AEROBIC FITNESS AND LEISURE PHYSICAL ACTIVITY AS MODERATORS OF THE STRESS–ILLNESS RELATION

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ABSTRACT

Exercise as a moderator of the stress–illness relation was examined by exploring leisure physical activity and aerobic fitness as potential "buffers" of the association between minor stress on physical and psychological symptoms in a sample of 135 college students. The goal was to gather information regarding the mechanisms by which exercise exhibits its buffering effects. Researchers have examined both physical activity and physical fitness in an attempt to demonstrate this effect; however, whether both of these components are necessary to achieve the protective effects against stress is unknown. This study examined engaging in leisure physical activity and having high aerobic fitness to determine if both were necessary for the stress-buffering effects or if one factor was more important than the other.

Findings suggested a buffering effect for leisure physical activity against physical symptoms and anxiety associated with minor stress. This effect was not found with depression. Additionally, there was no moderating effect for aerobic fitness on physical or psychological symptoms. Collectively, the data suggested that participation in leisure physical activity as opposed to level of aerobic fitness is important to the stress-buffering effect of exercise. Implications for exercise prescription are discussed.

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INTRODUCTION

Stress has been implicated in the development and exacerbation of physical and psychological health problems. Research has linked stress with fluctuations in blood glucose levels in Type I diabetes (1) and Type II diabetes (2), disease activity in rheumatoid arthritis (3), and psychological distress (4–6).

Early research focused on laboratory-induced stressors and major life events to ascertain the relation between stress and physical/psychological health. Laboratory studies were criticized for their artificial nature, which limited the generalizability of their results (7). A variety of criticisms have plagued major life events research including weak relations between major life events and health outcomes (7,8) and the lack of an established temporal relation between major stress and illness onset (9). Researchers have theorized that minor life events, or the ongoing minor stressors associated with daily living, may be a more important predictor of physical and psychological complaints than major life events. Existing literature has supported this hypothesis (10–13).

Not all individuals facing high levels of minor stress develop the same degree of physical or psychological symptoms. As a result, research has focused on delineating variables that may determine differential response to stressful stimuli. One method is to examine possible moderators that could buffer the effects of stress. Moderator variables studied in the stress–illness relation include social support (14), self-esteem (15), hardiness (16), coping style (17), and exercise (18). Exercise has been less frequently studied as a moderator but has yielded promising results (19). Two aspects of exercise have been examined including physical activity and physical fitness; however, whether both of these components are necessary to achieve the protective effects against stress is unknown.

Physical activity can be defined as "bodily movement accomplished by muscle power and the expenditure of energy" (20) and includes leisure physical activity, occupational activity, and household chores (21). For the purpose of this study, only leisure physical activity was considered, as we were interested in examining only physical activity related to exercise. Physical fitness, on the other hand, refers to "a set of attributes that represent the capacity to perform the physical activity" and encompasses all systems in the body influenced by physical activity (20). Studies examining the buffering effect of physical fitness usually examine aerobic fitness, or cardiorespiratory fitness, which is a component of physical fitness that is determined by both physical activity and genetic factors (22). It is necessary to examine the influence of both variables as potential buffers, as studies to date have found small correlations between aerobic fitness and physical activity, ranging from .30 to .50 (23).

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Research initially focused on the "fitness hypothesis" to explain the stress-moderating effects of exercise. This hypothesis postulates that cardiovascular and sympathetic nervous system responses to behavioral stress will diminish following improvements in aerobic fitness level (24,25). Most of these studies have been laboratory-based and have yielded contradictory results (24–27). Other research has indicated that aerobic fitness has insufficiently explained the psychological benefits of exercise. For example, cross-sectional studies indicate that aerobic fitness and mood do not correlate consistently (28). Likewise, exercise intervention studies have found significant improvements in mood without corresponding changes in aerobic fitness (29,30). Overall, results indicate that other mechanisms must be responsible for the stress-moderating effects of exercise.

Unfortunately, little research has actually examined exercise as a moderator of the stress–illness relation. The limited research on aerobic fitness suggests it can moderate the effect of major stress on physical well-being (19,31). Results appear inconclusive for its moderating effect on psychological variables. Roth and Holmes (31) examined fitness as a moderator of major life events on depression and anxiety. They found only a nonsignificant trend for a stress by fitness interaction on depression and no significant interactions for anxiety. Even fewer studies have examined leisure physical activity as a moderator or buffer against stress. Existing studies also have examined only major life events and have shown positive results with regards to the moderating effect of physical activity on both physical symptoms (18,32) and psychological health (18).

To date, no studies have examined aerobic fitness and/or leisure physical activity as moderating the association between minor life events, as opposed to major life events, on physical or psychological symptoms. Given the data supporting the predictive utility of minor life events (10–13), it was expected that minor life events would account for significant variance in physical symptoms and mood over that accounted for by major life events. Additionally, studies have failed to examine aerobic fitness and leisure physical activity simultaneously. A concurrent analysis would provide information regarding their unique contributions to the prediction of physical and psychological health status. It was expected that after controlling for the effects of major life events, leisure physical activity would moderate the associations between minor stress and physical symptoms and minor stress and mood. It also was expected that after controlling for the effects of major life events, aerobic fitness would moderate the association between minor stress and physical symptoms. Given the mixed results regarding the association between aerobic fitness and mood, there was no a priori hypothesis with regard to the stress-moderating effect of aerobic fitness on mood.

METHOD

Participants

One hundred thirty-five volunteers were recruited from undergraduate psychology and kinesiology classes at a local southern university. All participants signed an informed consent.

Measures

Weekly Stress Inventory (WSI): The WSI (33) is an 87-item self-report inventory that assesses minor stressful events or daily hassles that might have occurred over the past week. Sample items include "had car trouble," "was late for work or an appointment," and "argued with a coworker." Subjects rate each item on a 7-point Likert-type scale indicating how stressful they perceive the event, ranging from 1 (*occurred but was not stressful*) to 7 (*caused me to panic*). The WSI yields three basic scores: (a) EVENT score which is the number of items endorsed; (b) IMPACT score which is the sum of the subjective ratings of each item; and (c) AVERAGE IMPACT score which is the average of the ratings assigned to the endorsed items. Only the EVENT score was used, as research indicates no differences in the predictive utility of frequency of life events versus impact (34–36). The WSI has good internal consistency with a coefficient alpha of .96 for EVENT, and it has adequate test–retest reliability (.60). Pilot studies have shown convergent validity ($r = .61$) using the EVENT score and the sum score on the Hassles Scale (37).

Life Experiences Survey (LES): The LES (38) is a 50-item self-report questionnaire assessing major life events occurring over the past 12 months. Sample items include death of a spouse, foreclosure on a mortgage or loan, and divorce. Again, only the TOTAL score yielding the total number of events was used (34,39). Test–retest reliability of the TOTAL score has been examined in two studies yielding correlations of .63 and .64. The authors argued that the reliability coefficients were an underestimate, given that subjects may have experienced some event during the 5-week time lag between repeat administrations of the measure (38).

Profile of Mood States (POMS): The POMS (40) is a 65-item adjective-rating scale used to measure affective states occurring over the past week. Responders rate each adjective on a 5-point intensity scale from 0 (*not at all*) to 4 (*extremely*). This measure was developed to assess mood as a state variable, as it is sensitive to fluctuating affective states. Factor analysis identified six mood states including Tension–Anxiety, Depression–Dejection, Anger–Hostility, Vigor–Activity, Fatigue–Inertia, and Confusion–Bewilderment. Because the purpose of the study is to examine the mechanism by which exercise exerts its influence, and since depression and anxiety are the most extensively studied psychological variables in the exercise literature, only the Depression–Dejection (DD) factor and Tension–Anxiety (TA) factor were used in this study. The POMS was chosen over the Beck Depression Inventory (BDI) and the State/Trait Anxiety Inventory (STAI) due to its emphasis on fluctuating affective states and because it provides more variability than the BDI and STAI for a nonclinical sample. The DD factor has been found to have adequate concurrent validity with the BDI ($r = .61$) and excellent internal consistency ($K\text{-}R_{20} = .95$). The TA factor has been shown to have high concurrent validity with the Taylor Manifest Anxiety Scale ($r = .80$) and excellent internal consistency ($K\text{-}R_{20} = .92$). Test–retest has been estimated to be greater than .74 on the DD factor and .70 on the TA factor.

Modified Wahler Physical Symptoms Inventory (WPSI): The WPSI (41) is a self-report measure of physical complaints and symptoms. In the standard administration, participants indicate how often they are bothered by a symptom from 0 (*almost never*) to 5 (*nearly everyday*). Only the SUM score, which equals the sum of the weightings, was used in this study. The internal consistency of the test is quite high ($K\text{-}R_{20}$s from .88 to .94). It also possesses good test–retest reliability with .94 for 1-day delay and .64 for a 3-month delay.

The WPSI examines health as a trait variable as it emphasizes the assessment of a person's usual physical complaints. The emphasis for the present study is to examine physical symptoms that occurred during the past week, thus treating physical complaints as a fluctuating or state variable. No standardized instrument could be located that examines physical symptoms in this manner; therefore, a modified version of the WPSI was developed. The Modified WPSI asked, "How much did ______ bother you in the past week?" with ratings from 0 (*not at all*) to 5 (*extremely*). The scale has been used in this manner in previous research (42).

Maximum Oxygen Consumed (est. VO2max): VO2max refers to the greatest rate of oxygen utilization attainable during strenuous activity and is measured to provide an index of cardiorespiratory fitness. VO2max was estimated using Bruce protocol. Participants began walking on a treadmill at 2.5 mph with 0 degrees incline. The speed and incline were increased at each stage by 2.0 mph and 1.5 degrees, respectively. Each stage lasted 3 minutes. Participants continued until voluntary volitional exhaustion, and the last stage completed was used to estimate VO2max. Heart rate response to Bruce protocol was measured.

Physical Activity Questionnaire: The Physical Activity Questionnaire (43) is a physical activity assessment instrument designed to assess historical, past year, and past week leisure and occupational activity. Reliability has been demonstrated with adequate test–retest reliability (ranging from .62 to .96 for leisure and occupational activity). Validity of the past week leisure activity has been shown with the Caltrac activity monitor (Spearman's rank order correlation = .62). Occupational activity was not used because the purpose of this study was to examine physical activity related to exercise. Additionally, the 1-week interval is consistent with the time frame of the other measures. Participants were asked to indicate the frequency and duration in which they engaged in leisure physical activity related to physical exercise (e.g. running, basketball, aerobics) over the past week. Leisure physical activity (LPA) was measured in kilocalories per week.

General Health Questionnaire (GHQ): The GHQ (44) is a 28-item self-report questionnaire used as a screening measure of psychological distress. A common considered cut-off score is five or more positive answers (45). The internal consistency of the GHQ is reported to range from .78 to .95, and test–retest estimates were between .51 and .90 (44).

Demographic Questionnaire: This questionnaire included questions regarding participants' age, sex, race, education level, employment, medical diagnoses, current medications, and tobacco, alcohol, and caffeine use.

Procedure

Participants were screened for contraindications to exercise testing such as any serious systemic disorder, acute infection, resting diastolic blood pressure over 120 mm Hg, resting systolic blood pressure over 200 mm Hg, uncontrollable metabolic disease, recent acute myocardial infarction, or neuromuscular, musculoskeletal, and rheumatoid disorders (46). Those individuals not passing the screen were not given the opportunity to participate. Participants underwent an exercise tolerance test to estimate VO2max. Participants also completed the GHQ, WSI, LES, POMS, WPSI, Physical Activity Questionnaire, and a demographic questionnaire. Participants received extra credit in their undergraduate course and a "fitness evaluation" as compensation for participation.

RESULTS

One hundred thirty-five participants were recruited. One person was not given the opportunity to participate due to a detected heart murmur, and it was recommended that the participant obtain a physician's evaluation.

TABLE 1
Descriptive Statistics on Independent and Dependent Variables

Variable	Mean	S.D.	Range
Wahler Physical Symptoms	15.94	12.33	0–69
Tension–Anxiety	9.95	5.76	1–28
Depression–Dejection	8.38	7.29	0–28
Major Life Events	8.93	5.36	0–27
Minor Life Events	30.21	14.47	0–84
LPA	3327.46	4583.81	0–39329.16
VO2max	46.11	10.91	23.01–81.01

LPA = Leisure Physical Activity in kilocalories/week; VO2max = Aerobic Fitness.

Simple statistics, including descriptive and frequency analyses, were computed on the demographic variables. The mean age of participants was 22.07 years ($SD = 4.39$), and their mean year in college was 3.31 years ($SD = 1.30$). Fifty-five percent of the sample was female, 70.9% were Caucasian, and 49.3% were unemployed. The mean score on the GHQ was 2.32 ($SD = 2.72$) indicating a nonclinical sample. Descriptive statistics were computed on all independent and dependent variables and are displayed in Table 1.

T-tests were computed to determine if there were gender differences on the outcome variables Depression–Dejection, Tension–Anxiety, and Wahler Physical Symptoms sum score. No significant gender differences were found on any of the dependent variables. Additionally, ethnicity was divided into three groups including Caucasian, African-American, and Other. A one-way analysis of variance (ANOVA) indicated no ethnic differences for scores on Depression–Dejection, Tension–Anxiety, or Wahler Physical Symptoms. Furthermore, age was not significantly correlated with any of the outcome variables, which may reflect the restricted range of age. The correlation between major life events and minor life events was .40, and the correlation between VO2max and LPA was .24.

Three-stage hierarchical regression analyses were used to evaluate the association between the dependent variables Depression–Dejection, Tension–Anxiety, and Wahler Physical Symptoms, and the predictor variables major life events, minor life events, VO2max, LPA, VO2max*minor life events, and LPA*minor life events. These analyses were chosen to test the variance explained by minor life events in the presence of major life events and to test the interaction effects of VO2max*minor life events and LPA*minor life events. A significant interaction ($p < .05$) was interpreted as indicating moderation of the association between minor life events and the outcome variable.

Separate regression equations were computed for each of the three dependent variables. For each regression, major life events was entered in Step 1. Minor life events was then entered in Step 2 to test for the variance explained above that accounted for major life events. In Step 3, the main effects of VO2max and LPA and the interaction terms VO2max*minor life events and LPA*minor life events were entered. Based on analyses of the residuals and examination of the distributions of the variables, square root transformations were made of each dependent and independent variable. Analyses were also run with case deletions. Results for both were comparable to those obtained with the raw data; therefore, the raw data are presented here to facilitate interpretation.

To test the variance explained by minor life events above that explained by major life events, each regression equation was examined at Step 2. With Wahler Physical Symptoms as the

TABLE 2
Hierarchical Regression with Wahler Physical Symptoms as the Dependent Variable

Variables in the Equation at Step 3			
Variable	Beta	T	*p*-value
Major Life Events	.09	.98	.33
Minor Life Events	.73	1.98	.05
LPA	.13	1.09	.29
VO2max	.18	.98	.33
Minor Life Events * LPA	−.46	−3.10	<.01
Minor Life Events * VO2max	−.13	−.32	.75

LPA = Leisure Physical Activity in kilocalories/week; VO2max = Aerobic Fitness.

TABLE 3
Hierarchical Regression with Tension–Anxiety as the Dependent Variable

Variables in the Equation at Step 3			
Variable	Beta	T	*p*-value
Major Life Events	.16	1.71	.09
Minor Life Events	.86	2.23	.03
LPA	.20	1.63	.11
VO2max	.14	.72	.47
Minor Life Events * LPA	−.34	−2.21	.03
Minor Life Events * VO2max	−.48	−1.12	.27

LPA = Leisure Physical Activity in kilocalories/week; VO2max = Aerobic Fitness.

dependent variable, the model was significant, $F(2, 130) = 13.75$, $p < .001$. Major life events and minor life events accounted for 16.2% of the variance in Wahler Physical Symptoms with minor life events providing an additional 11.6% above that accounted for by major life events. Major life events was no longer a significant predictor once minor life events was added into the equation. With Tension–Anxiety as the outcome variable, the model also was significant, $F(2, 130) = 8.43$, $p < .001$. Major life events and minor life events together accounted for 10.1% of the variance in Tension–Anxiety with minor life events providing an additional 4.3% above that explained by major life events. Again, major life events was no longer significant once minor life events was added into the equation. Finally, with Depression–Dejection as the outcome variable, the model was significant, $F(2, 130) = 12.44$, $p < .001$. Major life events and minor life events accounted for 14.8% of the variance in Depression–Dejection with minor life events providing 2.80% variance above that accounted for by major life events. Both variables were significant predictors.

To test the interaction terms, each regression equation was examined at Step 3. With Wahler Physical Symptoms as the outcome variable, results indicated the overall model was significant, $F(6, 121) = 6.41$, $p < .001$, and accounted for 20.4% of the variance. Results also indicated a significant minor life events*LPA interaction ($t = -3.10$, $p < .01$). The minor life events*VO2max interaction was not significant. Results are presented in Table 2.

When Tension–Anxiety was regressed on the predictor variables, results indicated the overall model was significant, $F(6, 121) = 4.09$, $p = .001$, and accounted for 12.7% of the variance. Results also indicated a significant minor life events*LPA interaction ($t = -2.21$, $p = .03$). The minor life events*VO2max interaction was not significant. Results are presented in Table 3.

When Depression–Dejection was regressed on the predictor variables, results indicated the overall model was significant, $F(6, 121) = 5.84$, $p < .001$; however, the interaction terms were not significant (see Table 4). In an exploratory analysis, the buffering effect for leisure physical activity appeared stronger for men than women, although this difference was not significant ($p = .2$ for raw data; $p = .07$ for transformed data).

In order to facilitate interpretation, the interactions between minor life events and LPA on Wahler Physical Symptoms, Tension–Anxiety, and Depression–Dejection are graphically depicted in Figures 1 through 3, respectively. For these figures, estimated regression coefficients were used to compute predicted values of the dependent variables as a function of the number of minor life events. These values were computed separately for different levels of LPA (low versus high). The LPA levels corresponded to the values of the first and third quartiles of the distribution of LPA (659 kilocalories/week and 4555 kilocalories/week, respectively). As can be seen in these figures, the value of the dependent variable increases more steeply as a function of the number of minor life events for participants with a low level of LPA than those with a high level of LPA.

TABLE 4
Hierarchical Regression with Depression–Dejection as the Dependent Variable

Variables in the Equation at Step 3			
Variable	Beta	T	*p*-value
Major Life Events	.29	3.28	.001
Minor Life Events	.90	2.42	.02
LPA	.24	2.06	.04
VO2max	.18	.99	.32
Minor Life Events * LPA	−.22	−1.49	.14
Minor Life Events * VO2max	−.68	−1.63	.11

LPA = Leisure Physical Activity in kilocalories/week; VO2max = Aerobic Fitness.

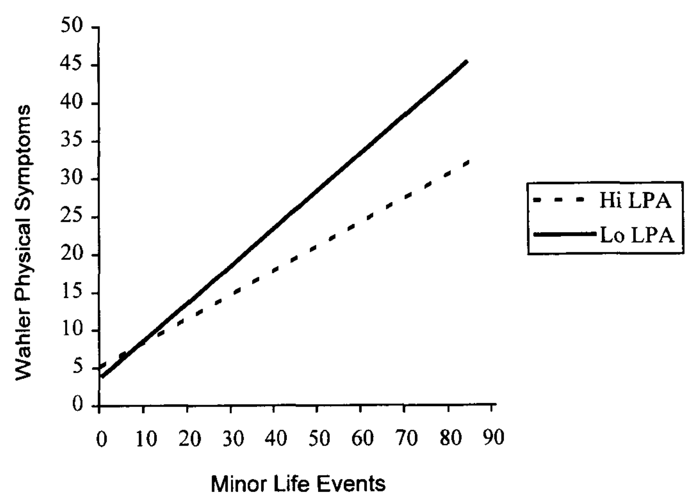

FIGURE 1: Participants with low LPA (leisure physical activity) (represented by the solid line) reported more physical symptoms with higher levels of minor life events than participants with high LPA (represented by the dashed line) ($p < .01$). The association between minor stress and physical symptoms is stronger in participants with low LPA than those with high LPA.

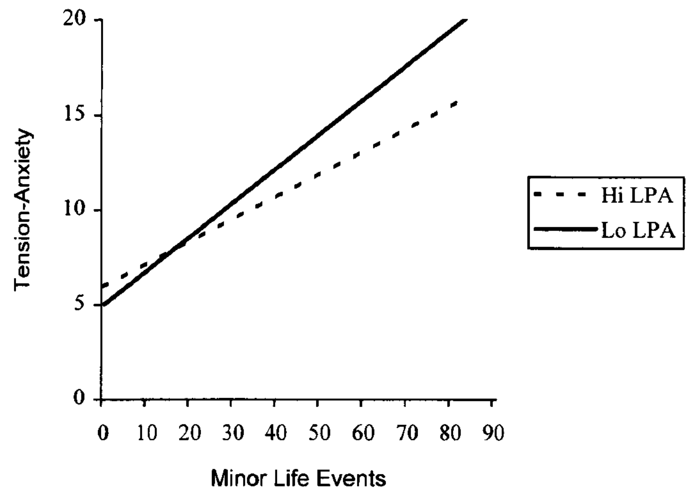

FIGURE 2: Participants with low LPA (leisure physical activity) (represented by the solid line) reported more anxiety with higher levels of minor life events than participants with high LPA (represented by the dashed line) ($p = .02$). The association between stress and anxiety is stronger in participants with low LPA than in participants with high LPA.

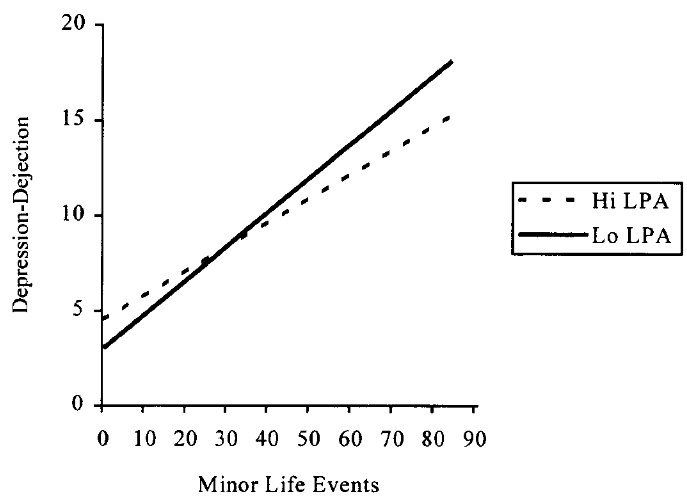

FIGURE 3: The association between minor life events and depression shows a similar pattern to the association between stress and physical symptoms and stress and anxiety. Participants with low leisure physical activity (LPA) (represented by the solid line) reported more depression with higher levels of stress than participants with high physical activity (represented by the dashed line); however, the difference was not significant ($p = .11$).

DISCUSSION

This study examined exercise as a moderator of the stress–illness relation by exploring leisure physical activity and aerobic fitness as "buffers" of the association between minor stress and physical and psychological symptoms in a sample of 135 college students. Examination of both aerobic fitness and leisure physical activity allowed for information to be obtained regarding their unique contributions to the stress-buffering effects of exercise.

Regression analyses confirmed existing data regarding the association of minor life events and physical and psychological health (3,9), thereby supporting the rationale for examining the moderating effects of exercise on minor life events. Collectively, results suggested that amount of leisure physical activity, as opposed to level of aerobic fitness, may be the mechanism by which exercise exerts its buffering effect against physical symptoms and anxiety in response to stress. These results are consistent with the Centers for Disease Control and Prevention's recent change in the conceptualization of exercise from an "exercise–fitness" model to a "broader physical activity–health paradigm" (47). Evidence suggests that the health benefits of physical activity increase in proportion to the total amount of activity, which is more important than the manner in which it is performed (i.e. intensity or mode) (47). Likewise, results of this study suggest that the mental health benefits, or the protective effects against stress, also may be higher with higher levels of participation in leisure physical activity.

Results suggested no moderating effect for aerobic fitness or leisure physical activity on depression. Further exploration provided some evidence that leisure physical activity may moderate the association between minor life events and depression among men, but not women. However, these results should be interpreted with caution due to the correlational nature of these analyses. This finding was not observed with physical symptoms or anxiety. Additionally, no significant gender differences were observed with aerobic fitness as the moderator.

Overall, the results are consistent with the lack of conclusive support for the fitness hypothesis, which has led researchers to question its sufficiency in explaining the benefits of exercise. Because the literature indicates aerobic fitness can only improve by 15%–20% with aerobic exercise training (46), perhaps there are other physiological changes, not assessed by aerobic fitness, that result with increased physical activity causing an improvement in the body's ability to combat stress (i.e. decreased report of physical symptoms). Given that this is a nonclinical sample, whether comparable results would be obtained in clinically distressed individuals remains an empirical question. Because studies have indicated improvements in mood following participation in exercise programs with no significant improvements in fitness (30), the notion that comparable results may be found in clinical samples is supported.

Results of this study also are consistent with the distraction hypothesis, another major hypothesis explaining the psychological benefits of exercise. This hypothesis posits that exercise is an effective method of getting one's mind off of one's stressors, providing a time-out period (48,49). This attentional shift allows for a temporary escape from the pressure of the stressors and thus acts as a kind of rejuvenation process. Consistent with the results of this study, the attentional distraction hypothesis would require the individual to just be physically active, not necessarily aerobically fit. Likewise, these results are consistent with the "mastery hypothesis," which suggests that engaging in an activity may instill a sense of accomplishment resulting in improved mood. This sense of mastery may or may not require high levels of aerobic fitness (19).

A promising aspect of these results is that they indicate mental health benefits related to physical activity in an overall nonclinical sample. These results appear to have clinical significance as well as statistical significance. For example, under periods of high stress (minor life events score = 60), individuals engaging in low physical activity report 37% more physical symptoms than those engaging in high physical activity. Similarly, under periods of high stress, individuals engaging in low physical activity report anxiety that is 21% higher than individuals engaging in high physical activity. In a recent review, Martinsen and Stephens (50) noted the lack of studies examining the mental health benefits of exercise in nonclinical populations. These authors suggested that evidence for mental health benefits in nonclinical populations will strengthen the rationale for exercise adherence. Just as research suggests that regular activity is necessary for the maintenance of physical health benefits obtained from exercise (51), regular physical activity participation may likewise be necessary to maintain the protective effects against stress, given its unpredictable nature. Fortunately, because the emphasis has changed to increasing physical activity as opposed to engaging in exercise with the goal of improving fitness, more individuals, including the elderly and chronically ill, may be able to obtain both the physical and mental health benefits of engaging in regular physical activity.

In summary, results of this study suggest that amount of leisure physical activity may moderate the association between minor stress and physical symptoms and anxiety. However, a limitation of this study is the use of a college sample, which may affect the generalizability of our findings. As would be expected for a younger, well-educated population, our sample had a higher rate of leisure physical activity and higher levels of aerobic fitness than would be seen in the general population and in special populations such as the elderly. Populations such as the elderly and chronically ill may have difficulty reaching the "dose" or level of physical activity necessary to obtain these stress-buffering benefits. Another important weakness of the current study is its cross-sectional design, and hence correlational results. Future longitudinal research is necessary to support the efficacy of leisure physical activity in moderating the stress–illness relation. Additionally, research indicates that the greatest physical health benefits are obtained from progressing from a sedentary lifestyle to one of moderate intensity physical activity (47). It would be useful to advance this understanding of exercise dose to determine the amount of physical activity necessary for the greatest mental health benefits. It also would be useful to incorporate measures of both occupational and household activity to determine if the key is leisure physical activity or total physical activity. Furthermore, research in clinical populations may provide additional information regarding the mechanisms involved in providing the beneficial effects of exercise.

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