

# SMOKING HISTORY AND EXERCISE DURATION IN HOT, DRY ENVIRONMENTS

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## INTRODUCTION

Epidemiological evidence suggests that the military have a higher percentage of smokers than the civilian population (1). A worldwide survey of U. S. military personnel conducted in 1985 under the direction of the Assistant Secretary of Defense for Health Affairs reported that 46% of male and 42% of female U. S. military personnel smoke cigarettes, compared with 36% and 29% of males and females, respectively, in the U.S. population (2). Conway and Cronan reported that among Navy personnel, smokers have lower physical endurance than nonsmokers (3) and that cigarette smoking is clearly detrimental to physical fitness, even among young men (4). Smoking also may negatively impact military readiness and performance of physical duties. Thus, several Navy directives have focused on preventing new recruits from beginning to smoke and on encouraging smoking cessation to ensure the development and maintenance of healthy, physically fit military personnel (5).

The effect of smoking history on thermoregulation and exercise capacity in the heat has civilian as well as military importance. The purpose of this investigation was to evaluate the effects of cigarette smoking on exercise duration in a hot, dry environment while wearing chemical/biological protective gear. It was hypothesized that self-reported cigarette smokers would be unable to perform aerobic exercise while wearing chemical/biological protection gear in a hot, dry environment as long as subjects who had never smoked.

## MATERIALS AND METHODS

### Subjects & Heat Exposure Exercise Trial

Twenty-four unacclimatized male Marines wearing chemical/biological protection ensembles with 34 kg of gear completed a treadmill walking protocol (1.34 m/s and 2% grade) to exhaustion on a Quinton® (Bothell, WA) motor-driven treadmill. Subjects were tested at a wet bulb global temperature (WBGT) (6) of either 34°C (n = 14) or 25°C (n = 10) while instrumented with 8 skin temperature thermistors (Model No. 409, Yellow Springs Instruments, Inc.; Yellow Springs, OH) and a disposable thermistor probe (Sheridan; Argyle, NY) inserted to a depth of 15 cm past the anal sphincter to measure core temperature. The 34°C WBGT corresponded to 49°C and 20% relative humidity (RH). The 25°C

WBGT corresponded to 32°C and 35% RH. Heart rate (Polar® Heart Watch; Stamford, CT) and oxygen uptake were also recorded.

### **Questionnaire Items**

*Exercise Habits.* In an attempt to isolate the effect of smoking on exercise in the heat, correlations between the groups' self-reported weekly exercise frequency, intensity, and duration were evaluated.

*Medical History.* Smoking status was assessed using a self-reported medical history questionnaire. After reviewing the medical history questionnaires, subjects were divided into currently smoking (mean pack years of 3.2) and no-smoking history (no-Hx) groups. Former smokers were excluded from this study. Since the average age of the smokers was 20.8 years, a 3.2-pack-year smoking history means that this group averaged one pack per day since the age of 17.6 years. The current smoking habit of this group was 16 cigarettes per day.

### **3-Mile Run Time and Body Fat Measurements**

Self-reported 3-mile run time from the Marines' most recent PFT was recorded as an indicator of aerobic fitness. Percent body fat was estimated using Lange® (Cambridge Scientific Industries, Cambridge, MD) skinfold calipers using the equation for the sum of 7 skinfold sites (7).

### **Statistical Analysis**

One-way analysis of variance on aerobic exercise duration in the heat at 34 °C and 25°C by each of the two smoking groups was performed to analyze the relationship between smoking and aerobic exercise duration in the heat. Statistical analysis of the data included t-tests between the two smoking groups to try to rule out differences between possible confounding factors of physical fitness and weekly physical activity.

## **RESULTS**

### **Subjects**

A total of 24 subjects (12 smokers and 12 no-Hx) completed the testing. The physical characteristics, exercise duration in the heat chamber, and 3-mile run times are shown in Table 1.

### **Questionnaire Items**

The mean frequency of weekly activity for smokers and no-Hx was not significantly different between groups ( $p = 0.12$ ). The mean ( $\pm$ SD) intensity rating during weekly activity for smokers and no-Hx was not significantly different ( $p = 0.70$ ). The average ( $\pm$ SD) duration of each bout of weekly activity for smokers and no-Hx was not significantly different between the groups ( $p = 0.96$ ).

### **3-Mile Run Time and Body Fat Percentage**

Smokers demonstrated a decreased aerobic fitness as shown by slower 3-mile run times ( $p = 0.03$ ) in normal, ambient conditions compared with the no-

**Table 1. Physical Characteristics, Exercise Duration in the Heat, and 3-Mile Run Time. Mean ( $\pm$ SD)**

	Group	Age	Weight	Body fat %	ExTime	d%	WBGT	N	3- Mile Time
(A)	Smoker	20.8	76.8	16.4 $\bar{x}$ ( $\pm$ 7.72)	26.92**		34 $\bar{x}$ $\pm$ 2.5	12	23.03*
	No-Hx	22.3	75.7	12.3 $\bar{x}$ ( $\pm$ 5.77)	32.83	22%	34 $\bar{x}$ $\pm$ 2.5	12	20.98
(B)	Smoker	21.4	81.8		23.57**		34	7	24.25*
	No-Hx	23.0	78.6		30.57	30%	34	7	21.19
(C)	Smoker	19.8	69.8		31.60		25	5	21.32
	No-Hx	21.2	71.4		36.00	14%	25	5	20.67

Note. \* $p \leq 0.05$ ; \*\* $p = 0.06$

(A) All subjects ( $n = 24$ ) separated by smoking status at 34°C and 25°C WBGT conditions.

(B) Subjects ( $n = 14$ ) by smoking status in the 34°C condition.

(C) Subjects ( $n = 10$ ) by smoking status in the 25°C condition.

ExTime = exercise duration (minutes) in the hot, dry environment.

d% = percentage difference in exercise duration between smoker and no-Hx groups.

WBGT = temperature °C (Yaglou & Minard, 1957)

3-Mile Time = 3-mile run time (minutes) in normal, ambient conditions from most recent FFT.

Hx subjects. The mean ( $\pm$ SD) body fat of the smoking group and the no-Hx group was not significantly different ( $p = 0.15$ ).

### Heat Exposure Exercise Trial

Two separate groups of 7 subjects at 34°C and two separate groups of 5 subjects at 25°C completed the heat exposure exercise trial. All tests ended when either the subject's core temperature exceeded 39.5°C or HR exceeded 90% of the subject's maximum HR, calculated as 220 - age, for a period of 5 min. Physical work performed in the heat chamber was calculated as 500 W at 34°C and 275 W at 25°C extrapolated from oxygen uptake measurements (8). Total heat chamber exercise time for smokers and no-Hx at 34°C and 25°C is reported in Table 1. When both groups' data were contrasted (34°C and 25°C hot, dry conditions, treadmill walking protocol), smokers displayed a 22% ( $p = 0.06$ ) lower mean aerobic exercise duration. Lower aerobic exercise duration of 30% ( $p = 0.06$ ) at 34°C and 14% ( $p = 0.22$ ) at 25°C suggest that current smokers do not perform aerobic exercise as long as no-Hx subjects in hot, dry conditions.

### DISCUSSION

Using vapor-barrier uniforms, such as those used to protect humans, both civilian and military, from airborne chemical or biological agents, poses a thermoregulatory challenge. These uniforms impede the cooling effect of transferring metabolic heat away from the skin - which is greatly increased during exercise - into the environment (9, 10, 11).

As the environmental temperature increased, the disparity in exercise duration while performing submaximal aerobic exercise in semi-impermeable chemical/biological protection gear increased. The decreased exercise duration of 14% at 25°C and 30% at 34°C illustrate that smokers do not perform as well as no-Hx subjects when ambient temperature increases. Decreased exercise duration in the heat cannot be attributed to differences between the groups' body fat percentages or weekly exercise activity, but it may be attributed to smoking. These findings have implications for civilian and military personnel who perform work tasks in hot, dry conditions while wearing chemical/biological protection gear.

While smoking history does seem to affect submaximal exercise in the heat at higher environmental temperatures, these findings should not be considered conclusive. However, additional experimentation with a larger number of subjects with a smoking history and at various incremental levels of heat stress and exercise intensities appears to be warranted. Subsequent studies should investigate possible mechanisms of the decreased performance of smokers in various high-heat environments.

## CONCLUSIONS

These findings suggest that smoking may adversely affect exercise duration in hot, dry conditions. The subjects demonstrated no significant difference in weekly exercise activity or body fat percentage, but the smoker group had significantly higher 3-mile run times ( $p < 0.05$ ) than the no-Hx group in normal ambient conditions (see Table 1). This result indirectly represents a baseline decreased aerobic fitness of the smoker group compared with the no-Hx group during sustained (26 to 36 min) submaximal exercise.

Marines who smoke and are required to wear chemical/biological protective gear while performing long duration aerobic tasks in the heat may not be able to perform those tasks for as long as Marines who have never smoked. The negative impact of smoking may result in the inability to complete physical duties while wearing chemical/biological protection gear and ultimately compromise the successful completion of the mission.

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