RELATIONSHIPS AMONG CHANGES IN HEALTH

BEHAVIORS IN A SIX-YEAR U.S. NAVY COHORT

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Relationships Among Changes in Health Behaviors
in a Six-Year U.S. Navy Cohort

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Summary

Problem and Objective

Although the importance of health behaviors in preventing disease and protecting or promoting health has been well demonstrated, the relationship between health behaviors is not clearly understood. Understanding how specific health behaviors are associated with other health behaviors may have implications for designing effective health promotion programs and understanding underlying motivations to practice healthy behaviors in general. While researchers have reported the interrelationships among health behaviors using cross-sectional data, the present study utilized longitudinal data to examine the relationships among changes in five key lifestyle behaviors among a 6-year cohort of U.S. Navy personnel.

Methods

Participants were 1,019 active-duty U.S. Navy personnel who completed a health behavior and lifestyle questionnaire in 1988 and 1994.

Results

There were several significant, though generally weak, correlations among exercise, diet, alcohol use, cigarette use, and sleep, with absolute values ranging from $r = .07$ to $r = .18$. Regression analyses indicated that change in dietary behavior was related to change in exercise activity ($p \leq .001$) and, to a lesser extent, to change in alcohol use ($p \leq .01$). A change in cigarette use was related to a change in the number of hours of nightly sleep ($p \leq .001$) and to a change in alcohol use ($p \leq .05$). The variance accounted for in each change relationship was small.

Conclusions

The results suggest that there is very little overlap among changes in the health behaviors examined in this study and that health promotion interventions should be behavior-specific.

Relationships Among Changes in Health Behaviors
in a Six-Year U.S. Navy Cohort

It has been well established that lifestyle factors, including health behaviors such as substance use, diet, and exercise, are strongly associated with morbidity and mortality. For example, tobacco use has been found responsible for more than one of every five deaths in the United States and is the single most important preventable cause of death and disease in this society.[1] Blair and colleagues found that even a modest improvement in fitness level among unfit adults conferred a substantial health benefit.[2] It has also been shown that lifestyle factors involve habitual modes of behavior and thinking, and, like all habits, they are difficult to change.[3] Despite nationwide efforts aimed at illness prevention and risk factor reduction, millions of individuals remain at high risk for cardiovascular disease and other serious health problems.[4] Among military personnel, progress has been made in recent years in reducing illicit drug use and smoking, yet the prevalence of both heavy alcohol use in general and smoking among those 18 to 25 years of age remains higher than that for civilians.[5]

Although the importance of health behaviors in preventing disease and protecting or promoting health has been well demonstrated, the relationship between health behaviors is not clearly understood. Understanding how specific health behaviors are associated with other health behaviors may have implications for designing effective health promotion programs and understanding underlying motivations to practice healthy behaviors in general. Recent studies have examined correlations among nutrition, exercise, sleep, smoking, and alcohol use, and other health protective behaviors, such as seat belt use and dental visits. Krick and Sobal[6] and Sobal and colleagues[7] found significant, though weak, correlations among health behaviors. Unger reported an association between stage of change of smoking cessation and alcohol use and exercise level.[8] In a review article, Blair, Jacobs, and Powell concluded that exercise was positively associated with weight control and caloric intake, and possibly substance use.[9]

Several researchers have noted the need for longitudinal studies of interrelationships among health behaviors.[7-9] One of the few longitudinal studies, an extensive research project on the relationship between health practices and physical health status, was

conducted by Breslow and his associates in the Alameda County Human Population Laboratory.[10] This series of studies established seven types of behaviors or health practices as risk factors for poor physical health status: smoking, excessive alcohol consumption, obesity, sleeping fewer than 7 or more than 8 hours a night, physical inactivity, snacking, and not eating breakfast. The Alameda seven health practices were also investigated in a study of changes in health habits among Air Force captains.[11] Results indicated positive changes in the smoking, alcohol consumption, and exercise habits of the sample but reported negative changes reflected in weight gain and reduced amount of nightly sleep. Relationships among these health factors were not examined. Other large longitudinal studies such as the Framingham Heart Study and the Multiple Risk Factor Intervention Trial have examined risk factors of morbidity and mortality from heart disease and other conditions such as exposure to passive smoke.[12-14] These risk factor studies generally indicate that the people most highly susceptible to disease have problems with several risk factors. Understanding how multiple risk factors, in particular factors pertaining to lifestyle, are related is important for optimal prevention planning and management.

Conway and colleagues[15] conducted a Navywide longitudinal survey of physical readiness and lifestyle habits in 1986, 1987, and 1988. While this study described changes in both fitness and individual health behaviors, it did not examine relationships among changes in various health behaviors and was limited by a follow-up period of three years. In contrast, the present study utilizes longitudinal data to evaluate relationships among lifestyle behaviors and addresses whether change in one health behavior is related to change in other health behaviors. The purpose of this study was to examine relationships among changes in five key lifestyle behaviors among a 6-year cohort of Navy personnel.

Methods

Participants and procedures. The targeted participants were 1,267 U.S. active-duty naval personnel who were part of a large representative sample of naval personnel randomly selected in 1988 to take part in a longitudinal study[15] examining health behavior

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and lifestyle habits. This cohort was selected for the present study because they represented the largest group from one of the years of the original longitudinal study who were still on active duty in the fall of 1994. Questionnaires were mailed to the targeted participants who were located by their current unit identification code (UIC) using computerized Navywide personnel and UIC address files.

Measures. Data for this report were collected from self-report questionnaires which assessed basic demographic information and a variety of health behavior and lifestyle measures. The five health behaviors examined in this study are described as follows. The wording of individual items was maintained from the 1988 (also referred to as the baseline) questionnaire to allow for comparison over time.

Exercise. Exercise activity was measured as the total kilocalories expended per week in nine types of common physical activities: running, bicycling, swimming, playing racket sports, continuous walking, performing aerobics, doing calisthenics, weightlifting, and playing basketball. Participants reported the number of times per week they participated in each activity (frequency) and the number of minutes they generally spent in one workout period for each activity (duration). A rate of kilocalories expended per minute was assigned to each activity using the table of energy expenditure from McArdle, Katch, and Katch.[16] The kilocalorie rate required for each minute of activity was multiplied by the total time in minutes per week that the participant reported engaging in each activity (frequency X duration). The resulting kilocalorie expenditure for each activity was then summed across all activities to provide a weekly estimate of exercise-related energy expenditure.

Diet. Participants were asked how often they ate certain types of low-fat and high-fat meats and dairy products, fish, vegetables, fruits, high-fiber foods, refined sugar products, saturated and polyunsaturated fats or oils, fried foods, and eggs during the last 7 days. The food choices were divided into "good" or healthful selections, such as fruits, vegetables, and low-fat foods, and "poor" or less healthful choices, such as high-fat meat and fried foods. The average number of servings per week of both good and poor food selections was calculated for each person, and an overall diet score was computed by

subtracting the mean poor score from the mean good score. Thus, the higher the overall diet score, the better the dietary choices.

Alcohol use. A measure of weekly alcohol use was computed as the product of two responses: the average number of drinks consumed per day during the last week and the number of days on which one drank during that week.

Cigarette use. Participants were asked how many cigarettes they usually smoked on a typical day during the past 30 days using a 12-category response scale: fewer than 1 cigarette per day, 1-5, 6-10, 11-15, 16-20, 21-25, 26-30, 31-35, 36-40, 41-45, 46-54, and 55+; nonsmokers were coded as zero cigarettes for regression analyses. In addition, current cigarette smoking status was assessed by asking participants whether they considered themselves to be a smoker (light, moderate, or heavy) or nonsmoker; responses were dichotomized (smoker/nonsmoker) for descriptive analyses.

Sleep. Participants were asked the number of hours they usually slept per night.

Data analysis. Descriptive statistics were used to characterize the sample and to examine levels of health behavior at both baseline and at the 6-year follow-up. Paired *t*-tests and chi square tests for matched samples were used to examine differences in demographics and health behaviors over time. Pearson product-moment correlational analyses were conducted between all baseline health behavior variables and separately for follow-up health behavior variables.

To analyze associations among 6-year changes in health behaviors, residualized gain scores for each of the five health behavior variables were computed. With this method of measuring change, a "gain" (i.e., change) is residualized by expressing a Time 2 score as a deviation from the Time 2-on-Time 1 regression line. The part of the Time 2 information that is predictable from the Time 1 score is thus partialed out. Residualized gain scores generally are considered preferable to raw change scores computed by subtracting Time 1 scores from Time 2 scores because they are not as sensitive to the effects of measurement error.[17]

More specifically, residualized gain scores were computed by conducting linear regressions predicting Time 2 (1994) scores for each of the five health behaviors from

their respective Time 1 (1988) scores. A residualized gain score for each person was then saved as the difference between the actual Time 2 score and the predicted Time 2 score.

Another series of five separate regressions was conducted to determine the associations among the five health behavior residualized gain scores. To predict the residualized gain score, or change, in a particular health behavior, the residualized gain scores of the other four health behaviors served as the independent variables. The independent variables were allowed to step into the regression equation if they accounted for significant variance in the health behavior change variable being examined. These analyses made it possible to assess the associations among variations in health behaviors over time. Pearson product-moment correlations were performed among the independent variables, or the residualized gain scores for the five health behaviors, to assess multicolinearity.

Results

A total of 1,019 people out of 1,267 targeted participants completed a follow-up questionnaire in 1994 (an 80.4% response rate). The 1988 survey indicated that 86% of participants were male, and the mean age was 30 (Table 1). Approximately 19% of the participants were officers, and more than 50% of the sample had an education level beyond high school. Over the 6-year period, the percentage of officers and the level of education of the sample, as well as age, significantly increased ($p \leq .001$).

Table 2 provides means and standard deviations or medians for all of the health behaviors. The average level of exercise as measured in kilocalories expended per week was 2,154 in 1988 and 2,478 in 1994. The average diet score was 15.1 at baseline and 15.5 at follow-up, with a range from 0 to 25.4 in 1988 and 0 to 29.7 in 1994. The median number of alcoholic drinks per week decreased from 2.0 in 1988 to 1.0 drink per week in 1994. Because all of the health behaviors were normally distributed except for alcohol use in 1988 and 1994, these two variables were logarithmically transformed for severe positive skewness.[18] All subsequent analyses involving alcohol use were performed using the transformed variables.

The mean scale score for the number of cigarettes smoked per day among smokers was 4.99 in 1988 and 4.48 in 1994, which on the 12-point scale, is approximately 16-20 cigarettes per day. In addition, the percentage of smokers was 33% in 1988 and 30% in

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Table 1. Demographics of six-year U.S. Navy cohort, 1988 and 1994

	1988 Percentage or Mean	n	1994 Percentage or mean	n
Sex (%)				
Male	86.3	879	86.3	879
Female	13.7	140	13.7	140
Age[a] (mean years)	29.5	1007	35.7	1019
Rank (%)				
Enlisted	81.1	825	78.3	798
Officer	18.9	192	21.7	221
Education level (%)				
< high school	1.0	9	.9	9
High school	47.8	449	37.0	374
> high school	51.2	481	62.2	629
Ethnicity (%)				
White	82.5	841	82.5	841
African-American	12.7	129	12.7	129
Other	4.8	49	4.8	49

[a]   Standard deviation for age was 5.6 in 1988 and 1994. Age range was 18-55 years in 1988 and 24-61 years in 1994.

Table 2. Means and standard deviations for health behaviors, six-year U.S. Navy cohort, 1988 and 1994

Health Behavior	Mean or Median	Standard Deviation	n
Exercise 1	2153.51	2453.04	819
Exercise 2	2477.72	2060.34	973
Diet 1	15.07	2.47	1007
Diet 2	15.51	2.70	1013
Alcohol use 1[a]	2.00	-	1013
Alcohol use 2[a]	1.00	-	1009
Cigarette use 1	4.99	2.54	335
Cigarette use 2	4.48	2.20	304
Sleep 1	6.41	1.10	1004
Sleep 2	6.58	1.08	1004

[a]   Median reported.

"1" and "2" following variable names denote 1988 and 1994 data, respectively. Diet score was computed by subtracting the mean poor foods score from the mean good foods score. A higher diet score indicates a healthier diet. Response scale for cigarette use was 1=<1 cigarette per day, 2=1-5 cigarettes, 3=6-10, 4=11-15, 5=16-20, 6=21-25, 7=26-30, 8=31-35, 9=36-40, 10=41-45, 11=46-54, and 12=55 or more; cigarette use means and standard deviations are presented for smokers only.

1994 (not shown in Table 2). The typical number of hours of sleep per night was 6.41 and 6.58 in 1988 and 1994, respectively. Paired t-tests and chi square tests for matched samples comparing baseline and follow-up values indicated significant change in all health behaviors: exercise, diet score, and hours of sleep increased and alcohol use, cigarettes per day, and the proportion of smokers decreased ($p\leq.001$, except for exercise and proportion of smokers which were significant at $p\leq.01$). There were several significant correlations among the different health behavior variables with the highest coefficient being -.18 for exercise and cigarette use in 1988 (Table 3). The lowest significant coefficient was -.07 for cigarette use and sleep in 1994. Diet had the greatest number of significant correlations with other health behaviors.

Table 3. Pearson product-moment correlation coefficients among health behaviors, six-year U.S. Navy cohort, 1988 and 1994

1988 Health Behaviors

	Exer 1	Diet 1	Alc 1	Cig 1	Sleep 1
Exercise 1					
Diet 1	.11**				
Alcohol use 1	-.02	-.04			
Cigarette use 1	-.18***	-.11***	.10**		
Sleep 1	.02	.09**	.03	-.12***	

1994 Health Behaviors

	Exer 2	Diet 2	Alc 2	Cig 2	Sleep 2
Exercise 2					
Diet 2	.17***				
Alcohol use 2	-.03	-.10***			
Cigarette use 2	-.09**	-.13***	.08*		
Sleep 2	.03	.11***	.01	-.07*	

* $p\leq.05$, ** $p\leq.01$, *** $p\leq.001$; 2-tailed

"1" and "2" following variable names denote 1988 and 1994 data, respectively.

Multiple regression analyses were conducted to determine significant associations among changes in exercise, diet, alcohol use, cigarette use, and sleep. To predict change in each of the five health behaviors, the residualized gain scores of the other four health behaviors served as the independent variables. For example, to predict change in exercise behavior, the independent variables were change in diet, change in alcohol use, change in tobacco use, and change in sleep. Pearson product-moment correlational analyses among all of the independent variables indicated that the highest significant coefficient was .18 thus indicating that multicolinearity was not a concern.

Results of the analysis of exercise indicated that a change in diet was significantly associated with a change in exercise behavior (Table 4). Increasing one's exercise behavior was associated with making a positive change in one's diet. Dietary change accounted for 2.9% of the variance in exercise change from 1988 to 1994.

Change in alcohol use was found to be significantly associated with a change in diet over time. Those who improved their diet decreased their alcohol use over the 6-year period. Change in alcohol use accounted for 1.2% of the variance in dietary behavior change.

Change in cigarette use was found to have a very small but positive significant association with a change in alcohol use, and it accounted for less than 1% of the variance in change in alcohol use.

Similar analysis was conducted to predict change in the number of hours of sleep over time. Results of this analysis indicated that a decrease in the number of cigarettes smoked per day was associated with an increase in the number of hours of sleep per night over time, and it accounted for 1.5% of the variance in change in sleep.

Table 4. Significant associations among changes in health behaviors based on stepwise regression analyses, six-year U.S. Navy cohort, 1988 and 1994

Health behavior	Associated health behavior	B	Beta	R	R^2	Adjusted R^2 change	p
Change in exercise	Change in diet	132.369	.171	.171	.028	.029	<.001
	(constant)	15.589					
Change in diet	Change in exercise	2.17E-04	.168	.171	.028	.029	<.001
	Change in alcohol use	-.643	-.107	.202	.038	.012	.004
	(constant)	.004					
Change in alcohol use	Change in diet	-.018	-.106	.112	.011	.012	.003
	Change in cigarette use	.018	.073	.133	.015	.005	.049
	(constant)	.019					
Change in sleep	Change in cigarette use	-.075	-.122	.123	.014	.015	.001
	(constant)	.005					
Change in cigarette use	Change in sleep	-.199	-.122	.123	.014	.015	.001
	Change in alcohol use	.314	.078	.145	.018	.006	.036
	(constant)	-.012					

To predict change in each of the five health behaviors, the residualized gain scores of the other four health behaviors served as the independent variables. For example, to predict change in exercise behavior, the independent variables were change in diet, change in alcohol use, change in tobacco use, and change in sleep.

Discussion

This study examined longitudinal data to investigate the relationships among five key health behaviors. Consistent with previous cross-sectional research, results of this longitudinal examination found few significant and generally weak associations among exercise, diet, alcohol use, cigarette use, and sleep.

This generally healthy sample of Navy personnel showed improvement in health behaviors over time. The sample significantly increased their exercise activity and decreased their alcohol and cigarette use. The sample's average diet score and number of hours of sleep per night also increased significantly over the 6-year period. The decrease in alcohol and cigarette use over time reflects cross-sectional trends seen within the Navy,[5] and the other improvements in such areas as exercise and diet may reflect societal trends in lifestyles. These improvements in health behaviors may also be related to the sample becoming older and more educated over time, and being career-oriented (i.e., having opted to stay in the service).

There were several significant bivariate correlations among the health behaviors. In general, exercise activity was significantly positively correlated with diet and negatively correlated with cigarette use. Diet generally was negatively correlated with alcohol use and cigarette use and positively correlated with the number of hours of sleep per night. Alcohol use was positively correlated with cigarette use, and cigarette use was negatively correlated with sleep. Although these correlations were significant and in the expected directions, the strength of these relationships was relatively weak, with absolute values ranging from $r = .07$ to $r = .18$.

The analyses of change in health behaviors showed that change in dietary behavior was related to change in exercise activity and change in alcohol use. An improvement in diet over time was associated with an increase in exercise and a decrease in alcohol use. Although several cross-sectional studies[19, 20] have reported a positive relationship between exercise and diet, a prospective study of more than 900 men found that changes in fitness were unrelated to changes in diet.[21] The results of the present study are in contrast to these findings and indicate that the relationship between exercise and specific dietary composition needs further examination.

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The negative relationship between dietary change and change in alcohol use indicates that those who improved their food choices also decreased their alcohol intake. This relationship seems reasonable considering, for example, people who are trying to modify their overall caloric intake. They may make a positive change in their food choices as well as a decrease in their alcohol consumption in order to reduce their overall caloric intake. Alternatively, the negative relationship between dietary change and change in alcohol use may be explained in that alcohol suppresses appetite and can take the place of healthy food in one's diet. Therefore, as one decreases their alcohol intake, they may improve their dietary choices.

The analysis of change in cigarette use indicated a very small association with alcohol use and also with the number of hours of sleep per night. A positive relationship between cigarette and alcohol use and other addictive substances has been reported in another cross-sectional Navy sample.[22] The negative relationship between cigarettes smoked per day and the number of hours of sleep per night is similar to results of a cross-sectional study on smoking and unhealthy habits which indicated that smokers were more likely than nonsmokers to get 6 hours or less of sleep each night.[23] It may be speculated that smokers tend to engage in more risk-taking behavior and less healthy practices in general, including sleeping less.

Although the change relationships among the health behaviors were mostly highly significant, the variance accounted for in each health behavior was small. This indicates that while change in one health behavior may be related to change in another health behavior, there are most likely other factors that more powerfully influence the behavioral change. There are, in fact, many other factors, including behavioral and social cognitive influences, that potentially mediate change in the health behaviors examined in this study. For example, several health behavior change theories, such as the health belief model[24], protection motivation theory[25], and the theory of reasoned action[26], all include beliefs about the perceived costs and benefits of performing health protective behaviors. Clearly, attitudes and beliefs play a role in health behavior; however, the purpose of this study was limited to examining the relationships among health behaviors themselves to investigate

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whether initiating or discontinuing one health behavior was related to modifying another health behavior.

A possible limitation of the study is the use of self-report measures. Some respondents may have positively biased reports of their health behaviors, which may have affected the results. However, self-reports of health provide useful qualitative information that is predictive of subsequent health outcomes.[27] In addition, while longitudinal data offer certain benefits over cross-sectional studies, longitudinal analyses do not definitively indicate a cause and effect relationship. Therefore, causal interpretations of the results cannot be made.

The results of this study indicated small associations among changes in health behaviors. In general, these findings suggest that people do not make changes in several health behaviors at the same time and that health behaviors are not modified as a set or group of behaviors. While these findings suggest that there may be a small amount of overlap among changes in some health behaviors (e.g., exercise and diet), health promotion interventions should be behavior-specific. Navy and other worksite health promotion programs should remain comprehensive in scope and tailored to specific community needs; however, it should not be assumed that efforts to modify one health behavior will necessarily affect other behaviors.

This examination of longitudinal data yielded results consistent with previous cross-sectional studies of the relationships among health behaviors, and it does not suggest that there is a general underlying motivation to practice a healthy lifestyle. Future studies using longitudinal data to examine theories of health behavior change will lead to a better understanding of how behavior-related factors and other variables make up individual patterns of health behavior.

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