Title
Effects of induced optimism on subjective states, physical activity, and stress reactivity

Journal
The Journal of Positive Psychology, 18(4)

ISSN
1743-9760

Authors
Chen, Ruijia
del Rosario, Kareena
Lockman, Alee
et al.

Publication Date
2023-07-04

DOI
10.1080/17439760.2022.2070529

The Journal of Positive Psychology

Dedicated to furthering research and promoting good practice

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/rpos20

Effects of induced optimism on subjective states, physical activity, and stress reactivity

Ruijia Chen, Kareena del Rosario, Alee Lockman, Julia Boehm, Kelb Bousquet-Santos, Erika Siegel, Wendy Berry Mendes & Laura D. Kubzansky

To cite this article: Ruijia Chen, Kareena del Rosario, Alee Lockman, Julia Boehm, Kelb Bousquet-Santos, Erika Siegel, Wendy Berry Mendes & Laura D. Kubzansky (2022): Effects of induced optimism on subjective states, physical activity, and stress reactivity, The Journal of Positive Psychology, DOI: 10.1080/17439760.2022.2070529

To link to this article: https://doi.org/10.1080/17439760.2022.2070529

THE JOURNAL OF POSITIVE PSYCHOLOGY
https://doi.org/10.1080/17439760.2022.2070529

Effects of induced optimism on subjective states, physical activity, and stress reactivity

Ruijia Chen[a], Kareena del Rosario[b], Alee Lockman[c], Julia Boehm[d], Kelb Bousquet-Santos[e], Erika Siegel[f], Wendy Berry Mendes[f] and Laura D. Kubzansky[a]

[a]Department of Social and Behavioral Sciences, Harvard T.H. Chan School of Public Health, Boston, Massachusetts, USA; [b]Department of Psychology, New York University, New York, New York, USA; [c]Department of Health Policy and Management, Harvard T.H. Chan School of Public Health, Boston, Massachusetts, USA; [d]Department of Psychology, Chapman University, Orange, California, USA; [e]Department of Biological and Health Sciences, University of Brasilia, Brasília, Brazil; [f]Department of Psychiatry and Behavioral Sciences, University of California, San Francisco, California, USA

ABSTRACT
This study examined effects of experimentally-induced optimism on physical activity and stress reactivity with community volunteers. Using an intervention to induce short-term optimism, we conducted two harmonized randomized experiments, performed simultaneously at separate academic institutions. All participants were randomized to either the induced optimism intervention or to a neutral control activity using essay-writing tasks. Physical activity tasks (Study 1) and stress-related physiologic responses (Study 2) were assessed during lab visits. Essays were coded for intensity of optimism. A total of 324 participants (207 women, 117 men) completed Study 1, and 118 participants (67 women, 47 men, 4 other) completed Study 2. In both studies, the optimism intervention led to greater increases in short-term optimism and positive affect relative to the control group. Although the intervention had limited effects on physical activity and stress reactivity, more optimistic language in the essays predicted increased physical activity and decreased stress reactivity.

ARTICLE HISTORY
Received 18 April 2021
Accepted 3 March 2022

KEYWORDS
Optimism; physical activity; stress reactivity; stress-buffering; physiologic responses

Introduction

Optimism is a key facet of positive psychological well-being that is associated with reduced morbidity and mortality, independent of psychological distress (Gawronski et al., 2016; Kim et al., 2017). Despite accumulating evidence regarding the relationship between optimism and health, underlying mechanisms remain unclear. Prior work has linked optimism with higher levels of physical activity and better physiological adjustment to stress exposure (Puig-Perez et al., 2015; Steptoe et al., 2006). Potential beneficial effects of optimism on physical activity and stress response may be partly a function of its regulatory component. Optimism reflects having confidence in the future, which in turn results in a greater likelihood of employing strategies for achieving one's goals, including effortful goal engagement, problem-focused coping with challenges, and goal-adjustment when goals become unattainable (Kubzansky et al., 2015; Peterson, 2000; Rasmussen et al., 2006). The ability to employ these strategies effectively and flexibly likely provides greater means with which to confront and manage life's challenges and to adopt more health-protective behaviors.

Despite increasing evidence of optimism's relationships with more physical activity and healthier physiological responses to stress, the vast majority of studies focusing on dispositional optimism and its associations with beneficial physical and physiological outcomes have been observational (Puig-Perez et al., 2015; Steptoe et al., 2006). As such, the direction of the effect is unclear, leaving open the question of whether optimism causally influences physical activity or physical activity increases optimism. Additionally, almost all previous studies have relied on self-reported optimism and positive affect which may be subject to social desirability and recall bias. Experimental research in which individuals are randomly assigned to an optimism intervention with targeted pathways related to improved health as outcomes – like physical activity and stress responses – is needed to establish the causal role of optimism in relation to these outcomes.

While most research has focused on trait-based optimism, a growing number of studies have considered whether optimism can be encouraged, cultivated or modified, and if health-related effects of more deliberately cultivated optimism are similar (Kluemper et al.,

CONTACT Ruijia Chen ruijia.chen@mail.harvard.edu
This article has been corrected with minor changes. These changes do not impact the academic content of the article.
Supplemental data for this article can be accessed online at https://doi.org/10.1080/17439760.2022.2070529

2009; Luthans & Youssef, 2007; Millstein et al., 2019; Peterson, 2000). A number of studies have used experimental methods to manipulate optimism, typically through interventions involving writing tasks (Malouff & Schutte, 2017; Meevissen et al., 2011). These interventions successfully increase optimism and other self-reported affective responses (e.g., positive affect) and decrease negative affect, depression, anxiety, and aggression, but a key outstanding question is whether these interventions can also sufficiently alter behavior and physiology in ways that explain downstream beneficial health effects. While some evidence suggests positive effects of these interventions, the generalizability of these effects to healthy community-dwelling adults is unclear. For example, many experimental studies to date have been conducted among patient populations with a recent disease diagnosis or acute event (Celano et al., 2018; Huffman et al., 2016) such individuals tend to be highly motivated to improve their health behaviors, willing to undergo relatively intensive intervention protocols, and also relatively unhealthy at the outset and therefore have substantial room to show improvement. Other studies testing short-term optimism manipulation strategies in non-patient populations also provide some evidence that writing task interventions could improve health and well-being; however, these have been conducted exclusively within student populations which may be more compliant than the general population (Burton & King, 2009; Jackowska et al., 2016). Therefore, a key outstanding question is whether optimism levels can be altered to subsequently lead to changes in downstream health-relevant processes like physical activity and stress reactivity within the general population.

The overall aim of this research was to examine the effects of an optimism intervention on physical activity (Study 1) and stress reactivity (Study 2) with community volunteers. We developed a short (1- or 2-week) intervention designed to induce optimism in the short-term and randomized participants either to the optimism intervention or an active control condition. The same intervention was used in both studies, and we harmonized the self-reported dependent variables. We assessed optimism and positive affect by self-reported measures and coder-rated assessments. We hypothesized that: 1) the intervention group relative to the control group would show increased self-reported optimism and positive affect, as well as decreased anxiety, depression, aggression, and negative affect; 2) in Study 1, the optimism intervention compared to the control group would show more engagement and persistence with physical activity tasks, as operationalized by a stepping task and a sit-stand task and self-reported exercise beliefs including perceived benefits and barriers of exercise as well as self-efficacy of exercising; 3) in Study 2, the optimism intervention compared to the control group would show healthier stress-related physiologic responses at rest and during an acute stressor; and 4) those who were rated as more optimistic would show more engagement and persistence in physical activity tasks and have better stress-related physiologic responses in the lab.

Methods

Overview

We conducted two harmonized experiments, performed simultaneously at two separate academic institutions. Each experiment employed a between-subjects design, with two conditions, whereby participants were randomized to either the optimism intervention or a neutral activity. Study 1's primary outcomes were engaging in physical activity, and Study 2's primary outcomes were acute physiologic responses. Informed consent was obtained from participants, and all procedures were approved by the Harvard T.H. Chan School of Public Health and the University of California, San Francisco Institutional Review Boards.

Participants

Study 1

Participants ages 22–60 years old were recruited through Craigslist, Student Employment Office websites at local universities, and flyers posted on community bulletin boards. Potential participants completed a telephone screening to determine their eligibility and willingness to adhere to the study protocol. Individuals with chronic diseases like heart disease, who were pregnant, had body mass index ≥30 kg/m^2, or had a current diagnosis of clinical depression or other major mental disorders were excluded.

As a goal of Study 1 was to assess whether optimism has beneficial effects on willingness to engage in physical activity, further exclusions included not being able to engage in physical activity or self-reporting regularly spending more than 60-minutes per week doing strenuous or moderate exercise. Additionally, participants were asked to refrain from eating for a half-hour and exercising for 2 hours prior to lab visits. Eligible individuals completed secure online consenting procedures through Qualtrics. Written consent for the in-lab portion of the study was obtained from participants during their lab visits.

Study 2

Participants ages 18–45 years old were recruited from the San Francisco Bay Area through on-site recruitment flyers and online Craigslist advertisements. Potential participants completed an online screening to assess their eligibility for participation. Exclusions were similar to those used in Study 1, except that exercise routines were not a reason for exclusion in Study 2. Participants were required to abstain from caffeine consumption, smoking, eating, and exercising four hours prior to the laboratory visit as these activities can alter resting physiologic responses. Eligible individuals completed consenting procedures before beginning the intervention tasks as well as upon arrival at the laboratory.

Procedures and materials

The protocol for both studies included three online writing tasks and one phone interview prior to a lab visit. In the lab, participants completed another writing task and one in-person interview. All the writing tasks and the lab study were conducted over one to two weeks (Figure 1). The four writing tasks for the intervention group included a values assessment, remembering past achieved goals, writing a gratitude letter, and imagining one's best possible self, all chosen based on prior literature suggesting such interventions may lead to greater optimism levels (Huffman et al., 2016, 2015; Meevissen et al., 2011). The control condition provided comparable demands for attention and writing but focused on neutral and less future-oriented activities. Prompts for the intervention condition writing tasks were identical in both studies; however, the first three prompts in the control condition were slightly modified for Study 2 (see supplemental online material (SOM)Table 1).

After completing the first three writing tasks online, participants of both studies were invited to come to the lab to complete the final part of the study. At the lab, participants completed a brief final screening to confirm accuracy of previously self-reported information, an imagery task, a fourth writing task, an in-person interview, and physical activity tasks (Study 1) or stress reactivity tasks (Study 2). For Study 1, participants were asked to engage in a stepping task and a sit-to-stand task. These physical activities have been used in the exercise literature as measures of physical fitness and are both safe and simple to learn in an in-lab setting (Ryhming, 1953; Strassmann et al., 2013). For all activities, duration of time spent in each activity and number of attempts were assessed. For study 2, participants were asked to complete a shortened Trier Social Stress Test (Kirschbaum & Hellhammer, 1994), during which participants delivered a 3-minute speech presenting their qualifications for a dream job to a panel of two evaluators while physiological stress responses were assessed (see supplemental online materials for details).

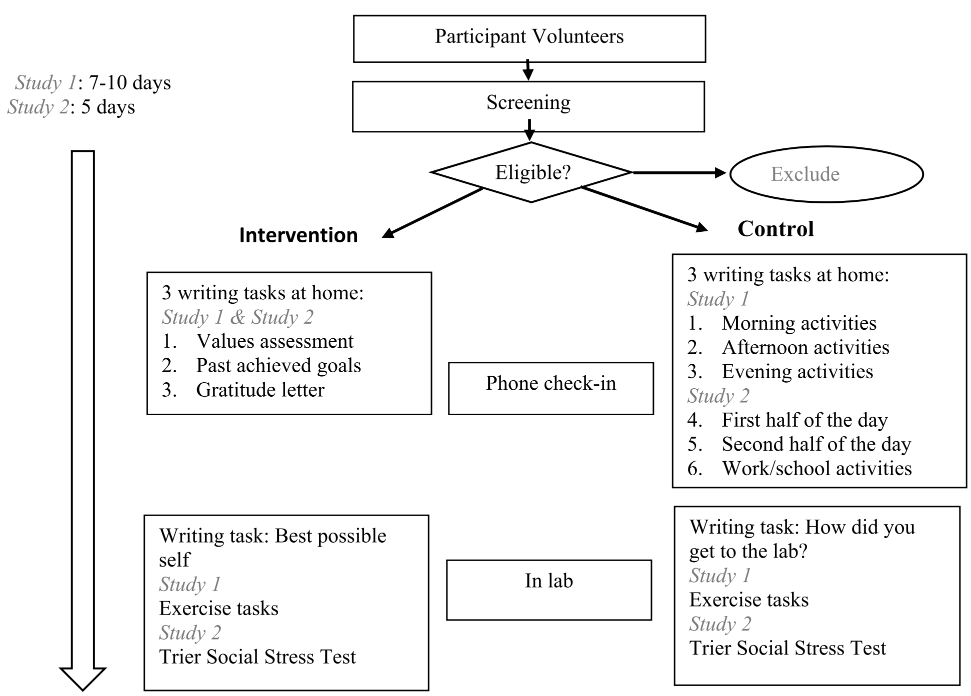

Figure 1. Study flow chart.

Table 1. Sample characteristics of study 1 and study 2.

	Study 1			Study 2		
	Intervention (N = 160)	Control (N = 164)	p	Intervention (N = 58)	Control (N = 60)	p
Age, Mean (SD)	30.40 (9.65)	29.37 (8.63)	.31	28.09 (6.3)	28.03 (6.1)	0.96
Gender, N (%)						
Male	56 (35.00)	61 (37.20)		23 (39.67)	24 (40.69)	
Female	104 (65.00)	103 (62.80)		34 (58.62)	32 (54.24)	
Other[a]	0	0	.68	1 (1.72)	3 (5.08)	0.58
Race/Ethnicity Status, N (%)						
Black/African American	19 (11.88)	17 (10.37)		4 (6.90)	6 (10.17)	
European American	64 (40.00)	65 (39.63)		21 (36.21)	24 (40.68)	
Hispanic/Latino	12 (7.45)	16 (9.76)		5 (8.62)	6 (10.17)	
Asian	59 (36.88)	54 (32.93)		18 (31.03)	17 (28.81)	
Other	6 (3.75)	12 (7.32)	.58	8 (13.79)	4 (6.78)	0.41
Income, N (%)						
Lower or equal to $39,999	100 (62.11)	86 (52.44)		28 (48.28)	26 (43.33)	
$40,000 to $79,999	37 (23.13)	52 (31.71)		17 (29.31)	17 (28.33)	
More than $80,000	22 (13.75)	25 (15.24)	.29	13 (22.41)	16 (25.67)	0.89
Employment, N (%)						
Working full-time	42 (26.25)	51 (31.10)		19 (32.76)	23 (38.98)	
Working part-time	18 (11.25)	15 (9.15)		10 (17.24)	14 (23.73)	
Not employed or currently looking for jobs	28 (17.50)	29 (17.68)		0	1(1.69)	
Full-time/part time student	70 (43.75)	69 (42.07)	.54	4 (6.90)	1(1.69)	0.22
Education, N (%)						
GED, high school or lower than high school	9 (5.63)	11 (6.71)		1(1.7)	5 (8.5)	
Some college or college degree	95 (59.38)	107 (65.24)		46 (79.31)	48 (80.0)	
Graduate school	56 (35.00)	46 (28.05)	.40	11 (18.97)	6(7.50)	0.12

Note. Chi-square analyses were conducted to compare differences in categorical variables between the intervention and the control group. T-tests were conducted to compare differences in continuous variables between the intervention and the control group.
[a]An 'other' option was not included in Study 1

Measures

Common measures: psychological well-being

Across both studies, we used the same measures obtained at the same intervals to assess subjective well-being. We replaced missing values with the mean of available items if ≤half of the items were missing, otherwise we treated the scale as missing (Bell, Fairclough, Fiero, & Butow, 2016).

State optimism, considered a manipulation check for the optimism intervention, was measured at baseline, mid-study, and post-intervention with seven items from the validated State Optimism Measure (Millstein et al., 2019). Participants were asked how they felt 'right now' on a scale of 0 to 10 regarding expectations for their present and the future. A total score was created by averaging scores across all seven items. In Study 1, α's ranged from 0.91–0.92 and, in Study 2, from 0.89–0.90.

Confidence about the future was assessed by asking participants to rate, on a ten-point scale ranging from 0 (worse) to 10 (well), how they believe the challenges in their lives right now will turn out.

Dispositional optimism refers to one's tendency to hold positive expectancies for their future (Scheier & Carver, 1985). It was measured at baseline and post-intervention using the validated Life Orientation Test Revised (LOT-R) (Scheier, Carver, & Bridges, 1994). Responses were modified to a seven-point continuum, ranging from 'strongly disagree' to 'strongly agree,' based on prior work suggesting the 7-point scale is more suited for electronically distributed questionnaires (Finstad, 2010). The total optimism score is the sum of the three positively worded items and the three negatively worded items reverse-scored, with higher scores reflecting higher optimism. In Study 1, α's ranged from 0.79–0.80 and, in Study 2, from 0.74–0.85.

Anxiety, depression, and aggression were assessed at baseline, mid-study, and post-intervention with items from the State-Trait Personality Inventory (STPI; e.g., I felt nervous; Spielberger, 1983). Using a seven-point scale, respondents rated the degree to which they agreed with each statement. The final anxiety, depression, and aggression scores were calculated by averaging across items, with higher scores reflecting higher levels of each construct. In Study 1, $\alpha_{anxiety}$ ranged from 0.83–0.87; $\alpha_{depression}$ was .84 at all time points; $\alpha_{aggression}$ ranged from 0.83–0.85. In Study 2, $\alpha_{anxiety}$ ranged from 0.83–0.86; $\alpha_{depression}$ ranged from .86 to .89; $\alpha_{aggression}$ ranged from 0.86–0.89.

Positive affect and negative affect were assessed at baseline, mid-study, and post-intervention by the Positive and Negative Schedule (PANAS), which included ten items capturing positive affect and ten items capturing negative affect (Watson et al., 1988). Response options ranged from 1 (strongly disagree) to 7 (strongly agree). Since some items from the PANAS and STPI are almost identical, we slightly modified the PANAS to avoid repeating similar questions. Separate subscales for positive and negative affect were derived by averaging across items. In Study 1, $\alpha_{positive}$ ranged from 0.89–0.90 and $\alpha_{negative}$ was 0.90 at all time points. In Study 2, participants completed the PANAS prior to, and on completion of, the stress task. Positive and negative affect subscales demonstrated high reliability at both time points: pre-stressor: $\alpha_{positive} = 0.89$; $\alpha_{negative} = 0.87$; post-stressor: $\alpha_{positive} = 0.91$; $\alpha_{negative} = 0.90$.

Study 1: exercise beliefs and physical activities

Perceived barriers and benefits to exercise were assessed at baseline and in lab by a subset of six items (7-point scale) from the validated Exercise Benefits/Barriers Scale (Sechrist et al., 1987). A separate score for perceived barriers and perceived benefits was derived by taking the mean of the relevant items ($\alpha_{barrier}$ = .57 to .59; $\alpha_{benefit}$ = .66 to .75). This measure was added after 94 participants had completed the protocol, so it is available only in a subset of participants. Despite the low Cronbach's alpha for the perceived barrier subscale, we considered it as initially derived to be consistent with prior literature. However, we also examined each item separately in analyses to assess if effects are similar across items within the subscale.

Exercise self-efficacy was measured at baseline and in lab by the validated Exercise Self-Efficacy Scale (Marcus et al., 1992), which assesses participants' degree of confidence about performing exercise during unfavorable circumstances. Responses ranged from 'not at all confident' to 'very confident' on an 11-point scale. A self-efficacy score was created by averaging across the items ($\alpha_{efficacy}$ = .73 to .74).

Stepping tasks. After completing the in-lab writing tasks and interview, participants were asked to complete a stepping task and a sit-to-stand task. For the stepping task, participants were asked to step up and down on a 14-inch high step platform at a rate of 22 steps per minute (generated by a metronome), until they were too fatigued to continue (Haas et al., 2017). Participants were asked to make as many attempts as they wanted for up to a total of 15 minutes. The research assistant recorded the duration of time participants spent stepping across all attempts, as well as the total number of attempts made. The final stepping task score was calculated by the duration divided by the number of attempts.

Sit-to-stand task. Participants were asked to perform a sit-to-stand exercise. This involved sitting in the middle of the chair and crossing their arms with each hand on the opposite shoulder and then completing sit-to-stand cycles at a rate of 22 cycles per minute. Participants were first asked to attempt this task for up to 60 seconds. If they decided to continue, the duration requested for each subsequent attempt increased by 30 seconds whereby the second attempt lasted up to 90 seconds and the third attempt lasted up to 120 seconds. As with the stepping task, the research assistant recorded the number of attempts and total duration completed. The sit-stand task score was created by dividing total duration by number of attempts.

Study 2: Stress Appraisals, Affect, and Physiological Measures

Stress appraisals were measured by assessing participants' perception of the demands and resources associated with the stress task (Berry Mendes et al., 2007). The nine-item appraisal measure uses a 7-point scale, ranging from 'strongly disagree' to 'strongly agree.' Participants reported stress appraisals immediately before and after the TSST. Following previous research (Jamieson, Nock, & Mendes, 2012), we created demand and resource scales from pre-stressor (pre-demands α = 0.87; pre-resources α = 0.74) and post-stressor (post-demands α = 0.87; post-resources α = 0.76) appraisals.

Affective responses to the stress task were measured as described above using the PANAS. We created positive and negative affect scales from pre- and post-stressor affect ratings (pre-stressor positive affect α = 0.89; pre-stressor negative affect α = 0.87; post-stressor positive affect α = 0.91; post-stressor negative affect α = 0.90).

Physiological measures included measures derived from electrocardiography (ECG) and impedance cardiography (ICG) using ECG and NICO modules integrated into an MP150 Data Acquisition System (Biopac Systems, Inc., www.biopac.com) with signals sampled at 1000 Hz. Spot sensors placed in a modified Lead II configuration measured ECG, and four mylar bands that completely encircled the neck and torso measured ICG. From these measures, we derived high-frequency heart rate variability (RSA) and pre-ejection period (PEP). PEP is a time-based measure of the contractile force measured from the time the ventricle contracts to the opening of the aortic valve. Shorter time indicates greater increases in sympathetic nervous system activity. RSA provides a relatively pure measure of parasympathetic nervous system responses, whereas PEP provides a relatively pure measure of sympathetic nervous system responses. We also collected blood pressure (BP) responses using a Colin Prodigy blood pressure monitor at 7 targeted times during the 2-hour visit. Our BP timing included end of the resting baseline, post-writing, post-interview of writing, beginning of speech preparation, beginning of speech delivery, beginning of math task, and end of math task.

Essay coded optimism and affect studies 1 and 2

For both studies, we trained coders to evaluate the in-lab writing tasks to assess the optimism and affect conveyed in the essays. Coders were trained by first coding approximately 10% of the essays, and the Inter-rater reliability was assessed and found to be satisfactory. Coders then met with other coders to clarify conceptual categories and calibrate their evaluations. Subsequently, each essay was then coded by at least two different judges. We averaged coders ratings at the item level and took the mean of the items to obtain final scores for optimism, positive affect, negative affect, and explanatory style.

Optimism was judged by evaluating goal-oriented thinking and perceived resources (e.g., 'The participant is optimistic about their future and expects good things to happen'). Judges provided ratings ranged from 1 (strongly disagree) to 7 (strongly agree). Study 1: alpha for the intervention group: $\alpha = 0.86$ and control group: $\alpha = 0.82$; Study 2: intervention group: $\alpha = 0.90$ and control group: $\alpha = 0.74$.

Affect was evaluated by judges by completing a PANAS 20-item scale, which we modified to include feelings of optimism, gratitude, resentment, and pessimism in addition to the standard items. All items were rated on a 5-point scale ranging from 1 (not at all) to 5 (a great deal). Items that describe positive feelings were averaged to obtain a score for positive affect, and items that described negative feelings were averaged to obtain a score for negative affect. (Study 1: positive affect $\alpha = 0.88$ (intervention), $\alpha = 0.85$ (control group); negative affect $\alpha = 0.71$ (intervention), $\alpha = 0.77$ (control); Study 2: positive affect $\alpha = 0.95$ (intervention), $\alpha = 0.93$ (control group); negative affect $\alpha = 0.81$ (intervention), $\alpha = 0.70$ (control)).

Data analyses

For both studies, we first evaluated the effectiveness of the randomization procedure by comparing the distribution of the demographic characteristics across the intervention and control groups, using chi-square tests or t-tests as appropriate. We then examined the pooled data from the two studies and conducted multilevel mixed-effect models to evaluate the combined effect of the manipulation on changes in optimism (short-term and trait) and the common self-report measures. We treated time as a fixed effect and study sites as a random effect.

Next, we examined the effect of the intervention on self-reported outcomes and study specific outcomes. In Study 1, we conducted an ANOVA with condition as the between-subjects factor and self-reported outcomes (perceived barriers, perceived benefits, self-efficacy) and in-lab exercise outcomes (stepping task, sit-to-stand task) as separate dependent variables. For in-lab exercise outcomes, we conducted sensitivity analyses to additionally adjust for baseline self-report physical activity which was assessed by asking participants the number of days they had engaged in moderate physical activities, such as bicycling at a regular pace or doubles tennis. In Study 2, we used an ANOVA to evaluate reactivity values across the four physiologic responses: RSA, PEP, and systolic and diastolic blood pressure (SBP and DBP). Reactivity was derived by subtracting the last minute of baseline from each minute of the stress task for each physiological response. In order to understand whether the intervention effects were due primarily to increases in positive affect rather than optimism per se, we conducted sensitivity analyses on all physical activity and stress reactivity outcomes to also control for increases in positive affect.

For essay coding, we conducted moderated regression analyses to predict psychological, physical activity, and physiological outcomes with condition, essay-coded optimism, and their interaction. The goal of these analyses was to determine if there was an association among more optimistic terms in the essay and better health-related responses in the lab. All analyses were performed using SAS 9.4 and figures were created using R. Data can be found online at https://osf.io/nysvx/.

Results

Sample description: studies 1 and 2

A total of 324 participants ($M_{age} = 30$; SD = 9) completed Study 1, of whom 64% were women. Participants were 40% European American, 11% African American, 35% Asian or Pacific Islander, 9% Latinx, and 6% in other racial/ethnic groups. Participants were diverse in their employment status with 39% employed full time or part time, 17% not employed or seeking employment, and 43% full-time or part time students. A total of 118 participants ($M_{age} = 28$; SD = 6.22) completed Study 2, of whom 57% were women, Participants were primarily

European American (38%) or Asian American (30%), and the remaining participants were Latinx (9%), African American (8%), and others (10%). The majority of participants, 56% were employed full-time or part time, 4% were full-time or part-time students, and the remaining from other categories (stay at home parent, disability, retired, etc.). Within both studies, participants assigned to the intervention versus control condition did not differ significantly in gender, age, race/ethnicity, income, employment or education (Table 1).

Psychological outcomes: pooled data

State optimism

We examined the extent to which the manipulation induced optimism by examining changes in state optimism across both studies. We found a main effect of time, F (2, 875) = 24.93, p < .001, and a time by group interaction, F (2, 875) = 4.69, p < .01. Over the course of the study, state optimism increased, but the increase in the intervention group was larger than the control group (Figure 2). Considering participants' confidence about the future at mid-study and the lab visit (it was not assessed at baseline), we observed a main effect of the intervention, F (1, 432) = 7.65, p = .006, with the intervention group showing greater confidence at both mid-study and final assessment than the control group (Table 2). We did not observe a time effect or a time by condition interaction for these two time points.

Dispositional optimism (LOT-R)

Across the two studies, we observed a main effect of time, F (1, 437) = 47.10, p < .001 and a time by condition interaction (F (1, 437) = 4.81, p = .029). Dispositional optimism increased in both conditions, but this time effect was qualified by the time by condition interaction such that there was a larger increase for the intervention, F (1, 215) = 42.31, p < .001 than for the control group, F (1, 222) = 10.60, p = .001.

Anxiety, depression, and aggression

Anxiety decreased over time in both conditions, F (2, 875) = 58.80, p < 0.001. Importantly, we again observed a time by group interaction, F (2, 875) = 6.24, p = .002. Simple effects tests showed that anxiety decreased more in the control condition F (2, 443) = 46.37, p < .001 than the intervention condition, F (2, 432) = 19.66, p < .001. Similar to anxiety, depression decreased over the study, F (2, 875) = 65.51, p < .001, but neither the group effect nor the time by group interaction was significant.

Aggression also showed a large main effect for time, decreasing over the course of the study, F (2, 875) = 77.77, p < .001. There was also a main effect for group with the intervention condition having lower rates of aggression than the control condition, F (1, 440) = 4.19, p = .041. These main effects were qualified by a significant time by group interaction, F (2, 875) = 4.18, p = .016. Simple effects tests indicated the control group exhibited a greater decrease in aggression over time F (2, 443) = 64.18, p < .001, than the intervention group F (2, 432) = 26.35, p < .001, but importantly the intervention group started with a lower overall aggression score at baseline ($M_{optimism}$ = 2.57, SD = 1.28, $M_{control}$ = 2.74, SD = 1.43).

Positive and negative affect

For positive affect, we observed two significant main effects for group F (1, 439) = 5.91, p = .016, and time F (2, 875) = 24.45, p < .001. Overall, the intervention

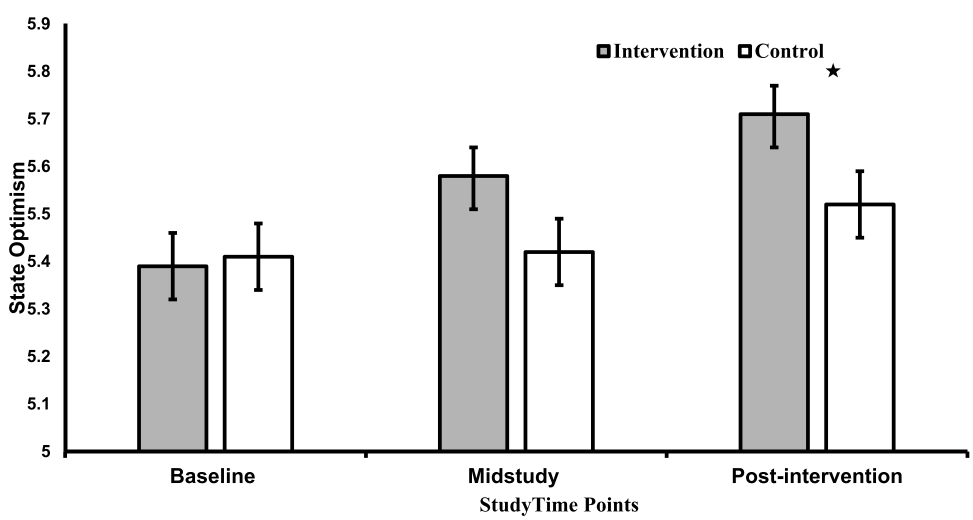

Figure 2. Distribution of state optimism at different time points across the two studies. Note. ★p < 0.05

Table 2. Psychological well-being measures and affect: pooled data.

Variables	Condition	Baseline		Midstudy		Final Assessment				
		Mean	SD	Mean	SD	Mean	SD	Source	F	P
[a] Confidence about the Future	Intervention			7.91	1.64	8.05	1.60	Group (G)	7.65	.006
	Control			7.63	1.73	7.79	1.71	Time (T)	2.97	.086
								T*G	0.01	.940
Dispositional optimism	Intervention	21.22	4.31			22.44	4.12	Group (G)	0.03	.869
	Control	21.57	4.34			22.19	4.49	Time (T)	47.10	<.001
								T*G	4.81	.029
Anxiety	Intervention	2.96	1.12	2.56	1.07	2.50	1.02	Group (G)	2.16	.143
	Control	3.07	1.28	2.87	1.24	2.49	0.98	Time (T)	58.80	<.001
								T*G	6.24	.002
Depression	Intervention	2.82	1.12	2.58	1.11	2.32	1.02	Group (G)	2.89	.090
	Control	2.92	1.33	2.84	1.31	2.47	1.10	Time (T)	65.51	<.001
								T*G	1.03	.359
Aggression	Intervention	2.57	1.28	2.14	1.25	2.00	1.00	Group (G)	4.19	.041
	Control	2.74	1.43	2.51	1.32	1.94	1.10	Time (T)	77.77	<.001
								T*G	4.18	.016
Pos affect	Intervention	5.01	0.93	5.28	0.85	5.04	0.96	Group (G)	5.91	.016
	Control	4.97	1.06	4.99	0.99	4.76	1.12	Time (T)	24.45	<.001
								T*G	5.99	.003
Neg affect	Intervention	2.78	1.10	2.40	1.06	2.29	1.02	Group (G)	2.07	.151
	Control	2.92	1.28	2.65	1.19	2.32	1.03	Time (T)	76.67	<.001
								T*G	4.19	.015

Note. Multilevel mixed-effect linear regression models evaluated the effect of the manipulation on changes in psychological well-being and affect across the two studies. Cohen's d effect sizes were calculated by comparing baseline to post-intervention means for the intervention and control conditions separately. Intervention (n = 218), control (n = 224).
[a]Assessed at only 2 time points

group reported higher positive affect and increases in positive affect over the course of time. However, these main effects are qualified by a significant time by condition interaction, F (2, 875) = 5.99, p = .003. The intervention group reported an increase in positive affect over time (F (2, 432) = 17.55, p < .001), whereas the control condition shows a slightly increase from baseline to mid-intervention and a significant decrease from mid-intervention to post-intervention (F (2, 443) = 12.89, p < .001). For negative affect, we observed a main effect for time F (2, 875) = 76.67, p < .001, no main effect for condition, and a time by condition interaction, F (2, 875) = 4.19, p = .015). Similar to results for anxiety, negative affect decreased over time for both groups, but there was a slightly larger decrease in the control group (F (2, 443) = 59.28, p < .001) than in the intervention group (F (2, 432) = 25.43, p < .001).

Study 1: exercise beliefs, self-efficacy, and willingness to engage in exercise

Exercise beliefs. For perceived benefits of exercise, we observed a main effect of time, F (1, 228) = 4.16; p = 0.043, and a time by condition interaction, F (1, 228) = 4.78, p = .030. Simple effects tests indicated the intervention group demonstrated increases in perceived benefits of doing exercise from baseline to post-intervention, F (1, 113) = 8.18, p = .005, whereas the control group did not, F (1, 117) = 0.00, p = .965 (see SOMTable 2). Perceived barriers for exercise also showed a main effect for time, F (1, 228) = 6.59, p = .011, with participants perceiving lower barriers to exercise over time, but neither the condition effect nor the time by condition interaction were statistically significant (SOM Table 2). Since the internal consistency of the perceived barrier subscale was relatively low, we also tested each single item in the model and the results remained similar across items.

Self-efficacy regarding exercise. We observed a significant main effect for time such that participants perceived an increase in exercise self-efficacy, F (1, 228) = 11.81, p < .001. Neither condition nor the group by time interaction were significant, F (1, 228) = 3.51, p = .062. In sensitivity analyses, when we additionally controlled for changes in positive affect, we still observed significantly larger increases in self-efficacy and perceived benefits of exercise in the intervention group compared with the control group. The results remain unchanged for perceived barriers. These analyses suggest that effects on these outcomes were not driven exclusively by increases in positive emotion (See SOM Table 4)

In-lab physical exercise. We compared the intervention and control groups in how much they engaged in the stepping and the sit-stand tasks (Figure 3) and observed no differences in either task. The results remain similar after controlling for baseline self-report physical activity and changes in positive affect.

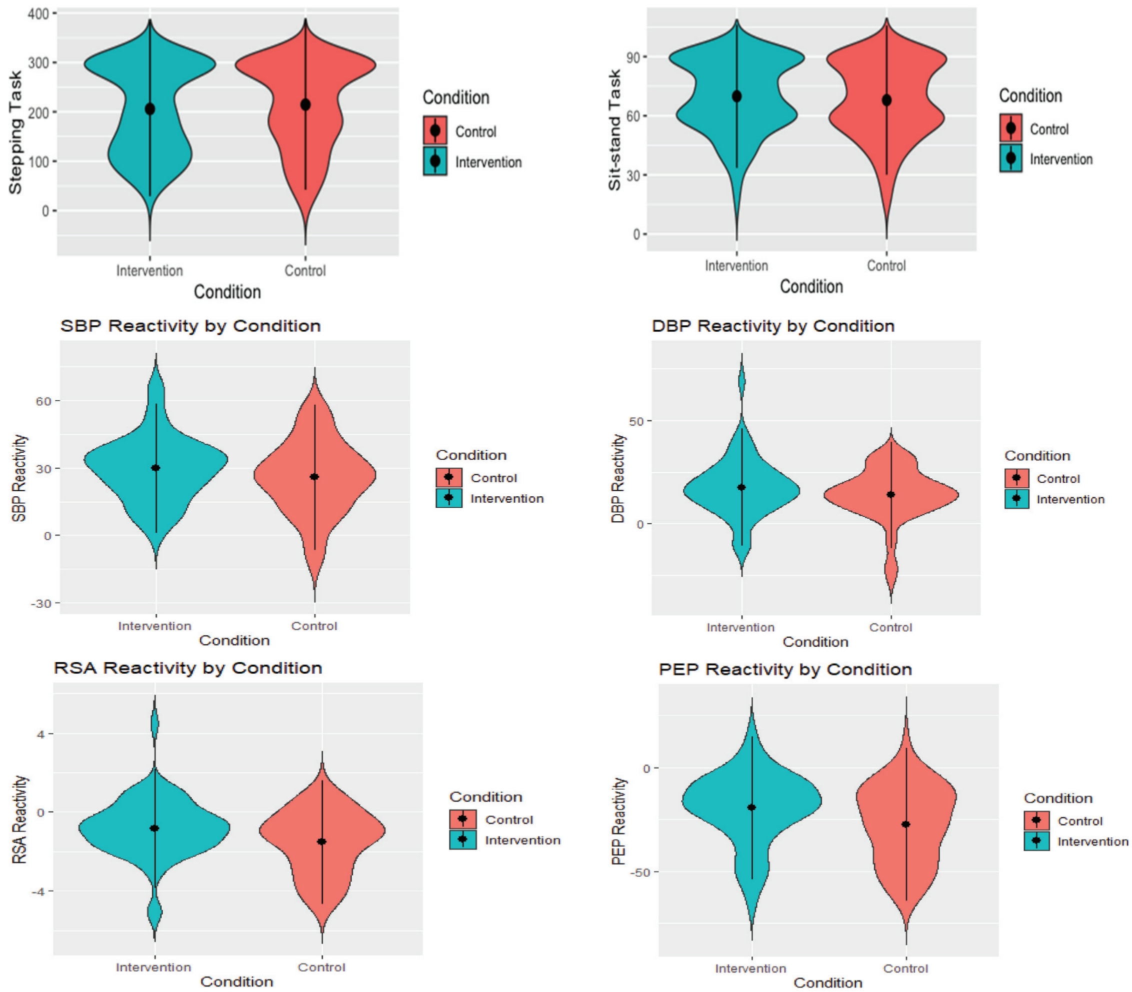

Figure 3. Distribution of outcomes by condition.

Study 2: appraisals, affect, and physiologic responses

Appraisals. We did not observe any condition differences in any of the demand or resource appraisals either pre- or post-stressor task, all *Fs* < 1.

Affective responses to stress task. We examined condition differences in positive affect pre- and post-stressor and observed no significant effects, both *Fs* < 1. We observed slight trends in negative affect by condition for both pre-stressor negative affect (F (1, 113) = 2.27, p = .13) and post-stressor negative affect (F (1, 112) = 3.08, p = .08) in somewhat unexpected directions. Individuals in the control versus intervention condition reported lower negative affect both pre- and post-stressor.

Physiological responses. We first examined whether participants differed in their resting physiologic response by condition, focusing on PEP, RSA, and blood pressure levels and observed no differences, all *Fs* < 1. We then examined reactivity during the stress task. We confirmed that the anticipation, speech, and math tasks engendered changes in physiology across both intervention and control groups, and observed significant changes for faster PEP, lower RSA, and increased blood pressure (SBP and DBP) during speech anticipation, speech delivery, and math task (all *p's* < .0001, except RSA anticipation, p < .01). We then examined physiologic responses by condition focusing on the first minute of each epoch given the beginning of the task tends to be the most reactive (Figure 3).

RSA. We observed significant differences between conditions for speech anticipation F (1, 107) = 4.62, p < .034 and speech delivery, F (1, 107) = 5.96, p < .016, but not during the math task, F (1, 105) = 0.97, *ns*. Participants in the optimism condition showed less vagal withdrawal during speech anticipation and speech delivery (*Ms* = −0.04, −0.82) than those in the control condition (*Ms* = −0.51, −1.55). In analyses controlling for changes in positive emotion, the intervention effect remained significant even with the change in positive emotion included as a covariate: speech anticipation, F (1, 111) F = 4.01, $p < .048$, speech delivery, F (1, 111) = 4.21, $p < .043$ (See SOM Table 4).

PEP. There were some weak indications that PEP differed by condition. Condition effects did not reach statistical significance for anticipation (F (1, 111) = 2.78, $p < .10$) and math (F (1, 99) = 2.85, $p = .094$), but were statistically significant for speech delivery (F (1, 105) = 5.10, $p < .026$). In general, the optimism condition led to lower SNS activation relative to the control condition during the stress task, but differences were unreliable and were significant only for the speech delivery portion ($M_{optimism} = -19.42$, $SD = 17.5$; $M_{control} = -27.32$, $SD = 18.7$). When controlling for change in positive affect there were no substantive changes to the primary models and PEP condition differences during speech delivery remained significant, F (1, 108) = 4.58, $p < .035$ (See SOM Table 4).

Blood pressure. We observed no significant differences by condition for DBP or SBP.

Essay coding

Optimism and affect. In both studies, individuals who wrote about their best possible selves were coded as more optimistic (Study 1, $M_{control} = 3.24$, $SD = 0.37$ $M_{optimism} = 6.07$, $SD = 0.45$; Study 2, $M_{control} = 4.12$, $SD = 0.26$ $M_{optimism} = 4.81$, $SD = 0.77$) than those who wrote about how they got to the lab (Study 1, F (1,292) = 3455.61, p < .0001; Study 2, F (1,111) = 41.50, p < .0001). Essays in both studies were coded as containing more positive affect (Study 1, $M_{control} = 1.43$, $SD = 0.28$, $M_{optimism} = 4.39$, $SD = 0.39$; Study 2, $M_{control} = 1.62$, $SD = 0.47$; $M_{optimism} = 2.72$, $SD = 0.70$) when participants wrote about optimistic/future-oriented themes than when they wrote about a neutral topic (Study 1 F (1, 292) = 4317.44, $p < .0001$; Study 2 F (1,111) = 97.49, $p < .0001$). In contrast, we observed no differences in negative affect in the written essays by condition (Study 1: F (1, 292) = 1.18, ns; Study 2: F (1, 111) = 0.08, ns).

Coded optimism and affect with physical activity (Study 1). Across both conditions, greater coder-rated optimism was associated with longer duration of stepping (b = 47.33, 95% CI = 23.65, 71.01) and sit-stand (b = 6.11, 95% CI = 0.63, 11.60) tasks. Across both conditions, greater coder-rated positive affect was associated with longer duration of stepping (b = 61.61, 95% CI = 33.61, 89.61) and sit-stand (b = 10.46, 95% CI = 4.07, 16.86) tasks. Greater coder-rated negative affect was associated with shorter duration of stepping task in the intervention group (b = −183.81, 95% CI = −366.60, −1.03), but not the control group.

Associations of coded optimism or affect with physiological reactivity (Study 2). Across both conditions, the more participants' essays were rated as optimistic, the less their heart rate variability decreased during the speech (b = 0.46, 95% CI = 0.19, 0.73) and math (b = .36, 95% CI = 0.03, 0.70) tasks. The more optimism expressed in participants' essays, the less vagal withdrawal we observed during the evaluated speech and math tasks. Essay coded positive affect showed similar albeit weaker associations (speech b = .31, 95% CI = 0.08, 0.54; math, b = 0.24, 95% CI = −0.04, 0.53) with vagal withdrawal. We did not observe effects of coder-rated optimism or affect on PEP, SBP, or DBP.

Discussion

This study examined effects of induced optimism on in-lab physical activity and stress reactivity through two experimental studies with community-dwelling individuals. Across both studies, the intervention led to greater increases in short-term optimism and positive affect in the intervention group compared with the control group. In general, coder-rated optimism and positive affect were associated with better performance on the in-lab physical activity tasks and healthier forms of stress reactivity. However, we found little to no evidence that the intervention led to reliable changes in self-reported anxiety, depression, and aggression nor did we observe differences in in-lab physical activity and stress reactivity.

Our findings that the writing tasks led to greater improvement in self-reports of optimism and positive affect in the intervention versus the control group are consistent with previous studies conducted in other populations. For example, in a study of 82 students, individuals who did versus did not receive a positive psychological intervention consisting of writing tasks exhibited greater improvement in optimism and positive affect (Peters et al., 2010). In another study of 54 Dutch-speaking participants, most of whom were students, a best possible selves writing intervention led to larger increases in optimism compared with writing about a daily activity task (Meevissen et al., 2011). Our research extends these findings to two larger samples of diverse, community-dwelling populations and provides further evidence that this type of intervention can be effective in boosting short-term optimism and positive affect.

These findings notwithstanding, we did not find evidence that experimentally induced optimism influenced in-lab physical activity. In contrast, observational studies have repeatedly demonstrated that higher self-reported (i.e., naturally varying) optimism levels are associated with greater engagement in physical activity or buffer against the harmful effects of stress on health (Bajaj et al., 2019; Huffman et al., 2016). However, it is notable that our intervention was able to change participants' exercise beliefs and improve perceived benefits of exercise. Perhaps the small increases in optimism that we obtained from the intervention were insufficient to change subsequent health-related behavior. This may be especially true for health behaviors like physical activity, which are largely habitual. Once established, health behavior is deeply embedded in individuals' daily routines, and thus changes in behavior may require longer interventions with more substantial changes in optimism.

We observed some differences in stress reactivity by condition with induced optimism associated with less vagal withdrawal and lower sympathetic nervous system activation – that is, both less PNS withdrawal and less SNS activation during the stress task. Together these findings suggest participants in the experimental condition had less arousal than participants in the control condition. We might speculate that the optimism condition increased a sense of calm resulting in less arousal during the stress task. However, it is important to note that the intervention did not result in differences in resting physiology nor in blood pressure reactivity, which are more closely associated with better physical health.

Despite the null effects of our optimism intervention on in-lab physical activity, we found effects of coder-rated optimism and affect from essays on outcomes in both studies. Overall, greater coded optimism was associated with greater persistence in both physical activity tasks and less vagal withdrawal during the stress tasks. These findings raise several interesting possibilities for understanding our findings and the relationship of optimism with our outcomes of interest. One possibility is that optimism as reflected in writing rather than based on direct self-report more accurately captures participants' true levels of their positive expectations. A second possibility is that optimism as reflected in writing provides a type of dose-level response such that individuals with more optimistic orientation in their writing benefitted most from the intervention.

Our study has several limitations. Although we excluded individuals who were highly physically active from Study 1, we did not establish a pre-intervention exercise assessment. Doing so might have increased our precision in determining if the intervention increased exercise in the lab. Most participants in both studies also had a college degree or more. As highly educated individuals tend to be more optimistic than those in less advantaged situations (Boehm et al., 2015), this may have caused some ceiling effects in our ability to induce optimism. There are also reasons to suspect that the intervention effects may vary depending on socioeconomic status or other sociodemographic factors and that our findings may not be generalizable to a broader population. Most previous research on optimism or related factors like purpose in life and health has found little evidence of effect modification by socioeconomic status or other sociodemographic factors (Boehm et al., 2020; Lee et al., 2021; Qureshi et al., 2022; Shiba et al., 2021). However, we suspect that limited resources might increase the likelihood of facing barriers that interfere with individuals' ability to translate their optimism or other facets of positive psychological well-being into action. Limited work has examined these potential sources of effect modification and it will be important for future studies to assess the possibility. Because writing prompts were different in the intervention versus control groups, we cannot be sure that the intervention per se led to higher coder-rated optimism. We did not assess trait characteristics that are likely to attenuate/exacerbate optimism effects such as levels of learned helplessness or perceived control. Future study should evaluate how trait characteristics may modify optimism effects. Lastly, our experiment was relatively short, and therefore we were unable to determine whether the effects would increase over time or to evaluate how long people would stay with the intervention. Additionally, we did not follow up with participants after they completed the lab visits. As a result, we could not assess if effects of the intervention would persist beyond the study period. One important avenue for future research is to develop a longer optimism experiment with follow up to evaluate the sustainability of the effect.

Despite these limitations, our study represents the largest experimental research to date to investigate the effects of induced optimism on physical activity and stress reactivity. Our experimental design allowed us to assess causality from optimism to physical activity and stress reactivity. Additionally, we recruited participants from community-dwelling adults with diverse age, socioeconomic, and racial/ethnic backgrounds. Our research is also among the very few studies that evaluated both participant and coder-rated optimism and their effects on physical activity and stress reactivity. The two studies used almost identical writing interventions with different outcomes and were simultaneously conducted at two large research institutions, providing a good example of study replication.

In sum, our results suggest that intentional interventions can have beneficial effects on optimism and positive affect, but the size of the effect may not be sufficient to lead to substantial changes in willingness to engage in physical activity and stress reactivity. Further research should aim to refine such interventions to move beyond creating relatively small (even if statistically significant) changes, investigate what factors make such interventions maximally effective, and assess the level of change required to change downstream behavior and other health-related responses. Furthermore, given findings that coder-rated optimism and affect were more strongly associated with physical activity duration and stress reactivity, behavioral measures of these psychological states may provide novel insight into changes occurring below the threshold of conscious awareness or that may not differ noticeably enough to translate into differences in self-reported levels.

Acknowledgments

Special thanks to Ijeoma Ezeofor, Annie Taylor, Caitlyn Wilson, Urvashi Pandya, Christina Pechette, Rebecca Nordland, Juliana DePietro, Natalia Maliborski, and Hayami Koga for their assistance with the project and to all the participants who graciously gave us their time.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work is supported by the Lee Kum Sheung Center for Health and Happiness at the Harvard T.H. Chan School of Public Health and the National Institute of Health under Grant (R24AG048024 and T32MH019391). Ruijia Chen is supported partly by the National Institute on Aging (1F99AG068431-01;4K00AG068431-02). Harvard Lee Kum Sheung Center for Health and Happiness;

Data availability statement

Please contact the first author if you are interested in working with the data reported in this manuscript. The data described in this article are openly available in the open science Framework at https://osf.io/nysvx/

Open Scholarship

This article has earned the Center for Open Science badges for Open Data and Open Materials through Open Practices Disclosure. The data and materials are openly accessible at https://osf.io/nysvx/.

Geolocation information

This study was conducted in Boston, Massachusetts and San Francisco, California.

References

Bajaj, A., Bronson, C. A., Habel, M., Rahman, S., Weisberg, H. R., & Contrada, R. J. (2019). Dispositional optimism and cardiovascular reactivity accompanying anger and sadness in young adults. *Annals of Behavioral Medicine*, *53*(5), 466–475. https://doi.org/10.1093/abm/kay058

Bell, M. L., Fairclough, D. L., Fiero, M. H., & Butow, P. N. (2016). Handling missing items in the Hospital Anxiety and Depression Scale (HADS): A simulation study, *9* (1), 1–10.

Berry Mendes, W., Gray, H. M., Mendoza-Denton, R., Major, B., & Epel, E. S. (2007). Why egalitarianism might be good for your health: Physiological thriving during stressful intergroup encounters. *Psychological Science*, *18*(11), 991–998. https://doi.org/10.1111/j.1467-9280.2007.02014.x

Boehm, J. K., Chen, Y., Williams, D. R., Ryff, C., & Kubzansky, L. D. (2015). Unequally distributed psychological assets: Are there social disparities in optimism, life satisfaction, and positive affect? *PloS One*, *10*(2), e0118066. https://doi.org/10.1371/journal.pone.0118066

Boehm, J. K., Qureshi, F., Chen, Y., Soo, J., Umukoro, P., Hernandez, R., Lloyd-Jones, D., & Kubzansky, L. D. (2020). Optimism and cardiovascular health: Longitudinal findings from the coronary artery risk development in young adults study. *Psychosomatic Medicine*, *82*(8), 774–781. https://doi.org/10.1097/PSY.0000000000000855

Burton, C. M., & King, L. A. (2009). The health benefits of writing about positive experiences: The role of broadened cognition. *Psychology & Health*, *24*(8), 867–879. https://doi.org/10.1080/08870440801989946

Celano, C. M., Albanese, A. M., Millstein, R. A., Mastromauro, C. A., Chung, W.-J., Campbell, K. A., Legler, S. R., Park, E. R., Healy, B. C., Collins, L. M., Januzzi, J. L., & Huffman, J. C. (2018). 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. *Psychosomatic Medicine*, *80*(6), 526. https://doi.org/10.1097/PSY.0000000000000584

Finstad, K. (2010). Response interpolation and scale sensitivity: Evidence against 5-point scales. *Journal of Usability Studies*, *5* (3), 104–110. https://uxpajournal.org/response-interpolation-and-scale-sensitivity-evidence-against-5-point-scales/

Gawronski, K. A., Kim, E. S., Langa, K. M., & Kubzansky, L. D. (2016). Dispositional optimism and incidence of cognitive impairment in older adults. *Psychosomatic Medicine*, *78*(7), 819. https://doi.org/10.1097/PSY.0000000000000345

Haas, F., Sweeney, G., Pierre, A., Plusch, T., & Whiteson, J. (2017). Validation of a 2 minute step test for assessing functional improvement. *Open Journal of Therapy and Rehabilitation*, *5* (2), 71. https://doi.org/10.4236/ojtr.2017.52007

Huffman, J. C., Beale, E. E., Celano, C. M., Beach, S. R., Belcher, A. M., Moore, S. V., Suarez, L., Motiwala, S. R., Gandhi, P. U., Gaggin, H. K., & Januzzi, J. L. (2016). Effects of optimism and gratitude on physical activity, biomarkers, and readmissions after an acute coronary syndrome: The gratitude research in acute coronary events study. *Circulation. Cardiovascular Quality and Outcomes*, *9*(1), 55–63. https://doi.org/10.1161/CIRCOUTCOMES.115.002184

Huffman, J. C., DuBois, C. M., Millstein, R. A., Celano, C. M., & Wexler, D. (2015). Positive psychological interventions for patients with type 2 diabetes: Rationale, theoretical model, and intervention development. *Journal of Diabetes Research*, *2015*(428349), 1–18. https://doi.org/10.1155/2015/428349

Jackowska, M., Brown, J., Ronaldson, A., & Steptoe, A. (2016). The impact of a brief gratitude intervention on subjective well-being, biology and sleep. *Journal of Health Psychology*, *21*(10), 2207–2217. https://doi.org/10.1177/1359105315572455

Jamieson, J. P., Nock, M. K., & Mendes, W. B. (2012). Mind over matter: reappraising arousal improves cardiovascular and cognitive responses to stress. Journal of experimental psychology. General, 141(3), 417. doi: 10.1037/a0025719

Kim, E. S., Hagan, K. A., Grodstein, F., DeMeo, D. L., De Vivo, I., & Kubzansky, L. D. (2017). Optimism and cause-specific mortality: A prospective cohort study. *American Journal of Epidemiology*, *185*(1), 21–29. https://doi.org/10.1093/aje/kww182

Kirschbaum, C., & Hellhammer, D. H. (1994). Salivary cortisol in psychoneuroendocrine research: Recent developments and applications. *Psychoneuroendocrinology*, *19*(4), 313–333. https://doi.org/10.1016/0306-4530(94)90013-2

Kluemper, D. H., Little, L. M., & DeGroot, T. (2009). State or trait: Effects of state optimism on job-related outcomes. *Journal of Organizational Behavior*, *30*(2), 209–231. https://doi.org/10.1002/job.591

Kubzansky, L. D., Boehm, J. K., & Segerstrom, S. C. (2015). Positive psychological functioning and the biology of health. *Social and Personality Psychology Compass*, *9*(12), 645–660. https://doi.org/10.1111/spc3.12224

Lee, H. H., Okuzono, S. S., Kim, E. S., De Vivo, I., Raffield, L. M., Glover, L., Sims, M., Grodstein, F., & Kubzansky, L. D. (2021). Optimism and telomere length among African American adults in the Jackson Heart Study. *Psychoneuroendocrinology*, *125*, 105124. https://doi.org/10.1016/j.psyneuen.2020.105124

Luthans, F., & Youssef, C. M. (2007). Emerging positive organizational behavior. *Journal of Management*, *33*(3), 321–349. https://doi.org/10.1177/0149206307300814

Malouff, J. M., & Schutte, N. S. (2017). Can psychological interventions increase optimism? A meta-analysis. *The Journal of Positive Psychology*, *12*(6), 594–604. https://doi.org/10.1080/17439760.2016.1221122

Marcus, B. H., Selby, V. C., Niaura, R. S., & Rossi, J. S. (1992). Self-efficacy and the stages of exercise behavior change. *Research Quarterly for Exercise and Sport*, *63*(1), 60–66. https://doi.org/10.1080/02701367.1992.10607557

Meevissen, Y. M., Peters, M. L., & Alberts, H. J. (2011). Become more optimistic by imagining a best possible self: Effects of a two week intervention. *Journal of Behavior Therapy and Experimental Psychiatry*, *42*(3), 371–378. https://doi.org/10.1016/j.jbtep.2011.02.012

Millstein, R. A., Chung, W.-J., Hoeppner, B. B., Boehm, J. K., Legler, S. R., Mastromauro, C. A., & Huffman, J. C. (2019). Development of the state optimism measure. *General Hospital Psychiatry*, *58*, 83–93. https://doi.org/10.1016/j.genhosppsych.2019.04.002

Peters, M. L., Flink, I. K., Boersma, K., & Linton, S. J. (2010). Manipulating optimism: Can imagining a best possible self be used to increase positive future expectancies? *The Journal of Positive Psychology*, *5*(3), 204–211. https://doi.org/10.1080/17439761003790963

Peterson, C. (2000). The future of optimism. *American Psychologist*, *55*(1), 44. https://doi.org/10.1037/0003-066X.55.1.44

Puig-Perez, S., Villada, C., Pulopulos, M. M., Almela, M., Hidalgo, V., & Salvador, A. (2015). Optimism and pessimism are related to different components of the stress response in healthy older people. *International Journal of Psychophysiology*, *98*(2), 213–221. https://doi.org/10.1016/j.ijpsycho.2015.09.002

Qureshi, S. J., Lloyd, J., Lloyd, J., Lloyd, J., Kubzansky, L., Bohem, J., & Boehm, J. K. Optimism and lipid profiles in midlife: A 15-year study of black and white adults. (2022). *American Journal of Preventive Medicine*, *62*(3), e169–e177. *In Press*. https://doi.org/10.1016/j.amepre.2021.09.011

Rasmussen, H. N., Wrosch, C., Scheier, M. F., & Carver, C. S. (2006). Self-regulation processes and health: The importance of optimism and goal adjustment. *Journal of Personality*, *74*(6), 1721–1748. https://doi.org/10.1111/j.1467-6494.2006.00426.x

Ryhming, I. (1953). A modified Harvard step test for the evaluation of physical fitness. *Arbeitsphysiologie*, *15*, 235–250. https://doi.org/10.1007/BF00933320

Scheier, M. F., & Carver, C. S. (1985). Optimism, coping, and health: Assessment and implications of generalized outcome expectancies. *Health Psychology*, *4*(3), 219. https://doi.org/10.1037/0278-6133.4.3.219

Scheier, M. F., Carver, C. S., & Bridges, M. W. (1994). Distinguishing optimism from neuroticism (and trait anxiety, self-mastery, and self-esteem): A reevaluation of the Life Orientation Test. *Journal of Personality and Social Psychology*, *67*(6), 1063. https://doi.org/10.1037//0022-3514.67.6.1063

Sechrist, K. R., Walker, S. N., & Pender, N. J. (1987). Development and psychometric evaluation of the exercise benefits/barriers scale. *Research in Nursing & Health*, *10*(6), 357–365. https://doi.org/10.1002/nur.4770100603

Shiba, K., Kubzansky, L. D., Williams, D. R., VanderWeele, T. J., & Kim, E. S. (2021). Associations between purpose in life and mortality by SES. *American Journal of Preventive Medicine*, *61* (2), e53–e61. https://doi.org/10.1016/j.amepre.2021.02.011

Spielberger CD. State-Trait Anxiety Inventory for Adults. Palo Alto, CA: Mind Garden; 1983. https://www.sciencedirect.com/topics/psychology/state-trait-anxiety-inventory

Steptoe, A., Wright, C., Kunz-Ebrecht, S. R., & Iliffe, S. (2006). Dispositional optimism and health behaviour in community-dwelling older people: Associations with healthy ageing. *British Journal of Health Psychology*, *11*(1), 71–84. https://doi.org/10.1348/135910705X42850

Strassmann, A., Steurer-Stey, C., Lana, K. D., Zoller, M., Turk, A. J., Suter, P., & Puhan, M. A. (2013). Population-Based reference values for the 1-min sit-to-stand test. *International Journal of Public Health*, *58*(6), 949–953.

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology*, *54* (6), 1063. https://doi.org/10.1037/0022-3514.54.6.1063