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Improvements in Depressive Symptoms and Affect during Cardiac Rehabilitation: Predictors and Potential Mechanisms

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Abstract

PURPOSE—Depression is indicative of poor prognosis in cardiac patients. Reductions in depression have been observed following cardiac rehabilitation (CR). Whether similar improvements in positive and negative affect occur is unknown. Greater understanding of depressive symptom and affect change is needed to enhance facilitators of emotional improvement after a cardiac event.

METHODS—CR attendees (n = 637) completed measures of depressive symptoms, affect, health status, and social support at CR intake and discharge. Body mass index, metabolic equivalents, and blood pressure were also measured. Relationships between changes in psychosocial and physical health indicators, and depressive symptoms, positive affect, and negative affect were examined.

RESULTS—From intake to discharge, depressive symptoms ($d = .40$, $P < .001$) and negative affect ($d = .26$, $P < .001$) decreased. Positive affect increased ($d = .34$, $P < .001$). In multivariate regression, predictors of depressive symptom reduction were increased vitality ($\beta = -.26$) and decreased bodily pain ($\beta = -.08$). Predictors of positive affect increase were increased vitality ($\beta = .25$), social support ($\beta = .16$), and physical role functioning ($\beta = .09$). Predictors of negative affect reduction were increased vitality ($\beta = -.23$) and social support ($\beta = -.10$). Changes in indicators of physical health were not related to depressive symptom or affect change.

CONCLUSIONS—Depressive symptom and affect improvements following CR were observed and most strongly associated with improvements in vitality and social support. Future research

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should explore how enhancement of these mechanisms may further improve depressive symptom and affect during CR.

Keywords

depression; cardiac rehabilitation; positive affect; negative affect

Cardiac rehabilitation (CR) leads to improvements in morbidity and mortality,[1,2] likely through improvements in modifiable risk factors. Importantly, the American Heart Association recognizes depression as a relevant risk factor in acute coronary syndrome due to the demonstrated relationship between depression and prognosis.[3] Approximately 15–45% of individuals with cardiovascular disease (CVD) exhibit depressive symptoms or clinical depression.[4,5] Prior research has established that depression improves following CR,[6] though continued depression at discharge remains predictive of increased mortality risk.[7]

Less is known about whether other aspects of psychological functioning, such as positive and negative affect, are similarly impacted by CR. Positive and negative affect represent distinct constructs, evidenced most prominently by different patterns of neurological activation.[8–10] For example, left hemisphere impairment has been associated with negative emotions such as crying, whereas right hemisphere impairment was related to positive mood states such as laughing. Negative affect includes a broader range of negative emotions (ie, fear, hostility) than are included in the depression criteria, but excludes the vegetative or cognitive components of depression. In addition, positive affect (eg, joy, happiness, alertness) reflects mood states that are not part of depression diagnostic criteria or that function as mere opposites of aspects of negative affect.

CR may contribute to increased positive affect in multiple ways. Higher positive affect corresponds with exercise frequency in individuals with ischemic heart disease, and exercise has been shown to mediate the relationship between positive affect and survival.[11] Also, affect may improve as a result of psychoeducational lectures or social support provided by CR.

In addition to the impact of CR on affect, predictors of depression and affect change are not fully understood. Increased exercise capacity has been observed alongside improvement in depressive symptoms post-CR.[6] However, others reported no relationship between depression improvement and changes in exercise capacity or body mass index (BMI) in CR.[12] Regarding positive affect, increased positive affect over 5 y was recently linked to increased physical activity, sleep quality, and medication adherence in CHD.[13] Given evidence that positive affect is pertinent to health behavior engagement and improved long-term outcomes, understanding whether affect improves over the course of CR and is associated with other functional changes may extend understanding of the psychosocial and behavioral benefits of CR.

Examination of predictors of depressive symptom and affect change may provide insight into potential intervention targets to maximize the effect of CR on psychosocial functioning. Thus, the current study sought to examine changes in depressive symptoms and affect following CR completion in a large clinical cohort, as well as identify 1) baseline variables

predictive of depressive symptom and affect improvement; and 2) candidate mechanisms that may facilitate depressive symptom and affect improvement. Working from a biopsychosocial framework, we hypothesized that: 1) depressive symptoms and affect would improve from baseline to discharge; 2) baseline poor mood (ie, high depressive symptoms, low positive affect, and high negative affect) would predict larger improvements in that mood variable at discharge; and 3) improvements in social support and self-reported and objective indices of physical functioning would predict concurrent improvement in depressive symptoms and affect.

METHODS

Participants

Participants were enrollees in a comprehensive CR program in Providence, RI between October 1, 2014 and June 27, 2016 who completed ≥18 sessions (n = 650). We excluded patients with the uncommon CR indications: cardiac transplant (n = 2), percutaneous valve implantation (n = 3), and ventricular assist device/artificial heart (n = 1), and those with no diagnosis listed (n = 7) for a sample of 637 (patients with admission diagnoses of angina, coronary artery bypass graft surgery, heart failure, non-ST-segment elevation myocardial infarction, ST-segment elevation myocardial infarction, valve repair/replacement, and percutaneous coronary intervention).

Measures

Demographic, psychosocial, and medical information were collected through the CR program following published guidelines.[14] Clinical outcomes including systolic and diastolic blood pressure (BP), and body mass index (BMI) were collected by CR staff during intake and discharge visits. Metabolic equivalents (METs) were estimated from a treadmill exercise test at baseline and discharge. Additionally, patients completed the following psychosocial self-report measures during intake and discharge.

Patient Health Questionnaire-9 (PHQ-9)—The PHQ-9[15,16] is a 9-item depression screening measure. Scores <5 indicate no to minimal depressive symptoms, scores from 5–9 represent mild depression, and scores from 10–14 suggest moderate depression. Scores from 15–19 are moderately severe depressive symptoms and scores from 20–27 reflect severe depressive symptoms.

Positive and Negative Affect Scale (PANAS)—The PANAS[17] is a 20-item questionnaire which asks individuals to rate their experience of 20 emotions during the past week on a 5-point Likert scale. Two subscales are created, with 10 items reflecting positive affect and 10 reflecting negative affect. Subscale scores range from 10 to 50, with higher scores indicating higher affect. Although specific cut-offs do not exist for the PANAS, a large examination of a nonclinical sample indicated a mean of 31.31 ± 7.65 for positive and 16 ± 5.90 for negative affect.[18]

ENRICHD Social Support Instrument (ESSI)—The ESSI[19,20] is a 7-item questionnaire that measures social support. Higher total scores reflect higher social support.

Rand 36-Item Short Form Survey (Rand-36)—The Rand-36[21] is a 36-item questionnaire that assesses 8 health-related concepts. Higher scores denote higher functioning. For the current study, we reported the results of all subscales but included in regression analyses only subscales that ask about specific physical abilities (Physical Functioning Scale), physiological experiences (Pain Scale, Vitality Scale), or problems that are specifically stated as due to physical health (Physical Role Functioning Scale). We avoided sub-scales that represent conceptual overlaps with our primary outcome variables related to mood such as those asking about mental health symptom severity (Emotional Well-being Scale), problems that are specifically stated as due to mental health symptoms (Emotional Role Functioning Scale), problems due to mental *or* physical health (Social Functioning Scale), and ratings of general health that do not specify if patient is rating mental and/or physical health (General Health Scale).

PROCEDURES

Upon enrollment, patients completed an intake assessment that included review of demographic and medical history, completion of psychosocial questionnaires, and functional assessment. Staff entered demographic and medical history and patients completed self-report questionnaires using a patient portal. Patients are typically recommended to complete 36 total sessions or 3 sessions/wk for 12 wk. However, because of insurance reimbursement differences, some patients completed planned discharges from the program prior to reaching 36 sessions, but no earlier than 18 sessions. Thus, for the current study, “CR completion” was defined as completion of ≥18 sessions. In the program, patients are followed by a registered nurse, exercise physiologist or physical therapist as case managers under the supervision of a cardiologist and patients can meet individually with a dietician, pharmacist, and/or clinical psychologist as needed. CR sessions consisted of monitored exercise training and educational lectures on topics including cardiovascular conditioning and behavior modification aimed at secondary prevention. At exit, patients completed a discharge assessment which included completion of psychosocial questionnaires.

Statistical Analysis

Descriptive statistics were calculated to provide sample characteristics. Paired *t*-tests were used to examine mean differences between intake and discharge psychosocial and physical functioning measures.

Hierarchical multiple linear regressions (ie, stepped regression models) were used to examine predictors of discharge depressive symptoms and affect while controlling for baseline depressive symptoms and affect. First, stepped regression models were conducted in order to select baseline demographic/medical covariates to be included in subsequent analyses. The following were examined: age, sex, minority status (minority vs non-Hispanic Caucasian), and intake tobacco use status (never/former smoker vs current smoker). The presence of the following comorbidities was also examined: diabetes, renal disease, pulmonary disease, cerebrovascular disease, cancer, and peripheral artery disease. For each of the 3 outcomes (ie, discharge PHQ-9 score, positive affect, and negative affect), all baseline demographic/medical variables were examined in a separate hierarchical regression

model where step 1 included the intake outcome score (ie, PHQ-9 score, positive affect, or negative affect). Step 2 included the baseline demographic/medical variable entered alone. Any predictors that explained ≥1% of the variance (ie, corresponding to a small effect size, R^2 change >.01) in discharge depressive symptoms/affect after controlling for intake depressive symptoms/affect were included as covariates in final multivariable models.

Second, several stepped regression models were performed to identify important predictors of depressive symptom and affect improvement. Change (Δ) scores were created by calculating the difference between the intake and discharge scores. Change scores were calculated for the ESSI (social support), Rand-36 physical functioning, Rand-36 role limitations due to physical health, Rand-36 vitality, Rand-36 bodily pain, BMI, systolic and diastolic BP, and METs. For each of the 3 outcomes, Δ scores were entered into step 2 of a linear regression predicting discharge depressive symptoms and affect. Step 1 included intake depressive symptoms/affect and any baseline variables that met the above criteria to be included as covariates. Any Δ scores that explained at least 1% of the variance in discharge depressive symptoms or affect after controlling for the respective intake score were included in final multivariable models.

Finally, a multivariable regression model was used to determine independence of prediction. All Δ scores that predicted at least 1% of the variance in discharge depressive symptoms or affect were entered simultaneously into step 2 of a parallel hierarchal model to determine independence of prediction, with baseline scores and covariates included in step 1. For the multivariable analyses, patients missing data for any variables of interest were excluded from the analysis. The Statistical Package for the Social Sciences (IBM, SPSS) version 20.0 statistical software was used for analyses.

RESULTS

Sample Characteristics

The sample was primarily male (73.0%) and non-Hispanic Caucasian (94.3%), with an average age of 63.63 ± 11.32 years. The majority (77.10%) was married and/or living with a partner. Approximately 34% of the sample reported at least mild depressive symptoms (PHQ-9 ≥5). The mode number of sessions completed was 36 (n = 231, 36.3%). Additional sample characteristics are presented in Table 1. Changes in depressive symptoms, affect, physical functioning, and social support are reported in Table 2.

Depressive Symptoms

Depressive symptoms improved an average of 1.64 ± 3.15 points following treatment ($P < .001$, $d = .40$). Baseline intake PHQ-9 scores explained 43.8% of the variability in discharge PHQ-9 scores ($P < .001$), with higher intake scores predicting higher discharge scores ($\beta = .66$, $P < .001$). Minority status (ie, minority vs non-Hispanic Caucasian) was also related to discharge PHQ-9 scores after controlling for intake PHQ-9 scores ($\Delta R^2 = .014$), with minority individuals demonstrating higher discharge PHQ-9 scores than non-minority individuals (mean difference post-treatment = 2.07 [standard error = .87], $P < .05$). When examined separately after controlling for intake PHQ-9 scores and minority status,

predictors of lower PHQ-9 scores at discharge included increases in Rand-36 Vitality (ΔR^2 = .095), Rand-36 Physical Functioning (ΔR^2 = .031), Rand-36 pain (ΔR^2 = .028), and Rand-36 physical role functioning (ΔR^2 = .028; Table 3), all *P* values <.01. When entered into multivariable analyses together, after controlling for intake PHQ-9 score and minority status, the linear combination of variables explained an additional 10.3% of the variance in discharge PHQ-9 scores (*P* < .001). The strongest predictor of a decrease in PHQ-9 scores was improvement in Rand-36 Vitality (β = −.254), followed by improvement in Rand-36 Bodily Pain (β = −.081; Table 4).

As a post-hoc analysis, we further examined improvements in depressive symptoms for minority and nonminority individuals. Nonminority participants reported an average 1.72 ± 3.12 (from 4.07 at intake to 2.35 at discharge) point reduction in depressive symptoms (*P* < .001). Minority individuals reported an average .23 ± 3.34 (from 4.57 at intake to 4.43 at discharge) point reduction in depressive symptoms (*P* = .692).

Negative Affect

Negative affect decreased an average of 1.52 ± 4.77 points following CR (*P* < .001, *d* = .26). Intake negative affect explained 38.1% of the variance in discharge negative affect (*P* < .001). Higher negative affect at the time of intake predicted higher negative affect at discharge (β = .62, *P* < .001). Next, predictors of change in negative affect were examined separately (Table 3). Predictors of lower negative affect at discharge included improvement in Rand-36 Vitality (ΔR^2 = .063), ESSI (ΔR^2 = .014), Rand-36 Physical Role Functioning (ΔR^2 = .015), and Rand-36 Physical Functioning (ΔR^2 = .015). When entered into multivariable analyses, the combination of variables accounted for an additional 7.6% of the variance in discharge negative affect beyond intake negative affect (*P* < .001). The strongest predictors of a reduction in negative affect were improvements in Rand-36 Vitality (β = −.23) and ESSI (β = −.11; Table 4).

Positive Affect

Positive affect increased an average of 2.61 ± 7.07 points following CR (*P* < .001, *d* = .34). Intake positive affect explained 59.5% of the variability in discharge positive affect (*P* < .001). Higher intake positive affect predicted higher discharge positive affect (β = .66, *P* < .001). When examined individually, predictors of higher discharge positive affect included improvements in Rand-36 Vitality (ΔR^2 = .097), ESSI (ΔR^2 = .030), Rand-36 Physical Role Functioning (ΔR^2 = .04), and Rand-36 Physical Functioning (ΔR^2 = .031). In multivariable analysis, the combination of variables explained an additional 13.6% of variance in discharge positive affect (*P* < .001). The strongest predictors of higher discharge positive affect were increases in Rand-36 Vitality (β = .25), followed by increases in ESSI (β = .16).

Changes in objective indicators of physical health (METs, BMI, BP), were not significantly associated with depressive symptoms or affect change in any analysis (Table 3 and 4).

DISCUSSION

The current study examined changes in depressive symptoms and affect in CR completers, and improvements in both depressive symptoms and affect were observed. Independent,

multivariable predictors of depressive symptom improvement included increased vitality and decreased bodily pain. Multivariable predictors of positive affect were social support, vitality, and physical role functioning. Multivariable predictors of negative affect were vitality and social support.

Consistent with prior work, a significant small to moderate effect on depressive symptoms was observed. Approximately 34% of the sample reported at least mild symptoms at intake, whereas approximately 19% did at discharge. Symptoms of depression are a potential barrier to health behavior change[22] and specifically within CR setting,[23] so even a small change in symptomology may result in greater engagement in preventive behaviors, such as CR attendance and engagement. In addition, small reductions are clinically significant as even mild symptoms of depression are associated with increased mortality risk.[24]

The current findings showed small to moderate improvements in positive and negative affect during CR. To our knowledge, this is the first study to demonstrate that positive affect improves following CR. Increased positive affect is also likely to be clinically meaningful given prior work linking low positive affect to increased mortality risk.[11]

Increased vitality was most strongly and consistently predictive of depressive symptom and affect improvement. Items of the vitality subscale assessed subjective feelings of “pep,” energy, and fatigue. Prior meta-analytic work revealed moderately large increases in energy and reductions in fatigue following exercise-based CR.[25] Some have suggested that energy reflects feeling as though one is mentally or physically able to complete activities.[25,26] However, more work is needed to understand the importance of increased vitality and improvements in depressive symptoms and affect.

Social support remained stable for the overall sample. Nonetheless, improvements in social support were associated with improved positive affect and reduced negative affect. Higher social connectivity is related to higher positive affect,[27] potentially due to increased availability of instrumental, informational, and emotional support. For individuals with low social support upon program entry, CR may facilitate increased social support through staff involvement or interaction with other attendees. As a result, attendees learn skills to navigate barriers to disease management, while also having the opportunity to interact with and emotionally support other patients. These opportunities may lead to increases in positive emotionality.

In multivariable analyses, smaller relationships emerged between improved physical role functioning and positive affect, and between bodily pain and depressive symptoms. Individuals may report higher positive affect upon experiencing an increased ability to engage in their typical activities. It is feasible that engaging in repeated exercise significantly decreases pain experienced during daily life activities, which may decrease activity restriction and depression.[28–30] However, as changes in physical role functioning and bodily pain were not strongly nor consistently predictive across the different outcomes, replication of the current findings is needed.

Surprisingly, improvements in depressive symptoms and affect were unrelated to changes in objective indicators of physical health. However, the extant literature is mixed, with some

reporting no relationship between changes in depressive symptoms and BMI or exercise capacity.[6,12] Stronger effects may be apparent in individuals with higher depressive symptoms and negative affect or lower positive affect.

Limitations of the present study warrant mention. First, the sample was largely homogenous and may not generalize to samples with more women or minority participants. Second, engagement in psychiatric treatment concurrent with CR was not assessed. Third, the causality of the relationships among variables of interest warrants further study. Fourth, the present study included a heterogeneous group of cardiac patients. Future studies may consider testing the current findings in more targeted cardiac populations, and include cardiac-focused assessments, to determine whether the current findings apply similarly across cardiac samples. Additionally, inclusion of cardiac-specific metrics may allow for further examination of the contribution of improved cardiac health to improvements in mood. Finally, unmeasured physiological mechanisms, such as reduced inflammation or other psychosocial factors (ie, increased self-efficacy) may have also contributed to depressive symptom and affect change.

Nonetheless, this study demonstrated that depressive symptoms and affect improve following CR completion. To our knowledge, this study represents the first evidence of the positive affect-related benefits of CR. Concomitant improvements in vitality, social support, and bodily pain suggest they may be mechanisms of depressive symptom and affect improvement. Future investigators and practitioners are encouraged to incorporate consideration of the interaction of psychosocial factors and physical outcomes when designing and implementing interventions targeting cardiac patients.

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References

1. House, CM; Anstadt, MA; Stuck, LH; Nelson, WB. The association between cardiac rehabilitation attendance and hospital readmission. Am J Lifestyle Med. 2016.
2. Rutledge T, Redwine LS, Linke SE, Mills PJ. A meta-analysis of mental health treatments and cardiac rehabilitation for improving clinical outcomes and depression among patients with coronary heart disease. Psychosom Med. 2013; 75(4):335–349. [PubMed: 23630306]
3. Lichtman JH, Froelicher ES, Blumenthal JA, et al. Depression as a risk factor for poor prognosis among patients with acute coronary syndrome: systematic review and recommendations: a scientific statement from the American Heart Association. Circulation. 2014; 129(12):1350–1369. [PubMed: 24566200]
4. Hare DL, Toukhsati SR, Johansson P, Jaarsma T. Depression and cardiovascular disease: a clinical review. Eur Heart J. 2014; 35(21):1365–1372. [PubMed: 24282187]
5. Wenger NK. Current status of cardiac rehabilitation. J Am Coll Cardiol. 2008; 51(17):1619–1631. [PubMed: 18436113]
6. Milani RV, Lavie CJ. Impact of cardiac rehabilitation on depression and its associated mortality. Am J M. 2007; 120(9):799–806. [PubMed: 17765050]

7. Kachur S, Menezes AR, De Schutter A, Milani RV, Lavie CJ. Significance of comorbid psychological stress and depression on outcomes after cardiac rehabilitation. Am J Med. 2016; 129(12):1316–1321. [PubMed: 27480388]
8. Davidson RJ, Ekman P, Saron CD, Senulis JA, Friesen WV. Approach-withdrawal and cerebral asymmetry: Emotional expression and brain physiology: I. J Pers Soc Psychol. 1990; 58(2):330–341. [PubMed: 2319445]
9. Watson D, Clark LA. Measurement and mismeasurement of mood: recurrent and emergent issues. J Pers Assess. 1997; 68(2):267–296. [PubMed: 16370781]
10. Sackeim HA, Greenberg MS, Weiman AL, Gur RC, Hungerbuhler JP, Geschwind N. Hemispheric asymmetry in the expression of positive and negative emotions: neurologic evidence. Arch Neurol. 1982; 39(4):210–218. [PubMed: 7041863]
11. Hoogwegt MT, Versteeg H, Hansen TB, Thygesen LC, Pedersen SS, Zwisler A-D. Exercise mediates the association between positive affect and 5-year mortality in patients with ischemic heart disease. Circulation: Cardiovasc Qual Outcomes. 2013; 6(5):559–566.
12. Egger E, Schmid J-P, Schmid RW, Saner H, von Känel R. Depression and anxiety symptoms affect change in exercise capacity during cardiac rehabilitation. Eur J Cardiovasc Prev Rehabil. 2008; 15(6):704–708. [PubMed: 18813026]
13. Sin NL, Moskowitz JT, Whooley MA. Positive affect and health behaviors across five years in patients with coronary heart disease: the Heart and Soul Study. Psychosom Med. 2015; 77(9): 1058–1066. [PubMed: 26428445]
14. Balady GJ, Williams MA, Ades PA, et al. Core components of cardiac rehabilitation/secondary prevention programs: 2007 update. Circulation. 2007; 115(20):2675–2682. [PubMed: 17513578]
15. Löwe B, Kroenke K, Herzog W, Gräfe K. Measuring depression outcome with a brief self-report instrument: sensitivity to change of the Patient Health Questionnaire (PHQ-9). J Affect Disord. 2004; 81(1):61–66. [PubMed: 15183601]
16. Kroenke K, Spitzer RL, Williams JB. The PHQ-9. J Gen Intern Med. 2001; 16(9):606–613. [PubMed: 11556941]
17. Watson D, Clark LA, Tellegen A. Development and validation of brief measures of positive and negative affect: the PANAS scales. J Pers Soc Psychol. 1988; 54(6):1063–1070. [PubMed: 3397865]
18. Crawford JR, Henry JD. The Positive and Negative Affect Schedule (PANAS): construct validity, measurement properties and normative data in a large non-clinical sample. Br J Clin Psychol. 2004; 43(3):245–265. [PubMed: 15333231]
19. Vaglio J, Conard M, Poston WS, et al. Testing the performance of the ENRICHD Social Support Instrument in cardiac patients. Health Qual Life Outcomes. 2004 May 15.2:24. [PubMed: 15142277]
20. The Enriched Investigators. Enhancing Recovery in Coronary Heart Disease (ENRICHD) study intervention: rationale and design. Psychosom Med. 2001; 63(5):747–755. [PubMed: 11573023]
21. McHorney CA, Ware JE Jr, Raczek AE. The MOS 36-Item Short-Form Health Survey (SF-36): II. Psychometric and clinical tests of validity in measuring physical and mental health constructs. Med Care. 1993:247–263. [PubMed: 8450681]
22. Grenard JL, Munjas BA, Adams JL, et al. Depression and medication adherence in the treatment of chronic diseases in the United States: a meta-analysis. J Gen Intern Med. 2011; 26(10):1175–1182. [PubMed: 21533823]
23. Glazer KM, Emery CF, Frid DJ, Banyasz RE. Psychological predictors of adherence and outcomes among patients in cardiac rehabilitation. J Cardiopulm Rehabil Prev. 2002; 22(1):40–46.
24. Bush DE, Ziegelstein RC, Tayback M, et al. Even minimal symptoms of depression increase mortality risk after acute myocardial infarction. Am J Cardiol. 2001; 88(4):337–341. [PubMed: 11545750]
25. Puetz TW, Beasman KM, O'Connor PJ. The effect of cardiac rehabilitation exercise programs on feelings of energy and fatigue: a meta-analysis of research from 1945 to 2005. EurJ Cardiovasc Prev Rehabil. 2006; 13(6):886–893. [PubMed: 17143119]
26. O'Connor PJ. Evaluation of four highly cited energy and fatigue mood measures. J Psychosom Res. 2004; 57(5):435–441. [PubMed: 15581646]

27. Steptoe A, Dockray S, Wardle J. Positive affect and psychobiological processes relevant to health. Journal of Personality. 2009; 77(6):1747–1776. [PubMed: 19796062]

28. Goesling J, Clauw DJ, Hassett AL. Pain and depression: an integrative review of neurobiological and psychological factors. Curr Psychiatry Rep. 2013; 15(12):421.doi: 10.1007/s11920-013-0421-0 [PubMed: 24214740]

29. Mausbach BT, Chattillion EA, Moore RC, Roepke SK, Depp CA, Roesch S. Activity restriction and depression in medical patients and their caregivers: a meta-analysis. Clin Psychol Rev. 2011; 31(6):900–908. [PubMed: 21600868]

30. Hoffman MD, Hoffman DR. Does aerobic exercise improve pain perception and mood? A review of the evidence related to healthy and chronic pain subjects. Curr Pain Headache Rep. 2007; 11(2): 93–97. [PubMed: 17367586]

CONDENSED ABSTRACT

Increased understanding of contributors to depressive symptom and affect improvement following cardiac rehabilitation (CR) is needed. A sample of 637 participants completed assessments of depressive symptoms, affect, social support, health, and clinical outcomes at CR intake and discharge. Improved vitality and social support contributed to depressive symptom and affect change.

Table 1

Characteristics of Participants (maximum n = 637)[a]

Age	63.63 ± 11.32
Female	172 (27.0)
Non-Hispanic Caucasian	601 (94.3)
Comorbidity	
Cancer	47 (7.4)
Cerebrovascular disease	24 (3.8)
Diabetes	160 (25.1)
Peripheral artery disease	33 (5.2)
Previous myocardial infarction	37 (5.8)
Pulmonary disease	87 (13.7)
Renal disease	55 (8.6)
Admission event	
Angina pectoris	18 (2.8)
CABG	96 (15.1)
Heart failure	38 (6.0)
NSTEMI	107 (16.8)
STEMI	151 (22.1)
PCI	151 (23.7)
Valve repair/replacement	86 (13.5)
AACVPR risk score	
Low	136 (21.4)
Intermediate	334 (52.4)
High	167 (26.2)

Abbreviations: AACVPR, American Association of Cardiovascular and Pulmonary Rehabilitation; CABG, coronary artery bypass grafting; NSTEMI, non-ST-elevation myocardial infarction; PCI, percutaneous coronary intervention; STEMI, ST-elevation myocardial infarction.

[a]Data reported as mean ± standard deviation or number (%).

Table 2

Psychosocial and Clinical Outcomes at Intake and Discharge (maximum n = 637)[a]

	Intake	Discharge
Psychosocial Factors		
PHQ-9	4.10 ± 4.12	2.46 ± 3.29[c]
PHQ-9 ≥5	216 (34.0)	120 (18.9)[c]
PANAS PA	32.03 ± 7.65	34.64 ± 8.10[c]
PANAS NA	15.37 ± 5.86	13.85 ± 4.78[c]
ESSI	29.62 ± 5.16	29.45 ± 5.33
Rand-36 Physical Functioning	60.97 ± 23.54	75.09 ± 23.74[c]
Rand-36 Bodily Pain	64.22 ± 23.61	72.81 ± 24.17[c]
Rand-36 Physical Role Functioning	35.40 ± 40.50	67.85 ± 39.93[c]
Rand-36 Vitality	51.79 ± 20.48	64.96 ± 20.41[c]
Psychosocial Factors Not Included in Regression Analyses		
Rand-36 Social Functioning	75.67 ± 23.75	87.08 ± 18.98[c]
Rand-36 Emotional Role Functioning	64.23 ± 42.13	78.04 ± 35.21[c]
Rand-36 Emotional Well-being	76.98 ± 17.63	81.41 ± 16.04[c]
Rand-36 General Health	61.80 ± 19.66	66.54 ± 20.14[c]
Clinical Outcomes[b]		
BMI	30.48 ± 5.73	29.88 ± 5.45[c]
METs	6.70 ± 2.37	8.60 ± 2.60[c]
Diastolic blood pressure	67.47 ± 7.86	68.93 ± 7.13[c]
Systolic blood pressure	120.23 ± 16.01	119.98 ± 12.99

Abbreviations: BMI, body mass index; ESSI, Enhancing Recovery in Coronary Heart Disease Social Support Inventory (modified); METs, metabolic equivalents; NA, negative affect; PA, positive affect; PANAS, Positive and Negative Affect Schedule; PHQ-9, Patient Health Questionnaire-9; SF-36, 36-item Short Form Health Survey.

[a] Data reported as mean ± standard deviation or number (%).

[b] Sample sizes for clinical outcomes varied from 497 to 637

[c] Intake and discharge scores significantly different at $P < .001$ level.

Table 3

Multiple Linear Regressions[a] of End-of-CR Depressive Symptoms, Positive Affect and Negative Affect After Controlling for Baseline Mood and Affect (maximum n = 637)

	PHQ-9			PA			NA		
	ΔR^2	*b (SE)*	β	ΔR^2	*b (SE)*	β	ΔR^2	*b (SE)*	β
Demographic/Medical									
Age	.000	.003 (.009)	.012	.002	−.032 (.023)	−.044	.003	−.024 (.014)	−.055
Sex	.000	.055 (.221)	.008	.001	.496 (.577)	.028	.001	.243 (.335)	.023
Minority status	.014[e]	−1.730 (.426)[e]	−.120[e]	.000	.491(1.133)	.014	.009[d]	−2.003 (.651)[d]	−.096[d]
Tobacco use	.003	.681 (.403)	.051	.000	−.592 (1.054)	−.018	.003	1.141 (.613)	.059
Diabetes	.004[c]	.496 (.227)[c]	.065[c]	.000	−.415 (.596)	−.022	.003	.573 (.345)	.052
Renal disease	.000	.218 (.350)	.020	.004	−1.768 (.915)	−.062	.000	−.209 (.533)	−.012
Pulmonary disease	.001	.242 (.287)	.025	.009[d]	−2.180 (.751)[d]	−.092[d]	.001	.416 (.438)	.030
Cerebrovascular Disease	.001	−.421 (.516)	−.024	.004	−2.551 (1.349)	−.060	.001	.569 (.786)	.023
Cancer	.000	−.192 (.376)	−.015	.000	−.500 (.985)	−.016	.000	.114 (.574)	.006
Peripheral artery disease	.000	−.309 (.443)	−.021	.000	−.188 (1.166)	−.005	.000	−.302 (.675)	−.014
Psychosocial									
Δ ESSI[b]	.002	−.039 (.023)	−.049	.030[e]	.3437 (.061)[e]	.173[e]	.014[e]	−.136 (.036)[e]	−.117[e]
Δ SF-36 Physical Functioning[b]	.029[e]	−.029 (.005)[e]	−.171[e]	.031[e]	.072 (.013)[e]	.177[e]	.015[e]	−.030 (.008)[w]	−.123[e]
Δ SF-36 Vitality[b]	.089[e]	−.053 (.005)[e]	−.302[e]	.097[e]	.135 (.013)[e]	.313[e]	.063[e]	−.064 (.008)[e]	−.252[e]
Δ SF-36 Role Physical Functioning[b]	.026[e]	−.012 (.002)[e]	−.162[e]	.040[e]	.036 (.006)[e]	.199[e]	.015[e]	−.013 (.003)[e]	−.124[e]
Δ SF-36 Bodily Pain[b]	.025[e]	−.022 (.004)[e]	−.160[e]	.009[d]	.031 (.011)[d]	.093[d]	.005[c]	−.014 (.006)[c]	−.071[c]
Clinical Outcomes									
Δ BMI[b]	.001	.052 (.082)	.019	.000	−.102 (.219)	−.015	.004[c]	.268 (.127)[c]	.066[c]
Δ Systolic BP[b]	.000	−.002 (.007)	−.010	.001	.015 (.018)	.027	.002	.014 (.010)	.042
Δ Diastolic BP[b]	.000	−.005 (.011)	−.012	.000	.011 (.031)	.012	.003	.029 (.018)	.050
Δ METs[b]	.002	−.104 (.074)	−.046	.004	.320 (.194)	.060	.001	.108 (.122)	.032

Abbreviations: BMI, body mass index; BP, blood pressure; ESSI, Enhancing Recovery in Coronary Heart Disease Social Support Inventory; METS, metabolic equivalents; NA, negative affect; PA, positive affect; PHQ-9, Patient Health Questionnaire-9; Minority status, 0 = minority, 1 = non-Hispanic Caucasian; Rand-36, 36-item Short Form Health Survey; Sex, 0 = male, 1 = female; Tobacco use, 0 = current use denied, 1 = current use.

[a]For each regression analysis, Step 1 included intake PHQ-9, PA, or NA scores, respectively. For regressions examining the predictive ability of changes in psychosocial and clinical outcomes, Step 1 also included any baseline demographic/medical covariables that demonstrated a R^2 change ≥ .01 when examined separately. Step 2 included only the listed predictor.

[b]Change (Δ) score equals discharge score minus intake charge.

[c]$P < .05$;

[d]$P < .01$;

[e]$P < .001$.

Table 4

Multivariable Linear Regressions Predicting Depressive Symptoms, Positive Affect, and Negative Affect

	Depressive Symptoms			Positive Affect			Negative Affect		
Variables	***b (SE)***	***β***	***P***	***b (SE)***	***β***	***P***	***b (SE)***	***β***	***P***
Step 1									
Relevant mood variable	.529 (.024)	.662	.000	.629 (.034)	.595	.000	.504 (.026)	.617	.000
Minority status	−1.715 (.425)	−.119	.000	–	–	–	–	–	–
Step 2									
ΔSF-36 Physical Functioning[a]	−.007 (.005)	−.044	.148	.661 (.030)	.059	.067	−.009 (.008)	−.036	.278
ΔSF-36 Physical Role Functioning[a]	−.003 (.002)	−.045	.129	.017 (.006)	.095	.003	−.004 (.003)	−.041	.208
ΔSF-36 Bodily Pain[a]	−.011 (.004)	−.081	.005	–	–	–	–	–	–
ΔSF-36 Vitality[a]	−.045 (.005)	−.254	.000	.108 (.014)	.251	.000	−.056 (.008)	−.220	.000
ΔESSI[a]	–	–	–	.311 (.056)	.159	.000	−.121 (.034)	−.105	.000

Abbreviations: PHQ-9, Patient Health Questionnaire-9; minority status: 0 = minority; 1 = non-Hispanic Caucasian; ESSI, Enhancing Recovery in Coronary Heart Disease Social Support Inventory; Rand-36, 36-item Short Form Health Survey.

[a]Change (Δ) score created by calculating discharge score minus intake score.