solution phase, and proportion of error responses in the confirmation phase were the measures comprising the scores on the problem-solving task.

7. Pattern Discrimination. A screen display presented three six-column bargraphs sequentially. Problems were of a "matching to sample" form. The first "sample" pattern was followed by two comparison patterns. The subject responded by pressing one of three appropriately marked buttons to indicate that either one, two, or neither of the comparison patterns matched the sample. The sample pattern appeared for 5 seconds, and each comparison pattern appeared for 3 seconds, with 2 seconds between successive patterns. Accuracy and response time were recorded.

Each of five training sessions comprised three 50-minute periods, with a 10-minute break after each period. Each 50-minute period contained five 10-minute intervals of low, moderate, and heavy workloads. Red and green warning lights and meters (both monitoring tasks) were presented in all five workload intervals. The five successive intervals involved the following array of tasks: first (low workload), tracking in addition to monitoring; second (moderate workload), monitoring, mental arithmetic, and problem solving; third (moderate workload), monitoring, tracking, and problem solving; fourth (high-moderate workload), monitoring, pattern dscrimination, and problem solving; and fifth (high workload), monitoring, pattern discrimination, mental arithmetic, and tracking.

Procedure. Following 12 1/2 hours of training on the MTPB, each subject performed in four separate experimental sessions spread over a 2-week period. The four sessions were ground level (1,300 ft), with and without alcohol, and altitude (12,500 ft), with and without alcohol.

The order of presentation of the condition combinations was approximately counterbalanced. Subjects performed in groups of two or more for 3 hours in the morning, had a 1-hour lunch break, and performed again for 3 hours in the afternoon. Each 3-hour test block included three 60-minute cycles; within each cycle there were five 10-minute performance periods, with workload varying from light to heavy, followed by a 10-minute period for controlled breathalyzer measurements. The first test block began 1/2 hour after the placebo or the alcohol was ingested. Twenty minutes after ingestion of alcohol or placebo, at the start of the lunch break, and at the conclusion of testing, subjects completed nine-point rating forms assessing their degrees of attentiveness, tiredness, tenseness, boredom, and irritability (e.g., from 1 "very inattentive" through 9 "very attentive").

RESULTS

Breathalyzer. Mean breathalyzer levels were virtually identical for the ground level and the simulated altitude conditions at every period of measurement (see Figure 1). Peak values were 78 mg% during the altitude condition and 77 mg%

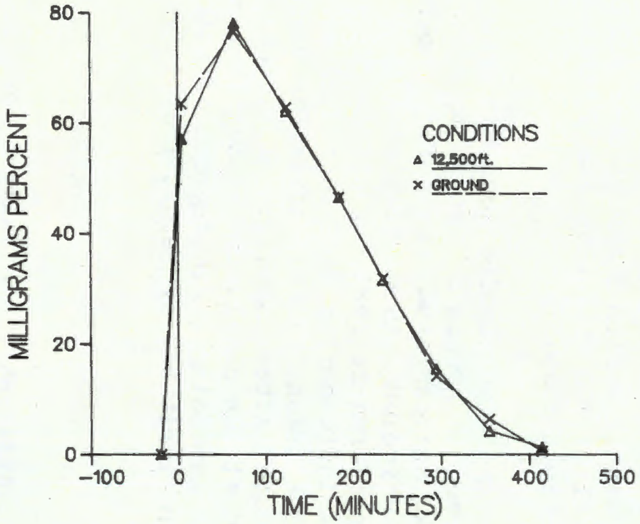

Figure 1. Breathalyzer readings recorded from 17 men at ground level and at a simulated altitude of 12,500 feet prior to and following the ingestion of 2.2 mL of 100-proof vodka per kg of body weight.

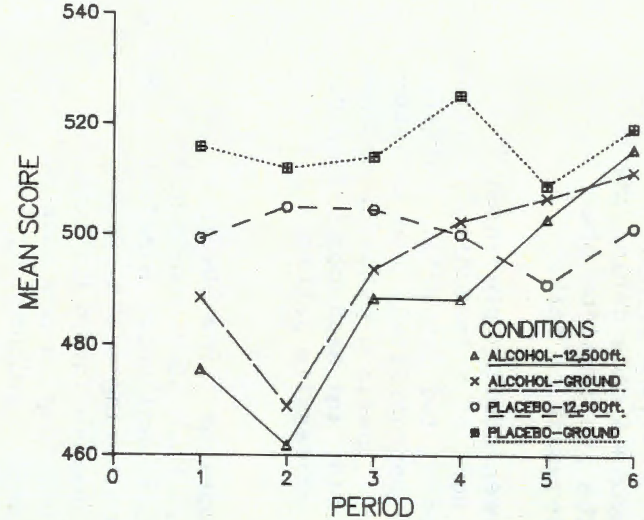

Figure 2. Mean composite scores across all MTPB tasks for 17 men with and without alcohol, at ground level, and at simulated altitude for the 6 work periods (a lunch break followed the third period).

during the ground level condition. The simulated altitude of 12,500 ft had no effect on the breathalyzer readings.

MTPB Performance. The overall composite scores for the seven MTPB tasks were calculated for each work hour and condition (see Figure 2). The best performance occurred at ground level under placebo conditions; the 12,500-ft simulated altitude produced some decrement for the placebo condition scores. Alcohol at ground level resulted in significantly impaired performance during the first 3 hours after drinking; the addition of altitude to the alcohol condition further depressed performance scores, but to about the same extent that placebo scores were depressed by altitude.

Statistically, an analysis of variance indicated significantly ($p < .01$) poorer performance as a result of ingesting alcohol, being at altitude, and performing earlier in the day. Only one interaction among these main effects was statistically significant, viz, alcohol and work period ($p < .01$). That interaction accounts for the overall poorer performance of subjects earlier in the day; as can be derived from Figure 2, the alcohol conditions had strong depressing effects on performance scores during the first 3 hours of testing.

Thus, there was no interactive effect of alcohol and altitude on performance scores. There were also no differential effects of the two major conditions (alcohol and altitude) on the five low-to-high workload levels (i.e., the five levels of workload were equally affected by the major conditions).

The individual tasks showed similar results (Table 1). The main effects of alcohol and altitude were significant for five of the seven tasks (the exceptions were: for alcohol, arithmetic and problem solving; for altitude, red lights and tracking). For all tasks, there were significant effects for workload (higher workloads generally lowered performance scores) and for work periods (the afternoon periods tended to show better performance than the morning work periods). Related to the latter finding was a significant work period by alcohol interaction that was present for all tasks except arithmetic and problem solving (for which no main effect of alcohol was obtained). Two individual tasks each showed an alcohol by altitude interaction (target identification and problem solving), but that interaction was in the direction opposite what would be expected (see Table 1); i.e., performance under alcohol conditions was affected slightly less by altitude than was performance under placebo conditions.

Mood Ratings. Average ratings for attentiveness, tiredness, tenseness, boredom, and irritation are presented in Table 2. In alcohol vs. placebo comparisons, analysis of variance indicated that alcohol significantly reduced tenseness and increased irritation ($p < .05$ in both cases). The altitude condition significantly increased feelings of boredom and decreased irritation as compared with the ground level condition ($p < .05$ in both cases). Time-of-day comparisons were statistically significant for all five mood factors; i.e., tiredness, tenseness, boredom, and irritation increased regularly from morning through midday to the late afternoon measurement time ($p < .01$ in all cases). Attentiveness was highest in the morning ($p < .05$), was lowest at midday, and showed modest recovery in the afternoon. Variations in the mood scores were unrelated to performance.

TABLE I. Standard Scores (Means and Standard Deviations) and Statistical Outcomes for Individual MTPB Tasks as a Function of Hourly Work Periods, Workload, Alcohol, and Simulated Altitude (12,500 ft).

		STANDARD SCORES				STATISTICAL SIGNIFICANCE ($p < .05$)									
		Alcohol		Placebo		Main Effects				Interactions					
		Alt	Grd	Alt	Grd	Alc	Alt	Per-iod	Work Load	Alc/ Alt	Alc/ Per	Alc/ Wkl	Alt/ Per	Alt/ Wkl	Wkl/ Per
Green Lights	M	487	498	500	515	.01	.01	.05	.01				.01		
	SD	104	100	102	89										
Red Lights	M	482	497	510	511	.01		.05	.01				.05		
	SD	116	95	96	87										
Meters	M	490	498	500	511	.01	.01	.01	.01				.01		
	SD	96	105	103	92										
Tracking	M	491	492	509	508	.01		.01	.01				.01		.01
	SD	93	98	98	92										
Arith-metic	M	495	497	495	513		.05	.01	.01					.01	.01
	SD	84	78	89	70										
Target Ident.	M	483	484	494	538	.01	.01	.01	.01	.01	.01			.05	
	SD	92	91	93	64										
Problem Solving	M	493	501	491	514		.01	.01	.01	.05					
	SD	85	72	72	65										

TABLE II. Means and Standard Deviations for Ratings of Mood Factors by Drug, Altitude, and Time.

		DRUG		ALTITUDE		TIME OF MEASUREMENT		
Factors		Alcohol	Placebo	12,500	Ground Level	Before Test	Noon	After Test
Attentiveness	M	4.78	4.99	4.82	4.95	5.26	4.62	4.78*
	SD	1.68	1.47	1.64	1.53	1.59	1.59	1.50
Tiredness	M	5.53	5.62	5.56	5.59	5.01	5.79	5.91**
	SD	1.64	1.62	1.65	1.60	1.49	1.60	1.64
Tenseness	M	4.10	4.49*	4.34	4.25	3.79	4.21	4.88**
	SD	1.81	1.68	1.74	1.78	1.66	1.69	1.76
Boredom	M	4.73	4.82	4.56	4.99*	4.13	5.00	5.19**
	SD	2.22	1.95	1.96	2.19	1.79	2.16	2.15
Irritation	M	2.97	2.51*	2.51	2.97*	2.06	2.82	3.34**
	SD	2.10	1.81	1.88	2.05	1.68	1.90	2.11

* $p < .05$ ** $p < .01$

DISCUSSION

In this study, the ingestion of alcohol resulted in a significant impairment in complex performance tasks for the first 3-4 hours after the drinking period. As a separate effect, the simulated altitude of 12,500 ft produced a smaller, but statistically significant, decrement in performance scores under both placebo and alcohol conditions. Thus, performance was adversely affected both by altitude and by alcohol, but there was no synergistic interaction between the two. Moreover, the breathalyzer recordings showed no differences between ground and simulated altitude conditions.

There exists ample evidence that acute alcohol intoxication impairs abilities related to flying (1,2,4,5). Further, based on several older studies (9,10,11), McFarland (8) concluded that "the alcohol in two or three cocktails would have the physiological action of four or five drinks at altitude of approximately 10,000 to 12,000 ft." That conclusion was rooted in the notion that the "oxygen want" consequent to exposure to higher altitudes would combine with alcohol-induced impairment of tissue cells in using oxygen properly and produce higher and more rapidly achieved peak blood alcohol levels (BAL's) as well as performance impairment.

The present study and three previous studies (3,6,7) suggest that alcohol effects at altitudes of 12,500 ft or less are not so simply defined. Neither this study (using oxygen masks and a breathalyzer) nor two previous investigations (both conducted in an altitude chamber and using blood samples) have demonstrated any difference in BAL's between ground level and 12,000- to 12,500-ft conditions (6,7). Further, this study and its antecedent (3) showed no interactive effects on performance of alcohol and altitude. Alcohol clearly produced decrements in performance. However, altitude also had a negative influence on performance (with or without alcohol) in this study (12,500 ft) and showed a similar effect in a previous study (12,000 ft) only during a midnight session when subjects were sleepy.

The data across these several studies suggest that (i) BAL's of .100% or less are not differently affected at altitudes of 12,000-12,500 ft when compared with ground level; (ii) there is no synergistic interaction on performance between those altitudes and those BAL's, although performance is adversely affected by alcohol at ground level and at altitude; (iii) altitudes of 12,000-12,500 ft may, of themselves, produce performance decrements in some subjects or under some conditions; (iv) when the latter occurs, the deleterious effect of alcohol appears to be simply additive.

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