Aerobic exercise has been associated with improvements not only in physiologic functioning, but also in psychologic functioning. This review examines the effects of exercise on several important aspects of psychologic functioning. Many studies of healthy subjects indicate that exercise is associated with benefits in various aspects of psychologic functioning, including enhanced mood and cognitive functioning, reduced psychophysiogetic reactivity to stress, and behavioral adjustments. However, the results have been inconsistent, and past studies have been plagued by methodologic problems. Furthermore, few exercise studies have been conducted with older cardiac patients. Thus, the relationship between psychologic functioning and exercise in older cardiac patients is an important area for further investigation.

INTRODUCTION

Aerobic exercise is almost universally accepted as a major component of most successful cardiac rehabilitation programs. In addition, the potential value of aerobic exercise in the primary prevention of coronary heart disease (CHD) is also receiving increased attention as a result of recent epidemiologic data demonstrating a significant inverse relationship between increased levels of habitual activity and reduced risk of CHD events. The following review highlights various aspects of psychologic functioning reported to be affected by exercise, including personality, mood, cognitive functioning, and behavioral adaptations. Studies of healthy and cardiac patients will be reviewed, with particular emphasis on the older cardiac patient.

PERSONALITY AND MOOD

Advocates of exercise as a means of CHD prevention and rehabilitation note that exercise significantly contributes to an enhanced sense of well-being and improved mood. Exercise has been associated with reduced negative emotional states such as anxiety, depression, and anger. For example, runners have been shown to be less depressed, less tense, and more self-confident, as well as more intelligent, self-sufficient, and reserved than nonrunners. In one controlled study, subjects participating in a 10-week aerobic exercise training program achieved significant reductions in state and trait anxiety as measured by standard psychologic questionnaires (Fig. 1). Subjects also reported reduced tension, fatigue, depression, and confusion as well as greater vigor relative to a matched nonexercise control group. Results from subsequent studies have supported these findings.

Other studies show that improvements in mood are most likely to be observed among those individuals who are either most physically deconditioned or most emotionally distressed at the outset. In one of the earliest controlled trials of exercise in depressed subjects, Greist et al reported that the level of improvement in a running group was

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equivalent to that of a group receiving time-limited psychotherapy. However, no statistical analyses were reported because of a lack of statistical power; and efforts to replicate the study with a larger sample were unsuccessful because of noncompliance and a large number of dropouts. 12

In general, results of past studies must be interpreted with caution and must consider methodologic problems. 13-16 For example, cross-sectional studies comparing groups of athletes and nonathletes17 or fit and unfit individuals18 are biased by selection factors, i.e., the individuals’ personality dispositions may be confounded with their participation in exercise. Similarly, single group experimental designs 19 confound exercise with other extraneous factors such as the passage of time or statistical regression to the mean; and nonrandom group assignment to exercise or nonexercise control conditions 5 is also subject to selection bias.

The use of nonrandomized experimental designs also makes it difficult to draw any definitive conclusions about the effects of exercise on personality functioning. The Cattell 16 Personality Factor Questionnaire (16 PF) has been widely used, but most studies fail to report significant changes in personality functioning. 20,21 Indeed, because traits such as intelligence and temperament are stable over time, it is unclear how such personality dimensions would be expected to change after 3 to 4 months of exercise. On the other hand, improvements in self-concept and self-esteem are associated with exercise training, although not consistently so. 22,23

Because Type A behavior is associated with an increased risk of CHD, 24 several investigators attempted to use exercise to modify aspects of the Type A personality. In the earliest report, Blumenthal et al. 25 found that individuals classified as Type A on the basis of the Jenkins Activity Survey (JAS) experienced a significant reduction in self-reported Type A behaviors after 10 weeks of exercise training, whereas a group containing Type B individuals did not change. However, this study was limited by the absence of a nonexercise control group and by the reliance on self-reported Type A behaviors (scores on the JAS), rather than the more valid structured interview (SI). More recently, two studies 26,27 investigated the use of exercise in altering the Type A behavior pattern. Roskies et al. 26 observed significant reductions in almost all Type A behavior components in a group that received stress management; however, they found virtually no changes in either an aerobic exercise group or a weight training group. In contrast, Blumenthal et al. 27 observed significant reductions in several behavioral components of Type A, as well as in cardiovascular responsivity to mental stress (see below), in both an aerobic exercise group and a strength training group.

None of the studies described above were conducted with coronary patients. To date, studies of the effects of exercise on mood and personality functioning in cardiac patients have been limited, and results are equivocal. Most studies suffer from the same methodologic problems mentioned earlier: small sample sizes, absence of nonexercise control groups, and nonrandom experimental designs.

Table 1 summarizes studies that have assessed changes in mood and personality functioning among patients with CHD. In general, the majority of studies show relatively few consistent improvements in any aspect of psychologic functioning. This observation may result from the fact that most patients do not display significant psychologic dysfunction before joining an exercise program. 28 For example, Hellerstein et al. 29 found evidence for depression in only 15% of their sample, and Blumenthal et al. 30 noted depression in 23% of their sample initially. In addition, studies have been conducted almost exclusively with middle-aged cardiac patients. Although several studies have investigated the effects of exercise on mood in healthy older adults, 31-33 results also have been inconsistent, probably because of differences in the initial characteristics of the subject population. Virtually all past published studies in this area have excluded older cardiac patients from participation, which may reflect an overly cautious attitude toward exercise prescription for the elderly by the medical community. As exercise becomes more commonplace for older, as well as younger, cardiac patients, it will be important to assess the effects of exercise on both mood and personality functioning in elderly cardiac patients.

In addition, it will be important to explore the mechanisms by which exercise may have an impact
<table>
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<td>Naughton, Brunn &amp; Lategola, 1988&lt;sup&gt;34&lt;/sup&gt;</td>
<td>14 male cardiac patients and 20 matched controls</td>
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<td>Blumenthal, Emery &amp; Rejeski&lt;sup&gt;26&lt;/sup&gt;</td>
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<td>Hellerstein, Hornsten, et al, 1967&lt;sup&gt;29&lt;/sup&gt;</td>
<td>189 male cardiac and 286 “other” patients</td>
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<td>Rovario, Holmes &amp; Holsten, 1984&lt;sup&gt;45&lt;/sup&gt;</td>
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<td>Self-perception, Trait anxiety, Beck Depression, Handicap Problem Inventory, MATE Scale, Tennessee Self-concept Scale</td>
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<td>Stern &amp; Cleary, 1982&lt;sup&gt;26&lt;/sup&gt;</td>
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<td>Erdman, Duivenwooden et al, 1986&lt;sup&gt;29&lt;/sup&gt;</td>
<td>80 male cardiac patients</td>
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<td>Plaveic, Turkeliin et al, 1976&lt;sup&gt;26&lt;/sup&gt;</td>
<td>53 male cardiac patients</td>
<td>&lt;60</td>
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<td>McPherson, Pevio et al, 1967&lt;sup&gt;39&lt;/sup&gt;</td>
<td>18 cardiac patients and healthy controls</td>
<td>39–50</td>
<td>Nonrandom graduated exercise or recreational swimming—24 weeks</td>
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<td>Mayou, 1983&lt;sup&gt;40&lt;/sup&gt;</td>
<td>129 male cardiac patients</td>
<td>51</td>
<td>Randomized control (standard medical care, advice, or exercise)—18 months</td>
<td>Interview mental state questionnaire</td>
<td>No significant differences</td>
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<td>Kavanaugh, Shephard et al, 1977&lt;sup&gt;41&lt;/sup&gt;</td>
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<td>Single group—4 years</td>
<td>MMPI</td>
<td>Reduced depression</td>
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On psychologic functioning. It has been suggested that psychologic improvement occurs as a result of increased endorphins in the peripheral bloodstream,<sup>42</sup> or as a result of enhanced feelings of mastery or self-efficacy.<sup>14</sup> However, these hypotheses have not been tested systematically among cardiac patients.
Cognitive Functioning

Several studies demonstrate that aerobic exercise may be related to improved cognitive functioning and reaction time (RT) performance. Cognitive functioning is typically assessed using several standardized neuropsychologic test instruments designed to measure such cognitive processes as problem-solving ability, short-term memory, and psychomotor speed. Reaction time is defined typically as the time required by the individual to respond to an auditory or visual stimulus. Older adults exhibit decrements in both cognitive functioning and RT performance as compared with younger subjects. Furthermore, cognitive impairment is increasingly recognized as a significant problem among coronary patients, especially elderly patients. Several studies have examined the effects of regular exercise on various aspects of cognitive functioning. Studies commonly address either acute or chronic effects of exercise. Acute effects are measured immediately before and after a single bout of exercise, whereas chronic effects are assessed before beginning an exercise program and after the program has terminated (usually after 8 to 12 weeks). Tomporowski and Ellis, in a thorough review of the acute effects of exercise on cognitive functioning, conclude that exercise initially appears to facilitate attentional processes by stimulating the central nervous system. However, this initial benefit of exercise may later be overridden by muscular fatigue.

The relative level of physical fitness of subjects also affects cognitive performance. In general, physically fit individuals are better able to perform cognitive tasks than less fit individuals, and performance of older fit individuals on simple RT tasks is similar to that of less fit college-age individuals.

Previous studies of the effects of exercise training on cognitive performance among healthy older subjects have provided mixed results. Several studies of institutionalized older adults have indicated improvements in cognitive functioning after an exercise intervention. However, Stamford et al. found no improvement in concentration and immediate recall (as measured by the Digit Span subtest from the WAIS) after a 12-week exercise intervention. Few randomized experimental studies of community-residing older adults have been conducted in this area. Dustman et al. found improvements in RT and several other measures of cognitive functioning after a 4-month exercise intervention; and Molloy et al. found improvements in memory in a study of the acute effects of exercise on patients who complained of memory problems. However, a more recent study of 101 healthy older men and women found no exercise effects reflected on an extensive battery of cognitive tests after a 4-month exercise intervention. Furthermore, although RT performance is significantly better among more fit older adults, there is no evidence that suggests RT performance improves after exercise training.

To our knowledge, no studies have examined the effects of exercise on cognitive functioning among older cardiac patients. Given the physically deconditioned state of this group, it would be fruitful to investigate the potential benefits of exercise for both physiologic and cognitive functioning among older cardiac patients. In addition, cardiac patients are often prescribed medications that may have an impact on cognitive functioning (e.g., beta blockers) and they may experience emotional distress that affects cognitive performance. Thus, cardiac patients, especially older patients, would be ideal subjects for examining the nonspecific aspects of an exercise program that may contribute to changes in cognitive functioning.

Psychophysiological Responsivity

Psychophysiological responsivity is typically assessed by measuring cardiovascular and neurohumoral responses to standard laboratory challenges. These challenges include both mental tasks (e.g., viewing stressful films, performing mental arithmetic, etc.) and physical tasks (e.g., cold pressor test, exercise treadmill testing, etc.). Previous research indicates that exaggerated responsivity of the sympato-adrenomedullary nervous system is associated with increased risk for CHD. For example, in a study using a primate model, cynomolgus monkeys were fed an atherosclerosis-producing diet and exposed to a laboratory stressor (threat of capture). Those monkeys, classified as having high heart rate reactivity (from rest to stress), had almost twice the degree of coronary atherosclerosis as the low heart rate reactors. In human studies, Type A individuals exhibit greater cardiovascular and neuroendocrine responsivity to behavioral challenges; other studies related increased reactivity to the development of hypertension.

Several studies have examined the role of exercise fitness in attenuating psychophysiological responses to laboratory stressors in young, healthy subjects. Several cross-sectional studies comparing healthy fit and unfit individuals found that during psychosocial stressors, the cardiovascular responses of fit individuals differ from those of unfit individuals. Fit
subjects display smaller increases in systolic blood pressure (SBP)\textsuperscript{60-62} diastolic blood pressure (DBP)\textsuperscript{60,63} and heart rate (HR)\textsuperscript{64} responses, as well as faster HR recovery\textsuperscript{65,66} during psychosocial stressors.

Studies examining the effect of exercise training on cardiovascular responsivity have produced conflicting results, as exemplified by two recent reports\textsuperscript{27,67} Both studies investigated the use of exercise training in altering cardiovascular responsivity to laboratory stressors. Blumenthal et al.\textsuperscript{27} noted significant reductions in cardiovascular responses to mental arithmetic in an aerobic exercise group but not in a strength training group. However, Seraganian et al.\textsuperscript{67} found no attenuation of stress responses in either of two exercise groups, or in a stress management group. The exercise training programs appeared to be similar, although differences in subject characteristics and in the kinds of stressors used may have contributed to the inconsistent findings.

None of the cardiovascular reactivity studies has been conducted with elderly or cardiac patients and there are no data regarding the effects of exercise on responsivity in these groups. However, in the future it will be important to investigate the effects of exercise training on cardiovascular responsivity, including responsivity to real-life stressors through the use of ambulatory devices, among young and old cardiac patients.

**BEHAVIORAL ADJUSTMENTS**

Employment and work satisfaction are common indices of adjustment in cardiac patients; most cardiac rehabilitation (CR) patients return to work within 1 year after myocardial infarction (MI).\textsuperscript{68} Past studies of cardiac patients have attempted to (1) predict which factors enhance or impede employment functioning and satisfaction, and (2) identify the effects of exercise on postsurgical psychosocial adjustment.

Most previous studies compared psychosocial adjustment of cardiac patients randomly assigned either to a structured exercise-based program or to a home treatment program. Two recent studies\textsuperscript{37,40} found minimal benefit of exercise training for cardiac functioning, daily life, and emotional state. However, both studies relied on self-report measures of physical activity and did not include objective measures of fitness levels. In addition, because the programs were multifaceted, results of participation could not be attributed to the exercise component per se.

In a randomized, longitudinal study,\textsuperscript{36} no differences were found between an exercise group and a nonexercise control group on measures of psychosocial functioning, including return to work. It was noted, however, that because of poor compliance in the treatment group, as well as self-initiated exercise in the control group, subjects' fitness levels were not experimentally manipulated and no differential outcome could therefore be expected.

The renegotiation of roles and responsibilities, interpretation of doctors' medical instructions, and sexual readjustment are additional challenges faced by cardiac patients and their families. Few studies have investigated the effects of exercise on marital and family functioning\textsuperscript{36} and data in this area are predominantly anecdotal. However, disruption of normal sexual functioning after MI is not uncommon\textsuperscript{69-71}; and anxiety, fear of death, diminished libido, impotence, and frigidity are commonly reported by cardiac patients and their spouses.\textsuperscript{72} Although several studies report that the frequency of sexual activity among cardiac patients may be increased after exercise training \textsuperscript{35,36} sexual activity has not been studied in older cardiac patients.\textsuperscript{73}

Finnegan and Suler\textsuperscript{74} noted that the affective sequelae of MI may disrupt attempts to change such health behaviors as exercise, diet, and smoking. Among cardiac patients, success or failure regarding one health behavior may affect the ability to maintain changes in other health behaviors.\textsuperscript{74} Thus, it will be important in future studies to examine the relationship of exercise to other health behaviors, such as diet and smoking, and to determine whether exercise can act as a catalyst to bring about changes in other health behaviors relevant to CHD. For example, younger subjects who engage in regular exercise (jogging) also display improved dietary habits.\textsuperscript{75} Thus, it will be useful to explore the relationship of exercise to other health behaviors among both younger and older cardiac patients.

**COMPLIANCE**

Noncompliance is particularly problematic in cardiac patients because noncompliance itself may be associated with increased risk of fatal CHD events.\textsuperscript{76} It has been estimated that 50% of cardiac patients in exercise programs drop out within the first 6 months of treatment.\textsuperscript{77} Psychologic predictors of noncompliance among exercise participants include emotional distress, low ego strength, and social introversion.\textsuperscript{78} Although little relationship has been found between compliance and age,\textsuperscript{79} other factors such as blue collar occupation, Type A behavior, angina, and smoking predict premature dropout from exercise programs.\textsuperscript{80}

In addition, the importance of spouse support for
compliance has been debated in the literature. Several studies of cardiac patients have found spouse support to be a significant predictor of exercise compliance, although a more recent study found no relationship between spouse support and compliance. In the latter study, however, there was large variability in length of time post-MI (from 3 months to 17 years), and a preexperimental design was used.

Increased symptom levels have been related to decreased compliance with exercise prescription, and dropouts from CR programs are likely to have had more than one MI and may exhibit coronary-prone behaviors. Thus, patients who may be at increased risk of further health problems appear less likely to comply with exercise prescription. Early identification of potential noncompliers and the setting of reasonable long-term and short-term goals have been emphasized in maximizing compliance to CR programs.

Goal setting is especially important in programs for older cardiac patients, because older patients may be in particular need of education regarding exercise and other health-promoting behaviors. As exercise programs for older cardiac patients become more widely available, it will be important to examine the effect of goal setting as well as other factors, such as spouse support, for compliance in this population.

CONCLUSIONS
Aerobic exercise is associated with improvements in several areas of psychologic functioning, including enhanced mood and personality functioning; improved cognitive abilities; reduced cardiovascular reactivity to stress; and positive changes in such behaviors as diet and smoking, as well as sexual functioning. Most research has been conducted with healthy subjects, however, and the few studies of cardiac patients tend to include only younger patients. Thus, the relationship of exercise to psychologic functioning among older cardiac patients has not been systematically examined.

A further area for study among older cardiac patients is the relationship of exercise to other health behaviors, such as diet, and to psychosocial functioning. Given the increased emphasis on caregiver burden in the rehabilitation literature, it would also be important to examine the effect of exercise on the degree of burden experienced by both the spouse and the family of the older cardiac patient.

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