Published in final edited form as:

Psychosom Med. 2018 ; 80(6): 526–534. doi:10.1097/PSY.0000000000000584.

Optimizing a positive psychology intervention to promote health behaviors following an acute coronary syndrome:

The Positive Emotions after Acute Coronary Events-III (PEACE-III) randomized factorial trial

Christopher M. Celano, M.D.^{1,2}, Ariana M. Albanese, B.A.², Rachel A. Millstein, Ph.D.^{1,2}, Carol A. Mastromauro, LICSW, MSW², Wei-Jean Chung, Ph.D.^{1,2}, Kirsti A. Campbell, M.D.^{1,2}, Sean R. Legler, B.S.^{1,2}, Elyse R. Park, Ph.D.^{1,2}, Brian C. Healy, Ph.D.^{1,3}, Linda M. Collins, Ph.D.⁴, James L. Januzzi, M.D.^{1,5}, and Jeff C. Huffman, M.D.^{1,2}

¹Harvard Medical School, Boston, MA, USA

²Department of Psychiatry, Massachusetts General Hospital, Boston, MA, USA

³Department of Neurology, Massachusetts General Hospital, Boston, MA, USA

⁴The Methodology Center and Department of Human Development and Family Studies, Pennsylvania State University, University Park, PA, USA

⁵Division of Cardiology, Department of Medicine, Massachusetts General Hospital and Cardiometabolic Trials, Baim Institute for Clinical Research, Boston, MA, USA

Abstract

Objective—Despite the clear benefits of physical activity and related behaviors on prognosis, most patients suffering an acute coronary syndrome (ACS) remain nonadherent to these behaviors. Deficits in positive psychological constructs (e.g., optimism) are linked to reduced participation in health behaviors, supporting the potential utility of a positive psychology (PP)-based intervention in post-ACS patients. Accordingly, we aimed to identify optimal components of a PP-based intervention to promote post-ACS physical activity.

Methods—As part of a multiphase optimization strategy, we completed a randomized factorial trial with eight conditions in 128 post-ACS patients to efficiently identify best-performing intervention components. All participants received a PP-based intervention, with conditions varying in duration (presence/absence of booster sessions), intensity (weekly/daily PP exercises), and content (PP alone or combined with motivational interviewing [MI]), allowing three concurrent comparisons within the trial. Study aims included assessments of the overall feasibility, acceptability, and impact of the intervention, along with the primary aim of determining which components were associated with objectively-measured physical activity and self-reported health behavior adherence at 16 weeks, assessed using longitudinal models.

Corresponding Author and Address for Correspondence: Jeff C. Huffman, M.D., Massachusetts General Hospital 55 Fruit Street, Boston, MA, USA 02114, Phone: (617) 724-2910, Fax: 617-724-9150, jhuffman@partners.org.

Conflicts of Interest

The authors have no other relevant conflicts of interest to report.

Results—The intervention was well-accepted and associated with substantial improvements in behavioral and psychological outcomes. Booster sessions were associated with greater activity to a nearly significant degree ($\beta=8.58$, 95% confidence interval= -0.49 - 17.65 , effect size difference=.43; $p=.064$), MI was associated with overall adherence ($\beta=0.95$, 95% confidence interval= 0.02 - 1.87 , effect size difference=.39; $p=.044$), and weekly exercise completion was generally superior to daily.

Conclusions—These findings will enable optimization of the PP-based intervention in preparation for a well-powered controlled trial.

Trial Registration—[ClinicalTrials.gov](https://clinicaltrials.gov/ct2/show/study/NCT02754895) identifier: NCT02754895

Keywords

acute coronary syndrome; multiphase optimization strategy; myocardial infarction; positive psychology; physical activity

Introduction

Acute coronary syndrome (ACS; myocardial infarction or unstable angina) is an acute and life-threatening manifestation of heart disease experienced by more than 7 million persons worldwide each year (1). Adherence to key cardiac health behaviors is critical for post-ACS recovery, as patients who fail to adhere to these health behaviors are more likely to experience recurrent cardiac events or death (2). However, the majority of patients with coronary heart disease do not follow a heart-healthy diet (3), approximately 30% of post-ACS patients are nonadherent to medications even in the first 6 months following their event (4), and in the weeks following an ACS, only one-quarter of patients who are cleared to be active perform any type of exercise (5).

Existing interventions do not appear to be sufficient to modify behavior. For example, fewer than half of 36 studied interventions for adherence to cardiovascular medications led to a significant improvement in medication adherence (6). Likewise, motivational interviewing (MI), an established health behavior intervention, has had only modest effects (effect size approximately .2) on physical activity in patients at high risk for heart disease (7). Regarding psychological interventions in heart disease, the vast majority have focused on reducing psychological ill-being, and most (8-10), though not all (11), have been applied only in patients with a clinical psychiatric condition (e.g., depression) rather than a broad population of cardiac patients. Furthermore, in cardiac patients, depression and anxiety treatments appear to improve mental health but have not consistently improved physical health outcomes or adherence (10, 12, 13). Given the prevalence of nonadherence and importance of promoting cardiac health behaviors in this population, innovative and broadly applicable interventions to promote physical activity and other health behaviors are needed in post-ACS patients.

Psychological constructs may play an important role in health behavior adherence. For example, depression is linked to limited adherence to health behaviors and poor cardiovascular outcomes post-ACS (14). In contrast, positive psychological constructs, such as positive affect and optimism, may have specific benefits (15). These constructs are not

simply the ‘flipside’ of depression (with only modest inverse correlations between optimism and depression (16), for example), and psychological well-being is associated with health behaviors, including physical activity, healthy diet, and medication adherence (15, 17). Furthermore, positive affect and optimism are associated with lower incidence of heart disease (18) and mortality (19), independent of sociodemographic variables, medical comorbidity, and the adverse effects of depression. Interventions promoting these positive constructs could therefore lead to greater adherence to key health behaviors and better cardiac health.

Positive psychology (PP) interventions focus on the cultivation of positive psychological constructs through systematic exercises, such as writing a letter of gratitude or using a strength in a new way (20). In healthy persons, PP interventions have led to reductions in depression and increases in well-being (21), and related programs in patients with hypertension or heart disease have led to greater physical activity and medication adherence (22, 23). However, there has been no prior study of the impact of PP-based interventions in the high-risk, high-yield post-ACS period to assess whether they may improve well-being and promote health behaviors associated with greater survival.

To address this need, our team has applied the multiphase optimization strategy (MOST) (24) to develop a PP-based intervention to promote physical activity and other health behaviors following ACS. Based on the literature and extended interviews with post-ACS patients (25), we created an 8-week, telephone-based PP intervention and tested it in a small (N=45) pilot trial. Compared to treatment-as-usual (TAU) patients, this intervention led to greater improvements in depression, anxiety, and positive affect (26). The next phase, tested in this current trial, was to select the most effective components for inclusion in the intervention prior to testing it in a randomized efficacy trial.

To accomplish this, we conducted an eight-condition factorial trial in 128 patients hospitalized for an ACS to further assess the feasibility and overall impact of our intervention and to examine which components of the intervention were associated with the greatest improvements in moderate to vigorous physical activity (MVPA; primary outcome) and overall self-reported health behavior adherence. The specific aspects of the treatment that were compared included the frequency of PP exercise completion (weekly vs. daily), the core content of the program (PP alone vs. PP plus motivational interviewing [MI]), and the presence or absence of booster sessions after the core program.

Methods

Positive Emotions after Acute Coronary Events (PEACE) is a multiphase intervention development program utilizing MOST to develop and optimize a PP-based intervention to promote physical activity in post-ACS patients. The current phase (PEACE-III), following qualitative and proof-of-concept phases (25, 26), aimed to determine which elements of the intervention are most associated with improvements in physical activity, other health behaviors, psychological states, and other patient-centered outcomes. Detailed methods of this trial have previously been published (27).

In short, this factorial design experiment was conducted to provide information about which components would be selected for inclusion in an optimized PP-based intervention that would subsequently be tested in a future randomized controlled efficacy trial. The factorial design allowed for the completion of three concurrent (n=64 vs. n=64) comparisons of intervention components to facilitate efficient intervention development (28). Components that showed consistent evidence for a main effect on health behavior outcomes in this trial would be included in the optimized intervention, even if the component or component level (e.g., weekly exercises) did not have a statistically significant main effect compared to the other component or level (e.g., daily exercises). Factorial trials have previously been used successfully in optimization of behavioral interventions to efficiently test multiple components via several concurrent comparisons (28).

Prior to study initiation, the trial was registered on clinicaltrials.gov and approved by the Partners Healthcare Institutional Review Board. All participants provided full written informed consent.

Participants

Participants were adults admitted to an inpatient cardiology unit for an ACS at one of two urban academic medical centers between November 2014 and November 2016 who had suboptimal health behavior adherence (see CONSORT checklist document, Supplementary Table 1, Supplemental Digital Content 1). To meet criteria for myocardial infarction, consistent with international criteria (29), participants were required to have two or more of the following: typical chest pain, elevated cardiac necrosis markers, and/or electrocardiographic changes consistent with myocardial infarction. Unstable angina, per prior studies (30), required new-onset angina within 2 months, exacerbation of existing angina at rest or with minimal exercise, or angina within 2 weeks of a myocardial infarction. Health behavior adherence was measured using Medical Outcomes Study Specific Adherence Scale (MOS) (31) items for diet, medications, and physical activity (range: 4-24). Suboptimal adherence was defined as a summed MOS score $\leq 14/18$, or a total score of 15 with a physical activity score ≤ 5 . Patients were excluded if they demonstrated cognitive deficits on a six-item screen (32), had a medical condition likely to lead to death within 6 months, or were unable to communicate in English or participate in physical activity.

Procedures

Potential participants underwent screening for eligibility, and eligible patients completed written consent. In situations in which more than one patient could be approached, women and minority patients were approached preferentially given their historical underrepresentation in medical research and to meet funder-specified targets for women and minorities. During hospitalization, participants completed baseline outcome measures, then were randomized to one of eight conditions (see Table 1) using the Stata *ralloc* procedure in blocks of 16. Though all conditions were planned to contain 16 participants, an early allocation sequence error led to assignment of between 14-17 participants to each condition.

Study Interventions

Following randomization, participants completed an in-person session with a study interventionist. At this session, the interventionist provided the participant with a treatment manual (see Supplementary Table 2, Supplemental Digital Content 2, for sample pages). The interventionist also outlined the program, assigned the first PP exercise, and (for those with MI content) discussed physical activity and other health behavior goals. Of note, throughout the intervention (and this article), the term ‘PP exercise’ refers to a PP-based activity (e.g., performing kind acts) rather than physical activity.

Following discharge, participants completed eight weekly phone sessions during which the interventionist reviewed the prior week’s exercise, helped participants to translate skills to promote well-being in daily life, assigned a PP exercise for the next week, and (for those in MI conditions) outlined MI principles and assigned a health behavior goal. Half of participants completed three booster sessions with relevant PP and/or MI content at weeks 10, 12, and 14 following completion of the core 8-week program.

PP—The PP exercises were chosen based on the literature and our prior work delivering PP interventions (25, 26). Interventionists explained the rationale for each PP exercise type via guided review of the treatment manual; participants then completed exercise(s) independently during the week (on a daily or weekly basis, depending on group assignment), and wrote about the exercise and its effects. For example, participants in the weekly version of “Remembering Successes” recalled one past success and wrote in detail about it. Participants in the daily version wrote about smaller, daily successes. For those assigned to the MI component of the intervention related to goal-setting for physical activity, the random assignment to daily or weekly PP exercise frequency had no bearing on the MI component of the intervention, with the discussion and nature of physical activity the same for all participants receiving MI.

The core 8 weekly sessions involved completion of specific activities (e.g., writing a gratitude letter, using personal strengths in a new way; see Supplementary Table 3, Supplemental Digital Content 3, for additional detail).

MI—The MI intervention component focused primarily on physical activity, though participants could choose to complete another health behavior goal once they reached their activity goal. At each session, interventionists would: (i) inquire about progress towards the prior week’s goal, (ii) advise participants about the benefits of physical activity (and other health behaviors as applicable), (iii) assess participants’ current stage of change, and (iv) assist with setting a new goal. Each week, interventionists also introduced a new skill/tool related to behavior change (e.g., benefits of activity tracking, approaches to problem-solving barriers).

See Supplementary Table 3 for further detail on session-specific activities):

Booster sessions—For participants randomized to booster sessions, PP boosters focused on the ongoing use of PP skills in daily life, with a goal of practicing one skill between

sessions. For those also receiving MI, MI booster sessions reviewed ongoing physical activity goal progress, discussed relapse prevention, and revised long-term goals.

Sessions were audio-recorded, and intervention fidelity was rated by the study project director (CC) and behavioral intervention supervisor (EP) for PP and MI content, respectively. PP fidelity was rated using a scale created as part of intervention development (26), and MI fidelity was rated with established MI fidelity scale and methods (33).

Data collection and outcomes

Baseline sociodemographic, medical, and medication-related data were gathered via participant interview supplemented by chart review; enrollment in cardiac rehabilitation during the study period was likewise gathered via patient report and chart review. Self-report assessments were completed in-hospital (baseline) prior to randomization and by phone at 8 and 16 weeks by blinded study staff.

Study Aim #1: Feasibility, acceptability, and impact across all conditions—To examine intervention feasibility, we recorded frequency of completion of all assigned exercises. For acceptability, immediately after each PP exercise completion, participants rated the ease and helpfulness (utility) of that week's exercise on a 0-10 Likert scale. To examine the immediate impact of PP exercises, participants rated their positive affect and optimism (from 0 [not happy/optimistic] to 10 [very happy/optimistic]) immediately before and after completion of each exercise. The change in positive affect and optimism was considered to represent the immediate impact of the intervention on those constructs. Finally, we explored the overall pre-post impact of the PP-based intervention (summed across all conditions, given that every condition was an active intervention) on our self-report study outcome measures at 16 weeks.

Study Aim #2 (Primary Aim): Between-condition differences in MVPA at 16 weeks—MVPA, as measured by accelerometer, was chosen as the primary study outcome given its links to health outcomes, including mortality (34). Participants wore Actigraph GT3X+ accelerometers (Actigraph, Pensacola, FL) at weeks 8 and 16, with the cutoff for MVPA set at 1952 counts/minute. We did not record MVPA at baseline given that participants were hospitalized, but data on pre-ACS activity were collected using the 7-day Physical Activity Recall (PAR) scale (35) to control for this in study analyses. Consistent with prior research (36) participants were required to have 8 hours of wear time for at least 4 days; accelerometers were returned to participants for additional wear as needed.

Study Aim #3: Between-condition differences in self-reported adherence and psychological outcomes at 16 weeks—The main secondary outcome measure was health behavior adherence, specifically adherence to physical activity, medication, and diet, measured using the MOS items capturing these three domains. Use of self-report items to measure cardiac health behaviors can be challenging, especially using very brief scales. The MOS Specific Adherence Scale has been used in numerous prior studies of post-ACS patients to examine cardiac health behaviors,(37-39) and this scale has been found to have test-retest reliability of .55-.57 over two years.(31, 40) Low scores on this scale have also

been prospectively linked to readmissions in cardiac patients.(41) Among behaviors, diet can be difficult to measure using self-report, though brief dietary self-report scales have been associated with 24-hour dietary recall and biomarkers of intake (42, 43). MOS diet items have been found to have two-year test-retest reliability of .60 (44), with reliability ratings of .50-.70 considered adequate-good for other dietary measures such as food frequency questionnaires (45-47). Furthermore, self-report of dietary adherence using this scale in medical populations found that 23%-60% met criteria for adherence (31, 48), suggesting that respondents do not appear to grossly overestimate adherence to diet. We used this scale in several prior studies, including in post-ACS patients (38) and found it to be responsive to change (mean item change 1.00 [SD 1.3] over 6 months following ACS, representing 23% change), with no ceiling effects (mean item score: 4.3/6 for diet). Of note, for baseline assessments, participants were asked about pre-ACS adherence to these health behaviors.

We also examined the impact of the intervention on four key psychological constructs. Positive affect was measured via the positive affect subscale of the Positive and Negative Affect Schedule (PANAS; range 10-50; internal consistency (α) in this sample=.87) (49). Optimism was measured via the Life Orientation Test—Revised (LOT-R; range 6-24); this scale has been previously used in studies of post-ACS patients (38, 50) and has been found to be significantly inversely correlated with depression and anxiety, and to have good test-retest reliability and internal consistency (51, 52); in this sample internal consistency was very good (α =.82). Depression and anxiety was measured via Hospital Anxiety and Depression Scale subscales for depression and anxiety (HADS-D, HADS-A; range 0-21; α =.77 [anxiety] and .83 [depression]) (53).

Data Analysis

Baseline characteristics were summarized using descriptive statistics (means, proportions, and standard deviation [SD]); As per the CONSORT 2010 clinical trial reporting guidelines for randomized trials (54), group differences in baseline characteristics are reported but not compared with significance tests. Reporting the characteristics of groups allows readers to ascertain how similar groups are, but applying significance tests simply assesses the likelihood that such differences occurred by chance, when it is known that they would occur by chance given that participants were randomly allocated (55).

Aim #1: Feasibility, acceptability, and overall impact—To assess feasibility, we calculated the mean number of sessions completed, first across all participants and then excluding immediate dropouts (those completing zero exercises). Next, we examined differences in frequency of exercise completion across treatment conditions for each of the three group comparisons (e.g., booster vs. no booster) using a full factorial model (main effects and all two- and three-way interactions) using effect coding with values of $-\frac{1}{2}$ and $\frac{1}{2}$ for each intervention. For acceptability, we calculated the means and SDs of the ease and utility scores. To examine the immediate impact of the intervention on optimism and positive affect, we assessed changes in pre-post 0-10 Likert scale ratings using generalized estimating equation models with an exchangeable working correlation structure. This analytic approach allowed us to account for intra-individual variability. *A priori*, we set 70% completion of assigned exercises, ratings of 7.0/10 on ease/utility scales, and significant ($p <$

05) pre-post improvements on happiness and optimism as benchmarks for feasibility, acceptability, and immediate impact. For the overall pre-post impact of the intervention (all conditions) at 16 weeks, we utilized the time coefficient from the random effects regression model used for all self-report outcomes (see Aim #3), and calculated the pre-post effect size (ES; Cohen's *d*) on our outcome measures (self-reported adherence (MOS), including the single exercise item, and psychological outcomes). For all aims, the ES was calculated by dividing the main effect coefficient of each variable at each time point by the SD of the residual in the regression model. We also observed the magnitude of the ES for each outcome as compared to those seen in participants randomized to the treatment as usual (TAU) condition in our prior trial in post-ACS patients (26), allowing us to assess whether the intervention appeared to impact outcomes above and beyond the natural history of post-ACS recovery.

Aim #2: Between-group comparisons on MVPA—To compare the effect of the conditions on MVPA at 16 weeks, we used a random effects model with main effects and interactions for each intervention and for time, and intervention $\times$ time interactions, adjusting for pre-ACS physical activity via the PAR; we again utilized full factorial effect coding for the interventions. Comparisons ($n=64$ vs. $n=64$) were made between boosters and no boosters, PP alone and PP-MI, and weekly versus daily PP exercise assignment. Secondary analyses repeated the analyses excluding immediate dropouts and adjusting for cardiac rehabilitation enrollment during the 16-week period.

With $N=128$, the study would have been powered at 80% to detect a medium ES (Cohen's $d=.5$) between-group difference in MVPA using alpha of .05. Because all participants received an active PP-based intervention, we were aware that of significant differences may not be reached. We therefore also focused on ES differences for each comparison, given that even non-significant between-group differences could inform decisions about selecting intervention components.

Aim #3: Comparison of group differences in self-reported adherence and psychological outcomes—Group differences on change in self-reported adherence (the MOS summed items and physical activity item) and psychological measures (PANAS, LOT-R, HADS-A, and HADS-D) at 16 weeks were assessed using an analysis of response profiles model with full factorial effect coding for the interventions, a categorical effect of time, a time by intervention interaction, and an unstructured covariance matrix, including the baseline value of each outcome. For this analysis, a common baseline was assumed since subjects were randomized to group; β values reported are scale dependent and not standardized values. As for Aim #2, along with tests for significance across the three between-group comparisons, we calculated ES differences. Given the potential for dietary adherence assessment to be less reliable, we repeated our analyses for health behavior adherence including only items for medication adherence and physical activity.

Analyses were performed using Stata 14.2 (College Station, TX); all tests were two-tailed and alpha set at .05; if a Bonferroni correction were used given the three concurrent comparisons, alpha would be .0167.

Results

Baseline data

A total of 128 hospitalized patients were enrolled (see CONSORT diagram, Figure 1). Of these, 26 (20%) were immediate dropouts (zero exercises completed); follow-up data were obtained from 97 participants (76% of total participants and 87% [89/102] of those who were not immediate dropouts). Baseline sociodemographic, medical, and psychological characteristics are provided in Table 2. At baseline, 48 (38.1%) and 31 (24.6%) participants scored above the HADS-A and HADS-D cutoffs [>7] for possible clinically significant anxiety and depression, respectively. Participants were somewhat younger than ACS patients who were approached but did not enroll (66.3 years [SD 11.9]), and the cohort also had greater representation of women and minority participants (non-enrolling approached patients: 39% women, 21% minority).

Feasibility

Participants completed a mean of 5.14 (SD 3.33) of the 8 potential initial weekly sessions (64% of all possible sessions); excluding immediate dropouts, participants ($n=102$) completed a mean of 6.45 (SD 2.32) sessions (81% of all possible sessions). There were no significant between-group differences in the number of exercises completed across any of the three comparisons (boosters vs. non-boosters, PP-MI vs. PP-only, weekly vs. daily).

Acceptability and immediate impact

Participants' mean ratings (0-10 Likert scale) of PP exercise ease and utility were 7.88 (SD 2.2) and 7.92 (SD 2.2), respectively. There were significant improvements in positive affect (mean pre-exercise happiness 7.35 [SD 2.0], mean post-exercise improvement 0.86, $t=9.35$; $p<.001$) and optimism (mean pre-exercise optimism 7.73 [SD 1.9], mean improvement 0.44, $t=6.33$; $p<.001$) immediately following exercise completion.

For overall impact across all conditions, the PP-based intervention was associated with pre-post improvements in overall adherence (mean baseline score: 11.3 [out of 18], estimated mean week 16 score: 14.4; $z=11.7$; $p<.001$; $ES=1.27$), self-reported physical activity (MOS item; baseline: 2.52 [out of 6], week 16: 3.95; $z=8.0$; $p<.001$; $ES=.92$), depression (HADS-D; baseline: 4.84, week 16: 3.11; $z=-5.0$; $p<.001$; $ES=-.60$), anxiety (HADS-A; baseline: 7.01, week 16: 5.28; $z=-4.39$; $p<.001$; $ES=-.46$), positive affect (PANAS; baseline: 36.4, week 16: 40.3; $z=4.89$; $p<.001$; $ES=.59$), and optimism (LOT-R; baseline: 16.9, week 16: 18.4; $z=2.72$; $p=.006$; $ES=.25$). There were similar improvements between baseline and 8 weeks across all conditions. When compared to pre-post changes over the 8 week post-ACS period for patients receiving TAU in our prior trial, the PEACE-III PP intervention had greater improvements in health behavior adherence (MOS; ES difference=.24), positive affect (PANAS; ES difference=.29), anxiety (HADS-A; ES difference=.29), and depression (HADS-D; ES difference=.57), but not in LOT-R score or self-reported physical activity.

MVPA

For the main study aims related to the three concurrent group comparisons on MVPA (primary study outcome measure) and other outcomes at 16 weeks (Table 3), there was a

substantial, near-significant effect of booster sessions on MVPA ($p=.064$; $ES=.43$) and minimal effect of content (PP vs. PP-MI; $p=.82$; $ES=-.05$) or frequency of PP exercises (weekly vs. daily; $p=.95$; $ES=.02$). Secondary analyses were similar, with the effect of booster sessions on MVPA becoming statistically significant when adjusting for cardiac rehabilitation enrollment ($p=.005$; $ES=.80$) and when additionally excluding immediate dropouts ($p=.014$; $ES=.72$).

Health behavior adherence

Regarding the main secondary aim examining group differences in MOS score at 16 weeks (Table 3), there was a significant effect of MI content on MOS improvement ($p=.044$; $ES=.39$), and nonsignificant effects in favor of weekly exercises ($p=.48$; $ES=.14$) and booster sessions ($p=.20$; $ES=.25$). Secondary analyses were similar, with the MI condition effect on adherence remaining significant when adjusting for cardiac rehabilitation enrollment and excluding immediate dropouts. When excluding diet, we found the effects of MI and booster sessions to have continued but attenuated and non-significant associations with self-reported adherence (see Supplementary Table 4, Supplemental Digital Content 4). When analyzing only the MOS physical activity item (Supplementary Table 4), results favored the MI ($p=.19$; $ES=.27$), booster ($p=.22$; $ES=.25$), and weekly ($p=.84$; $ES=.04$) conditions, without reaching statistical significance.

For psychological outcomes, findings were generally mixed (Supplementary Table 4), with no condition showing significant superiority, including on secondary analyses, aside from weekly exercise assignment being associated with greater improvement in optimism when adjusting for cardiac rehabilitation ($p=.026$; $ES=.46$; excluding immediate dropouts $p=.038$; $ES=.44$).

For all study outcomes, we also examined all two-way and three-way interactions, and only one was significant: the combination of daily exercises without booster sessions led to fewer depressive symptoms at 16 weeks. Finally, there were no differences in serious adverse events by group. Pre-treatment and post-treatment means and SD of outcome data are displayed for all 8 conditions in Supplementary Table 5, Supplemental Digital Content 5.

Discussion

In sum, a phone-delivered, PP-based intervention was well-accepted in this cohort of recently hospitalized ACS patients. The intervention—across all conditions—was also associated with improvement in health behavior adherence and psychological outcomes in post-ACS patients. Furthermore, we found somewhat consistent between-condition differences on our main health behavior outcome measures, generally in favor of booster sessions, combined PP and MI content, and weekly PP exercise assignment.

Participants' reports of exercise ease, exercise utility, and pre-post improvements in well-being all reached or surpassed the trial's *a priori* benchmarks for acceptability. The intervention's feasibility was more mixed, with 20% of participants dropping out prior to completing any exercises. Immediately following hospitalization, some participants had ongoing cardiac issues complicating participation, and some had underestimated post-

hospitalization time demands. Our cohort may have been at elevated risk for dropout. Participants had suboptimal physical activity at baseline and were recruited in-hospital (with a corresponding risk of rapid readmission), and prior work has found that unplanned admissions (56) and low baseline physical activity among behavioral intervention study participants (57) have both been associated with elevated risk of early dropout. These factors suggest that, despite being a ‘teachable moment,’ hospitalization may not be the ideal time for intervention initiation, and waiting 1-2 weeks may allow more appropriate selection and participation. Of note, excluding immediate dropouts, participants completed over 80% of all possible sessions, and 87% provided follow-up data, suggesting that, once post-ACS participants engaged, the phone-delivered intervention was quite feasible.

The PP-based intervention, across all conditions, led to immediate improvement in positive affect and happiness, as well as sustained improvement in psychological well-being over 16 weeks. These findings are consistent with studies of PP-based interventions in other populations that found short-term (58) and sustained (20, 59) improvements in psychological health. The intervention was also associated with improvement in self-reported health behaviors; prior PP interventions have had more mixed effects on this outcome (22, 23, 60). The intervention also had a greater overall impact on psychological and behavioral outcomes at 8 weeks when compared to post-ACS patients receiving TAU over the same period in our prior work (26).

Regarding our primary study goals, we generally found that continuation of the intervention beyond 8 weeks (via booster sessions) was associated with greater physical activity. Though it may seem unsurprising that adding booster sessions may lead to greater improvement, the behavioral intervention literature has been somewhat mixed on the use of booster sessions (61, 62), necessitating a specific evaluation in this trial. We also found that adding an MI component to the intervention was associated with generally—though not universally—better outcomes. Though the effects of MI were surprisingly equivocal on MVPA, MI was superior for overall self-reported health behavior adherence. Though the MI intervention could have increased participant cognitive burden despite time matching of the PP and PP-MI interventions, frequency of intervention completion was not lower with MI.

This combination of PP and MI may be appealing, as MI alone has been associated with only small-moderate effects on physical activity in cardiac and related conditions (63). Furthermore, specific subgroups may be less likely to benefit from MI alone, such as those with low expectation of improvement or low overall optimism (64, 65) and a PP component could boost well-being and motivation to better prepare patients to make change via MI. An important next step would be to compare a PP-MI intervention to MI alone.

Finally, weekly PP exercise assignment appeared to be modestly more effective than daily exercise assignment, including on psychological measures. This is consistent with prior studies in non-medical populations finding that completing PP activities in a more clustered, intermittent manner is linked to greater improvement in well-being (66). Given that weekly exercise completion is less burdensome for patients, and was associated with generally equal or better impact on outcomes, weekly PP exercise assignment may be optimal for this intervention.

Overall, this dose-finding trial worked well within our multiphase optimization strategy. The goal of this factorial design trial was to efficiently and concurrently answer several questions about intervention content, duration, and intensity of this program within 128 post-ACS patients, and three separate trials of 128 patients would not have provided additional information. Factorial design experiments within a MOST framework have been used successfully to optimize behavioral interventions (24, 28), and we were likewise able to reach consensus on the optimal components of this program.

The strengths of this study included a reasonably diverse sample of nearly 30% minority participants and a nearly equal split between men and women, as well as inclusion of both objective and self-report measures of adherence. The trial also had several limitations, including the relatively high frequency of initial dropout, leading to lower power than originally planned, though follow-up data were available from the vast majority of the remaining population. The use of brief self-report to measure adherence, especially diet, using the MOS is an additional limitation given the brief nature of this scale, difficulty measuring diet in this manner, and relatively limited data on reliability and validity. In addition, this was not a formal efficacy trial, and though the pre-post improvements in adherence that were larger than seen in a prior post-ACS cohort receiving treatment as usual suggest that the intervention may have promise, such data is by no means definitive and a specific trial of the optimized intervention, compared to a relevant control condition, is required as a next step.

In conclusion, this factorial design trial allowed us to gather information about numerous aspects of intervention content and delivery. A next-step PP-based intervention in post-ACS patients would likely include MI, weekly PP exercises, and booster/continuation sessions to reinforce intervention content, and may best be initiated several weeks post-hospitalization. Ultimately, if this phone-delivered PP-based intervention can improve physical activity in post-ACS patients, this could substantially improve prognosis and have a substantial public health benefit.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Source of Funding

Funding: this research project was supported by the National Heart, Lung, and Blood Institute through grant R01HL113272 (to Dr. Huffman). Time for analysis and article preparation was also funded by the National Heart, Lung, and Blood Institute through grant K23HL123607 (to Dr. Celano). The content is solely the responsibility of the authors and does not represent the official views of the National Institutes of Health. The sponsor had no role in the design, analysis, interpretation, or publication of the study.

Acronyms

ACS	acute coronary syndrome
HADS	Hospital Anxiety and Depression Scale

LOT-R	Life Orientation Test-Revised
MI	motivational interviewing
MVPA	moderate to vigorous physical activity
PANAS	Positive and Negative Affect Schedule
PP	positive psychology
SD	standard deviation
TAU	treatment as usual
MOST	multiphase optimization strategy
PEACE	Positive Emotions after Acute Coronary Events study
MOS	Medical Outcomes Study Specific Adherence Scale
SMART goals	Specific, Measureable, Attainable, Relevant, and Time-based goals
PAR	7-day Physical Activity Recall Scale

References

1. Reed GW, Rossi JE, Cannon CP. Acute myocardial infarction. *Lancet*. 2017; 389:197–210. [PubMed: 27502078]
2. Chow CK, Jolly S, Rao-Melacini P, Fox KA, Anand SS, Yusuf S. Association of diet, exercise, and smoking modification with risk of early cardiovascular events after acute coronary syndromes. *Circulation*. 2010; 121:750–8. [PubMed: 20124123]
3. Twardella D, Merx H, Hahmann H, Wusten B, Rothenbacher D, Brenner H. Long term adherence to dietary recommendations after inpatient rehabilitation: prospective follow up study of patients with coronary heart disease. *Heart*. 2006; 92:635–40. [PubMed: 16159977]
4. Mathews R, Wang TY, Honeycutt E, Henry TD, Zettler M, Chang M, Fonarow GC, Peterson ED, Investigators T-AS. Persistence with secondary prevention medications after acute myocardial infarction: Insights from the TRANSLATE-ACS study. *Am Heart J*. 2015; 170:62–9. [PubMed: 26093865]
5. Kronish IM, Diaz KM, Goldsmith J, Moise N, Schwartz JE. Objectively Measured Adherence to Physical Activity Guidelines After Acute Coronary Syndrome. *J Am Coll Cardiol*. 2017; 69:1205–7. [PubMed: 28254185]
6. van Dalem J, Krass I, Aslani P. Interventions promoting adherence to cardiovascular medicines. *Int J Clin Pharm*. 2012; 34:295–311. [PubMed: 22271222]
7. Avery L, Flynn D, van Wersch A, Sniehotta FF, Trenell MI. Changing physical activity behavior in type 2 diabetes: a systematic review and meta-analysis of behavioral interventions. *Diabetes Care*. 2012; 35:2681–9. [PubMed: 23173137]
8. Freedland KE, Carney RM, Rich MW, Steinmeyer BC, Rubin EH. Cognitive Behavior Therapy for Depression and Self-Care in Heart Failure Patients: A Randomized Clinical Trial. *JAMA Intern Med*. 2015:1–10.
9. Freedland KE, Skala JA, Carney RM, Rubin EH, Lustman PJ, Davila-Roman VG, Steinmeyer BC, Hogue CW Jr. Treatment of depression after coronary artery bypass surgery: a randomized controlled trial. *Arch Gen Psychiatry*. 2009; 66:387–96. [PubMed: 19349308]
10. Berkman LF, Blumenthal J, Burg M, Carney RM, Catellier D, Cowan MJ, Czajkowski SM, DeBusk R, Hosking J, Jaffe A, Kaufmann PG, Mitchell P, Norman J, Powell LH, Raczynski JM,

- Schneiderman N. Effects of treating depression and low perceived social support on clinical events after myocardial infarction: the Enhancing Recovery in Coronary Heart Disease Patients (ENRICH) Randomized Trial. *J Am Med Assoc.* 2003; 289:3106–16.
11. Gulliksson M, Burell G, Vessby B, Lundin L, Toss H, Svardsudd K. Randomized controlled trial of cognitive behavioral therapy vs standard treatment to prevent recurrent cardiovascular events in patients with coronary heart disease: Secondary Prevention in Uppsala Primary Health Care project (SUPRIM). *Arch Intern Med.* 2011; 171:134–40. [PubMed: 21263103]
 12. Rollman BL, Belnap BH, LeMenager MS, Mazumdar S, Schulberg HC, Reynolds CF 3rd. The Bypassing the Blues treatment protocol: stepped collaborative care for treating post-CABG depression. *Psychosom Med.* 2009; 71:217–30. [PubMed: 19188529]
 13. Huffman JC, Mastromauro CA, Beach SR, Celano CM, DuBois CM, Healy BC, Suarez L, Rollman BL, Januzzi JL. Collaborative care for depression and anxiety disorders in patients with recent cardiac events: the Management of Sadness and Anxiety in Cardiology (MOSAIC) randomized clinical trial. *JAMA Intern Med.* 2014; 174:927–35. [PubMed: 24733277]
 14. Lichtman JH, Froelicher ES, Blumenthal JA, Carney RM, Doering LV, Frasure-Smith N, Freedland KE, Jaffe AS, Leifheit-Limson EC, Sheps DS, Vaccarino V, Wulsin L. 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; 129:1350–69. [PubMed: 24566200]
 15. DuBois CM, Lopez OV, Beale EE, Healy BC, Boehm JK, Huffman JC. Relationships between positive psychological constructs and health outcomes in patients with cardiovascular disease: a systematic review. *Int J Cardiol.* 2015; 195:265–80. [PubMed: 26048390]
 16. DuBois CM, Beach SR, Kashdan TB, Nyer MB, Park ER, Celano CM, Huffman JC. Positive psychological attributes and cardiac outcomes: associations, mechanisms, and interventions. *Psychosomatics.* 2012; 53:303–18. [PubMed: 22748749]
 17. Sin NL, Moskowitz JT, Whooley MA. Positive Affect and Health Behaviors Across 5 Years in Patients With Coronary Heart Disease: The Heart and Soul Study. *Psychosom Med.* 2015; 77:1058–66. [PubMed: 26428445]
 18. Tindle HA, Chang YF, Kuller LH, Manson JE, Robinson JG, Rosal MC, Siegle GJ, Matthews KA. Optimism, cynical hostility, and incident coronary heart disease and mortality in the Women's Health Initiative. *Circulation.* 2009; 120:656–62. [PubMed: 19667234]
 19. Chida Y, Steptoe A. Positive psychological well-being and mortality: a quantitative review of prospective observational studies. *Psychosom Med.* 2008; 70:741–56. [PubMed: 18725425]
 20. Seligman ME, Steen TA, Park N, Peterson C. Positive psychology progress: empirical validation of interventions. *Am Psychol.* 2005; 60:410–21. [PubMed: 16045394]
 21. Bolier L, Haverman M, Westerhof GJ, Riper H, Smit F, Bohlmeijer E. Positive psychology interventions: a meta-analysis of randomized controlled studies. *BMC Public Health.* 2013; 13:119. [PubMed: 23390882]
 22. Ogedegbe GO, Boutin-Foster C, Wells MT, Allegrante JP, Isen AM, Jobe JB, Charlson ME. A randomized controlled trial of positive-affect intervention and medication adherence in hypertensive African Americans. *Arch Intern Med.* 2012; 172:322–6. [PubMed: 22269592]
 23. Peterson JC, Charlson ME, Hoffman Z, Wells MT, Wong SC, Hollenberg JP, Jobe JB, Boschert KA, Isen AM, Allegrante JP. A randomized controlled trial of positive-affect induction to promote physical activity after percutaneous coronary intervention. *Arch Intern Med.* 2012; 172:329–36. [PubMed: 22269589]
 24. Collins LM, Murphy SA, Nair VN, Strecher VJ. A strategy for optimizing and evaluating behavioral interventions. *Ann Behav Med.* 2005; 30:65–73. [PubMed: 16097907]
 25. Huffman JC, DuBois CM, Mastromauro CA, Moore SV, Suarez L, Park ER. Positive psychological states and health behaviors in acute coronary syndrome patients: A qualitative study. *J Health Psychol.* 2016; 21:1026–36. [PubMed: 25114026]
 26. Huffman JC, Millstein RA, Mastromauro CA, Moore SV, Celano CM, Bedoya CA, Suarez L, Boehm JK, Januzzi JL. A positive psychology intervention for patients with an acute coronary syndrome: treatment development and proof-of-concept trial. *J Happiness Stud.* 2016; 17:1985–2006. [PubMed: 28082831]

27. Huffman JC, Albanese AM, Campbell KA, Celano CM, Millstein RA, Mastromauro CA, Healy BC, Chung WJ, Januzzi JL, Collins LM, Park ER. The Positive Emotions after Acute Coronary Events behavioral health intervention: Design, rationale, and preliminary feasibility of a factorial design study. *Clin Trials*. 2017; 14:128–39. [PubMed: 28079394]
28. Collins LM, Trail JB, Kugler KC, Baker TB, Piper ME, Mermelstein RJ. Evaluating individual intervention components: making decisions based on the results of a factorial screening experiment. *Transl Behav Med*. 2014; 4:238–51. [PubMed: 25264464]
29. Thygesen K, Alpert JS, Jaffe AS, Simoons ML, Chaitman BR, Wagner DR. Third universal definition of myocardial infarction. *J Am Coll Cardiol*. 2012; 60:1581–98. [PubMed: 22958960]
30. Ruo B, Rumsfeld JS, Hlatky MA, Liu H, Browner WS, Whooley MA. Depressive symptoms and health-related quality of life: the Heart and Soul Study. *J Am Med Assoc*. 2003; 290:215–21.
31. DiMatteo MR, Hays RD, Sherbourne CD. Adherence to cancer regimens: implications for treating the older patient. *Oncology*. 1992; 6:50–7. [PubMed: 1532737]
32. Callahan CM, Unverzagt FW, Hui SL, Perkins AJ, Hendrie HC. Six-item screener to identify cognitive impairment among potential subjects for clinical research. *Med Care*. 2002; 40:771–81. [PubMed: 12218768]
33. Robb SL, Burns DS, Docherty SL, Haase JE. Ensuring treatment fidelity in a multi-site behavioral intervention study: implementing NIH Behavior Change Consortium recommendations in the SMART trial. *Psychooncology*. 2011; 20:1193–201. [PubMed: 22012943]
34. Aune D, Norat T, Leitzmann M, Tonstad S, Vatten LJ. Physical activity and the risk of type 2 diabetes: a systematic review and dose-response meta-analysis. *Eur J Epidemiol*. 2015; 30:529–42. [PubMed: 26092138]
35. Sallis JF, Haskell WL, Wood PD, Fortmann SP, Rogers T, Blair SN, Paffenbarger RS. Physical activity assessment methodology in the Five-City Project. *Am J Epidemiol*. 1985; 121:91–106. [PubMed: 3964995]
36. Cain, KL., Geremia, CM. Accelerometer data collection and scoring manual for adult & senior studies. San Diego, CA: San Diego State University; Jun, 2017 Accessed at: <http://sallis.ucsd.edu/measures.html>
37. Ziegelstein RC, Fauerbach JA, Stevens SS, Romanelli J, Richter DP, Bush DE. Patients with depression are less likely to follow recommendations to reduce cardiac risk during recovery from a myocardial infarction. *Arch Intern Med*. 2000; 160:1818–23. [PubMed: 10871976]
38. Huffman JC, Beale EE, Celano CM, Beach SR, Belcher AM, Moore SV, Suarez L, Motiwala SR, Gandhi PU, Gaggin HK, Januzzi JL. Effects of optimism and gratitude on physical activity, biomarkers, and readmissions after an acute coronary syndrome: the Gratitude Research in Acute Coronary Events study. *Circ Cardiovasc Qual Outcomes*. 2016; 9:55–63. [PubMed: 26646818]
39. Hays RD, Kravitz RL, Mazel RM, Sherbourne CD, DiMatteo MR, Rogers WH, Greenfield S. The impact of patient adherence on health outcomes for patients with chronic disease in the Medical Outcomes Study. *J Behav Med*. 1994; 17:347–60. [PubMed: 7966257]
40. Sherbourne CD, Hays RD, Ordway L, DiMatteo MR, Kravitz RL. Antecedents of adherence to medical recommendations: results from the Medical Outcomes Study. *J Behav Med*. 1992; 15:447–68. [PubMed: 1447757]
41. Marti CN, Georgiopolou VV, Giamouzis G, Cole RT, Deka A, Tang WH, Dunbar SB, Smith AL, Kalogeropoulos AP, Butler J. Patient-reported selective adherence to heart failure self-care recommendations: a prospective cohort study: the Atlanta Cardiomyopathy Consortium. *Congest Heart Fail*. 2013; 19:16–24. [PubMed: 22958604]
42. Adjoian TK, Firestone MJ, Eisenhower D, Yi SS. Validation of self-rated overall diet quality by Healthy Eating Index-2010 score among New York City adults, 2013. *Preventive medicine reports*. 2016; 3:127–31. [PubMed: 26844200]
43. Loftfield E, Yi S, Immerwahr S, Eisenhower D. Construct validity of a single-item, self-rated question of diet quality. *J Nutr Educ Behav*. 2015; 47:181–7. [PubMed: 25449828]
44. DiMatteo MR, Sherbourne CD, Hays RD, Ordway L, Kravitz RL, McGlynn EA, Kaplan S, Rogers WH. Physicians' characteristics influence patients' adherence to medical treatment: results from the Medical Outcomes Study. *Health Psychol*. 1993; 12:93–102. [PubMed: 8500445]

45. Cade J, Thompson R, Burley V, Warm D. Development, validation and utilisation of food-frequency questionnaires - a review. *Public Health Nutr.* 2002; 5:567–87. [PubMed: 12186666]
46. Willett, W., editor. *Nutritional epidemiology*. 3rd. New York: Oxford University Press; 2013.
47. Parr CL, Veierod MB, Laake P, Lund E, Hjartaker A. Test-retest reproducibility of a food frequency questionnaire (FFQ) and estimated effects on disease risk in the Norwegian Women and Cancer Study (NOWAC). *Nutrition journal.* 2006; 5:4. [PubMed: 16448553]
48. Kravitz RL, Hays RD, Sherbourne CD, DiMatteo MR, Rogers WH, Ordway L, Greenfield S. Recall of recommendations and adherence to advice among patients with chronic medical conditions. *Arch Intern Med.* 1993; 153:1869–78. [PubMed: 8250648]
49. 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; 54:1063–70. [PubMed: 3397865]
50. Ronaldson A, Molloy GJ, Wikman A, Poole L, Kaski JC, Steptoe A. Optimism and recovery after acute coronary syndrome: a clinical cohort study. *Psychosom Med.* 2015; 77:311–8. [PubMed: 25738438]
51. Glaesmer H, Rief W, Martin A, Mewes R, Brahler E, Zenger M, Hinze A. Psychometric properties and population-based norms of the Life Orientation Test Revised (LOT-R). *Br J Health Psychol.* 2012; 17:432–45. [PubMed: 22106985]
52. Scheier MF, Carver CS, Bridges MW. Distinguishing optimism from neuroticism (and trait anxiety, self-mastery, and self-esteem): a reevaluation of the Life Orientation Test. *J Pers Soc Psychol.* 1994; 67:1063–78. [PubMed: 7815302]
53. Bjelland I, Dahl AA, Haug TT, Neckelmann D. The validity of the hospital anxiety and depression scale. An updated literature review. *J Psychosom Res.* 2002; 52:69–77. [PubMed: 11832252]
54. Moher D, Hopewell S, Schulz KF, Montori V, Gotzsche PC, Devereaux PJ, Elbourne D, Egger M, Altman DG. CONSORT 2010 explanation and elaboration: updated guidelines for reporting parallel group randomised trials. *BMJ.* 2010; 340:c869. [PubMed: 20332511]
55. Altman DG, Dore CJ. Randomisation and baseline comparisons in clinical trials. *Lancet.* 1990; 335:149–53. [PubMed: 1967441]
56. Brunetto AT, Ang JE, Olmos D, Tan D, Barriuso J, Arkenau HT, Yap TA, Molife LR, Banerji U, de Bono J, Judson I, Kaye S. A study of the pattern of hospital admissions in a specialist Phase I oncology trials unit: unplanned admissions as an early indicator of patient attrition. *Eur J Cancer.* 2010; 46:2739–45. [PubMed: 20667711]
57. Thompson TP, Greaves CJ, Ayres R, Aveyard P, Warren FC, Byng R, Taylor RS, Campbell JL, Ussher M, Michie S, West R, Taylor AH. Factors associated with study attrition in a pilot randomised controlled trial to explore the role of exercise-assisted reduction to stop (EARS) smoking in disadvantaged groups. *Trials.* 2016; 17:524. [PubMed: 27788686]
58. Huffman JC, DuBois CM, Healy BC, Boehm JK, Kashdan TB, Celano CM, Denninger JW, Lyubomirsky S. Feasibility and utility of positive psychology exercises for suicidal inpatients. *Gen Hosp Psychiatry.* 2014; 36:88–94. [PubMed: 24230461]
59. Moskowitz JT, Carrico AW, Duncan LG, Cohn MA, Cheung EO, Batchelder A, Martinez L, Segawa E, Acree M, Folkman S. Randomized controlled trial of a positive affect intervention for people newly diagnosed with HIV. *J Consult Clin Psychol.* 2017; 85:409–23. [PubMed: 28333512]
60. Cohn MA, Pietrucha ME, Saslow LR, Hult JR, Moskowitz JT. An online positive affect skills intervention reduces depression in adults with type 2 diabetes. *J Posit Psychol.* 2014; 9:523–34. [PubMed: 25214877]
61. Ashby WA, Wilson GT. Behavior therapy for obesity: booster sessions and long-term maintenance of weight loss. *Behav Res Ther.* 1977; 15:451–63. [PubMed: 414734]
62. Fleig L, Pomp S, Schwarzer R, Lippke S. Promoting exercise maintenance: how interventions with booster sessions improve long-term rehabilitation outcomes. *Rehabil Psychol.* 2013; 58:323–33. [PubMed: 24041250]
63. Lundahl B, Moleni T, Burke BL, Butters R, Tollefson D, Butler C, Rollnick S. Motivational interviewing in medical care settings: a systematic review and meta-analysis of randomized controlled trials. *Patient Educ Couns.* 2013; 93:157–68. [PubMed: 24001658]

64. Goossens ME, Vlaeyen JW, Hidding A, Kole-Snijders A, Evers SM. Treatment expectancy affects the outcome of cognitive-behavioral interventions in chronic pain. *Clin J Pain*. 2005; 21:18–26. [PubMed: 15599128]
65. Scheier MF, Helgeson VS, Schulz R, Colvin S, Berga SL, Knapp J, Gerszten K. Moderators of interventions designed to enhance physical and psychological functioning among younger women with early-stage breast cancer. *J Clin Oncol*. 2007; 25:5710–4. [PubMed: 17998547]
66. Lyubomirsky S, Layous K. How do simple positive activities increase well-being? *Curr Dir Psychol Sci*. 2013; 22:57–62.

Figure 1.
CONSORT diagram of recruitment and study flow

Table 1

Study conditions in the PEACE-III factorial trial.

<i>Condition</i>	<i>Program Content</i>	<i>PP Exercise Frequency</i>	<i>Booster Sessions</i>
1	PP only	Weekly	No
2	PP only	Daily	No
3	PP + MI	Weekly	No
4	PP + MI	Daily	No
5	PP only	Weekly	Yes
6	PP only	Daily	Yes
7	PP + MI	Weekly	Yes
8	PP + MI	Daily	Yes

MI=motivational interviewing; PP=positive psychology

Table 2

Baseline characteristics of participants.

Characteristic	Total (N=128)	Group 1 (PP alone/ wkly/no booster)	Group 2 (PP alone/ daily/no booster)	Group 3 (PP-MI/ wkly/no booster)	Group 4 (PP-MI/ daily/no booster)	Group 5 (PP alone/ wkly/ booster)	Group 6 (PP alone/ daily/ booster)	Group 7 (PP-MI/ wkly/ booster)	Group 8 (PP-MI/ daily/ booster)
<i>Sociodemographic characteristics</i>									
Age; mean (SD)	63.1 (12.0)	63.3 (14.4)	62.2 (13.4)	63.5 (12.9)	65.5 (8.9)	63.7 (8.9)	62.2 (11.9)	59.4 (11.1)	65.7 (14.7)
Female sex	76 (59)	13 (81)	9 (56)	8 (50)	12 (71)	6 (40)	10 (59)	8 (47)	10 (71)
White race	94 (73)	11 (69)	12 (75)	12 (75)	14 (82)	8 (53)	12 (71)	14 (82)	11 (79)
Married	70 (55)	7 (44)	8 (50)	10 (63)	10 (59)	7 (47)	8 (47)	10 (59)	10 (71)
Lives alone	36 (29)	4 (27)	5 (31)	3 (19)	6 (35)	5 (33)	4 (25)	4 (24)	5 (36)
<i>Medical characteristics</i>									
Admission diagnosis of MI	75 (59)	10 (63)	12 (75)	10 (63)	10 (59)	7 (47)	8 (47)	10 (59)	8 (57)
Length of hospitalization (d); mean (SD)	3.2 (2.7)	3.6 (3.4)	3.8 (2.6)	2.8 (2.1)	4.3 (4.9)	2.9 (1.8)	2.6 (1.1)	2.5 (1.9)	3.0 (1.5)
BMI	30.0 (6.2)	29.8 (8.4)	28.7 (4.6)	28.7 (5.0)	28.4 (5.8)	30.0 (5.0)	31.5 (6.9)	31.0 (7.6)	31.9 (4.8)
Type 2 diabetes	35 (27)	3 (19)	1 (6)	5 (31)	9 (53)	4 (27)	2 (12)	5 (29)	6 (43)
Current smoker	18 (14)	1 (6)	2 (13)	1 (6)	3 (18)	2 (13)	3 (18)	4 (24)	2 (14)
Hypertension	112 (88)	13 (81)	12 (75)	15 (94)	16 (94)	15 (100)	16 (94)	13 (76)	12 (86)
Hyperlipidemia	103 (80)	13 (81)	13 (81)	12 (75)	12 (71)	15 (100)	11 (65)	15 (88)	12 (86)
Prior ACS	42 (33)	5 (31)	8 (50)	4 (25)	4 (24)	8 (53)	3 (18)	5 (29)	5 (36)
Peak troponin T (ng/ml); mean (SD)	1.3 (2.8)	0.2 (0.2)	1.4 (2.4)	2.7 (4.4)	1.2 (3.0)	1.2 (2.4)	1.3 (3.4)	1.7 (2.7)	0.5 (1.1)
LVEF (%); mean (SD)	57 (12)	57 (11)	57 (14)	57 (13)	58 (18)	59 (11)	55 (9)	56 (10)	60 (9)
Antidepressant treatment at discharge	27 (21)	3 (19)	3 (19)	4 (25)	5 (29)	3 (20)	1 (6)	5 (29)	3 (21)
Anxiolytic treatment at discharge	19 (15)	4 (25)	1 (6)	2 (13)	1 (6)	0 (0)	3 (18)	3 (18)	5 (36)
<i>Baseline self-report outcome measures (measure; range); all listed as mean (SD)</i>									
Positive affect (PANAS;10-50)	36.4 (7.5)	37.4 (6.6)	36.4 (8.4)	36.3 (7.3)	39.1 (6.1)	34.5 (6.4)	35.5 (9.4)	34.9 (7.7)	36.9 (8.6)
Optimism (LOT-R; 0-24)	22.9 (5.8)	23.3 (6.6)	22.6 (6.4)	23.9 (6.8)	23.1 (5.1)	23.7 (4.8)	22.4 (6.2)	22.1 (5.8)	22.5 (5.3)
Anxiety (HADS-A; 0-21)	7.0 (4.6)	8.0 (4.4)	6.9 (5.5)	5.7 (5.4)	6.4 (4.6)	6.9 (4.3)	7.5 (4.7)	6.6 (4.3)	8.2 (3.6)
Depression (HADS-D; 0-21)	4.8 (3.8)	5.3 (4.5)	5.8 (5.3)	4.6 (3.3)	4.6 (3.9)	4.7 (3.6)	4.9 (3.8)	4.5 (2.7)	4.3 (3.1)

Characteristic	Total (N=128)	Group 1 (PP alone/ wkly/no booster)	Group 2 (PP alone/ daily/no booster)	Group 3 (PP-MI/ wkly/no booster)	Group 4 (PP-MI/ daily/no booster)	Group 5 (PP alone/ wkly/ booster)	Group 6 (PP alone/ daily/ booster)	Group 7 (PP-MI/ wkly/ booster)	Group 8 (PP-MI/ daily/ booster)
Adherence (MOS; 3-18)	11.3 (2.5)	11.1 (2.8)	11.6 (2.2)	11.3 (2.7)	11.9 (3.4)	11.3 (2.3)	10.9 (2.8)	11.1 (1.9)	10.9 (1.9)

BMI=body mass index; HADS=Hospital Anxiety and Depression Scale; LOT-R=Life Orientation Test-Revised; LVEF=left Ventricular ejection fraction; MI= myocardial infarction; MOS=Medical Outcomes Study specific adherence scale; PANAS=Positive And Negative Affect Schedule. **All variables are presented as *n* (%) unless specified.**

Between-group comparisons using random effects models for each component on outcome variables at 16 weeks.

Table 3

Outcome	Motivational Interviewing				Booster Sessions				Weekly Exercises			
	β	95% CI	ES	p	β	95% CI	ES	p	β	95% CI	ES	p
Primary planned analyses												
Including cardiac rehabilitation participation as a covariable												
MVPA	-1.07	-10.15, 8.01	-.05	.82	8.58	-0.49, 17.65	.43	.064	0.30	-8.77, 9.36	.02	.95
Adherence (MOS)	0.95	0.02, 1.87	.39	.044	0.60	-0.33, 1.52	.25	.20	0.34	-0.59, 1.26	.14	.48
Including cardiac rehabilitation, excluding immediate dropouts (n=26)												
MVPA	-2.36	-12.02, 7.29	-.14	.63	13.53	4.02, 23.04	.80	.005	-1.13	-10.80, 8.55	-.07	.82
Adherence (MOS)	0.89	-.01, 1.78	.40	.052	0.72	-0.17, 1.61	.32	.12	0.15	-0.74, 1.05	.07	.74
Including cardiac rehabilitation, excluding immediate dropouts (n=26)												
MVPA	-1.75	-10.80, 7.31	.11	.71	11.19	2.25, 20.13	.72	.014	-3.36	-12.4, 5.71	-.22	.47
Adherence (MOS)	1.01	0.11, 1.90	.46	.027	0.83	-0.06, 1.73	.38	.068	0.18	-0.72, 1.07	.08	.70

MOS= Medical Outcomes Study specific adherence scale; MVPA=moderate to vigorous physical activity.