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Dose-Response Relationship Between Exercise Intensity, Mood States, and Quality of Life in Patients With Heart Failure

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Background: We conducted a secondary analysis to (1) compare changes in mood disorders and quality of life (QOL) among 4 groups of patients with heart failure in a home-based exercise program who had varying degrees of change in their exercise capacity and (2) determine whether there was an association between exercise capacity, mood disorders, and QOL. **Methods:** Seventy-one patients were divided into 4 groups based on changes in exercise capacity from baseline to 6 months: group 1 showed improvements of greater than 10% (n = 19), group 2 showed improvements of 10% or less (n = 16), group 3 showed reductions of 10% or less (n = 9), and group 4 showed reductions of greater than 10% (n = 27). **Results:** Over time, patients in all 4 groups demonstrated significantly lower levels of depression and hostility ($P < .001$) and higher levels of physical and overall quality of life ($P = .046$). Group differences over time were noted in anxiety ($P = .009$), depression ($P = .015$), physical quality of life ($P < .001$), and overall quality of life ($P = .002$). Greater improvement in exercise capacity was strongly associated with lower depression scores ($r = -0.49$, $P = .01$). **Conclusions:** An improvement in exercise capacity with exercise training was associated with a decrease in depression and anxiety and an increase in QOL in patients with heart failure.

KEY WORDS: dose-response, exercise, heart failure, mood states, quality of life

Heart failure (HF) is a debilitating chronic condition that affects an estimated 5.7 million Americans, and the projections show that the prevalence will increase 46% from 2012 to 2030, resulting in more than 8 million Americans 18 years or older with heart failure.¹ Most individuals with heart failure experience deficits in physical functioning and fatigue and report decreased quality of life (QOL).^{2–4} A common finding in patients with heart failure is exercise intolerance, which causes progressive functional deterioration.⁵ In addition to physical impair-

ments, patients with heart failure also exhibit psychological challenges, specifically anxiety and depression, and it is associated with increased morbidity and mortality.⁶ Recent heart failure guidelines advise regular exercise for patients with heart failure to improve their functional capacity and decrease their symptoms.^{2,7} Research supports the importance of promoting exercise training to reduce mortality, hospitalizations, and risk for other chronic diseases in patients with heart failure.^{8–10} Controlled clinical trials have also shown that exercise training programs improve aerobic capacity, delay onset of anaerobic metabolism, and improve autonomic balance.^{11–13} Furthermore, improvements in exercise capacity in this patient population led to increased metabolism, strength, and vitality^{14–17} and significant reductions in depressive symptoms.¹⁸ The HF-ACTION (“Heart Failure: A Controlled Trial Investigating Outcomes of Exercise Training”) trial also showed that greater physiological and clinical benefits seem likely in patients with heart failure who adhere to a higher volume of exercise.¹⁵

Although previous exercise research indicate that regular exercise represents an effective therapy in the management of patients with heart failure due to left ventricular systolic dysfunction, the benefits of exercise training on mood disorders and quality of life remain inconsistent. Likewise, the relationship between

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exercise capacity and mood states and quality of life varies across studies. The heterogeneity of populations with heart failure, differences in exercise prescriptions (eg, varying intensity and progression), and use of a variety of measures of exercise capacity, depressive symptoms, and quality of life likely explain the differences seen across studies. A number of investigators have found an improved quality of life along with increased exercise capacity and cardiorespiratory fitness after participation in exercise training.^{19–24} One study showed improvements in both quality of life and exercise capacity, but no significant correlations were found between the two,²⁵ whereas yet another study demonstrated only a weak relationship between improvement in exercise capacity and improvement in quality of life.²⁶ Some investigators have reported improvements in exercise capacity without improvements in quality of life^{20,21,27} or improvements in quality of life with little or no change in exercise capacity,^{28,29} which strongly suggests that changes in exercise capacity and quality of life are not related and changes in one may occur without associated changes in the other. In a randomized clinical trial conducted by our research team to examine the effects of a 6-month, home-based exercise training program, we found no significant differences between the intervention and control groups in exercise capacity or quality of life measures upon follow-up.³⁰ Finally, in the recently reported HF-ACTION study,^{23,31} medically stable outpatients with heart failure and a reduced left ventricular ejection fraction were randomized to an aerobic exercise training group or a control group and followed for a mean of 2.5 years with scheduled measurements of health status. Compared with baseline, the exercise group had significant improvements in health status at 3 months, and these were sustained for the duration of the study. However, the health status questionnaire used did not measure mood disorders or quality of life.³¹

Thus, there remain gaps in knowledge about the influence of exercise training on mood disorders and quality of life in heart failure. Likewise, the association between physiologic and emotional factors is highly inconclusive based on past clinical trials of exercise. Therefore, we conducted a secondary analysis to (1) compare changes in mood disorders, specifically anxiety, depression, hostility, and quality of life, among 4 groups of patients who had all participated in a home-based exercise program and who had varying degrees of change in their exercise capacity and (2) determine whether there was an association between exercise capacity, mood disorders, and quality of life. Specifically, we wanted to determine whether positive changes in mood states and quality of life were dependent on the degree to which patients experienced significant improvements in their exercise capacity related to exercise training.

Methods

Study Design

A complete description of the study design and methods of the parent study describing the effects of the 6-month, home-based exercise program has been published elsewhere.³⁰ In brief, we randomized patients with heart failure to an exercise group and a control group. All patients underwent cardiopulmonary exercise testing using a bicycle at baseline and 6 months to establish maximum VO_2 . Patients assigned to the exercise group were asked to perform a graduated, exercise protocol consisting of low-level aerobic exercise and resistive training 5 days per week. Aerobic training was initially 10 minutes at 40% maximal heart rate and progressively increased up to 45 minutes at 60% maximal heart rate for the remainder of the program. Participants in the control group maintained their usual level of daily activities, with no systematic exercise component. Participants were visited monthly by a nurse to review the exercise protocol and to collect daily exercise diaries and pedometer readings. The research protocol was reviewed and approved by the appropriate institutional review board. Written informed consent was obtained from all participants. Data used for this secondary analysis were de-identified.

Study Participants

Thorough descriptions of the recruiting and screening processes, as well as the methods, have been previously published.³⁰ Briefly, the study was limited to patients with chronic heart failure (defined as New York Heart Association [NYHA] classes II through IV and left ventricular systolic dysfunction with a left ventricular ejection fraction of $\leq 40\%$), aged 18 to 80 years, who read and spoke English. Exclusion criteria for participation in the study included myocardial infarction or recurrent angina within the previous 3 months, orthopedic impediments to exercise, severe obstructive pulmonary disease, stenotic valvular disease, history of uncontrolled ventricular tachyarrhythmias, or absence of an implantable cardioverter-defibrillator, despite a history of sudden cardiac death. All participants were stable on standard medical therapy (eg, angiotensin-converting enzyme inhibitors or angiotensin II receptor blockers, β -blockers, diuretics, aldosterone blockers, and digoxin as necessary) at the time of baseline testing.

Seventy-one of the original 87 participants in the exercise group who had complete data at baseline and 6 months related to the current analyses were included in the secondary analysis. Four comparative groups were established based on documented changes in exercise capacity (peak VO_2) from baseline to 6 months: group 1, participants with improvements greater than 10% ($n = 19$); group 2, participants with improvements

less than 10% ($n = 16$); group 3, participants with reductions less than 10% ($n = 9$); and group 4, participants with reductions greater than 10% ($n = 27$). The selected cutoff points for the 4 groups were based on findings from a study that showed that improvements of 10% or greater in exercise capacity were associated with lower mortality and hospital readmission for heart failure during a 5-year follow-up.³²

Participants were asked to complete the Multiple Affect Adjective Checklist (MAACL) and the Minnesota Living with Heart Failure Questionnaire to assess mood disorders (ie, anxiety, depression, and hostility) and quality of life at baseline and 6 months. The MAACL is composed of 132 alphabetically arranged adjectives. Scores for anxiety range from 0 to 21 (norm, ≤ 7), scores for depression range from 0 to 40 (norm, 11), and scores for hostility range from 0 to 28 (norm, 7). Higher scores reflect higher levels of dysphoria. The reliability and validity of the MAACL have been demonstrated in patients with heart failure.³³ The Minnesota Living with Heart Failure Questionnaire is a disease-specific, 21-item instrument designed to measure the extent to which participants experienced various symptoms and prevented them from living as they wanted in the previous month. The items can be combined to form an overall quality of life score, as well as physical health (8 items) and emotional health (5 items) scores. Response options are presented as 6-point ordinal scales ranging from 0 (no) to 5 (very much), with a total maximum score of 105 (40 for physical and 25 for emotional health); a lower score indicates better quality of life.³⁴

Demographic information (ie, age, race, marital status, education, current employment status, and annual income) were obtained through self-reports. Information pertaining to medical history and current clinical status (eg, etiology of heart failure, NYHA class, ejection fraction) were obtained from participants' medical records.

Statistical Analysis

Descriptive baseline characteristics of groups were tabulated as means (SDs) or as percentages. Differences in sociodemographics and clinical characteristics were calculated for the 4 groups of participants using χ^2 or Kruskal-Wallis test (nonparametric tests for unequal group sizes), depending on the level of measurement. Regression analyses were computed to describe changes in mood disorders and QOL between baseline and 6 months and to determine whether group differences were significant over time. For a statistically significant analysis of covariance ($P < .05$), pairwise comparisons between the 2 groups of participants who showed improvements in exercise capacity and the 2 groups of participants who showed reductions in exercise capacity were made using the Bonferroni correction for multiple testing. Univariate analysis was conducted using Pearson product-moment correlation coefficients. All analyses were performed using SPSS for Windows (version 13.0; SPSS, Inc, Chicago, Illinois).³⁵

Results

The demographic and clinical characteristics of participants who showed improvements in exercise capacity (groups 1 [$n = 19$] and 2 [$n = 16$]) and participants who showed reductions in exercise capacity (groups 3 [$n = 9$] and 4 [$n = 27$]) from baseline to 6 months are illustrated in Tables 1 and 2. There were no significant differences in age, gender, race, marital status, employment status, and education among participants in the 4 groups. In addition, there were no significant differences among the groups with regard to ejection fraction, peak VO_2 , 6-minute walk test, NYHA class, heart failure etiology, medical history (ie, comorbidities), and medication use. However, the 4 groups were significantly different by analysis of variance on the number of hospitalizations during the year of study, with group 1 experiencing a

TABLE 1 Baseline Characteristics (Sociodemographic)

	All Participants (N = 71)	Group 1 ^a (n = 19)	Group 2 ^b (n = 16)	Group 3 ^c (n = 9)	Group 4 ^d (n = 27)	P
Age, mean (SD), y	55.56 (11.13)	55.21 (10.75)	55.50 (12.51)	56.33 (11.41)	55.59 (11.09)	.996
Male, n (%)	47 (66.2)	13 (68.4)	10 (62.5)	6 (66.7)	18 (66.7)	.986
Race, n (%)						.298
Hispanic	10 (14.1)	5 (26.3)	2 (12.5)	1 (11.1)	2 (7.4)	
White	47 (66.2)	11 (57.9)	9 (56.3)	8 (88.9)	19 (70.4)	
African American	14 (19.7)	3 (15.8)	5 (31.3)	0 (0)	6 (22.2)	
Married, n (%)	43 (60.6)	10 (52.6)	9 (56.3)	8 (88.9)	16 (59.3)	.300
Employed, n (%)	20 (28.3)	7 (36.8)	3 (18.8)	2 (22.2)	8 (29.6)	.661
Education, n (%)						.086
<12	26 (26.6)	2 (7.7)	7 (26.9)	3 (11.5)	14 (53.8)	
12–16	29 (40.8)	10 (34.5)	7 (24.1)	5 (17.2)	7 (24.1)	
>16	16 (22.1)	7 (43.8)	2 (12.5)	9 (12.7)	6 (37.5)	

^aParticipants with improvements in peak VO_2 greater than 10%.

^bParticipants with improvements in peak VO_2 less than 10%.

^cParticipants with reductions in peak VO_2 less than 10%.

^dParticipants with reductions in peak VO_2 greater than 10%.

TABLE 2 Baseline Characteristics (Clinical)

	All Participants (N = 71)	Group 1 ^a (n = 19)	Group 2 ^b (n = 16)	Group 3 ^c (n = 9)	Group 4 ^d (n = 27)	P
Ejection fraction, mean (SD), %	26.68 (6.61)	24.86 (6.40)	29.00 (8.22)	28.33 (6.49)	26.02 (5.47)	.144
Peak VO ₂ , mean (SD), mg/kg per min	13.72 (3.38)	12.01 (2.92)	13.95 (3.09)	14.50 (6.49)	14.50 (3.50)	.144
Six-minute walk, mean (SD), ft	1436.86 (209.47)	1457.18 (176.63)	1357.57 (167.52)	1573.25 (331.52)	1420.33 (189.50)	.799
NYHA class, n (%)						.539
II	56 (78.9)	13 (68.4)	14 (87.5)	8 (88.9)	21 (77.8)	
III	13 (18.3)	5 (26.3)	1 (6.3)	1 (11.1)	6 (22.2)	
IV	2 (2.8)	1 (5.3)	1 (6.3)	0 (0)	0 (0)	
HF etiology, ischemic, n (%)	30 (42.3)	7 (36.8)	6 (37.5)	4 (44.4)	13 (48.1)	.855
History of hypertension, yes, n (%)	32 (45.1)	9 (47.4)	8 (50.0)	3 (33.3)	12 (44.4)	.873
History of diabetes, yes, n (%)	22 (31.0)	6 (31.6)	5 (31.3)	4 (44.4)	7 (25.9)	.780
History of dyslipidemia, yes, n (%)	34 (47.9)	9 (47.4)	7 (43.8)	4 (44.4)	14 (51.9)	.955
History of depression, yes, n (%)	37 (52.1)	6 (16.2)	9 (24.3)	13 (35.1)	9 (24.3)	.367
Medication use, n (%)						
ACE inhibitors	52 (73.2)	11 (57.9)	13 (81.3)	7 (77.8)	21 (77.8)	.364
Angiotensin receptor blockers	13 (18.3)	5 (26.3)	3 (18.8)	1 (11.1)	4 (14.8)	.718
β-blockers	50 (70.4)	15 (78.9)	9 (56.3)	7 (77.8)	19 (70.4)	.486
Diuretics	61 (85.9)	16 (84.2)	12 (75.0)	8 (88.9)	25 (92.6)	.443
Aldactone	21 (29.6)	5 (26.3)	6 (37.5)	1 (11.1)	9 (33.3)	.525
Digoxin	49 (69.0)	12 (63.2)	12 (75.0)	5 (55.6)	20 (64.1)	.646
Antidepressants	27 (38.0)	3 (11.1)	8 (29.6)	9 (33.3)	7 (25.9)	.851

Abbreviations: HF, heart failure; NYHA, New York Heart Association.

^aParticipants with improvements in peak VO₂ greater than 10%.

^bParticipants with improvements in peak VO₂ less than 10%.

^cParticipants with reductions in peak VO₂ less than 10%.

^dParticipants with reductions in peak VO₂ greater than 10%.

mean of 0.56 hospitalizations, group 2 experiencing a mean of 0.45, group 3 experiencing a mean of 1.09, and group 4 experiencing a mean of 1.7 ($P = .02$).

T3 Table 3 summarizes the changes in mood disorders and quality of life across the 4 groups from baseline to 6 months. Over time, all participants demonstrated significantly lower levels of depression and hostility ($P < .001$) and significantly higher levels of physical and overall quality of life ($P = .046$). Group differences over time were noted in anxiety ($P = .009$), depression ($P = .015$), physical quality of life ($P < .001$) and overall quality of life ($P = .002$). Pairwise comparisons between the 4 groups on levels of anxiety and depression and physical and overall quality of life were statistically significant between participants who demonstrated any improvement in exercise capacity (groups 1 and 2) when compared with participants who showed any reduction in exercise capacity (groups 3 and 4) ($P < .05$). Change scores for the 4 groups between baseline and 6 months are summarized in Figure 1. All scores showed decreasing effects in the psychological outcomes as changes in exercise capacity worsened.

The correlation matrix for the key variables is presented in Table 4. Greater improvement in exercise capacity was strongly associated with lower depression but only weakly associated with lower anxiety and hostility and higher emotional quality of life. An improvement in exercise capacity was not associated with changes in physical and overall quality of life. Younger age and less education were associated with increased dysphorias and lower quality of life. Higher levels of anxiety, depression, and hostility were associated with poorer quality of life.

Discussion

In this secondary analysis of data from an HF home exercise program, we examined the clinical outcomes of mood disorders and quality of life in those participants who participated in exercise training (ie, who were randomized to the experimental arm).³⁰ In the parent trial, we had hypothesized that both mood disorders and quality of life would improve as a consequence of exercise training. Similar to previous investigators,²²

TABLE 3 Baseline and 6-Month Outcomes (N = 71)

Variable	Group 1 ^a (n = 19)		Group 2 ^b (n = 16)		Group 3 ^c (n = 9)		Group 4 ^d (n = 27)		P (T × G)
	Baseline	6 mo	Baseline	6 mo	Baseline	6 mo	Baseline	6 mo	
Mood disorder (MAACL ^e)									
Anxiety	7.6 (4.3)	6.1 (4.4)	8.6 (4.5)	7.2 (4.4)	9.2 (4.0)	8.0 (3.6)	7.4 (3.8)	8.7 (4.0)	.009
Depression	13.3 (7.1)	6.8 (3.8)	14.3 (5.7)	8.0 (3.2)	15.1 (6.7)	11.8 (5.8)	14.4 (5.7)	12.5 (4.9)	.015
Hostility	13.0 (6.9)	7.6 (4.5)	15.4 (5.2)	8.7 (3.8)	16.7 (6.2)	12.4 (6.4)	14.9 (7.4)	11.1 (5.5)	.277
Quality of life (MLHFQ ^f)									
Physical	21.7 (9.5)	16.9 (8.5)	19.9 (10.7)	17.4 (10.7)	19.7 (8.8)	19.9 (6.9)	20.1 (9.4)	22.0 (11.4)	.000
Emotional	10.8 (6.8)	9.3 (6.3)	11.8 (6.8)	10.8 (8.4)	13.1 (5.3)	13.5 (4.5)	12.1 (6.6)	13.4 (8.1)	.325
Overall	48.0 (18.1)	39.1 (20.4)	43.9 (22.9)	36.7 (21.7)	45.5 (22.9)	47.7 (20.9)	46.9 (21.0)	49.4 (25.0)	.002

Values are given as mean (SD). Scores for anxiety, depression, and hostility range from 0 to 21 (norm, ≤7), 0 to 40 (norm, 11), and 0 to 28 (norm, 7), respectively.

MAACL, Multiple Adjective Affect Check List; MLHFQ, Minnesota Living with Heart Failure Questionnaire; T × G, time × group interaction.

^aParticipants with improvements in peak VO₂ greater than 10%.

^bParticipants with improvements in peak VO₂ less than 10%.

^cParticipants with reductions in peak VO₂ less than 10%.

^dParticipants with reductions in peak VO₂ greater than 10%.

^eHigher scores reflect higher levels of dysphoria.

^fHigher scores indicate greater symptom interference and lower quality of life.

we found no difference in these outcomes between the experimental and control groups, although the trends were in the hypothesized direction.³⁰ Therefore, we used a secondary analysis to compare participants in the exercise group who had positive changes in peak VO₂ from baseline with those participants who had negative changes in VO₂ from baseline in an attempt to understand the relationship between exercise and psychological outcomes. We found significant differences over time in anxiety, depression, physical quality of life, and overall quality of life in the 4 patient groups. Greater improvement in exercise capacity was also strongly associated with lower depression scores. Thus, it seems that positive psychological outcomes occurred with exercise training in those participants who experienced an increase in exercise capacity. These positive findings are validated by other studies that reported the impact of exercise training on psychological effects among participants with heart failure.^{18,36,37}

Before our analysis, several competing theories could be offered to explain the lack of effect of exercise training on psychological outcomes. First, exercise may not be a powerful enough intervention to alter the emotional response of participants, many of whom have lived with a chronic, progressive syndrome for years. The development of complications (eg, atrial arrhythmias) and the unplanned hospital admissions due to acute decompensation may affect the emotional status of these participants far more than participation in an exercise regimen. This interpretation is supported by data from the parent study. Hospitalizations occurred in 43% of the participants in the control group and 40% of the participants in the exercise group ($P = 0.75$).³⁸ Similarly, in the largest heart failure exercise trial conducted to date, the percentage of participants who experienced a rehospitalization during the period of follow-up (mean, 2.5 years) was 63% in the exercise arm compared with 65% in the control arm. When examining the number of hospitalizations specifically for heart failure between the 2 groups, 30% in the exercise group had a total of 344 hospitalizations, whereas 34% in the control group had a total of 393 hospitalizations (hazard ratio, 0.87 [95% confidence interval, 0.75–1.00]; $P = .06$).³⁸ Thus, participants in both the exercise and control groups experienced a significant number of hospitalizations, suggesting a relatively high vulnerability to acute decompensation, whether the participant exercised regularly.

A second theory is that participants with a certain clinical profile may adhere to the exercise prescription but may not achieve optimal benefit and therefore not experience positive psychological changes. Randomization procedures should ensure that participants with a variety of clinical profiles (heart failure etiology, ejection fraction, peak VO₂, medications, etc) are equally represented across the treatment groups. However,

TABLE 4 Correlational Matrix of Key Variables (N = 71)

Variables	1	2	3	4	5	6	7	8	9	10	11
1. Group	1.000										
2. Age	-0.016	1.000									
3. Education	0.153	-0.077	1.000								
4. Ejection fraction	-0.022	0.003	-0.014	1.000							
5. NYHA class	0.106	-0.225	0.015	-0.067	1.000						
6. MAACL, ^a anxiety, 6 mo	-0.281 ^b	-0.160	-0.254 ^b	-0.020	-0.104	1.000					
7. MAACL, depression, 6 mo	-0.491 ^c	-0.251 ^b	-0.400 ^c	0.036	-0.022	0.594 ^c	1.000				
8. MAACL, hostility, 6 mo	-0.293 ^b	-0.173	-0.331 ^c	-0.031	-0.151	0.670 ^c	0.544 ^c	1.000			
9. MLHFQ, ^d physical, 6 mo	-0.221	-0.063	-0.214	0.048	-0.073	0.262 ^b	0.388 ^c	0.310 ^c	1.000		
10. MLHFQ, emotional, 6 mo	-0.238 ^b	-0.142	-0.255 ^b	0.133	-0.158	0.355 ^c	0.455 ^c	0.307 ^c	0.544 ^c	1.000	
11. MLHFQ, overall, 6 mo	-0.219	-0.209	-0.240 ^b	0.094	-0.193	0.254 ^b	0.440 ^c	0.368 ^c	0.880 ^c	0.650 ^c	1.000

Abbreviations: MAACL, Multiple Adjective Affect Check List; MLHFQ, Minnesota Living with Heart Failure Questionnaire; NYHA, New York Heart Association.

^aHigher scores reflect higher levels of dysphoria.

^bCorrelation is significant at the .05 level (2 tailed).

^cCorrelation is significant at the .01 level (2 tailed)

^dHigher scores indicate greater symptom interference and lower quality of life.

within the exercise arm, participants may have certain clinical characteristics that mute their response to exercise. This explanation is less convincing given our comparison of the 4 groups on a variety of sociodemographic and clinical variables. No significant differences were noted across groups. In particular, it can be noted that baseline peak VO₂ values were not significantly different among the 4 groups.

A final explanation for the frequently conflicting findings related to exercise and emotional outcomes in heart failure is that participants' adherence to an exercise regimen erodes with time. Adherence to exercise was assessed in the parent study by self-report activity logs and pedometer recordings because the exercise was a home-based walking program on city streets. Both techniques have limited accuracy because they rely on self-report or faithful use of the pedometer. However, investigators in the HF-ACTION trial gave subjects in the experimental arm either a bicycle or treadmill after the first 3 months of supervised exercise and used heart rate monitors, as well as self-report, to measure adherence.³⁸ Adherence to the exercise prescription decreased from a median of 95 minutes per week during months 4 through 6 of follow-up to 74 minutes per week during months 10 through 12. In the third year of follow-up, participants in the exercise group exercised a median of 50 minutes per week (the training goal was 120 minutes). At all time

points, only 30% of the participants in HF-ACTION exercised at or greater than the target number of minutes per week.³⁸ Clearly, some participants adhere to the prescribed exercise regimen throughout the study, and these may be the ones who benefit psychologically from exercise.

In interpreting our results, it is clear that the resolution of mood disorders and the improvement in QOL in participants with heart failure were associated with the degree of improvement in exercise capacity. Participants in the 2 groups who experienced an improvement in peak VO₂ may have been more adherent to the exercise protocol than participants who experienced a reduction in peak VO₂. Given the limitations of self-report about adherence, this explanation remains speculative. It is also important to note that participants who had documented improvements in exercise capacity experienced significantly fewer hospitalizations than those who had reductions in exercise capacity. Whether fewer hospitalizations were related to higher levels of adherence to exercise (and therefore levels of improved exercise capacity) cannot be determined from our data.

Our findings are limited by being a secondary analysis conducted on subgroups of a parent study. The attention nurses provided to participants in the monthly home visits may have acted as an intervention that muted the power of the exercise intervention to alter the overall quality of life of the participants. The

What's New and Important

- Improvement in exercise capacity is strongly correlated with positive psychological outcomes and overall quality of life.
- Improvement of mood disorders in patients with heart failure was associated with the degree of improvement in exercise capacity.
- It is imperative for clinicians to regularly assess patient's level of exercise and provide them with opportunities to increase exercise capacity.

age of our sample is considerably younger than the general population of participants with heart failure. The subgroups were not randomized but rather were identified based on the participants' differing physiologic response to participation in an exercise training program. Thus, we cannot be sure that the differences in peak VO_2 caused the differences noted in mood disorders and quality of life. Likewise, our statistical analyses did not take into account the potential overlap between our predictor variables. However, our findings support the interpretation that improvements in physiological benefits may lead to improvements in mood disorders and quality of life in patients with heart failure who participate in an exercise training program.

Conclusions

Patients with HF have mood disorders and reduced QOL that may be positively influenced by exercise training. The psychological benefits of exercise are well documented in healthy populations, but the results of exercise training in the population with HF are more controversial with some trials showing negative or mixed results. On the basis of the findings of the current study, improvement in psychological outcomes is associated with positive changes in exercise capacity as a result of exercise training. It remains unclear whether decreases in exercise capacity are related to nonadherence to an exercise protocol or to clinical deterioration despite adherence to exercise.

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