

Naval Health Research Center

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SMOKING, EXERCISE, AND PHYSICAL FITNESS

T.L. CONWAY
T.A. CRONAN

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NAVAL HEALTH RESEARCH CENTER
P.O. BOX 85122
SAN DIEGO, CALIFORNIA 92186-5122

NAVAL MEDICAL RESEARCH AND DEVELOPMENT COMMAND
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Terry L. Conway, Ph.D.
Naval Health Research Center
Health Services Research Department

Terry A. Cronan, Ph.D.
San Diego State University
Psychology Department

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SUMMARY

Problem

Research on smoking and physical activity provides strong evidence of smoking's negative impact and physical activity's positive impact on long-term health. However, evidence is lacking regarding the association between smoking and spontaneous exercise activity and the independent effects of these factors on fitness.

Objective

The primary objective of the present study was to assess the independent effects of cigarette smoking on physical fitness after controlling for the effects of exercise on physical fitness.

Approach

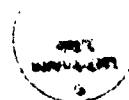
The associations between exercise activity, smoking behavior, and physical fitness were examined in 3,045 Navy personnel. Exercise and smoking behaviors were measured using a "life-style" survey. Physical fitness was assessed using scores on the Navy's Physical Readiness Test (PRT). Analyses of variance were conducted to examine the relationships among smoking status, exercise activity, and PRT performance. Multiple regression procedures were used to examine the relationship between smoking and physical fitness after controlling for the effects of exercise.

Results

Smoking was associated both with lower exercise levels and lower physical endurance--both cardiorespiratory (1.5-mile run) and muscular (sit-ups). After controlling for the effects of exercise activity, smoking was still significantly associated with lower physical endurance but was not related to overall body strength (lean body mass) or percent body fat.

Conclusions

Smoking is a detriment to physical readiness among relatively young, fit Navy personnel. Findings reported here suggest that smokers will have lower physical endurance than nonsmokers even after accounting for differences in the average exercise levels of smokers and nonsmokers. Cigarette smokers should be given strong encouragement to stop smoking as part of any program efforts to improve Navy physical readiness.



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Smoking, Exercise, and Physical Fitness

A large body of medical and epidemiological research on smoking has convinced most health professionals that cigarette smoking produces serious long-term ill effects on health. Smokers have higher mortality rates and are more likely to develop cardiovascular disease, cancer of various organs, and emphysema (Ravenholt, 1985; Surgeon General, 1983, 1989; USDHHS, 1982). Smoking also appears to have rapid-onset negative effects on health and physiological functioning, including acute respiratory disease and reduced lung capacity (Beck, Doyle, & Schachter, 1981; Enjeti, Hazelwood, Permutt, Menkes & Terry, 1978; John, 1977). A related area of physiological functioning that is affected by cigarette smoking even among healthy young people is physical fitness (Bahrke, Poland, Baur, & Connors, 1988; Biersner, Gunderson, & Rahe, 1972; Conway & Cronan, 1988; Jensen, 1986). Results of those studies indicate that there is a negative relationship between smoking and several components of physical fitness.

Published findings on the association between smoking and physical activity have been somewhat inconsistent (Blair, Jacobs, & Powell, 1985), although smoking has been associated with lower physical activity in supervised exercise programs (Dishman, Sallis, & Orenstein, 1985). There has also been little published research on the relationship between smoking and "spontaneous" exercise activities (Dishman et al., 1985). Furthermore, no studies have examined the association between smoking and various components of physical fitness after taking the effects of exercise activities into account.

The purpose of this study was to examine the interrelationships among smoking, spontaneous exercise activity, and physical fitness. Specifically, the associations in three areas were examined: (a) between smoking and spontaneous exercise activity, (b) between several indicators of physical fitness and both smoking and exercise, and (c) between smoking and physical fitness after taking into account the effects of exercise activity.

Methods

Participants

Participants were a randomly selected group of 3,045 Navy personnel (2,712 men and 333 women) who volunteered to participate in a Navy-wide evaluation of physical fitness and health. The average age of participants was 28.2 years

(SD = 7.0) with a range from 17-59 years of age. Enlisted personnel comprised 88% and officers 12% of the sample. The average educational achievement of the total sample was 12.9 (SD = 1.9) years, with officers averaging more years of schooling (mean = 16.7, SD = 2.1) than enlisted personnel (mean = 12.4, SD = 1.2). Of the 2,750 individuals who identified their race/ethnic group, there were 79.6% Caucasians, 11.4% Blacks, 4.8% Hispanic/Puerto Ricans, and 4.2% Filipino/Malayans.

Measures

Physical fitness was assessed by performance on the Navy's required Physical Readiness Test (PRT) which includes the following components: 1.5-mile run/walk (cardiorespiratory endurance), 2-minute sit-ups test (muscular endurance), and body composition. The body composition assessment provided two measures: (a) an estimate of the percentage of body weight attributable to fat (percent body fat) using a circumference measurement technique (Wright, Dotson, & Davis, 1980, 1981) and (b) an estimate of lean body mass (computed as 1.00 minus percent body fat, expressed as a fraction, times body weight in pounds); lean mass is an indicator of overall body strength (Beckett & Hodgdon, 1987).

Participants also completed self-report surveys consisting of a variety of health- and fitness-related attitudes and behaviors as well as demographic items. Smoking measures taken from the survey included: (a) smoking status, which classified individuals as having never smoked, being a former smoker, or being a current smoker and (b) average amount smoked per day. The latter measure was based on a 10-category response scale: 0, 1-5, 6-10, 11-15, 16-20, 21-25, 26-30, 31-35, 36-40, and 41+ of cigarettes, cigars, or pipefuls of tobacco per day.

Self-reported exercise activities also taken from the survey included reports on nine common exercise activities: running, continuous walking, swimming, bicycling, playing racket sports, aerobic dancing/exercising, weight lifting, performing calisthenics, and playing basketball. Two components for each of these activities were assessed: (a) frequency (i.e., times per week engaged in an exercise) and (b) duration (i.e., time spent exercising during a workout period).

An overall "exercise frequency" variable was computed by summing the number of times per week that a person reported engaging in each of the nine exercises

listed above. For example, if a person reported that he/she ran three times per week, bicycled two days per week, and did calisthenics seven days per week, his/her exercise frequency score would be 12 exercise sessions per week. To estimate the usual "duration" of a person's exercise sessions, self-reports on the average number of minutes spent during each exercise session were averaged across any of the nine common exercise activities that an individual reported doing. The frequency and duration measures for each of the nine exercise activities were also used to estimate the number of kilocalories expended per week in exercise activities. The tables of McArdle, Katch, and Katch (1986) were used to calculate kilocalories expended weekly on each of the exercise activities. Total number of exercise kilocalories expended per week was computed by summing the kilocalories expended across each of the nine exercise activities.

Statistical Analyses

The primary method of analysis was a one-way analysis of variance comparing exercise and physical fitness levels across three groups based on smoking status: never smoked, former smoker, and current smoker. A one-way analysis of variance was also used to compare physical fitness levels across six groups based on exercise level ranging from zero kilocalories, >0-1,000, >1,000-2,000, >2,000-3,000, >3,000-4,000, and >4,000 kilocalories expended in exercise activities per week. Results of these analyses indicated whether there were significant relationships between smoking and physical fitness, between smoking and exercise levels, and between exercise and physical fitness levels.

Because an association was expected between smoking and exercise level (i.e., smokers were expected to exercise less), a multiple regression analysis was used to determine whether smoking was independently associated with physical fitness above and beyond any indirect association related to the fact that smokers exercised less and, consequently, were less physically fit. In the multiple regression analyses, kilocalories expended during exercise were forced to enter first into the equation predicting physical fitness. In a second step, amount of tobacco smoked was entered into the equation to assess whether the smoking variable accounted for significantly more variance in physical fitness than could be accounted for by exercise alone.

Results

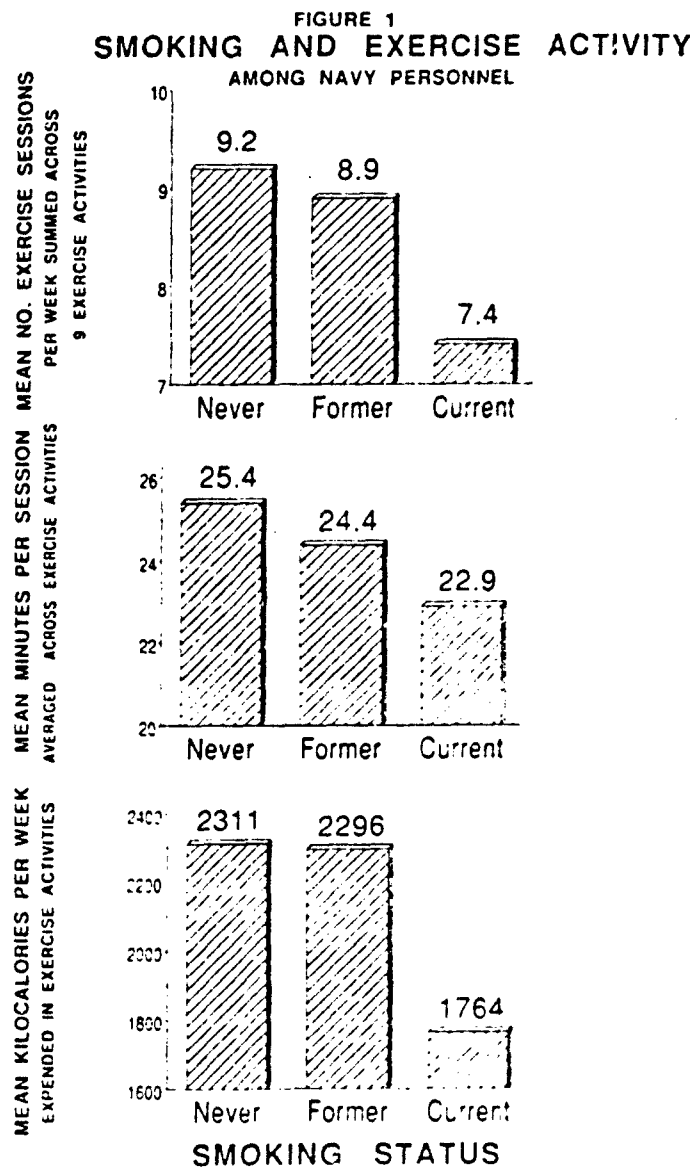
Descriptive statistics on the total sample for the smoking, exercise, and physical fitness measures analyzed are provided in Table 1.

Table 1

Descriptive Statistics for the Physical Fitness, Exercise, and Smoking Measures for a Sample of Navy Personnel

Measure	Mean	SD	N
<u>Physical Fitness Measures</u>			
1.5-Mi Run	12.54	2.20	2532
Sit-Ups	52.79	18.44	2685
% Body Fat	15.82	5.20	2551
Lean Body Mass	141.96	21.13	2320
<u>Exercise Measures</u>			
Exercise Sessions (mean number per week)	8.32	5.94	3007
Minutes per Exercise Session (mean across exercise activities)	24.06	12.25	3000
Exercise Kilocalories (KCALs) (mean expended per week)	2070.84	1781.83	2960
<u>Smoking Measures</u>			
Cigarettes/Cigars/Pipes (mean smoked per day)			
Total Sample:	8.54	12.14	3014
Smokers Only:	19.74	10.93	1304
Group Smoking Status:	---	---	3019 (100%)
Never Smoked	---	---	921 (31%)
Former Smoker	---	---	783 (26%)
Current Smoker	---	---	1315 (44%)

Analysis of variance results indicated that smoking was associated with lower levels of spontaneous exercise activities. As can be seen in Figure 1, those

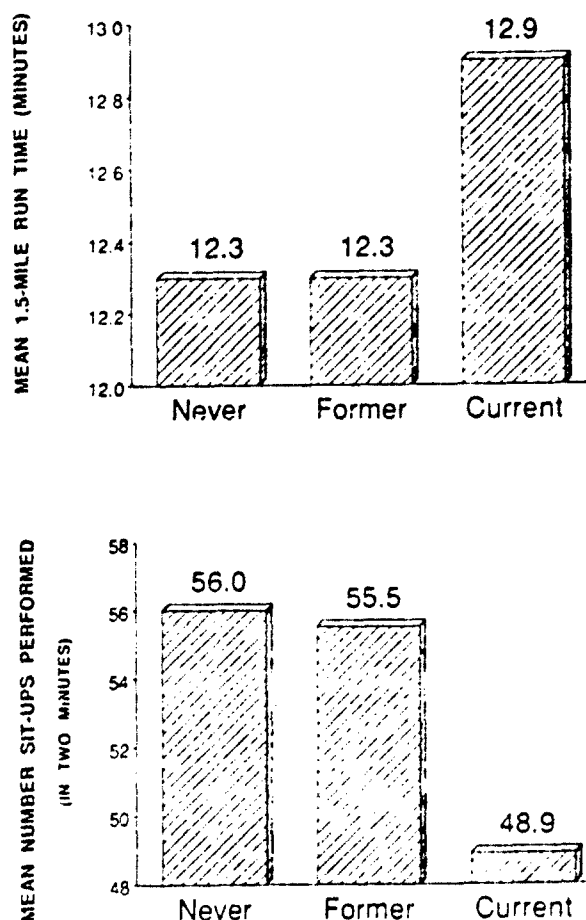


who had never smoked and former smokers engaged in significantly more exercise sessions per week than did smokers ($F(2,2985) = 31.7, p < .0001$). Smokers also exercised for significantly less time during their workout sessions than did those who had never smoked and former smokers ($F(2,2978) = 10.8, p < .0001$). In general, smokers expended fewer kilocalories per week exercising than did

those who had never smoked and former smokers ($F(2,2938) = 33.8, p < .0001$); the latter two groups did not differ significantly on any of the exercise variables.

Smoking also was associated with lower levels of physical fitness. The endurance components of physical fitness, shown in Figure 2, produced a similar pattern of findings. Smokers ran the 1.5-mi run significantly more slowly ($F(2,2509) = 25.7, p < .0001$) and did significantly fewer sit-ups ($F(2,2661) = 47.0, p < .0001$) than did former smokers and those who had never smoked; the latter two groups did not differ significantly on the run and sit-ups tests.

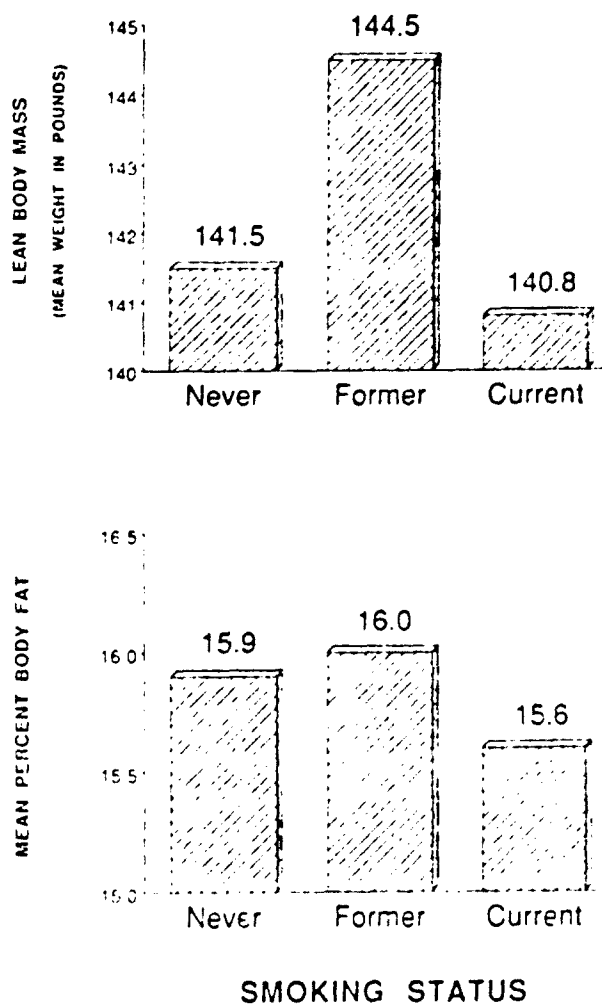
FIGURE 2
SMOKING AND PHYSICAL ENDURANCE
AMONG NAVY PERSONNEL



SMOKING STATUS

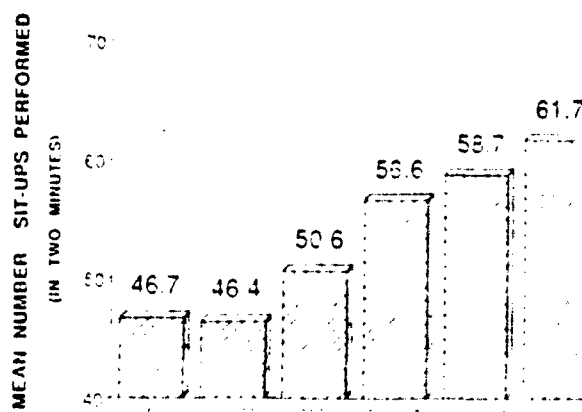
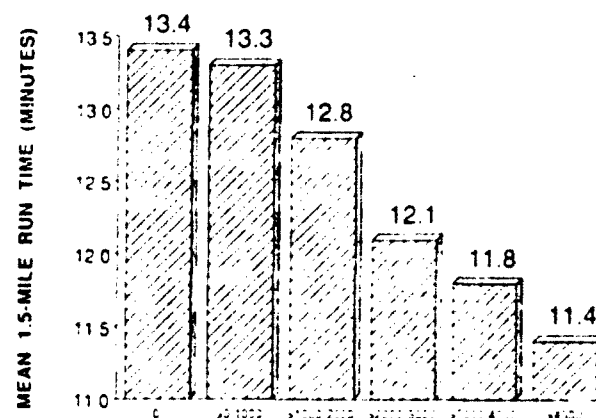
Considering the body composition measures shown in Figure 3, smokers also had significantly less lean body mass ($F(2,2298) = 6.2, p < .01$) than former smokers but did not differ from those who had never smoked. At the $p < .05$ probability level, there were no significant group differences in percent body fat ($F(2,2528) = 2.0, p = .13$); however, a post hoc t -test indicated a marginally significant mean difference between former and current smokers ($t = 1.90, p = .057$).

FIGURE 3
SMOKING AND BODY COMPOSITION
AMONG NAVY PERSONNEL



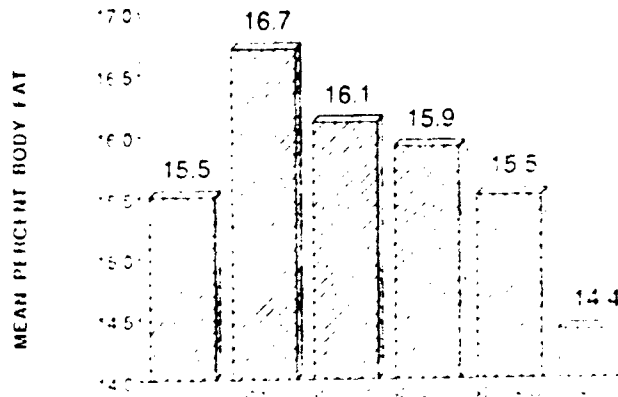
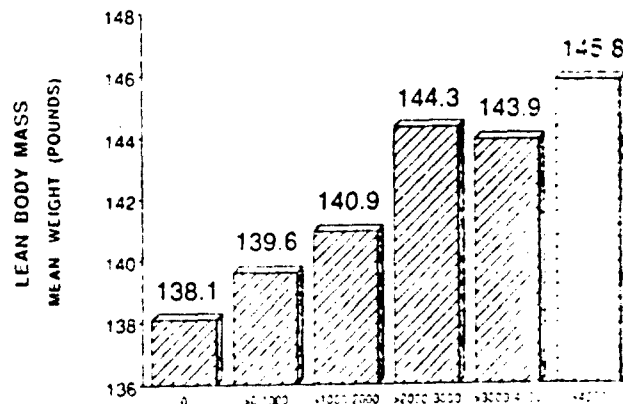
As would be expected, exercise activity was associated with higher levels of physical fitness. Findings for the endurance fitness measures, shown in Figure 4, indicated that those who exercised more ran the 1.5-mi run significantly faster ($F(5,2457) = 57.9, p < .0001$) and did more sit-ups ($F(5,2610) = 52.2, p < .0001$) than those who exercised less. Considering the body composition measures (Figure 5), those who exercised more had higher lean body mass ($F(5,2260) = 6.5, p < .0001$) than those who exercised less. Additionally, except for the subgroup who reported zero exercise (averaging just below the overall group mean on percent body fat), those who exercised more also had lower percent body fat ($F(5,2485) = 9.2, p < .0001$) than those who exercised less.

FIGURE 4
EXERCISE AND PHYSICAL ENDURANCE
AMONG NAVY PERSONNEL



KILOCALORIES SPENT EXERCISING

FIGURE 5
EXERCISE AND BODY COMPOSITION
AMONG NAVY PERSONNEL



KILOCALORIES SPENT EXERCISING

At the bivariate level, these findings indicated that physical fitness was associated positively with exercise and negatively with smoking. However, because smoking and exercise were also negatively associated, multiple regression analyses were conducted to determine whether smoking made an independent contribution to the prediction of physical fitness above and beyond the effects of exercise. The variable estimating kilocalories per week expended during exercise activities was forced to enter the equation first, then average amount of tobacco smoked per day was entered.

Results indicated that smoking had an independent negative association ($p < .0001$) with the 1.5-mi run (cardiorespiratory endurance) and the sit-ups test (muscular endurance) after controlling for the effects of exercise. However, smoking did not significantly predict lean body mass (overall strength indicator) or percent body fat after controlling for exercise. In predicting the average of the two physical endurance indicators (1.5-mi run and sit-ups tests), the exercise variable produced an R of .35, and the tobacco use variable contributed an additional 2.3% of the explained variance to yield an R of .38. Regression findings for each of the individual components of physical fitness are shown in Table 2.

Table 2
Results of Regression Analyses Predicting Physical Fitness from
Exercise and Smoking among Navy Personnel

Criterion	Predictor*	B-weight	beta	R	R-Sq.Change
1.5-Mi Run	Exercise (KCALS per week)	-.0004	-.29	.32	.10**
	Tobacco Smoked (per week)	.0241	.13	.34	.02**
	Constant	13.0722			
Sit-Ups	Exercise (KCALS per week)	.0027	.26	.29	.08**
	Tobacco Smoked (per week)	-.2084	-.14	.32	.02**
	Constant	49.0334			
% Body Fat	Exercise (KCALS per week)	-.0003	-.16	.11	.01**
	Tobacco Smoked (per week)	-.0060	-.01	.11	.00
	Constant	16.5698			
Lean Body Mass	Exercise (KCALS per week)	.0013	.11	.11	.01**
	Tobacco Smoked (per week)	-.0305	-.02	.11	.00
	Constant	139.5867			

* Exercise was forced to enter first.

** $p < .001$.

A final set of analyses was performed to ensure that the results reported above were not due to confounding effects of age. Age was considered a possible confounding variable because of concern that older individuals exercised less, were less physically fit, and smoked more. Thus, another series of regression analyses were computed that were identical to those reported above except that age was controlled for first (i.e., age was forced to enter the equation first, exercise second, and amount smoked third). The pattern of results predicting the various components of physical fitness from exercise and smoking after first controlling for age was identical to the pattern reported above in which age was not taken into account. The similarity in the pattern of results for both series of analyses indicated that age effects were not confounding the observed relationships between physical fitness and both exercise and smoking. This observation is consistent with previous findings reported by Conway & Cronan (1988).

Discussion

This study has examined the association between smoking and spontaneous exercise activities as well as the relationship between physical fitness and smoking after controlling for the effects of exercise. Findings indicate that current smokers engage in fewer exercise sessions per week, exercise for shorter time periods, and, overall, expend fewer kilocalories per week in exercise activities than do former smokers or those who have never smoked. There also is a negative association between tobacco use and physical endurance, both cardiorespiratory (1.5-mi run) and muscular (sit-ups) even after controlling for the effects of exercise. Other results indicate that tobacco use is not significantly related to lean body mass (strength indicator) or percent body fat after taking exercise levels into account.

The relationships between exercise and physical fitness were as would be expected. Physical endurance, both cardiorespiratory (1.5-mile run) and muscular (sit-ups), as well as lean body mass showed clear linear relationships with caloric expenditure resulting from exercise activity. The relationship between exercise activity and percent body fat was also monotonic and approximately linear in the expected direction (i.e., more exercise associated with lower percent fat) with one exception--those who reported zero exercise had an average percent body fat that was similar to those who exercised at relatively high levels.

The relationships between smoking and exercise activity and between smoking and physical endurance were also as might be expected. Current smokers averaged almost two fewer exercise sessions per week and two minutes less per typical exercise session than did former smokers or those who had never smoked. Consequently, smokers typically expended about 500 fewer kilocalories per week in exercise activities than did former smokers or those who had never smoked. Current smokers also required an average of 30 seconds more to complete the 1.5-mile run test, and they performed seven fewer sit-ups than did former smokers and those who had never smoked.

The relationships between smoking and the two measures of body composition, however, did not show patterns similar to the endurance components of physical fitness. There was only a marginally significant association between percent body fat and smoking, with the largest mean difference (0.4% body fat) found between former smokers and current smokers. Lean body mass did differ significantly, but not linearly, between groups with former smokers having about three to four pounds more lean mass than current smokers and those who had never smoked. These findings suggest the interesting speculation that individuals who are somewhat "heavysset" (e.g., the image of the big, strong dockworker comes to mind) with a lot of lean mass and a bit of extra fat are more likely to become former smokers than smaller, thinner individuals. This may be true simply because smoking is physically harder on "big" people who are already having to work harder to move their body mass. Thus, being physically large (e.g., having a lot of lean mass and possibly extra fat mass) may predispose a smoker to quit. This speculation seems more likely than assuming that former smokers somehow develop additional lean mass as a result of quitting smoking.

Although it is not surprising that smokers reported less "spontaneous" exercising than nonsmokers, there has been little previous research to confirm this association in individuals reporting their own typical exercise habits, rather than exercise engaged in as part of an organized program or intervention (Dishman et al., 1985). Additionally, finding a negative association between tobacco use and physical endurance (cardiorespiratory and muscular) is consistent with previous research (e.g., Bahrke et al., 1988; Biersner, et al., 1972; Conway & Cronan, 1988; Jensen, 1986). However, this previous research did not take exercise activities into account; thus, it could not be ruled out that the negative association between smoking and physical fitness was a spurious effect related to the fact that smokers typically exercise less than nonsmokers.

and, therefore, are less physically fit because they exercise less rather than because they smoke per se. The findings presented here, however, provide evidence for the conclusion that smoking is independently associated with poorer endurance fitness even after the effects of exercise are taken into account.

The marginally significant difference in percent body fat, with former smokers having the highest average and current smokers the lowest average percent body fat, is consistent with previous research indicating that smokers tend to be thinner than nonsmokers (e.g., Albanes, Jones, Micozzi, & Mattson, 1987; Shimokata, Muller, & Andres, 1989; Blitzer, Rimm, & Giefer, 1977). However, the current findings indicating that former smokers also have significantly greater lean body mass than both never and current smokers, along with inconsistencies in previous research findings regarding whether former smokers are fatter than nonsmokers (cf., Albanes et al., 1987 versus Blitzer et al., 1977), indicate the need for further research on smoking and body composition. Special attention should be given to assessing the pattern of associations between smoking and different measures of body composition (e.g., weight, weight-height ratios such as body mass index, estimated total lean body mass, estimated overall percent body fat, caliper measures of fat at specific body sites, etc.).

Last, a cautionary note regarding the generalizability of these findings is in order. The results presented here are potentially limited by the restriction in range on some variables related to the characteristics of this sample. For example, the individuals in this study were predominately male and relatively young (primarily in their 20's, 30's, and low 40's, with very few individuals over 50 years of age). They were also generally healthy and physically fit; individuals who are seriously ill or do not meet minimum fitness standards are usually separated from military service. This sample also had a higher percentage of smokers than is seen in the U. S. population, although the higher smoking rate is consistent with the overall higher rates found among U. S. military personnel (Ballweg & Bray, 1989).

However, the point should also be made that the individuals in this sample would be considered typical of "middle Americans" in similar age groups who are not physically or mentally disabled or institutionalized. Additionally, if it is assumed that the distributions of the exercise and physical fitness measures are somewhat restricted in range because of Navy recruiting and retention requirements, any statistically significant relationships found between these

variables and smoking status would likely be attenuated in this sample and actually be stronger in a population with greater ranges in the distributions for exercise and physical fitness.

Assuming these basic findings regarding the relationships among smoking, exercise, and physical fitness generalize to the population at large, they have important implications for health and well-being. It is now well-substantiated that smoking is detrimental to health and is associated with higher mortality rates (e.g., Ravenholt, 1985; Surgeon General, 1983, 1989; USDHHS, 1982). There also is a growing body of evidence linking exercise and physical fitness to long-term health (e.g., Blair, Kohl, Paffenbarger, Clark, Cooper, & Gibbons, 1989; Paffenbarger, Hyde, Wing, & Hsieh, 1986). The findings from this study indicate that not only are smoking, exercise, and physical fitness interrelated but that smoking is related to endurance components of physical fitness even after controlling for the effects of exercise activity. Thus, these results suggest that the lower levels of physical fitness among smokers are not simply attributable to the fact that they exercise less. Instead, these findings indicate that smoking has a detrimental effect on fitness that is independent of the impact of exercise on physical fitness. Such results underscore the importance of examining the causal links between smoking and exercise and their independent impact on fitness and health.

Conclusions

Although the total amount of variance accounted for is modest, highly reliable results from several studies indicate that smoking is a detriment to physical readiness among relatively young, fit military personnel (Bahrke, Poland, Baur, & Connors, 1988; Biersner, Gunderson, & Rahe, 1972; Conway & Cronan, 1988; Jensen, 1986). Findings reported here suggest that smokers have lower physical endurance than nonsmokers even after taking into account the differences in exercise levels of smokers and nonsmokers. Consequently, smokers should be given strong encouragement to stop smoking as part of any program efforts to improve physical "readiness" or fitness. Additionally, results of other research indicate that individuals who maintain an exercise program are more likely to give up smoking than those who quit exercising (Koplan, Powell, Sikes, Shirley, & Campbell, 1982). Thus, designers of smoking prevention and cessation programs would do well to increase the exercise activities of participants to facilitate the

adoption and maintenance of nonsmoking behavior. Future research should explore the causal links, both direct and indirect, among smoking, exercise, and physical fitness. Understanding how behaviors such as smoking and exercise interact may have important implications for predicting both short- and long-term health and fitness.

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22a NAME OF RESPONSIBLE INDIVIDUAL Terry L. Conway, Ph.D.			22b TELEPHONE (Include Area Code) (619) 553-8465	22c OFFICE SYMBOL Code 40

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