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PHYSICAL ACTIVITY, PHYSICAL FITNESS, AND PSYCHOLOGICAL CHARACTERISTICS OF MEDICAL STUDENTS

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Abstract—Exercise habits, cardiovascular fitness, and selected psychological characteristics were assessed in a sample of over 200 men and women at entrance to medical school. Fitness was measured with a step test, and other variables were measured with standardized questionnaires. Anger ('anger-in') showed the strongest negative correlation with both exercise and fitness. Anger suppression, Type A behavior, and daily stress showed significant negative correlations with both exercise and fitness variables, although the strengths of these associations were uniformly weak. Associations of exercise/fitness with depression and total anger inventory were nonsignificant. Few gender differences were found. Both exercise and fitness showed similar patterns of association with psychological variables. Both exercise and fitness were associated with a style of anger expression that has been found to be related to cardiovascular risk in other studies.

INTRODUCTION

OVER 1000 articles have been written on the psychological effects of exercise and physical fitness [1]. The proposed psychological benefits, while widely accepted, have been supported by relatively few well-designed studies [1, 2]. Recently, however, improved studies have begun to substantiate some of these reported psychological benefits of exercise and fitness [3].

The most convincing studies documenting psychological benefits of exercise have involved the use of aerobic exercise for treatment of patients with mild to moderate depression [4, 5]. In addition, several studies have reported mood elevation with exercise in subjects without prior signs of clinical depression [6, 7]. A prospective study from a large community sample concluded that physical inactivity may be a risk factor for the development of depressive symptoms [8].

Inverse associations of exercise with physiological and psychological indices of coronary-prone (Type A) behavior have been observed [9, 10]. Since recent investigations indicate that much of the coronary heart disease (CHD) risk formerly attributed to Type A behavior may in fact be primarily related to sub-components of anger and hostility [11–13], it is important to determine the associations of exercise with anger and hostility as well as with various modes of anger expression.

Numerous studies have shown that exercise and aerobic fitness influenced the quantity and quality of responses to psychological stress [14]. Some have demon-

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strated decreased physiologic responses and a more rapid return to baseline of physiologic parameters following psychological stress in high-fitness populations [15, 16]. Others have shown lower levels of anxiety during recovery periods following psychological stress in high-fitness individuals [17, 18]. In addition, studies have shown decreases in trait anxiety after chronic exercise training [19, 20]. Retrospective studies have also shown a protective effect of regular exercise in maintaining both physical and emotional well-being following periods of increased life-event stress as measured by questionnaires [21, 22].

There are numerous methodologic problems with previous studies of the relationships among exercise, fitness and psychological variables. Many previous investigations included only men or only women, though sex differences have been found in the few studies with both sexes [23–25]. Some studies included a small number of psychological variables, though it is often hypothesized that exercise influences a wide variety of variables. Some studies measured exercise behavior and some measured cardiovascular fitness, but no studies measured both. It is, therefore, unclear whether psychological variables are more likely to be associated with exercise or fitness. The present study was designed to address these shortcomings by studying both men and women, including measures of several psychological variables, and including measures of both exercise and fitness. The specific hypothesis is that both reported exercise and cardiovascular fitness are negatively associated with depression, Type A behavior, various profiles of anger, and perceived stress levels.

The present study was conducted with medical students as subjects. While this is a select sample, the students are relatively homogeneous in age and educational achievement, so these potential confounders are controlled. There is also substantial variability in exercise habits across medical students [26, 27]. This variability in a homogeneous population allows a powerful test of the questions under study

METHODS

Subject characteristics

The sample group consisted of the 1986 and 1987 entering first-year medical school classes at University of California, San Diego (UCSD) School of Medicine. Of the 243 possible participants, 207 (85%) elected to participate in a cardiology risk factor assessment as part of a Preventive Cardiology Academic Award that was begun at UCSD in 1986.

Women represented 29.5% of the sample. Mean age for the entire group was 23.4 yr. The breakdown of race/ethnicity for the group was 65% Caucasian, 16% Asian, 9% Hispanic, 7% Black, and 3% others. Ninety per cent of the subjects were single.

Assessment of fitness and exercise variables

Assessment of all variables was carried out during one day of orientation week for each of the entering classes. Students were tested in groups, and every attempt was made to standardize conditions and provide a uniform testing environment for all subjects.

To assess cardiovascular fitness, a submaximal 5 min step test adapted from Sharkey [28] was administered to the participants. After resting comfortably for 5 min, subjects were instructed to step up and down a bench $15\frac{3}{4}$ inches tall for men and 13 inches tall for women, with each step corresponding to the beat of a metronome set at a rate of 90 beats per min. After 5 min of exercise, subjects sat on the bench and a pulse rate was taken for 15 s by trained technicians. A Fitness Index (FI) was computed using this heart rate and adjusting for age, sex and body weight [28]. The estimate of maximal oxygen consumption was expressed as ml/kg/min.

Height and weight were measured with a secured height anthropometer and balance beam scale without shoes. Body mass index (BMI; kg/m^2) was used as a measure of obesity.

Exercise was assessed with a number of questionnaire variables. We assessed exercise frequency by asking: 'In a typical week, how many times do you perform physical activity or exercise in your leisure time at least 20 min without stopping, which is vigorous enough to make you breathe hard and/or sweat?' Duration of exercise or physical activity was assessed with, 'How long have you been doing vigorous activities at this level in months?' In addition to these more quantitative questions, subjects were also asked to rate their relative exercise level; 'How much physical activity do you usually get, compared to others of your same age and sex?' Subjects were asked to consider both leisure and work activities, and respond on a five-point scale from 'much less' to 'much more'.

Assessment of psychological variables

Depression was assessed using the 20-item Center for Epidemiologic Studies Depression Scale (CES-D) that is designed to measure depressive symptomatology in the general population [29]. This scale has been found to be a reliable and valid measure in both community and clinical populations [29].

Psychological stress was assessed by asking the respondents to use a rating scale from zero 'very low, almost none', to five 'very high, almost constant', to indicate the amount of stress and tension in their every day lives.

The Bortner Short Rating Scale was used to measure overt pattern A behavior [30]. This test has been found to have good correlations with other self-reported measures of Type A behavior, such as the Jenkins Activity Survey ($r = 0.70$), [31] and the Framingham Type A scale ($r = 0.60$) [32]. In addition, it has been shown to have excellent test-retest reliability in both patients with clinical chest pain ($r = 0.84$) [33], as well as in a population of undergraduate and medical students ($r = 0.72$–0.74) [34].

Anger was assessed using two self-reported rating scales. The State-Trait Anger Scale (STAS) [35, 36] was used to compute the summary variable, anger inventory. The STAS was designed 'to assess both the intensity of angry feelings and individual differences in anger-proneness'. Construct validity was supported by good correlations with the Buss-Durkee Hostility Inventory ($r = 0.66$–0.73) [37]. The Anger Expression Self-Analysis Questionnaire [37] was used to assess the subjects' propensity to express or suppress angry feelings and emotions. The anger expression scores obtained from this survey have shown good correlations ($r = 0.46$–0.49) with an earlier questionnaire designed by Harburg [38] to classify subjects as predominantly expressing anger in an outward fashion or exhibiting suppression of anger in various situations [37]. Subjects were asked to rate how they generally feel when they are angry or furious. Three variables were computed. 'Anger-in' reflects a style of suppressing anger and hostility. 'Anger-out' reflects outward expression of angry feelings. 'Anger-control' reflects the extent to which the subject feels he or she is able to retain control over anger and hostile impulses.

All analyses were conducted using the SYSTAT software package.

RESULTS

Sex differences in fitness, exercise, or psychological variables

Variable means, standard deviations, and independent sample t-tests grouped by sex are presented in Table I. Statistically significant differences between men and women were observed for only three variables. Women had higher mean Type A scores ($p < 0.05$) whereas men had higher mean scores on anger-in ($p < 0.001$). Men

TABLE I.—VARIABLE MEANS, SDS, AND INDEPENDENT SAMPLES t-TESTS, GROUPED BY SEX

Variable	Women ($N = 54$) Mean	(SD)	Men ($N = 153$) Mean	(SD)	t	p
Fitness index (FI)	47.7	(8.7)	47.3	(8.6)	0.33	0.739
Exercise freq.	3.8	(2.9)	4.1	(2.8)	0.617	0.539
Exercise duration	52.7	(56.1)	62.9	(55.6)	1.194	0.235
Exercise rating	3.0	(1.0)	3.3	(1.2)	1.603	0.111
BMI	22.2	(2.6)	23.6	(3.1)	3.250	0.001
CES-D	10.5	(7.9)	10.3	(7.3)	0.206	0.838
Daily stress	2.5	(0.9)	2.3	(0.9)	1.202	0.232
Bortner Type A	183.0	(29.9)	172.8	(30.2)	2.240	0.027
Anger inventory	25.5	(4.6)	25.8	(5.3)	0.311	0.756
Anger-in	13.8	(3.3)	15.6	(3.6)	3.267	0.001
Anger-out	15.0	(2.8)	14.7	(2.9)	0.617	0.539
Anger-control	8.9	(1.7)	9.0	(2.0)	0.261	0.795
Age	23.6	(2.9)	23.2	(2.2)	0.740	0.461

Table II.—Pearson correlation matrix

Women: $N = 54$ (*$p < 0.05$ if $r \geq 0.25$)

	FI	Frequency	Duration	Rating	BMI
FI	1.000				
Exercise frequency	0.35*	1.000			
Exercise duration	0.14	0.31*	1.000		
Exercise rating	0.41*	0.68*	0.32*	1.000	
BMI	−0.35*	0.03	0.33*	−0.12	1.000
CES-D	−0.08	−0.23	−0.21	−0.26*	−0.12
Stress	−0.02	−0.18	0.06	−0.24	0.35*
Type A	0.04	0.19	−0.05	0.01	0.01
Anger inv.	−0.12	−0.01	0.11	0.02	0.09
Anger-in	−0.08	−0.25*	−0.10	−0.36*	−0.12
Anger-out	−0.11	0.25*	0.07	0.24	0.13
Control	0.12	−0.07	−0.09	−0.20	−0.37*
Age	0.03	0.11	−0.00	0.05	0.36*

	CES-D	Stress	Type A	Anger inv.	Anger-in	Anger-out	Control
CES-D	1.000						
Stress	0.39*	1.000					
Type A	0.34*	0.42*	1.000				
Anger inv.	0.36*	0.01	0.27*	1.000			
Anger-in	0.44*	0.11	0.12	0.32*	1.000		
Anger-out	0.04	−0.05	0.30*	0.39*	−0.36*	1.000	
Control	0.12	−0.03	−0.05	−0.06	0.22	−0.24	1.000
Age	−0.06	−0.12	0.13	0.11	0.03	0.18	0.02

Men: $N = 153$ (*$p < 0.05$ if $r \geq 0.16$)

	FI	Frequency	Duration	Rating	BMI
FI	1.000				
Exercise frequency	0.37*	1.000			
Exercise duration	0.29*	0.49*	1.000		
Exercise rating	0.47*	0.68*	0.47*	1.000	
BMI	−0.31*	0.04	−0.01	−0.13	1.000
CES-D	−0.18*	−0.11	−0.19*	−0.22*	0.10
Stress	−0.16*	−0.23*	−0.08	−0.29*	0.04
Type A	0.04	−0.02	−0.21*	−0.08	−0.01
Anger inv.	−0.05	−0.07	−0.18*	−0.10	0.08
Anger-in	−0.20*	−0.21*	−0.26*	−0.26*	−0.01
Anger-out	0.08	0.01	−0.08	−0.04	0.23*
Control	−0.14	−0.07	0.02	−0.09	0.01
Age	0.02	0.08	0.09	0.05	0.28*

	CES-D	Stress	Type A	Anger inv.	Anger-in	Anger-out	Control
CES-D	1.000						
Stress	0.39*	1.000					
Type A	0.26*	0.33*	1.000				
Anger inv.	0.40*	0.37*	0.44*	1.000			
Anger-in	0.38*	0.36*	0.08	0.45*	1.000		
Anger-out	0.19*	0.10	0.37*	0.37*	−0.13	1.000	
Control	−0.30*	−0.20*	−0.25*	−0.47*	−0.08	−0.30*	1.000
Age	0.01	0.14	0.07	0.19*	−0.01	−0.01	−0.10

had a higher mean BMI ($p < 0.001$), which probably reflects the greater muscle mass in men.

Univariate associations

Table II summarizes Pearson correlations among fitness, exercise, psychological, and demographic variables separately for women and men.

The FI showed significant positive correlations with exercise frequency per week in both groups ($r = 0.35$; 0.37). In men, FI was also positively correlated with exercise duration in months ($r = 0.29$). Of the three exercise variables, the exercise rating (as compared to others) was most highly correlated with FI for both groups ($r = 0.41$; 0.47). As expected, very high correlations were found in both groups between the exercise rating score and reported exercise frequency ($r = 0.68$; 0.68). Body mass index was significantly negatively correlated with FI for both groups ($r = -0.35$; -0.31) but was significantly positively correlated with exercise duration only for females ($r = 0.33$).

There were significant negative correlations between FI and anger-in ($r = -0.20$), CES-D ($r = -0.18$), and daily stress ($r = -0.16$) scores for men, but there were no significant correlations between FI and psychological variables for women. Exercise frequency showed significant negative corrrelations with anger-in for both groups ($r = -0.25$; -0.21) and with daily stress for men ($r = -0.23$), and significant positive correlations with anger-out for women ($r = 0.25$). Exercise duration showed significant negative correlations with the anger inventory ($r = 0.18$), anger-in ($r = -0.26$), Type A ($r = -0.21$), and CES-D scores ($r = -0.19$) in men, but no significant correlations with psychological variables in women. The exercise rating showed significant negative correlations with anger-in ($r = -0.36$; -0.26) and CES-D scores for both groups ($r = -0.26$; -0.22) as well as with daily stress for men ($r = -0.29$).

There were low to moderate correlations among psychological variables, indicating that they tapped different domains of psychological functioning.

Multivariate associations

Stepwise multiple regression analysis was used to further examine the relationship of the fitness and exercise variables with the psychological variables. Using multiple regression, the association between independent and dependent variables can be determined after adjusting for multiple other independent variables. The confounding variables of sex and BMI were forced into all model statements first. This was done because the primary hypotheses did not concern sex or BMI, but both of these variables were significantly associated with some fitness, physical activity, and psychological variables. Forcing sex and BMI into the models first yields associations that are adjusted for these confounders. All remaining independent variables were entered into the initial model statement with an alpha to enter of 0.05. After a subset of predictors was identified in the stepwise model, a final model statement was created using only these significant variables. Data are shown for all variables used in the final model statements. Two kinds of regressions were run. First, FI was used as the dependent variable and related to the physical activity measures. Second, seven psychological variables were studied in relation to each fitness and physical activity variable in separate regressions.

Table III shows the regression of Fitness Index as predicted by exercise frequency, exercise duration, sex, and BMI. Exercise frequency was a significant positive correlate ($\beta = 0.376$, $p \leqslant 0.001$), and BMI a significant negative correlate ($\beta = -0.317$, $p \leqslant 0.001$) of FI. The significance level of the overall regression was $p \leqslant 0.001$, with 21.5% of the variance in FI being accounted for by the variables in the final model statement. Exercise frequency was the only physical activity variable that was an independent correlate of FI.

Table IV shows the results of four regressions. Fitness Index, exercise frequency, exercise duration, and exercise rating were predicted by all psychological variables, sex, and BMI in separate analyses. Again, data are shown for all significant variables remaining in each of the final model statements. Looking initially at the regression of FI as predicted by the psychological variables, BMI was again a significant negative correlate of FI, ($\beta = -0.305$, $p \leqslant 0.001$). Anger-in was the only psychological variable that was a significant negative correlate of FI ($\beta = -0.183$, $p \leqslant 0.01$). The significance level for the total regression was $p \leqslant 0.001$, with 10.5% of the variance in FI being accounted for by final model statement variables.

The regression with exercise frequency as the dependent variable showed anger-in ($\beta = -0.171$, $p \leqslant 0.025$) and daily stress ($\beta = -0.208$, $p \leqslant 0.009$) as significant negative correlates. Type A behavior was a significant positive correlate ($\beta = 0.156$, $p \leqslant 0.04$). Overall significance level of the regression was $p \leqslant 0.003$, with 6.6% of the variance in exercise frequency being accounted for by the three psychological variables in the final model statement.

The regression of exercise duration as predicted by psychological variables also showed anger-in as a significant negative correlate ($\beta = -0.205$, $p \leqslant 0.005$). In contrast to its relationship with exercise frequency, Type A behavior was a nearly significant negative correlate of exercise duration ($\beta = -0.138$, $p \leqslant 0.054$). Significance level for the overall regression was $p \leqslant 0.006$, with 5.4% of the variance in exercise duration accounted for by the final model statement variables.

The final regression in Table IV of exercise rating as predicted by psychological variables again showed anger-in as a significant negative correlate ($\beta = -0.228$, $p \leqslant 0.002$). In addition, exercise rating was negatively correlated with daily stress ($\beta = -0.220$, $p \leqslant 0.002$), sex (male = 1, female = 2; $\beta = -0.176$, $p \leqslant 0.014$), and anger-control ($\beta = -0.164$, $p \leqslant 0.016$). The significance level for the total regression was $p \leqslant 0.001$, with 14.5% of the variance in exercise rating being accounted for by sex and the three psychological variables in the final model statement.

TABLE III.—MULTIPLE REGRESSION ANALYSIS OF THE ASSOCIATION OF FITNESS INDEX WITH EXERCISE FREQUENCY AND DURATION, SEX AND BMI

Variable	*B*	SE	Beta	*p*
Sex	−0.418	1.269	−0.022	0.742
BMI	−0.629	0.131	−0.317	0.001
Exercise frequency	1.159	0.199	0.376	0.001
Constant	64.072	5.002	0.000	0.001
N: 189	SE of estimate: 7.703			
Adjusted Squared Multiple *R*: 0.215	*F*-ratio: 18.160			$p \leq 0.001$

Note: The following independent variables were entered into the initial regression statement: sex, BMI, exercise frequency, exercise duration. *B* is the standardized regression coefficient, and Beta is the unstandardized coefficient.

TABLE IV.—MULTIPLE REGRESSION ANALYSES OF THE ASSOCIATION OF FITNESS AND EXERCISE VARIABLES WITH PSYCHOLOGICAL VARIABLES, SEX AND BMI

Variable	*B*	SE	Beta	*p*
Fitness Index vs psychological variables				
Sex	−1.565	1.389	−0.082	0.262
BMI	−0.605	0.140	−0.305	0.000
Anger-in	−0.447	0.173	−0.183	0.010
Constant	76.192	6.137	0.000	0.000
N: 189		SE of estimate: 8.226		
Adjusted Squared Multiple *R*: 0.105		*F*-ratio: 8.374		$p \leqslant 0.001$
Exercise frequency vs psychological variables				
Sex	−0.421	0.473	−0.067	0.375
BMI	0.059	0.047	0.090	0.217
Daily Stress	−0.619	0.236	−0.208	0.009
Type A	0.015	0.007	0.156	0.042
Anger-in	−0.136	0.060	−0.171	0.025
Constant	3.601	2.329	0.000	0.124
N: 193		SE of estimate: 2.782		
Adjusted Squared Multiple *R*: 0.066		*F*-ratio: 3.715		$p \leqslant 0.003$
Exercise duration vs psychological variables				
Sex	−10.916	9.269	−0.088	0.240
BMI	0.709	0.930	0.055	0.447
Type A	−0.258	0.133	−0.138	0.054
Anger-in	−3.210	1.132	−0.205	0.005
Constant	145.161	44.932	0.000	0.001
N: 195		SE of estimate: 55.119		
Adjusted Squared Multiple *R*: 0.054		*F*-ratio: 3.785		$p \leqslant 0.006$
Exercise rating vs psychological variables				
Sex	−0.049	0.181	−0.176	0.014
BMI	−0.027	0.018	−0.101	0.142
Daily Stress	−0.267	0.087	−0.220	0.002
Anger-in	−0.074	0.023	−0.228	0.002
Control	−0.102	0.042	−0.164	0.016
Constant	7.445	0.893	0.000	0.000
N: 189		SE of estimate: 1.081		
Adjusted Squared Multiple *R*: 0.145		*F*-ratio: 7.581		$p \leqslant 0.001$

Note: The following independent variables were entered into the initial regression statements: sex, BMI, CES-D, daily stress, Type A, anger inventory, anger-in, anger-out, anger-control. *B* is the standardized regression coefficient, and Beta is the unstandardized coefficient.

DISCUSSION

The primary finding was that both fitness and exercise behavior were significantly associated with various psychological variables, but the associations were uniformly weak. The combination of psychological variables, sex and BMI accounted for 5.4–14.5% of the variance in fitness and exercise. While anger-in was consistently associated with exercise and fitness in the present sample, stress and Type A were inconsistently associated, and depression and other anger-related variables were not associated at all with exercise and fitness.

This study also allowed a comparison of whether exercise or fitness was more highly associated with psychological variables. The findings indicate that the associations were similar for both fitness and exercise. In the regression analyses, psychological variables accounted for 6.6% of exercise frequency, 5.4% of exercise duration, and 14.5% of the exercise rating variance. While psychological variables accounted for 10.5% of the variance in fitness index, BMI was a significant contributor to the model. The similarity of findings for fitness and exercise measures was expected, because cardiovascular fitness is determined primarily by exercise. Fitness index and exercise rating can be expected to be the best indicators of long-term physical activity practices, and these two variables produced the highest adjusted R^2 with psychological variables. These findings indicate that exercise and fitness are both associated with important psychological variables in this sample of young men and women, though the direction of causation cannot be determined in this study.

The most striking and consistent finding was the association of the fitness and exercise variables with the psychological variable anger-in. Univariate analysis showed significant negative correlations of this variable with fitness index, exercise frequency, exercise duration, and exercise rating in men. Significant negative correlations with anger-in were also seen with exercise frequency and exercise rating in women. Multivariate analyses using the entire sample showed anger-in to be a significant negative correlate of all four measures of fitness and exercise.

This finding not only has importance in relation to the association of fitness/exercise and mental health, but it also may have relevance to coronary heart disease (CHD). Several recent studies have shown an increased risk of CHD in men and women who suppress anger. In a large prospective study, men and women who suppressed anger had significantly increased rates of elevated blood pressure and all-cause mortality [40]. Other studies found that suppressed anger was associated with elevated resting blood pressure [41, 42] and with exaggerated blood pressure reactivity to stress [43]. Thus, it may not be the amount or intensity of anger one experiences that is related to risk of CHD. Rather several studies indicate it is the manner in which this emotion is expressed, with high 'anger-in' scores or anger suppression being positively associated with CHD. Interestingly, in the present study this is the single dimension of anger which showed significant negative correlations with multiple measures of exercise and fitness in both men and women.

This result might be interpreted in a number of ways. One possibility is that fitness or regular exercise decreases the quantity of angry feelings that are suppressed or internalized, or that exercise/fitness in some way alters the nature of anger expression. This suggests that reduction of anger-in is a possible mechanism by which physical activity could protect one from CHD. Another possibility, however, is that levels of anger-in somehow affect the amount of exercise that is performed. Suppression of anger may lead one to exercise less often. Although the cross-sectional nature of this study precludes any conclusions concerning the causal relationship of these variables, it is none the less a finding that warrants further investigation.

Type A was a significant negative correlate of exercise duration. These results are consistent with experimental studies finding reductions in indices of Type A behavior in men [44] and women [45] after periods of regular aerobic exercise.

Daily stress was a significant negative correlate of exercise frequency in multivariate analyses. Since this was the only significant finding for the daily stress rating, the association between exercise and daily stress is considered weak.

The CES-D depression score failed to show any significant correlations with exercise or fitness. This is somewhat surprising in light of numerous studies demonstrating beneficial effects of exercise such as mood elevation in non-clinical populations and improvement in clinically depressed patients [4–7]. There was substantial variability in depression in this sample, so restriction of range is not a likely explanation for this failure to replicate earlier studies. Perhaps the associations between exercise and depression are stronger in older populations.

Although the current study has generated some interesting findings, it has also demonstrated that a considerable number of psychological variables had no significant relationships with exercise and fitness in this population. There are several possible explanations for the lack of findings with these variables.

Lack of variability of psychological variables

It is possible that in this highly selected homogeneous population, means and standard deviations of psychological variables would be affected such as to bias against finding hypothesized associations. While mean scores on the CES-D scale of depression were slightly higher than those obtained in several large community samples [29, 46], mean scores of anger-in and anger-out were slightly lower than those obtained in a population of high-school students [37]. Because Table I showed substantial variability in all variables, this is unlikely to be an explanation for the failure to find significant relationships with more psychological variables.

Lack of variability of exercise and fitness variables

The mean fitness levels of both men and women fell in the 'very good' to 'excellent' categories [28]. The mean exercise frequency per week reported in this group was four times per week, which is quite high. This sample of young adults was generally very active and fit. The general lack of unfit and inactive subjects suggests that a restricted range on these measures could have suppressed observed associations. Replication of this study in a population with wider variation in fitness and physical activity is recommended.

Measurement error

Measurement error is assumed to be an important source of variance in both the self-report measures and the step-test. However, the fact that significant relationships were found argues against measurement error severely limiting the power of the study. None the less, it is likely that error has reduced the number and extent of observed significant associations.

Timing of assessments

All measurements were made during the first week of medical school. It is reasonable to expect that such a transition could alter both psychological state and physical activity patterns. Thus, the reported assessments may not have been 'typical' of this group, and non-representative values could have accounted for the lack of associations.

No associations

An equally likely possibility for the lack of significant associations of fitness or exercise with some of the psychological variables is that the initial hypothesis was incorrect in assuming that fitness and exercise would be negatively associated with all psychological measures being examined.

Thirty-six medical students did not participate in the study, so it is possible that self-selection could have influenced the results of this study. Unfortunately, it was not possible to compare participants and non-participants.

Further limitations of this study include its cross-sectional design and the limited age range and highly selected nature of the subject sample. On the other hand, this sample can be expected to provide high quality data for a test of the association of exercise/fitness and psychological variables in young adults. The availability of both men and women allowed us to conclude that there were few gender differences in these associations. While all measures of exercise and fitness had important limitations, the use of multiple measures permitted the examination of consistency across measures. The findings of this study indicate that, among the psychological variables studied, the strongest and most consistent finding was a negative association of suppression of angry feelings with exercise and fitness. Since anger suppression has predicted CHD in previous studies [11–13, 40], this finding suggests another possible beneficial effect of physical activity and fitness that may be relevant to CHD. Because no other studies have examined the association between anger-in and exercise/fitness, this finding needs to be replicated in other samples.

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