Effects of Optimism and Gratitude on Physical Activity, Biomarkers, and Readmissions After an Acute Coronary Syndrome

The Gratitude Research in Acute Coronary Events Study

Jeff C. Huffman, MD; Eleanor E. Beale, BA; Christopher M. Celano, MD; Scott R. Beach, MD; Arianna M. Belcher, BS; Shannon V. Moore, BA; Laura Suarez, MD; Shweta R. Motiwala, MD; Parul U. Gandhi, MD; Hanna K. Gaggin, MD; James L. Januzzi, MD

Background—Positive psychological constructs, such as optimism, are associated with beneficial health outcomes. However, no study has separately examined the effects of multiple positive psychological constructs on behavioral, biological, and clinical outcomes after an acute coronary syndrome (ACS). Accordingly, we aimed to investigate associations of baseline optimism and gratitude with subsequent physical activity, prognostic biomarkers, and cardiac rehospitalizations in post-ACS patients.

Methods and Results—Participants were enrolled during admission for ACS and underwent assessments at baseline (2 weeks post-ACS) and follow-up (6 months later). Associations between baseline positive psychological constructs and subsequent physical activity/biomarkers were analyzed using multivariable linear regression. Associations between baseline positive constructs and 6-month rehospitalizations were assessed via multivariable Cox regression. Overall, 164 participants enrolled and completed the baseline 2-week assessments. Baseline optimism was significantly associated with greater physical activity at 6 months (n=153; β=102.5; 95% confidence interval, 13.6–191.5; P=0.024), controlling for baseline activity and sociodemographic, medical, and negative psychological covariates. Baseline optimism was also associated with lower rates of cardiac readmissions at 6 months (n=164), controlling for age, sex, and medical comorbidity (hazard ratio, 0.92; 95% confidence interval, [0.86–0.98]; P=0.006). There were no significant relationships between optimism and biomarkers. Gratitude was minimally associated with post-ACS outcomes.

Conclusions—Post-ACS optimism, but not gratitude, was prospectively and independently associated with superior physical activity and fewer cardiac readmissions. Whether interventions that target optimism can successfully increase optimism or improve cardiovascular outcomes in post-ACS patients is not yet known, but can be tested in future studies.

Clinical Trial Registration—URL: http://www.clinicaltrials.gov. Unique identifier: NCT01709669.

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Key Words: acute coronary syndrome ▪ comorbidity ▪ confidence intervals ▪ exercise ▪ myocardial infarction ▪ optimism

Over 2.5 million persons worldwide are hospitalized each year for an acute coronary syndrome (ACS; myocardial infarction or unstable angina). Among post-ACS patients, ≈20% will be rehospitalized for ischemic heart disease or suffer mortality within the next year. It is therefore critical to identify factors that may protect against adverse events and improve prognosis during the high-risk post-ACS period.

Positive psychological factors (eg, positive affect and optimism) may have a beneficial impact on cardiac prognosis. Syntheses of the literature have found that positive psychological well-being is associated with superior cardiac health and reduced mortality in patients with medical illness, independent of traditional cardiac risk factors and negative psychological conditions (eg, depression).

Among these positive psychological factors, optimism (a general expectation that the future will be favorable) may be most strongly associated with superior medical outcomes in those with and without known heart disease, with longitudinal studies and a comprehensive meta-analysis finding links between optimism and superior cardiac prognosis. In addition, gratitude (a disposition toward appreciating and being thankful for people, events, and experiences in one’s life) is a common and often powerful experience after an ACS, with approximately one-half of patients reporting increased gratitude in the post-ACS period. The effects of gratitude on...
post-ACS recovery are worthy of investigation given its prevalence and the beneficial effects of other positive psychological constructs on cardiac health.

Previous studies suggest that psychological well-being may affect cardiac prognosis through superior adherence to key cardiac health behaviors, especially physical activity, that are associated with reduced rates of recurrent events and death after ACS. In addition, some studies have shown positive psychological well-being to be associated with lower levels of circulating biomarkers associated with cardiac mortality, such as inflammatory markers and lipid levels. However, critical gaps in the literature exist. First, there has been minimal study of the prospective impact of positive psychological constructs in post-ACS patients, despite the ongoing need to identify factors that affect prognosis in this high-risk population. Second, despite the potential importance of gratitude, there has been no previous study of the association of gratitude with clinical outcomes.

Third, relatively few studies exploring positive psychological constructs and health outcomes have examined >1 positive psychological construct in post-ACS patients, despite the ongoing need to identify factors that affect prognosis in this high-risk population. Second, despite the potential importance of gratitude, there has been no previous study of the association of gratitude with clinical outcomes. Third, relatively few studies exploring positive psychological constructs and health outcomes have examined >1 positive psychological construct in post-ACS patients, despite the ongoing need to identify factors that affect prognosis in this high-risk population. Second, despite the potential importance of gratitude, there has been no previous study of the association of gratitude with clinical outcomes. Third, relatively few studies exploring positive psychological constructs and health outcomes have examined >1 positive psychological construct in post-ACS patients, despite the ongoing need to identify factors that affect prognosis in this high-risk population. Second, despite the potential importance of gratitude, there has been no previous study of the association of gratitude with clinical outcomes. Third, relatively few studies exploring positive psychological constructs and health outcomes have examined >1 positive psychological construct in post-ACS patients, despite the ongoing need to identify factors that affect prognosis in this high-risk population.

Accordingly, in the Gratitude Research in Acute Coronary Events (GRACE) study, we examined the prospective effects of optimism and gratitude, measured 2 weeks post-ACS, on: (1) subsequent physical activity, (2) levels of inflammatory and other prognostic biomarkers, and (3) rates of cardiac readmission, during the next 6 months. We hypothesized that both optimism and gratitude would be associated with superior outcomes in all 3 domains, independent of multiple relevant covariates.
Gratitude was measured using the Gratitude Questionnaire-6 (GQ-6),
27 a brief, validated, 6-item measure of dispositional gratitude, with
good internal consistency in this cohort (α = 0.84).

Negative Psychological Variables
Depression and anxiety were measured to control for these vari-
able in our analyses. We assessed depression using the Patient
Health Questionnaire-9 (PHQ-9),
23 a 9-item scale inquiring about
the frequency of the 9 symptoms of major depression in the previ-
ous 2 weeks; the PHQ-9 has good sensitivity and specificity for ma-
dor depression in patients with heart disease.
29 For anxiety, we used
the 7-item Hospital Anxiety and Depression Scale anxiety subscale
(HADS-A).
30 This scale is designed for the use with medically ill
patients and has been used in studies of cardiac patients.
31 Internal
consistency of these measures was also high in this sample
(α = 0.82 and α = 0.85, respectively).

Physical Activity (Aim No. 1; Primary Study Outcome)
Physical activity was chosen as the primary outcome measure be-
cause it is a key modifiable risk factor in patients with ACS,
11,32 and
previous studies have found that both dispositional optimism and in-
terventions targeting gratitude have been associated with increased
physical activity.
23 Population studies find that objective measures must be used to
accurately assess activity.
14 In this study, physical activity in steps
per day was measured using the Fitlinxx Pebble uniaxial accelerom-
eter (Fitlinxx, Shelton, CT). Similar to other published protocols for
measuring physical activity,
15 we considered 6 valid days of wear (8
confirmed hours of wear time per day) to be sufficient. If partici-
pants failed to achieve adequate step data collection, they rewore the
devices.
We selected the Fitlinxx devices for several reasons. In this pop-
ulation of hospitalized patients, we highly prioritized simple, non-
invasive measurement methods to encourage participation, and full
completion of the physical activity assessment protocol; the Pebble is
a small (half-dollar coin sized) device that fits noninvasively on belts
or shoes. We also prioritized accuracy, and found on our own testing
that step counts recorded with these devices matched manual step
counts better than other noninvasive devices. Although the Fitlinxx
devices are classified as accelerometers, they have been most often
validated and used to count steps rather than examine activity intel-
ligence or caloric expenditure,
16 and we therefore decided on mean steps
per day as the primary activity outcome variable.

To control for baseline physical activity preceding the ACS, the
7-day PAR was used to recall activity in the 7 symptom-free days
before admission. The PAR has good test–retest reliability and cor-
relates with activity measured by diary and accelerometer in med-
ically ill persons.
37 We chose to administer this measure in the hospital
given the level of detail required for this assessment; waiting until
the 2-week visit to obtain this information may have resulted in
less detailed or less accurate recollection of baseline activity before
hospitalization.

Biomarkers (Aim No. 2)
We collected prognostic biomarkers at 2 weeks and 6 months.
We focused primarily on circulating markers related to systemic
inflammation given that coronary heart disease is increasingly
understood as a disorder of inflammation
28 and that there are es-
tablished links between these markers and adverse prognosis in
cardiac patients.
24 We measured 4 commonly studied prognostic markers associated
with inflammation: high-sensitivity C-reactive protein, IL-6, tumor
necrosis factor-α (TNF-α), and soluble intracellular adhesion mol-
ecule-1 (sICAM-1); an endothelial adhesion molecule that mediates
pathways responsible for vascular inflammation.
We also measured N-terminal pro-B-type natriuretic peptide (NT-proBNP),
a marker associated with overall mortality risk after ACS.
29 Samples were
analyzed in batch by immunoassay kits, as per published methods,
via the MGH Research Core Laboratory (high-sensitivity C-reactive
protein and sICAM-1) and the Singulex Corporation (IL-6, TNF-α,
and NT-proBNP).

Rehospitalizations (Aim No. 3)
Our main readmissions outcome was nonelective cardiac readmis-
sions. Data on readmissions were triangulated from participants, care
providers, and health records to obtain the most complete informa-
tion about these medical events. Participants were queried about all
readmissions at the 6-month follow-up assessment, with data system-
atically gathered about timing of admission, symptoms, cause, and
treatment. Study staff also contacted patients’ primary medical or
cardiology providers at the end of the 6-month study period to in-
quire about readmissions and their cause, to assist in adjudication
of admission diagnosis and to identify additional admissions not identi-
fied by participants.

Finally, participants’ electronic medical records across the par-
ticipating hospital’s healthcare system (which includes 10 acute care
hospitals, several subacute settings, and numerous community health
centers throughout the hospital’s metropolitan area) were systemati-

cally reviewed during the 6-month follow-up timeframe. For admis-
sions outside this system, additional records were obtained to identify
principal diagnosis and other specific details, as required. All future
admissions that had been planned at the time of discharge from the
index admission (eg, readmission for sequential cardiac stent place-
ment in those with complex lesions) and any elective admissions
were excluded from the analysis. Determination of cardiac (versus
noncardiac) cause for readmissions was made based on all available
data, including principal diagnosis; when unclear, this determination
was adjudicated by study cardiologists.

We selected cardiac readmissions as the main outcome for this
aim given that hospitalized patients may have a variable burden of
other medical conditions for which they may be hospitalized and that
readmissions would be most relevant to understand the ef-
facts of optimism and gratitude on cardiac health. As an exploratory
outcome, we also collected data on nonelective all-cause admissions.

Statistical Analysis
Because the study examined the effects of 2-week psychological
status on subsequent outcomes, participants must have completed
2-week assessments to be included in study analyses. Descriptive sta-
tistics (eg, means, proportions, SDs) were used to characterize the
study population’s baseline sociodemographic and medical charac-
teristics, and their scores on baseline outcome measure assessments.

Aim No. 1 (Primary Aim): Association of Baseline
Optimism and Gratitude, Measured 2 Weeks Post-ACS, With
Physical Activity Measured by Accelerometer 6 Months
Later
We examined associations of baseline LOT-R (optimism) and GQ-6
(gratitude) scores with mean number of daily steps 6 months later,
via multivariable linear regression. To control for relevant covariates,
we used a hierarchical series of models with increasing covariates
and measures of ACS severity and history (peak troponin T and previous ACS),
and a measure of overall medi-
cal comorbidity (the Charlson comorbidity index
40). Finally, in the
fully adjusted model (model 3), we added measures of depression
and anxiety (PHQ-9 and HADS-A). For this outcome, in models 2
and 3 we also controlled for baseline physical activity using the 7-day
PAR. In all models, we used linear regression with bootstrap SEs
to account for any departures from normality of the residuals. For this
primary analysis, we also completed sensitivity analyses to assess for
significant differences in the effects of optimism/gratitude on out-
comes between men and women, and between White and non-White
participants.

Aim No. 2: Association of Baseline Optimism/Gratitude at
2 Weeks With Prognostic Cardiac Biomarkers at 6 Months
Later
We examined levels of each biomarker (high-sensitivity C-reactive
protein, IL-6, TNF-α, sICAM-1, and NT-proBNP) separately 6
months post baseline as the dependent variable. We performed

multivariable analyses using linear regression, with hierarchical adjustment for the 3 successive models as above. Given departures from normality in the distribution of biomarker values, the values were log-transformed, and bootstrap SEs were used to account for any residual non-normality. In secondary analyses, we completed identical analyses that also controlled for baseline levels of the biomarkers at 2 weeks within each model.

**Aim No. 3: Association of Baseline Optimism/Gratitude With Rehospitalizations During the Following 6 Months**

We performed time-to-event analyses to assess these associations. In preliminary analyses, we divided baseline LOT-R and GQ-6 scores at the median split and examined between-group differences in non-elective cardiac rehospitalizations using Kaplan–Meier curves and log-rank tests of significance. For our primary analyses, we used multivariable Cox regression to examine connections between continuous LOT-R and GQ-6 scores and rehospitalizations. We controlled for age and sex in the primary model; additional covariates were not included in the model because of the risk of overfitting based on the expected rate of rehospitalization (15%). However, in an exploratory model, we additionally controlled for overall medical burden/comorbidity (Charlson comorbidity index) given the substantial effects of comorbid conditions on post-ACS readmission rates.41 We then repeated all analyses for all-cause (non-elective) rehospitalizations as an outcome variable.

All analyses were performed using Stata statistical software (PC version 11.2, StataCorp, College Station, TX). For our initial enrollment goal of 150 participants, assuming follow-up data from 85% of subjects (consistent with our similar previous studies31,42), and an estimated moderate effect size (P=0.3) of positive psychological constructs on activity (univariate), the study was powered at 94% to detect a significant association between both positive psychological constructs and physical activity in steps. All tests were 2-tailed. Statistical significance was set at P<0.05 for all aims, although a conservative correction for multiple comparisons in the aim no. 2 biomarker analyses using a Bonferroni correction would have set the P value for significance at <0.01.

**Results**

Figure 1 presents the study flow diagram for GRACE. Among 212 patients who were enrolled in-hospital, 164 successfully completed the 2-week baseline visit. Rehospitalization data at 6 months were available from all 164 participants; adequate physical activity data were collected from 153 participants (93%) at 6 months, and biomarker data were collected from 152 participants (92%).

Baseline sociodemographic characteristics, medical variables, psychiatric status, and baseline study outcome variables are listed in Table 1. Overall, the mean age of subjects was 61.5 (SD, 10.5) years, 84% were men, and 84% were White. This was the first ACS for 58% of participants. These baseline variables are also displayed, split by median baseline gratitude (GQ-6) and optimism (LOT-R) scores, in Table I in the Data Supplement.

With respect to baseline psychological variables (2-week visit), participants had a mean LOT-R score of 17.7 (SD, 5.6), higher than general population norms for this age group (14.8 [SD, 3.4]),27 and a mean GQ-6 score of 36.5 (SD, 5.8), consistent with published norms (36.9 [SD, 4.9]).27 Depression (PHQ-9: mean score, 4.4 [SD, 4.5]) and anxiety (HADS-A: mean score, 4.3 [SD, 4.0]) scores were below established cutoffs for clinically significant depression (PHQ-9≥10) or anxiety (HADS-A≥8), and were slightly lower than mean values in other cardiac populations (PHQ-9=4.8; HADS-A=6.8).44,45

![Figure 1. Study recruitment and enrollment. ACS indicates acute coronary syndrome.](http://circoutcomes.ahajournals.org/)

**Aim No. 1: Physical Activity**

See Tables 2 and 3 for physical activity outcomes data. Baseline optimism (LOT-R) was associated with an increased number of steps when controlling for age and sex (model 1: β=94.4; 95% confidence interval [CI, 26.5–162.2]; P=0.006), when additionally controlling for social and medical variables including pre-ACS physical activity (model 2: β=99.3; 95% CI, 32.6–166.0; P=0.004), and in the fully adjusted model that included depression and anxiety (model 3: β=102.5; 95% CI, 13.6–191.5; P=0.024). In contrast, baseline gratitude (GQ-6) was not associated with physical activity (P>0.10) in any of the models. There were no significant differences in the associations between the positive psychological constructs and steps between men and women, or between White and non-White participants (P>0.05 for all analyses).

**Aim No. 2: Biomarkers**

Adjusting for age and sex, baseline optimism was associated with high-sensitivity C-reactive protein 6 months post baseline (β=−0.04; 95% CI, −0.08 to −0.007; P=0.020), although the association became marginal when controlling for social and medical variables (β=−0.03; 95% CI, −0.07 to 0.003; P=0.075) and when depression and anxiety were added to the
Baseline optimism was associated with TNF-α, controlling for age and sex ($\beta=-0.012$; 95% CI, −0.022 to −0.002; $P=0.019$), and when additionally controlling for social and medical variables ($\beta=-0.012$; 95% CI, −0.021 to −0.003; $P=0.009$); this association became nonsignificant when depression and anxiety were added. Baseline gratitude was associated with TNF-α in all 3 models (fully adjusted model: $\beta=-0.009; 95\%$ CI, −0.018 to −0.0004; $P=0.039$). There were no associations between positive psychological constructs and IL-6 or NT-proBNP, and no significant associations when 2-week biomarker levels were added to the model (Table III in the Data Supplement).

**Aim No. 3: Rehospitalizations**

During the 6-month follow-up period, 35 (21.3%) patients had a readmission for any cause, and 28 (17.1%) had a nonelective cardiac readmission (Tables 2 and 3). On preliminary time-to-event analysis using a median split (LOT-R $\leq$19 versus $\geq$22), baseline optimism was marginally associated with nonelective cardiac readmissions during the following 6 months (Kaplan–Meier Curve, Figure 2; log-rank test, $\chi^2=3.31; P=0.069$). On main analysis via Cox regression, baseline optimism was associated with fewer nonelective cardiac readmissions (hazard ratio, 0.92; 95% CI, 0.86–0.97; $P=0.005$), controlling for age and sex. On exploratory analysis including medical comorbidity (Charlson comorbidity index) in the model, optimism remained associated with nonelective cardiac readmissions (hazard ratio,0.92; 95% CI, 0.86–0.98; $P=0.006$).

About all-cause readmissions, baseline optimism was not associated with nonelective readmissions during 6 months on preliminary analysis (Figure II in the Data Supplement; log-rank test, $\chi^2=1.22; P=0.27$). However, on Cox regression, baseline optimism was associated with fewer nonelective readmissions controlling for age and sex (hazard ratio, 0.94; 95% CI, 0.89–0.997; $P=0.040$), and when including the Charlson comorbidity index (hazard ratio, 0.94; 95% CI, 0.89–0.998; $P=0.043$). Gratitude was not associated with rehospitalizations using median split (GQ-6≤37 versus ≥38; Figures III and IV in the Data Supplement) or continuous GQ-6 scores.

**Discussion**

This was the first study to concurrently examine the effects of multiple positive psychological constructs on outcomes in patients with ACS, a population at substantial risk for poor health, rehospitalizations, and mortality. It was also the first to examine the prospective effects of these positive constructs on health behaviors, prognostic biomarkers, and clinical outcomes within the same study to explore possible mechanisms by which these constructs may confer benefit.

We found that optimism, measured 2 weeks after ACS, was associated with greater physical activity in mean steps per day at 6 months, controlling for pre-ACS physical activity and numerous baseline demographic and medical factors. The relationship between optimism and physical activity also held when controlling for depression and anxiety, suggesting a unique effect of positive psychological well-being on post-ACS physical activity. CIs for physical activity were wide, given the substantial variability in number of mean steps taken by participants.
These results are consistent with previous studies finding optimism to be associated with increased levels of activity, although many of these previous studies were cross-sectional in nature or used nonclinical populations, and none had objectively measured activity. To our knowledge, only 1 previous study assessed optimism and physical activity after an ACS. In a well-designed observational study by Ronaldson et al., post-ACS optimism measured by the LOT-R was associated with several cardiac health behaviors but not with post-ACS physical activity at 12 months. However, physical activity in that study was measured solely by self-report. Our finding that higher optimism predicts greater increases in objectively measured activity has substantial clinical relevance given that increasing physical activity after an ACS is associated with fewer recurrent events and lower rates of death.

In contrast, optimism was not strongly associated with inflammatory biomarkers or NT-proBNP at 6 months. In previous work, relationships between positive psychological variables and biomarkers have generally been less consistent than connections of these variables to health behaviors, and this was true in our study population. This suggests that benefits from positive psychological states may be more related to behavior than to a direct decrease in systemic inflammation or other circulating markers, at least in the early post-ACS period. Whether a longer follow-up period would have revealed more robust associations between optimism and biomarkers remains unclear.

Finally, and of note, optimism at 2 weeks was associated with reduced rates of nonelective cardiac readmissions at 6 months, independent of age, sex, and (on exploratory analysis) medical comorbidity, with each point on the LOT-R associated with an 8% reduction in risk of rehospitalization. These findings also held for all-cause readmissions, although this relationship was largely driven by rates of cardiac readmission. Given the high rates of cardiac readmissions in post-ACS patients, this finding may have substantial clinical relevance. Prevention of early readmissions is a major initiative across Western healthcare systems to improve patient outcomes and reduce costs, and optimism may be 1 patient-level factor associated with reduced readmissions.

In contrast to the effects of optimism, baseline gratitude was not associated with behavioral, biological, or clinical outcomes in this cohort, aside from an association with 6-month TNF-α. This finding suggests that not all positive psychological constructs necessarily have the same effect on medical and behavioral outcomes and that it is important to examine specific psychological constructs within the field of psychological well-being. In patients with ACS, gratitude, with an inward positive focus on past and current events, may have had a lesser effect on future orientation and subsequent behavior compared with optimism, which is by its nature future focused. Our findings are consistent with qualitative research in patients with ACS finding that, although optimism and gratitude are both common after ACS, only optimism is

Table 2. Associations Between Baseline Optimism/Gratitude and 6-Month Physical Activity

<table>
<thead>
<tr>
<th>Two-Wk Predictor Variables</th>
<th>Optimism (LOT-R)</th>
<th>Gratitude (GQ-6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outcome</td>
<td>β</td>
<td>CI</td>
</tr>
<tr>
<td>Physical activity in mean</td>
<td></td>
<td></td>
</tr>
<tr>
<td>steps/d (primary study</td>
<td></td>
<td></td>
</tr>
<tr>
<td>outcome)</td>
<td>94.4*</td>
<td>26.5 to 162.2</td>
</tr>
<tr>
<td>2</td>
<td>99.3*</td>
<td>32.6 to 166.0</td>
</tr>
<tr>
<td>3</td>
<td>102.5†</td>
<td>13.6 to 191.5</td>
</tr>
</tbody>
</table>

Model 1: controlling for age and sex. Model 2: controlling for model 1 covariates plus living alone, previous acute coronary syndrome, peak troponin T, and Charlson comorbidity index. Model 3: controlling for model 2 covariates plus depression and anxiety. β indicates regression coefficient; CI, confidence interval; GQ-6, Gratitude Questionnaire-6; and LOT-R, Life Orientation Test-Revised.

*P<0.01, †P<0.05.

Table 3. Associations Between Baseline Optimism/Gratitude and Rehospitalizations, Showing Measures of Effect

<table>
<thead>
<tr>
<th>Two-Wk Predictor Variables</th>
<th>Optimism (LOT-R)</th>
<th>Gratitude (GQ-6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outcome</td>
<td>HR</td>
<td>CI</td>
</tr>
<tr>
<td>Cardiac</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0.92*</td>
<td>0.86 to 0.97</td>
</tr>
<tr>
<td></td>
<td>0.92*</td>
<td>0.86 to 0.98</td>
</tr>
<tr>
<td>All-cause</td>
<td>0.94†</td>
<td>0.89 to 1.0</td>
</tr>
<tr>
<td></td>
<td>0.94†</td>
<td>0.89 to 1.0</td>
</tr>
</tbody>
</table>

Model 1 (exploratory): controlling for age and sex. Exploratory model (readmissions): controlling for age, sex, and Charlson comorbidity index. β indicates regression coefficient; CI, confidence interval; GQ-6, Gratitude Questionnaire-6; HR, hazard ratio; and LOT-R, Life Orientation Test-Revised.

*P<0.01, †P<0.05.
associated with initiation of physical activity and other health behaviors.38

Why might optimism, but not gratitude, affect health outcomes? First, optimism focuses on future expectations. Given that our outcomes were focused on events that happened post assessment (eg, whether participants became more active), believing that one’s future (and future health) were likely to improve may have played a substantial role in their motivation and confidence to make change. In contrast, gratitude is largely a current- or past-focused construct, in which people experience well-being by taking stock of their immediate and previous experiences. Second, optimism in many cases can be a more action-based cognition—a sense that one can do something to reach a goal, which may promote beneficial changes in health behavior. Thoughts or expressions of gratitude may be less directly linked to making behavioral changes.

This observational study had several important limitations. It occurred at a single academic site and enrolled a preponderance of White men, potentially limiting generalizability; the lack of significant differences in outcomes by sex and race may have been because of limited power given the relatively small number of women and non-White participants. To address this issue, we considered limiting recruitment of White men mid-study. However, after review, we concluded that having a greater number of total participants—thus increasing the power to detect significant relationships between positive psychological constructs and outcomes—was the greatest priority for this initial trial. Approximately 20% of initially enrolling participants did not provide baseline data, typically because of intervening medical issues before the 2-week baseline visit, although >90% of those who provided baseline data completed all components of the 6-month assessments. We measured steps per day rather than activity intensity, and although step counts correlate well with overall observed activity,49 more comprehensive activity assessment devices are available. We also did not obtain objective follow-up data on other health behaviors. Finally, the 6-month period for assessing readmissions, while representing a critical high-risk period, was relatively short and limited analytic power.

Despite these limitations, this study suggests a distinct contribution of optimism to increased physical activity and readmission reduction during the critical post-ACS period. The effects of optimism on physical activity were above and beyond the adverse effects of depression and anxiety, and were in contrast to gratitude, which was not linked to outcomes. These findings suggest that optimism, if measured shortly after an ACS, could be used as a novel predictor of reduced physical activity or readmissions. Our findings probably also apply to other conditions, such as hypertension or type 2 diabetes mellitus, for which increasing physical activity and other health behaviors may be critical in slowing disease progression or reducing mortality. These findings are also relevant to the prevention of chronic illnesses, given the benefits of physical activity in preventing a wide range of conditions. Furthermore, key questions remain: is it possible to promote optimism in patients with cardiovascular illness, and will such interventions result in improvement in clinical outcomes? A pair of randomized trials in hypertension and heart disease found a positive affect–based program to be associated with superior improvements in physical activity and other health behaviors.39,50 Future studies are required to determine whether similar programs are effective in patients with ACS and whether they can modify prognosis.

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Disclosures
None.

References


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Data Supplement (unedited) at:
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## Supplemental Table 1. Baseline sociodemographic and clinical characteristics (N=164) in the GRACE study, organized by low or high optimism or gratitude

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>GQ-6 &lt; 38 ( (n=77) )</th>
<th>GQ-6 ≥ 38 ( (n=87) )</th>
<th>LOT-R &lt; 26 ( (n=85) )</th>
<th>LOT-R ≥ 26 ( (n=79) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographics and psychosocial characteristics</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (mean [SD])</td>
<td>60.3 (10.5)</td>
<td>62.6 (10.5)</td>
<td>60.3 (10.5)</td>
<td>62.8 (10.6)</td>
</tr>
<tr>
<td>Male sex</td>
<td>69 (90)\dagger</td>
<td>68 (78)\dagger</td>
<td>73 (86)</td>
<td>64 (81)</td>
</tr>
<tr>
<td>White</td>
<td>65 (84)</td>
<td>72 (83)</td>
<td>71 (84)</td>
<td>66 (77)</td>
</tr>
<tr>
<td>Married</td>
<td>53 (69)</td>
<td>60 (69)</td>
<td>55 (65)</td>
<td>58 (70)</td>
</tr>
<tr>
<td>Living alone</td>
<td>21 (27)</td>
<td>17 (20)</td>
<td>27 (32)</td>
<td>11 (14)\dagger</td>
</tr>
<tr>
<td>Medical history</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Body mass index (mean [SD])</td>
<td>29.1 (5.8)</td>
<td>28.7 (4.7)</td>
<td>28.9 (5.4)</td>
<td>28.9 (5.1)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>42 (55)\dagger</td>
<td>61 (70)\dagger</td>
<td>51 (60)</td>
<td>52 (66)</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>19 (25)</td>
<td>15 (17)</td>
<td>19 (22)</td>
<td>15 (19)</td>
</tr>
<tr>
<td>Hyperlipidemia</td>
<td>61 (79)</td>
<td>71 (82)</td>
<td>68 (80)</td>
<td>64 (81)</td>
</tr>
<tr>
<td>Current smoking</td>
<td>16 (21)\dagger</td>
<td>5 (6)\dagger</td>
<td>15 (18)</td>
<td>6 (8)</td>
</tr>
<tr>
<td>Prior acute coronary syndrome</td>
<td>31 (40)</td>
<td>38 (44)</td>
<td>41 (48)</td>
<td>28 (35)</td>
</tr>
<tr>
<td>Admission diagnosis of myocardial infarction</td>
<td>44 (57)</td>
<td>44 (51)</td>
<td>45 (53)</td>
<td>43 (54)</td>
</tr>
<tr>
<td>Length of stay (days; mean [SD])</td>
<td>3.2 (2.6)</td>
<td>2.9 (1.8)</td>
<td>3.0 (2.1)</td>
<td>3.1 (2.4)</td>
</tr>
<tr>
<td>Troponin T</td>
<td>1.8 (4.4)</td>
<td>1.2 (2.4)</td>
<td>1.4 (4.0)</td>
<td>1.5 (2.9)</td>
</tr>
<tr>
<td>Charlson Index (age adjusted)</td>
<td>3.2 (1.4)</td>
<td>3.5 (1.7)</td>
<td>3.2 (1.6)</td>
<td>3.5 (1.5)</td>
</tr>
<tr>
<td>Medications at discharge</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aspirin</td>
<td>73 (95)</td>
<td>86 (99)</td>
<td>83 (98)</td>
<td>76 (96)</td>
</tr>
<tr>
<td>Beta blocker</td>
<td>64 (83)</td>
<td>80 (92)</td>
<td>75 (88)</td>
<td>69 (87)</td>
</tr>
<tr>
<td>Angiotensin converting enzyme inhibitor/Angiotensin receptor blocker</td>
<td>37 (48)</td>
<td>53 (61)</td>
<td>45 (53)</td>
<td>45 (57)</td>
</tr>
<tr>
<td>Antiplatelet agents</td>
<td>59 (77)</td>
<td>68 (78)</td>
<td>66 (78)</td>
<td>61 (77)</td>
</tr>
<tr>
<td>Statin</td>
<td>72 (94)</td>
<td>81 (93)</td>
<td>81 (95)</td>
<td>72 (91)</td>
</tr>
<tr>
<td>Antidepressant</td>
<td>14 (18)</td>
<td>13 (15)</td>
<td>19 (22)\dagger</td>
<td>8 (10)\dagger</td>
</tr>
<tr>
<td>Anxiolytic</td>
<td>7 (9)</td>
<td>9 (10)</td>
<td>12 (14)</td>
<td>4 (5)</td>
</tr>
<tr>
<td>Self-report measures at baseline 2-week visit (mean [SD])</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Life Orientation Test-Revised (optimism; range: 0-24)</td>
<td>15.0 (5.8)\dagger</td>
<td>20.1 (4.1)\dagger</td>
<td>13.5 (4.6)\dagger</td>
<td>22.3 (1.5)\dagger</td>
</tr>
<tr>
<td>Gratitude Questionnaire-6 (gratitude; range: 6 - 42)</td>
<td>32.3 (5.9)\dagger</td>
<td>40.3 (1.6)\dagger</td>
<td>34.0 (6.7)\dagger</td>
<td>39.3 (2.9)\dagger</td>
</tr>
<tr>
<td>Patient Health Questionnaire-9 (depression; range: 0-27)</td>
<td>5.3 (5.4)\dagger</td>
<td>3.3 (3.1)\dagger</td>
<td>6.0 (5.1)\dagger</td>
<td>2.4 (2.5)\dagger</td>
</tr>
<tr>
<td>Hospital Anxiety and Depression Scale-Anxiety subscale (anxiety; range: 0-21)</td>
<td>5.2 (4.5)\dagger</td>
<td>3.6 (3.4)\dagger</td>
<td>5.8 (4.5)\dagger</td>
<td>2.8 (2.6)\dagger</td>
</tr>
<tr>
<td>Metabolic equivalents/day (Physical Activity Recall)</td>
<td>38.0 (9.9)</td>
<td>36.1 (7.0)</td>
<td>38.0 (10.9)</td>
<td>35.9 (4.5)</td>
</tr>
<tr>
<td>Biomarker levels at baseline 2-week visit (mean [SD])</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C-reactive protein</td>
<td>6.0 (10.5)</td>
<td>4.3 (8.0)</td>
<td>5.5 (9.5)</td>
<td>4.7 (9.1)</td>
</tr>
<tr>
<td>Interleukin-6</td>
<td>3.8 (3.5)</td>
<td>3.6 (4.7)</td>
<td>3.8 (3.4)</td>
<td>3.7 (4.9)</td>
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<tr>
<td>Soluble intercellular adhesion molecule-1</td>
<td>0.5 (0.1)</td>
<td>0.5 (0.2)</td>
<td>0.5 (0.1)</td>
<td>0.5 (0.2)</td>
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<tr>
<td>N-terminal pro-B-type natriuretic peptide</td>
<td>183 (244)</td>
<td>124 (124)</td>
<td>164 (223)</td>
<td>138 (150)</td>
</tr>
</tbody>
</table>

*All figures are N (%) unless otherwise specified. \dagger Significant \( p < .05 \) difference between groups.
Supplemental Table 2. Associations of 2-week optimism and gratitude with biomarkers at 6 months

<table>
<thead>
<tr>
<th>Biomarker (6 month)</th>
<th>Model</th>
<th>Two week predictor variables (log-transformed β)</th>
<th>Optimism (LOT-R)</th>
<th>Gratitude (GQ-6)</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>β</td>
<td>CI</td>
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<tr>
<td>hsCRP</td>
<td>1</td>
<td>-0.042†</td>
<td>-0.08, -0.01</td>
<td>-0.012</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>-0.033‡</td>
<td>-0.07, 0.003</td>
<td>-0.01</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>-0.04‡</td>
<td>-0.08, 0.003</td>
<td>-0.005</td>
</tr>
<tr>
<td>sICAM -1</td>
<td>1</td>
<td>-0.012†</td>
<td>-0.02, -0.002</td>
<td>-0.006</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>-0.009‡</td>
<td>-0.02, 0.001</td>
<td>-0.005</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>-0.007</td>
<td>-0.02, 0.003</td>
<td>-0.001</td>
</tr>
<tr>
<td>IL-6</td>
<td>1</td>
<td>-0.012</td>
<td>-0.03, 0.01</td>
<td>-0.001</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>-0.007</td>
<td>-0.03, 0.01</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>-0.004</td>
<td>-0.03, 0.02</td>
<td>0.005</td>
</tr>
<tr>
<td>TNF-α</td>
<td>1</td>
<td>-0.012†</td>
<td>-0.02, -0.002</td>
<td>-0.011*</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>-0.012*</td>
<td>-0.02, -0.003</td>
<td>-0.012*</td>
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<tr>
<td></td>
<td>3</td>
<td>-0.008</td>
<td>-0.02, 0.003</td>
<td>-0.009†</td>
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<tr>
<td>NT-proBNP</td>
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<td>-0.05, 0.01</td>
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<tr>
<td></td>
<td>2</td>
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<tr>
<td></td>
<td>3</td>
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<td>-0.04, 0.03</td>
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</table>

Model 1: controlling for age and gender

Model 2: controlling for Model 1 covariates plus living alone, prior acute coronary syndrome, peak troponin T, Charlson comorbidity index

Model 3: controlling for Model 2 covariates plus depression and anxiety

*p<.01, †p<.05, ‡p<.10
Supplemental Table 3. Associations of 2-week optimism and gratitude with biomarkers at 6 months, controlling for 2-week biomarker levels (log-transformed)

<table>
<thead>
<tr>
<th>Biomarker (6 month)</th>
<th>Model</th>
<th>Optimism (LOT-R)</th>
<th></th>
<th></th>
<th></th>
<th>Gratitude (GQ-6)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>β</td>
<td>CI</td>
<td>β</td>
<td>CI</td>
<td></td>
<td></td>
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<tr>
<td>hsCRP</td>
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<td>-.015</td>
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<td>.011</td>
<td>-0.02, 0.04</td>
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<tr>
<td></td>
<td>2</td>
<td>-.011</td>
<td>-0.04, 0.02</td>
<td>.009</td>
<td>-0.02, 0.04</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>-.021</td>
<td>-0.06, 0.02</td>
<td>.011</td>
<td>-0.02, 0.04</td>
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<tr>
<td>sICAM</td>
<td>1</td>
<td>-.008</td>
<td>-0.02, 0.001</td>
<td>-.003</td>
<td>-0.01, 0.01</td>
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</tr>
<tr>
<td></td>
<td>2</td>
<td>-.007</td>
<td>-0.02, 0.003</td>
<td>-.002</td>
<td>-0.01, 0.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>-.006</td>
<td>-0.02, 0.004</td>
<td>.002</td>
<td>-0.01, 0.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IL-6</td>
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<td>-.006</td>
<td>-0.02, 0.01</td>
<td>.003</td>
<td>-0.01, 0.02</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>-.001</td>
<td>-0.02, 0.02</td>
<td>.006</td>
<td>-0.01, 0.02</td>
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</tr>
<tr>
<td></td>
<td>3</td>
<td>-.001</td>
<td>-0.02, 0.02</td>
<td>.007</td>
<td>-0.01, 0.03</td>
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<td></td>
</tr>
<tr>
<td>TNF-α</td>
<td>1</td>
<td>-.006</td>
<td>-0.01, -0.0001</td>
<td>-.003</td>
<td>-0.01, 0.003</td>
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<tr>
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<td>-.005</td>
<td>-0.01, 0.001</td>
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</tr>
<tr>
<td></td>
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<td>-.006</td>
<td>-0.02, 0.003</td>
<td>-.003</td>
<td>-0.01, 0.004</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NT-proBNP</td>
<td>1</td>
<td>-.005</td>
<td>-0.02, 0.02</td>
<td>.006</td>
<td>-0.01, 0.02</td>
<td></td>
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<tr>
<td></td>
<td>2</td>
<td>.004</td>
<td>-0.02, 0.02</td>
<td>.004</td>
<td>-0.01, 0.02</td>
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<td>3</td>
<td>-.004</td>
<td>-0.03, 0.02</td>
<td>-.003</td>
<td>-0.02, 0.01</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Model 1: controlling for age, gender, and baseline biomarker level (log-transformed)

Model 2: controlling for Model 1 covariates plus living alone, prior acute coronary syndrome, peak troponin T, Charlson comorbidity index

Model 3: controlling for Model 2 covariates plus depression and anxiety

‡ p<.10
Supplemental Figure 1. Timeline of study assessments

GQ-6=Gratitude Questionnaire Six Item Form; HADS-A=Hospital Anxiety and Depression Scale—Anxiety Subscale; LOT-R=Life Orientation Test-Revised; PAR=Physical activity recall; PHQ-9=Patient Health Questionnaire-9.
Supplemental Figure 2. Time to all-cause non-elective readmissions, split by baseline optimism (LOT-R ≤19 vs ≥20)
Supplemental Figure 3. Time to non-elective cardiac readmission, split by baseline gratitude (GQ-6≤37 vs ≥38)

*chi-square=2.20; P=.14
Supplemental Figure 4. Time to non-elective all-cause readmission split by baseline gratitude (GQ-6 ≤37 vs ≥38)