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Correlation of the breath and blood alcohol levels with task performance

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A study on the after effects of alcohol ingestion on psychomotor task performance is reported. There was significant deterioration in performance of all the tests after 8 hours of ingestion. The performance decrement was seen beyond 12 hours in tests involving attention, psychomotor coordination and reaction time. Performace decrement has been noticed with even zero levels of blood alcohol in this study.

Introduction

Performance decrements under effect of alcohol are extensively recorded in literature. Self control, judgement, muscular coordination and discretion often deteriorate even with consumption of small amounts of ethanol. Visual and auditory sensations are also known to suffer.

Effects of alcohol assume greater significance when the subject is engaged in performance of a complex task like flying. With advent of complicated high performance aircraft, a pilot's physical and mental efficiency is required to be at a peak most of the time. Factors like accelerative forces and vestibular sensations demand a great deal trom the aircrew and psychomotor performances under such situations have to be extremely efficient.

Many studies have been conducted on effects of alcohol on skilled task performance. Havard[7] studied driving ability and performance deterioration in his subjects even with small concentration of alcohol in blood which was not sufficient to produce a conventional clinical picture of drunkennesss. Walls[15] showed that it was not necessary to always have higher concentrations of alcohol in blood for causing a road accident.

Asknes[2] demonstrated that levels of alcohol far below the commonly accepted legal limits, had definite adverse effects upon flying skills. He found that flying skills were measurably decreased by only one-fourth of the amount of alcohol necessary to produce decrement in driving performance. Harper and Williams[6] also supported Askne's findings that low levels of alcohol adversely affected flying performance.

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Billing et al[3] recorded tracking data and procedural errors in instrument rated pilots under influence of 0.04, 0.08 and 0.12% blood alcohol concentrations and found marked decrement in performance at all levels, thus narrowing down the lower levels to 40mg%. Henry et al[8] studied the acute effects of three graded doses of ethyl alcohol on psychomotor performance in an automated system around a link flight Trainer. The results revealed that decrement was present in lower dosages also and showed progressive trend with moderate and higher dosages also and corresponding blood levels (average of pre and post task breath samples) for these three doses were 25, 55 and 85 mgm% respectively, the levels well below those currently employed in reference to automobile driving or definite limits of legal intoxication.

Soodan[14] studied performance of sixteen pilots five and seven hours after consumption of 3 ounces of alcoholic drink, on simulated flying task. Study revealed performance decrement in 5 hour stage and also in 7 hour stage, though of a lesser degree. Rai et al[19] emphasised that even 8 and 12 hours after ingestion of 180 ml of Indian Rum or whisky, when blood ethanol levels were zero, tolerance to +Gz was significantly reduced by 0.3g and 0.2g respectively.

On the other side, Chiles and Jennings[4] have stressed that the performance task must be complex in order to demonstrate the deleterious effects of alcohol. They found that relatively simple mental arithmatic problem solving was not impaired due to alcohol. This was supported by Smith[18] who found no significant performance decrement on simple tasks under alcohol. He concluded that only complex tasks showed much performance decrement.

Alcohol has been incriminated to be responsible for a large number of fatal aircraft accidents. Numerous studied have been undertaken to highlight this problem. Harper and Williams[6] while investigating general aviation accidents, found that alcohol was a factor in 56 out of 158 cases and about half of alcohol positive cases had crashed 18 minutes or less, after take-off. Mohler[9] in a similar study found that alcohol in excess of 150 mgm% was present in 23% of accidents investigated. Davis[5] in a survey of 2,123 toxicological analysis done at AFIP, found ethanol in 102 cases (4.8%). Alha and Tamminen[1] found evidence of uncontaminated alcohol in 5 pilots and 3 other aircrew out of a total of 41 fatal cases in Finland. Smith(55) discovered blood ethanol levels in excess of 50 mgm% in 13.9% of pilot fatalities. Ryan and Mohler[11] found that though in 1663, 43 % of fatal aircraft accidents involved alcohol, the percentage declined to 20 with 8 hour "bottle to throttle" rule. Zeller[16] in his report to 9th meeting of Joint Committee on Aviation Pathology analysed accidents or incident in 89 US Air Force aircraft accidents between 1962 and 197 in which alcohol and/or drugs are mentioned to be associated with mishap. Review indicated a constant rate of occurence, alcohol being the most common factor. Analysis indicated that relationship in most cases was associated or contributory, though not causal.

As the acute effects of alcohol on skilled performance are too well-known, many countries have enforced the rules specifying "bottle to throttle" interval. In US Air Force this interval is 8 hours while in India, the Air Staff Instructions lay down a period of 12 hours which must lapse between consumption of alcohol and flying. The quantity of liquour permitted is, however, not specified. This also brings us to the commonly asked question—as to which level of alcohol is "safe"—as far as flying is concerned? As is pointed out by the available studies—No level of alcohol could be considered safe. In a study undertaken at Institute of Aviation Medicine, Bangalore performance decrement was observed even after the blood alcohol levels had declined to zero.[17]

Material and Methods

The study aimed at observing the after effects of ethanol ingestion on Psychomotor task performance. Subjects were healthy, asymptomatic volunteers from the staff and course officers their age varying between 23 to 40 years with average of 28.25 years. They were all used to having 2-3 large pegs of whisky or Rum almost thrice a week. These subjects were given 180 ml of Whisky or Rum with snacks in the night and their performance assessed soon after finishing the drinks, 8 and 12 hours later. Plasma ethanol levels were determined by gas Chromatographic technique and are mentioned in Table No. 1.

Table I

Blood ethanol levels in 10 subjects

Subject	Blood ethanol in mgm/100 ml		
	1/2 hr	8 hrs	12 hrs
1.	66	0	0
2.	85	0	0
3.	95	0	0
4.	100	0	0
5.	112	0	0
6.	101	0	0
7.	60	0	0
8.	51	0	0
9.	125	0	0
10.	130	0	0

It is evident that though ethanol was present in plasma one hour after the drinks, the same had declined to zero in the 8 and 12 hour samples. This is in confirmation with the disappearance rate of ethanol from blood at the rate of 15 mgm% per hour.

The tests employed were Flight oriented Psychomotor Test, critical Fusion Frequency, Stability of Attention and choice reaction time. Flight Oriented Psychomotor Test (FOPT) was designed, fabricated and standardised at Institute of Aviation Medicine and involved Psychomotor coordination, reaction time and memory. The test consists of a seat, rudder pedals, a stick and display of lights along with a screen on which a number can be flashed. The display of lights in front of the subject consists of 3 double (parallel) rows of light mounted on 2 horizontal and one vertical double row, each row consiting of 8 bulbs. To and fro movements of the stick makes contacts to light the bulbs (one at a time) in the left vertical row, side to side movement of stick does so in the upper horizontal row while rudder movement lights the bulbs in lower horizontal row. Investigator, with the help of a selection box projects 3 digit number on the screen placed above the display. After a few seconds the display number is put off and subject has to memorise this 3 digit number. First digit corresponds to the bulb which is to be lighted in left vertical row, while second and third digits correspond to the bulbs required to be lit in superior rows of the upper and lower horizontal double rows respectively. A chronoscope circuit automatically records the time in seconds and milliseconds for lighting each combination of bulbs. Time taken in lighting the 3 correct bulbs is recorded and the error score also maintained. The performance time is calculated by dividing the total time taken for completing each sub-task (each combination) correctly by the number of sub tasks completed correctly. Higher the score, poorer is the performance.

Second test was critical Fusion Frequency (CFF) which is a fairly commonly employed test. The subject is asked to look at the flickering light. The number of flickers is increased gradually and subject has to report as soon as he sees the lights steady without flickers. This end point is taken for scoring and expressed as flickers per second. Higher the score, better is the performance.

Third test is called stability of Attention Test (SAT) where 25 zig-zag lines from left to right are traced with eyes only, without using a pointer. Start of line is indicated by a digit and the end with an alphabet. The task set is to trace all the 25 lines within 4 minutes. Number of lines correctly traced within this time is the score. Naturally, higher the score, better is the performance.

Next test is called Choice Reaction Time Test (CRTT) where the subject is required to press two buttons with fingers of each hand i.e., right and left. As soon as a light on the right side lits up, he should release the right button to put off this light. Similarly, if bulb is lit on the left side, he has to release button pressed by his left hand finger to put off this light. If a bell rings, he has to release both buttons to stop the bell. This test measures reaction time in milliseconds with the help of chronoscope and average of nine readings (3 for each type of stimulus) is taken as average reaction time. Higher the score, poorer is the performance.

Results

Mean values of various performance tests before and after consumption of alcohol and significance of their difference is mentioned in Table II.

Table II

Mean values of performance tests before and after consumption of alcohol and significance of their difference

Test	Mean values at				Mean difference between		
	Basal	1/2 HR	8 HR	12 HR	Basal & 1/2 HR	B & 8 Hrs	B & 12 Hrs
CFF	35.3	31.8	34.0	33.4	—3.5**	—1.3*	—1.9*
SAT	20.5	15.2	17.2	19.4	—5.3***	—3.3**	—1.1
FOPT	5.9	8.5	7.7	6.9	2.7**	1.8**	1.0**
CRTT	230	373	282	272	143***	52**	42

***Sig at P = 0.001, **Sig at P = 0.01, *Sig at P = 0.05

CFF and SAT : Figures are performance scores
— indicates deterioration
+ indicates improvement

FOPT : Figures are performance time in seconds
CRTT : Figures are performance time in milli secs
+ indicates deterioration
— indicates improvement

Discussion

The results of analysis shows that there is a significant deterioration in performance of all the tests after 8 hours of ingestion of alcohol. Deterioration continues even at 12 hours and is statistically significant in CFF and FOPT. In SAT and CRTT, the performance decrement is seen upto 12 hours but it is statistically significant only upto 8 hours.

While assessing the result of FOPT, the deterioration as judged by the time factor is already mentioned. Besides this, the mean error scores before and after the consumption of alcohol showed very significant deterioration due to increase in number of errors (Table III).

Table III

Mean error scores in FOPT before and after consumption of alcohol and significance of their difference

Group Test (n = 10)	Mean error score at				Mean difference of error scores between		
	Basal	1/2 hr	8 hr	12 hr	B & 1/2 hr	B & 8 hr	B & 12 hr
FOPT	0.2	3.0	1.0	1.1	+2.8**	+0.8**	+0.9**

***Sig at P = 0.001, **Sig at P = 0.01, *Sig at P = 0.05 + indicates deterioration

Thus, the deterioration in performance of tests involving attention, psychomotor coordination and reaction time persisted 12 to 13 hours after ingestion of 180 ml of whisky/Rum, the previous night.

It is thus concluded that performance decrement due to alcohol ingestion is evident as far as very complex tasks like flying are concerned. The question as to which minimum level of alcohol in blood is compatible with flight safety—is just a matter of hair splitting. Performance decrement has been noticed with alcohol levels as low as

25 mgm% while in our study even zero levels encountered—12 hours after drinks have yielded significant decrement in performance. As the task performance has to be judged in the totality of the individual other factors which ensue after a drinking bout have to be taken into account. Even if the alcohol levels have declined to zero, the insult to the tissues persists even longer and in this respect no two individuals are alike.

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