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A LIMITED REVIEW OF THE EFFECT OF
CIGARETTE SMOKING ON PERFORMANCE
WITH EMPHASIS ON AVIATION

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Naval Aersopace Medical Institute
Pensacola, Florida

22 November 1972

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LCDR R. S. Gibson, MSC, USN, and LT W. F. Moroney, MSC, USN



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13 ABSTRACT <p>Increased knowledge concerning the detrimental effects of smoking has created a desire to identify any adverse effects that smoking might have on aircrew performance. A limited review of the literature was undertaken to provide some perspective on the likely effects of smoking on variables related to aircrew performance. The authors concluded that cigarettes do significantly affect various sensory thresholds, but that the significance of these effects appear to be of little practical importance. They also noted that withdrawal does produce significant performance decrements.</p>			

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SPECIAL REPORT 72-2

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SUMMARY PAGE

THE PROBLEM

Increased knowledge concerning the detrimental effects of cigarette smoking has created a desire to identify any adverse effects that smoking might have on aircrew performance. More specifically, there is a need to know whether the effects of smoking are sufficient to require restrictive regulations such as those governing the use of alcohol.

THE APPROACH

Psychological Abstracts, 1961-1971, and HEW's Bibliography on Smoking and Health, 1969, were reviewed for studies on the effects of smoking on performance. Other selected references were also examined.

THE CONCLUSIONS

The results indicate that although cigarettes do significantly affect various sensory thresholds, the significance of these effects appear to be of little practical importance; however, it should be noted that withdrawal does produce significant performance decrements. The literature had very few references concerned with the effects of CO and nicotine in an aviation environment at altitude. Although peripheral studies do not indicate a need for a crash program, research support in this area appears to be desirable. In particular, smoking-induced reduction in visual field at altitude merits consideration.

INTRODUCTION

There is an abundance of literature describing the adverse effects of cigarette smoking on health. Increased knowledge concerning the detrimental effects of smoking has created a concern for any adverse effects that smoking might have upon aircrew performance. More specifically, there is a need to know whether the effects of smoking are sufficient to require restrictive regulations such as those governing the use of alcohol. In the event that the literature on smoking at this time is not adequate for developing definitive statements about the effects of smoking on aircrew performance it would be of value to determine whether the performance-related effects are of sufficient magnitude to require an immediate, large-scale research program. Confronted with questions of this type, a limited review of the literature was undertaken to provide some perspective on the likely effects of smoking on variables related to aircrew performance.

APPROACH

Psychological Abstracts for the past eleven years, 1961-1971, and HEW's Bibliography on Smoking and Health, 1969, were reviewed for studies concerned with the effects of smoking on performance. Other selected references were also examined.

RESULTS

Studies relevant to the effects of smoking on performance may be divided into three groups: (a) studies employing refined measures of sensory motor performance; (b) studies employing complex and real-world oriented tasks such as driving simulators; and (c) studies concerned with the clinical effects of the per cent of carboxyhemoglobin, COHb, in the blood.

REFINED MEASURES

The studies contained within this category were concerned with some type of sensory threshold measure. These thresholds are related to the maximum levels of sensitivity for selected stimulus situations. Johnston (10) found that smoking decreased the size of the visual field. Nonsmokers who had smoked for two weeks experienced a mean decrease of 26% in the size of their visual field. Smokers who had abstained from smoking for two weeks experienced a mean increase of 36% in the size of their visual field. Krippner (11) also reported that

abstinence from smoking increases the size of the visual field of smokers. Utilizing two experimental groups, he reported that individuals who were deprived of smoking and individuals who smoked denicotinized cigarettes showed similar performance when tested; therefore, he proposed that the restrictive effect of smoking upon peripheral vision may be attributed to the nicotine component of tobacco smoke.

Warwick and Eysenck (20) investigated the effect of smoking on critical flicker fusion frequency (CFF), an indicant of central nervous system sensitivity. They reported that the CFF threshold of smokers, who abstained from smoking for 12 hours, increased significantly after smoking one cigarette. The oral administration of 0.1 mg of nicotine, after that same period of abstinence, produced similar results.

Studies of the effect of low COHb levels on visual sensitivity (man's ability to detect the presence of a light in total darkness) have produced results which indicate that increased COHb levels are accompanied by decreased visual sensitivity. McFarland (13) reported that the inhalation of the smoke from three cigarettes (smoked approximately 25 minutes apart) produced a decrease in visual sensitivity equal to that at an altitude of 8,000 feet. Magdelano (12) reported that the inhalation of smoke from three cigarettes smoked consecutively has the same effect on nocturnal vision as a 7,546 foot increase in altitude.

Findings of a different nature were reported by Ulett and Itil (18), who observed changes in the brain activity of heavy smokers (one or more packs per day) following a 24-hour deprivation period. They noted a significant increase in slow wave activity, a typical sign of decreased vigilance. The withdrawal symptoms of drowsiness, restlessness and dysphoria were also noted. Conversely, Philips (14) reported that the EEG recordings of "moderate" smokers indicated increased alertness as the result of smoking one cigarette.

REAL-WORLD ORIENTED TASKS

A study by Heimstra, Bancroft, and DeKock (8) measured the tracking error, reaction times, and vigilance performance of nonsmokers, smokers, and deprived smokers operating a simulated driving device for six hours. They reported that no significant differences were found between smokers and nonsmokers, but noted that deprived smokers showed more tracking and vigilance errors, thus supporting Ulett and Itil's findings. Johansson and Jansson (9) used an apparatus simulating night driving conditions in order to study the

effect of smoking on detection time and redetection time after glare. They concluded that the effect of tobacco smoking on the ability to detect objects on the road at night was negligible from a practical point of view.

Davies and Tune (3) reported that cigarette-deprived smokers evidenced a significantly greater decrement in vigilance on a visual vigilance task than individuals who were permitted to smoke. Similar results were obtained by Frankenhauser, Myrsten, Post and Johansson (6) on a reaction time task which was administered continuously over an 80-minute period. However, Bancroft, Heimstra and Warner (1), while reporting a similar pattern on a reaction time/vigilance task, failed to obtain a significant difference between non-smokers, smokers, and deprived smokers.

Browning (3) reported that flight personnel, under high G conditions and breathing 100% oxygen, showed an average loss of 7% in vital capacity, during flights of 1.5 hours duration. Smokers showed a significantly ($p < .05$) greater loss in vital capacity than nonsmokers. He noted that within 30 minutes after flying high-G profiles 64% of the nonsmokers had recovered their baseline (pre-flight) lung volume, while only 36% of the smokers had recovered their pre-flight lung volume. In one extreme case a crewmember's lung volume had not returned to its baseline within two hours. Browning suggested that the atelectasis (collapse of the lung's alveoli) resulting from breathing 100% oxygen under high-G conditions, when compounded by smoking, could be expected to reduce work output. It should be noted that the reported incidence of atelectasis in the fleet is minimal and the incidences of atelectasis reported by Browning were induced during an evaluation of air combat tactics, by a U. S. Navy air development squadron.

CLINICAL EFFECTS OF CARBOXYHEMOGLOBIN

The research done to establish safe exposure levels for noxious substances contains several studies relevant to the effects of cigarette smoking on human performance. A study by Stewart, Peterson, Barette, and Bachland (17) reported the results of exposing subjects to various sustained levels of carbon monoxide. The study used a variety of performance tests selected for their apparent relevance to both vocational endeavors and automobile driving where significant impairment of visual or auditory acuity, coordination, reaction time, manual dexterity, or time estimations would be intolerable. The tests included: driving simulation, hand steadiness, Crawford collar and pin tests, and the Crawford screw test. It was found that an eight-hour exposure to 100 ppm of CO resulted in COHb saturations of 11% to 13% but produced no impairment of performance on the tests. When COHb saturation was raised to 28%,

dramatic impairment of functions was observed. However, during the post-exposure period when the COHb had dropped to the 22% level, manual dexterity appeared normal.

Schulte (16) examined the effect of low levels of COHb (0, 5, 10, 15 and 20%) on a series of performance tests. The scores obtained included: (a) number of errors on a simple choice letter response test, a color response test, an arithmetic test, and a "t" crossing test; (b) the time to complete the plural noun underlining test, the arithmetic test and the "t" crossing test. While Schulte did find significant correlations between COHb levels and performance, he did not test for differences in performance under the various COHb levels. However, from an examination of the figures presented in his report it appears that significant differences in performance usually occurred when the COHb exceeds the 10% level. On some tasks, performance decrements appeared when the COHb level was between the 5% and the 10% level. However, some questions have arisen regarding the reliability of the analytical techniques employed by Schulte (Stewart et al, 17).

McFarland (13) has reported that inhalation of smoke from a single cigarette increases the COHb level approximately 2%, while smoking three cigarettes raises the COHb level 4%. Therefore, the relationship between the number of cigarettes smoked and COHb level is not linear.

Bartlett (2), in explaining the mechanism of CO absorption and excretion in smokers, stated:

"Regular cigarette smokers have repeatedly been shown to have COHb concentrations in the 5% to 10% range. Smokers of pipes and cigars have COHb levels that are somewhat lower than those of cigarette smokers, but higher than those of nonsmokers. These findings have led to the widespread error of supposing that smokers may be more susceptible to environmental CO than nonsmokers. Carbon monoxide from cigarette smoke and CO in the ambient air are not additive in their biologic effect. Carbon monoxide is absorbed only when the P_{CO} in the ambient air exceeds that in the pulmonary capillary blood. Thus, persons with COHb levels of 5% from smoking do not absorb further CO from the environment unless the ambient CO concentration is 30 ppm or more; on the contrary, they excrete CO at a rate roughly proportional to the P_{CO} gradient between their blood and the ambient air. This suggests

that smokers may be among the least susceptible of persons exposed to low atmospheric concentrations of CO, since their COHb concentrations are not increased by the exposure. This conclusion is modified, however, by the fact that smokers' CO excretion between cigarettes is slower in a CO-polluted environment than in pure air. Thus, their long-term average COHb concentrations are slightly higher in the presence of environmental CO than in its absence (Pp. 772 and 723)."

Schulte (16), in reviewing the literature, reported the following signs or symptoms at various concentrations of carboxyhemoglobin:

% COHb	Signs and Symptoms (P525)
0-10	No signs or symptoms
10-20	Tightness across the forehead, possible slight headache, dilation of the cutaneous blood vessels
20-30	Headache and throbbing in the temples
30-40	Severe headache, weakness, dizziness, dimness of vision, nausea, vomiting, and collapse
40-50	Same as above, greater possibility of collapse, syncope, and increased pulse and respiratory rates
50-60	Syncope, increased respiratory and pulse rates, coma, intermittent convulsions, and Cheyne-Stokes respiration
60-70	Coma, intermittent convulsions, depressed heart action and respiratory rate, and possible death
70-80	Weak pulse, slow respirations, respiratory failure, and death within a few hours
80-90	Death in less than an hour
90+	Death within a few minutes

An article by Goldsmith and Landaw (7) referenced a cigarette -induced CO exposure level study of 3311 longshoremen. Estimates of the COHb based upon the CO measured in the exhaled air indicated that smokers would have the following median percentages of carboxyhemoglobin:

light smokers (half pack or less)	3.8%
moderate smokers (more than half pack less than two packs)	5.9%
heavy smokers (2 packs or more)	6.8%

Part of the problem of estimating the potential hazard of CO from cigarette smoking is to estimate the mean CO concentration in the smokers lungs. If the data from Goldsmith and Landaw are used as values for the back solutions of the equations for estimating the percentages of COHb at equilibrium (California State Department of Public Health, (4)), an estimate of the effective mean concentration of CO in the lungs of smokers can be obtained. These estimates are as follows:

light smokers	23.8 ppm
moderate smokers	36.9 ppm
heavy smokers	42.5 ppm

All of these estimates are within the acceptable limits of 50 ppm set for long term industrial exposure by the American Conference of Government and Industrial Hygienists (15). Based upon the previously described findings of Stewart et. al. (17) the percentages of COHb in smokers would be within acceptable limits.

CONCLUSIONS

The results of the studies referenced indicate that although cigarettes do significantly affect various sensory thresholds, the significance of these effects appear to be of little practical importance. However, it should be noted that withdrawal does produce significant performance decrements. The literature has very few references concerning the effects of CO and nicotine in an aviation environment at altitude. Although peripheral studies do not indicate a need for a crash program, research support in this area appears to be desirable. In particular, the smoking-induced reduction in visual field at altitude merits consideration.

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