Happiness Improves Health

**Happiness Improves Health: Experimental Evidence from a Randomized Control Trial of
an Online Positive Psychology Intervention**

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Abstract

Happier people are healthier, but does becoming happier lead to better health? In the current work, we deploy a comprehensive, three-month positive psychological intervention (PPI) as an experimental tool to examine the effects of increasing happiness on physical health in a nonclinical population. In a randomized controlled trial (RCT), we found treatment participants had an incidence rate of sick days half as large as control participants, experiencing ever fewer sick days over the course of the program. These effects on physical health persisted three months after treatment and were mediated through the treatment effects on higher positive affect and life satisfaction, and lower negative affect. Beyond self-report, the positive intervention also had modest effects on lowering blood pressure and preventing weight gain. Combining experimental and longitudinal methodologies, this work provides critical evidence for a causal effect of happiness on physical health.

Keywords: Health; Life Satisfaction; Well-Being; Happiness; Randomized Controlled Trial

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Happiness feels good, but do its benefits extend beyond the psychological domain to include physical wellness? Evidence for a link between happiness—or subjective well-being—and health is strong and growing, rooted in cross-sectional correlational and prospective longitudinal studies accompanied by experiments leveraging momentary laboratory mood manipulations and observing causal effects on various health indicators (Lyubomirsky, King, & Diener, 2005). There remains, however, a dearth of studies examining the impact of long-term happiness interventions on physical health in samples of healthy adults (Diener, Pressman, Hunter, & Delgadillo-chase, 2017). Perhaps as a result of this missing line of externally valid experimental research, the causal impact of enduring happiness on improved physical health remains a subject of debate (Liu et al., 2016). In the present research, we aim to fill this gap in the literature using a 12-week positive psychology intervention as an experimental tool. We thus examine whether increasing psychological well-being can have direct causal effects over time on the physical health of generally healthy adults.

The Link Between Happiness and Health

The link between happiness and health is supported by correlational, longitudinal, and experimental evidence (Lyubomirsky et al., 2005). For instance, happier people have better cardiovascular health (Boehm, Vie, & Kubzansky, 2012) and immune functioning (Marsland, Cohen, Rabin, & Manuck, 2006) engage in healthier behaviors (Boehm et al., 2012), and live longer lives (Diener & Chan, 2011). In one particularly notable prospective study, the positivity of autobiographies written by nuns around age 22 predicted their survival rates from ages 75–95 (Danner, Snowdon, & Friesen, 2001). Synthesizing this broad-ranging literature, meta-analytic evidence suggests that subjective well-being is linked to increased survival in both healthy and ill

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samples (Chida & Steptoe, 2008), short-term immune functioning, pain mitigation, endocrine response, long-term cardiovascular health, and slower disease progression (Howell, Kern, & Lyubomirsky, 2007), as well as recovery and survival in ill patients (Lamers, Bolger, Westerhof, Smit, & Bohlmeijer, 2012). More broadly, the relationship between happiness and health is robust across 142 nations (Pressman, Gallagher, & Lopez, 2013) and United States counties (Lawless & Lucas, 2011).

Despite this consistency of evidence, the literature on the health benefits of happiness is plagued by a relative lack of long-term, externally-valid experimental evidence in healthy samples (such as from randomized controlled trials considered the gold standard in the medical sciences). Indeed, the existing experimental evidence comes primarily from brief positive affect inductions in the laboratory and measurement of the immediate, short-term effects on indicators of physiological health. For example, experimentally inducing happiness improves physiological health indicators like heart rate variability, blood pressure, and immune function (Pressman & Cohen, 2005).

The handful of studies examining the health effects of increasing subjective well-being over the long-term—PPIs of various forms—have focused on populations with particular health issues. Some such psychological interventions have targeted the alleviation of subjective ill-being, such as stress or depression, producing reductions in all-cause mortality two years later in men (Linden, Phillips, & Leclerc, 2007), decreased future cardiac events (Rutledge, Redwine, Linke, & Mills, 2013), and modest improvements in physical health (O’Neil, Sanderson, Oldenburg, & Taylor, 2011). Other interventions have focused more directly on increasing subjective well-being, but only in specific clinical populations with existing health issues. For instance, a positive affect intervention involving regular positive thought generation, gift receipt,

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and self-affirmation has produced health behavior changes in chronic cardiopulmonary disease patients (Charlson et al., 2014) greater medication adherence in hypertensive African Americans (Ogedegbe et al., 2012) and increased physical activity in coronary care patients (Peterson et al., 2012). Similarly, compared to controls, women in cancer treatment made fewer cancer-related appointments after completing an emotional or positive writing intervention (Stanton et al., 2002). Finally, in a small study of coronary patients ($N = 69$), those participating in one of three distinct six-week PPIs showed evidence of reduced inflammation and waking cortisol levels compared to wait-list controls (Nikrahan et al., 2016). Intensive happiness interventions seem to improve health behaviors and health indicators within clinical populations.

But does happiness lead to better health even in a nonclinical population? Answering this question requires the administration of an externally valid happiness intervention within the context of randomized controlled trial (RCT), per the best practices in clinical science research.

The Present Research

Though the link between happiness and health is well supported by existing evidence, the existing evidence is limited by an enduring absence of a randomized controlled trials experimentally examining the causal effects of increasing happiness on health outcomes within healthy, nonclinical populations. In the present study, we aim to address this gap in the psychological literature by conducting an RCT examining the health effects of a 12-week positive psychology intervention (PPI), focused explicitly on increasing subjective well-being through empirically supported exercises and activities (Lyubomirsky & Layous, 2013; Quoidbach, Mikolajczak, & Gross, 2015; Sheldon & Lyubomirsky, 2006). We randomly assigned healthy adults to Active Treatment or Wait-List Control groups. Participants completed

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measures of subjective well-being and physical health before treatment (pre-test), over the course of treatment (weekly), and three months (post-test) and six months (follow-up) after treatment.

This design allowed us to examine the causal effects of the happiness intervention on health as they unfold over time. Specifically, the weekly assessments afford examinations of effects across the duration of treatment—quantified in terms of both the number of days and weeks of feeling sick at both the average person level and the level of individual observations. The post and follow-up assessments allowed exploration of the persistency of the effects across a broader array of validated health outcomes, including both self-reports and objective measurements. Further, the longitudinal design of the study allowed us to directly examine whether preceding increases in psychological well-being predict physiological wellness. Finally, employing best analytical practices in clinical science, we conducted intention-to-treat analyses by including all participants regardless of their compliance with treatment instructions, reporting findings from both the observed and imputed data. In short, we used a comprehensive PPI as an experimental tool to examine whether happiness can really improve health.

Method

Participants

Participants were 100 community adults between ages 25 to 75 from Charlottesville, VA. Interested individuals completed a depression prescreen and those reaching threshold for severe depression—scoring ≥ 15 on the Patient Health Questionnaire-9, PHQ-9 (Kroenke, Spitzer, & Williams, 2001)—were referred to appropriate mental health services. All eligible participants consented to participating in the study, including to being randomized into an Active Treatment ($n = 50$) or a Waitlist Control group ($n = 50$). Demographics are presented in Table 1. Attrition information is presented in Tables 1 and 2. Power was preregistered in a design and rationale paper to detect between-subjects effect of $d = .40$ with 80% power (Kushlev et al., 2017).

Treatment

We used a comprehensive 12-week online PPI: ENHANCE (Enduring Happiness and Continued Self-Enhancement). ENHANCE features 10 (plus introductory and concluding) modules, administered via a custom-developed web platform. Each of the modules, selected based on the strength of the empirical evidence for happiness activities (Quoidbach et al., 2015), featured didactic, writing, and behavioral components and were organized into three broad character growth domains. The Treatment program was administered from the months of September to December.

The first section of the program, *The Core Self*, targeted self-discovery and future planning across Modules 1–3, including activities centered on value affirmation, goal pursuit, and character strengths. The second section, *The Experiential Self*, dealt with the manner in which participants experience the external world and their internal feelings across Modules 4–6, including mindfulness, self-compassion, and savoring. Lastly, in the third section, *The Social Self*, involved building and maintaining healthy social lives across Modules 7–10, including fostering positive interactions with strong and weak social ties, as well as prosocial behavior. Further details on the modules are available elsewhere (Kushlev et al., 2017).

Weekly Assessments

Participants completed weekly reports of health and well-being, obtained through a brief online survey for each of the ten active weeks of treatment. Descriptive information for is presented in Table 1. We measured health each week with a self-report item from the Behavioral Risk Factor Surveillance System (BRFSS; Centers for Disease Control and Prevention, 2014): *Thinking about your physical health, which includes physical illness and injury, for how many days during the past week was your physical health not good?* This item combines breadth (i.e.,

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not focusing on any specific health condition) and specificity (i.e., clearly defining physical health symptoms with reference to a specific recent period of time), which maintains a level of objectivity and limits cognitive biases and demand characteristics of other self-report items.

Each weekly assessment further included the Scale of Positive and Negative Experiences, SPANE (Diener et al., 2010) to measure positive and negative affect “in the past week.”

Participants also completed single-items for life satisfaction: *In the past week, how satisfied were you with things in your life?*, and meaning in life: *In the past week, to what extent did you feel a sense of meaning and purpose in your life?* Other measures beyond the scope of this report, such as person-activity fit, were also included (see Kushlev et al., 2017).

Comprehensive Assessments

In addition to brief weekly assessments over the duration of treatment, participants completed a larger baseline assessment prior to random assignment (September), and identical assessments at three-month post-test (immediately after the intervention; December), and six-month follow-up (March). These assessments contained items from the BRFFS, including the number of days in the past month that participants 1) felt sick, 2) were prevented from usual activity by their health, and 3) felt healthy and full of energy (Table 2 for descriptives). In addition, we obtained basic objective measures associated with health—blood pressure and body mass index (BMI)—at each of the three comprehensive assessments. Blood pressure was categorized following American Heart Association recommendations. BMI was categorized using the current recommendations of the World Health Organization (see Table 3 for observed frequencies). Participants also reported whether they had experienced any of 9 physical symptoms over the past 24 hours, which included both chronic conditions (e.g., acne, shortness

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of breath) and typically more momentary conditions (e.g., runny nose, headaches); this measure was used for imputation purposes.

Finally, participants completed the SPANE, the Satisfaction with Life Scale, (SWLS; Diener, Emmons, Larsen, & Griffin, 1985), and the Meaning in Life Questionnaire, Presence Subscale (MLQ-P; Steger, Frazier, Oishi, & Kaler, 2006) at each comprehensive assessment. In the present report, these measures, which are the primary subject of a related report (Heintzelman et al., 2018), were used for imputation purposes only. Data are available on the Open Science Framework: https://osf.io/jhtyc/?view_only=7056daf688ea43ec8abe6467b6ba1592.

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Table 1. *Person-level descriptives and treatment effects for raw and imputed data by treatment condition (weekly measures).*

	N Reporting		Mean				SD				Treatment Effect	
	Raw		Raw		Imputed		Raw		Imputed		Raw	Imputed
	C	T	C	T	C	T	C	T	C	T	IRR	IRR
<u>Demographics</u>												
Age	50	50	41.0	45.5			14.0	13.7				
Gender (1 = woman)	49	48	0.84	0.81			0.37	0.39				
<u>Sick Days and Weeks Totals</u>												
Sick Days	50	48	8.82	4.31	9.57	6.85	11.3	7.42	11.3	8.86	.49***	.73***
Weeks W/ 1 Sick Day	50	48	3.62	1.75	3.98	2.94	3.19	1.94	3.14	2.47	.48***	.76*
Weeks W/ 2 Sick Days	50	48	2.10	0.90	2.29	1.54	2.79	1.57	2.78	2.06	.43***	.69*
Weeks W/ 3 Sick Days	50	48	1.28	0.67	1.39	1.04	2.19	1.34	2.23	1.66	.52**	.77
Weeks W/ 4 Sick Days	50	48	0.84	0.42	0.89	0.61	1.84	1.07	1.86	1.29	.50*	.71
Weeks W/ 5 Sick Days	50	48	0.54	0.29	0.57	0.39	1.57	0.99	1.58	1.14	.54 [†]	.70

Note. C = Control; T = Treatment; IRR = Incidence Rate Ratio; ***p < .001; **p < .01; *p < .05; [†]p < .10

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Table 2. Means and standard deviations for health measures at each assessment point by treatment condition.

		N Reporting	N Sick Days		Health Issues Prevent Activity		Healthy/ Full of Energy		General Self-Rated Health	
			Mean	SD	Mean	SD	Mean	SD	Mean	SD
Baseline	Control	50	2.54	3.29	1.68	2.31	14.96	9.02	3.69	0.87
	Treatment	50	3.40	6.80	2.44	3.70	15.36	9.73	3.80	0.95
Post	Control	45	3.07	3.44	1.80	2.88	14.98	8.96	3.71	0.92
	Treatment	40	1.85	3.18	1.53	2.79	18.25	10.07	4.00	1.02
Follow-up	Control	45	3.82	5.70	3.44	5.81	13.43	9.39	3.54	0.95
	Treatment	39	1.59	2.16	1.55	3.12	9.39	8.95	4.06	0.85

Note. Due to a procedural artefact (position of question on the survey), fewer participants completed the general self-rated health measure, yielding a similar effect size to the other measures, partial- $\eta^2 = .03$, which did not reach statistical significance, $F(2,120) = 1.87$, $p = .158$; there was no systematic difference between conditions in this spurious missing data (Control = 5, Treatment = 6 noncompleters at baseline).

Table 3. *Frequencies of the ordinal categories for blood pressure and body mass index.*

	Baseline			Post-Test			Follow-up		
	Control	Treatm.	%Total	Control	Treatm.	%Total	Control	Treatm.	%Total
<u>BP Category</u>									
0: Normal	25	18	43%	18	18	46%	19	14	42%
1: Elevated	1	4	5%	5	6	14%	8	4	15%
2: Hypertension 1	16	20	36%	9	11	26%	11	16	34%
3: Hypertension 2	8	7	15%	9	2	14%	7	0	9%
<u>BMI Ordinal Category</u>									
0: Normal or lower	29	27	57%	23	22	58%	23	22	58%
1: Overweight	12	14	28%	13	9	28%	13	9	28%
2: Obese	9	8	17%	9	2	14%	9	2	14%

Note. Blood Pressure categories: 0=Normal (less than 120/80 mmHg); 1=Elevated (120≤Systolic<130 and Diastolic<80 mmHg); 2=Hypertension Stage 1 (130≤Systolic<140 or 80≤Diastolic<90 mmHg); 3=Hypertension Stage 2 (Systolic≥140 or Diastolic ≥90 mmHg). BMI categories: 0=Normal or lower (BMI < 25), 1=Overweight (25≤BMI<30); 2=Obese (BMI≥30).

Results

Weekly Assessments: Effects Across the Course of Treatment

Analytic strategy. For models including the weekly reported number of sick days, we specified a Poisson distribution which is particularly well suited for non-normally distributed frequency outcomes with a high occurrence of nonevents (i.e., days with no symptoms; Bolker et al., 2009). We analyzed the data both as person averages across time and at the level of weeks through multilevel conditional growth models. This strategy produces interpretable effect size estimates by examining treatment effects on the overall incidence rate ratios (IRR) of sickness.

As the person-level analyses are particularly vulnerable to the differential missing data across conditions (Table 1), we conducted the analyses with the available data, as well as after imputing the missing data (including the two participants who did not complete any surveys). We used multiple imputation with chained equations (MICE) with a predictive mean matching (PMM) method of imputation with package MICE 2.46.0 (Buuren & Groothuis-Oudshoorn, 2011) in R 3.4.3 (Table 1 includes descriptives for the imputed data). Each participant's number of sick days for each missing week was predicted based on the variables of interest to be used in the conducted analyses (Buuren & Groothuis-Oudshoorn, 2011): participant's (1) condition (2) age and sex, (3) baseline reports of physical symptoms, life satisfaction, positive affect, negative affect, and meaning in life, and (4) nonmissing weekly reports of number of sick days.

For the multilevel growth models, we compared change over time between experimental conditions as indicated by the fixed effect interaction between Time (as a Level 1 within-subjects factor) and Treatment (as a Level 2 between-subjects factor). We modeled the random intercept of sick days, and the random effect of time allowing for each participant's score over time to be modeled as observed. Since fixed effects were of primary interest, the covariance between the

random intercept and slope was constrained for parsimony. For best interpretability, Time was coded from -9 (Week 1) to 0 (Week 10), so that model intercept can be interpreted as the mean difference after the intervention, and the Treatment coefficient as the instantaneous effect of Treatment after undergoing the intervention. All models were estimated using restricted maximum likelihood (REML) estimator to provide greater robustness to missing data. In addition, we controlled for covariates at baseline (as used in the imputations). Between and within subjects correlations are provided as Supplementary Online Material in Table S1.

Assumption tests. As expected, the observed number of sick days fit the theoretical Poisson distribution substantially better than the normal distribution, $\lambda = .84$. Even in the Poisson distribution, however, we still observed a substantial number of outlying observations—only 0.5% of observations included being sick for 6 days a week and only 2.1% included being sick all 7 days—which persisted after log-transforming sick days. Recoding 6 and 7 days into 5 days showed better fit to the Poisson distribution, and so we focus on the transformed variable in subsequent analyses. Further details on assumptions testing, as well as analyses on the raw untransformed variable, are provided online <http://rpubs.com/AnonForPeerReview/SWBHealth>

Average treatment effects on sick days and weeks across time. On average, treatment participants, were half as likely to experience sick days over the course of the study than control participants, as shown by a significant main effect of treatment in generalized linear model with a Poisson distribution, $b(se) = -.72(.08)$, $z = -8.49$, $p < .001$, $IRR = 0.49$. Controlling for the number of completed surveys reduced but did not explain away this main effect of treatment, $b(se) = -.44(.09)$, $z = -4.94$, $p < .001$, $IRR = 0.64$, even though the number of reported surveys was associated with the average number of sick days, $b(se) = .16(.02)$, $z = 7.51$, $p < .001$, $IRR = 1.17$. After imputing the missing data, treatment participants still had about 53% lower incidence

rate of sick days than control participants, $b(se) = -.31(.12)$, $t(24.0) = -2.67$, $p = .013$, $IRR = 0.73$. As an alternative estimate of effect size, we measured the effect of condition on the number of weeks with sick days (Table 1 for details). In the raw data, treatment participants were about half as likely to experience weeks with one or more, two or more, three or more, and four or more sick days. In the imputed data, treatment participants were about 50% less likely to experience weeks with one or more and two or more sick days (Table 1).

Change in sick days across time. The conditional growth model revealed a significant Treatment by Time interaction on number of sick days, $IRR = .89$, $p = .009$, such that people in the treatment condition experienced significantly lower rate of being sick over the course of the study (Figure 1). The instantaneous effect of Treatment during Week 10 was $IRR = .33$, $p = .001$, suggesting that, compared to controls, treatment participants had only one-third the rate of incidence of sick days at the end of the intervention. These effects remained virtually unchanged after controlling for indicators of health and subjective well-being at baseline (see Table 4 for model details).

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Table 4. *Growth models for number of sick days throughout the course of treatment.*

N _{ID} = 98 n _{obs} = 767	Growth Model (GM) Type														
	IO-GM			UGM: Unconditional			UGM: Curvilinear			CGM: Conditional			CGM: w/Controls		
	IRR	95%CI	p	IRR	95%CI	p	IRR	95%CI	p	IRR	95%CI	p	IRR	95%CI	p
Fixed Components															
(Intercept)	.40	.40-.40	<.001	.32	.23-.45	<.001	.32	.22-.47	<.001	.48	.32-.71	<.001	.05	.00-.55	.014
Time				.97	.93-1.02	.225	.97	.86-1.09	.616	1.00	.95-1.05	.886	1.00	.96-1.06	.856
Time-Squared							1.00	.99-1.01	.955						
Treatment										.33	.17-.64	.001	.34	.18-.63	<.001
Time X Treatment										.89	.82-.97	.009	.89	.82-.97	.009
Age													1.02	1.00-1.04	.088
SwL Baseline													.80	.54-1.19	.267
PA Baseline													.95	.60-1.52	.837
NA Baseline													1.65	1.09- 2.49	.018
Meaning Baseline													1.30	1.04-1.62	.019
Sickness Baseline													1.04	.88-1.22	.684
Random Components															
$\tau_{00, ID}$		1.26			1.26			1.26			1.11			.83	
ICC _{ID}		.56			.55			.55			.52			.45	
AIC		1613.69			1592.09			1594.09			1584.64			1580.98	
-2 Log-Likelihood		1609.69			1584.09			1584.09			1572.64			1556.98	
Deviance		710.58			619.39			619.18			627.88			630.48	
Family		poisson (log)			poisson (log)			poisson (log)			poisson (log)			poisson (log)	

Note. IRR=Incidence Rate Ratio=Exp(B), representing the rate of incidence of sick days. Treatment IRR represents the instantaneous effect of Treatment during the last week of the intervention (0=Control; 1=Treatment. Time: 0=Week10 (last week); -9 = Week1). PA=Positive Affect; NA=Negative Affect; SwL=Satisfaction with Life. IO=Intercept Only; UGM=Unconditional Growth Model; CGM=Conditional Growth Model.

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Figure 1. Effect of treatment on a number of days feeling sick over time. Error bars are standard errors of the mean.

Does happiness lead to health? We found consistent evidence that people felt sick less often over the course of a PPI compared to controls. Next, we examined whether improvements in physical health were due to treatment effects on subjective well-being with a series of mediational analyses of Treatment effects on physical health through subjective well-being.

First, we explored whether Treatment produced changes in subjective well-being over time in the course of treatment. We found a significant Treatment by Time interaction on both life satisfaction, $b(se) = .08(.02)$, $\beta = .08$, $t(666) = 3.57$, $p < .001$, positive affect, $b(se) = .05(.02)$, $\beta = .08$, $t(667) = 2.47$, $p = .014$, and negative affect, $b(se) = -.06(.02)$, $\beta = -.09$, $t(665) = -2.80$, $p = .005$. As shown in Figure 2, experimental participants grew more satisfied with their lives and reported increasingly higher positive affect and lower negative affect throughout the course of treatment, whereas control participant experienced no change. Treatment also increased participants' meaning in life compared to controls, $b(se) = .05(.02)$, $\beta = .08$, $t(667) = 2.32$, $p = .021$.

Did the observed changes in subjective well-being indicators over treatment drive the observed improvements in health? To explore this question, we specified a multilevel moderated mediation model, whereby the conditional effect of Time by Treatment on the three subjective well-being indicators—positive affect, negative affect, and life satisfaction—was tested as a mediator of the changes in reported sick days (see Figure 3). We used MLMED macro (Rockwood & Hayes, 2017) on SPSS21, using 10,000 Monte Carlo simulations to estimate the confidence intervals around indirect effects (MC-CI). The effect of the mediator on sick days was decomposed into between-subjects and within-subjects components, and only the within-subjects components were used to estimate the indirect effects. Random intercepts and slopes of

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time were estimated for both the mediator and outcome, allowing different trajectories across time between participants in both subjective well-being and health. The random slope of the mediator on outcome was not estimated, assuming a fairly uniform relationship between subjective well-being and health across participants.

There was a significant omnibus moderated mediation effect of treatment on days sick through positive affect, $b = -.04$, 95%MC-CI $[-.07, -.01]$. Indeed, the conditional indirect within-subject effect of Time on sick days through positive affect for treatment participants was significant, $b = -.03$, 95%MC-CI $[-.05; -.01]$, $z = -2.41$, $p = .016$. Thus, to the extent that treatment participants felt higher positive affect over the course of treatment than control participants, they also tended to experience fewer sick days. Life satisfaction demonstrated the same pattern with a significant index of moderated mediation, $b = -.05$, 95%MC-CI $[-.07, -.02]$, and a significant conditional indirect effect for treatment participants, $b(SE) = -.03$, 95%MC-CI $[-.05; -.01]$, $z = -3.13$, $p = .002$. Finally, we observed a similar moderated mediation effect for negative affect, $b = -.02$, 95%MC-CI $[-.04, -.01]$, with a significant indirect effect conditional on treatment, $b = -.02$, 95%MC-CI $[-.04; -.01]$, $z = -2.93$, $p = .003$.ⁱ These effects did not depend on the scoring of the indicator of sickness.ⁱⁱ Overall, the PPI increased treatment participants' subjective well-being, which, in turn, explained their decrease in sick days.

Taking further advantage of the longitudinal nature of the data, we next ran time-lagged correlational analyses predicting sick days in a given week from the difference in subjective well-being between that week and the previous week, while controlling from sick days during the previous week. To retain Week 1 responses, we conservatively assumed no increase in well-being from Week 0. Over and above being sick in the previous week, $IRRs > 1.47$, $p < .001$, a change over the previous week in positive affect, $IRR = .75$, 95%CI $[.66; .85]$, $z = -4.42$, $p < .001$,

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negative affect, $IRR = 1.23$, 95%CI[1.09; 1.39], $z = 3.39$, $p < .001$, and life satisfaction, $IRR = .83$, 95%CI[.75; .91], $z = -3.83$, $p < .001$, significantly predicted how sick people felt during the current week. These analyses further suggest that Treatment improved physical health specifically by increasing subjective well-being.

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Figure 2. Effects of treatment on indicators of subjective well-being over time. Error bars are standard errors of the mean. Note that the drop in indicators of subjective well-being in Week 7 was preceded by the 2016 U.S. Presidential Election, won by Donald J. Trump.

Figure 3. Moderated mediation model of within-subject change over Time by Treatment through positive affect on days of feeling sick.

Comprehensive Assessments: Do the Effects of Happiness on Health Persist?

Days of good and bad health. We next turned to explore changes in health outcomes in the comprehensive assessments from baseline to the final follow-up assessment. We first performed complete-case analysis, utilizing mixed ANOVAs with condition as between-subjects factor and assessment point—baseline, post-test, and follow-up—as a within-subjects factor. As shown in Figure 4, control participants experienced an increasing number of sick days over each of the months preceding the second and third comprehensive assessments. Thus, while control participants got sicker over the duration of the fall/winter flu and cold season, treatment participants tended to experience *fewer* sick days in the fall and winter months at post-test and follow-up than in the summer months at baseline. Importantly, this drop in sick days at post-test was maintained three months after the intervention ended (at the 6-month Follow-up). This Treatment x Time interaction on the number of sick days was significant, $F(2,160) = 3.76, p = .025$, partial- $\eta^2 = .04$ (Table 2). Additionally, there was a significant treatment effect over time on the number of days that participants felt their health prevented them from doing their usual daily activities, $F(2,158) = 3.54, p = .031$, partial- $\eta^2 = .04$ (Figure 4, Table 2). Conversely, treatment participants, compared to controls, reported an increasing number of days when they felt healthy and full of energy from baseline to follow-up, $F(2,156) = 6.10, p = .003$, partial- $\eta^2 = .07$.ⁱⁱⁱ

While easily interpretable and familiar, the above complete-case analyses present, of course, a strong assumption that the data are missing completely at random (MCAR). Thus, we next performed the same analyses, in a multilevel growth model framework, which drops observations pairwise, rather than listwise, and employs an estimator (REML) that is robust to missing data. As before, we specified a poisson distribution for the count outcomes of number of

days. These analyses produced the same pattern of results. Specifically, from baseline to follow-up, treatment participants were only half as likely as controls to experience sick days, $IRR = .53$, $p < .001$, or days in which their health prevented daily activities, $IRR = .50$, $p < .001$. Treatment participants were also one-fifth more likely to have days of feeling healthy and full of energy, $IRR = 1.19$, $p < .001$. No curvilinear effects of time emerged. Model details are available at: <http://rpubs.com/AnonForPeerReview/SWBHealthComp>.

Auxiliary objective measures of health. Next, we turn to examining the influence of treatment on objective measures of blood pressure and BMI (for descriptives, see Table 3; for model details, see <http://rpubs.com/AnonForPeerReview/SWBHealthComp>). First, using mixed ANOVA, we found a significant Treatment by Time interaction for blood pressure, $F(2,142) = 3.74$, $p = .026$, $\text{partial-}\eta^2 = .05$. As shown in Figure A, the average blood pressure of treatment participants decreased, from Elevated to Normal, between baseline and post test, whereas control participants' blood pressure remained, on average, Elevated. Pairwise comparisons with Tukey corrections indicated a single significant decrease in blood pressure risk category from baseline to immediate post-test in treatment participants, Mean Difference (SE) = $-.50(.16)$, $t(142.0) = -3.05$, $p = .032$, $d = -.44$. In contrast, there were no differences in the control participants, $ps > .250$. We explored this overall pattern further by specifying a growth mixed model, including the squared term of time. Given the ordinal categorical variable, we specified a cumulative link, proportional odds, ordered mixed model (R, package: *Ordinal*, function: *clmm*). This model yielded a statistically significant curvilinear effect of Treatment by Time, $b(se) = 1.35(0.67)$, $p = .043$, with a nonsignificant linear interaction, $b(se) = -.50(0.37)$, $p = .168$. Thus, we find that the happiness treatment had a slight but noticeable effect on blood pressure risk.

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We next conducted the same series of tests for the BMI categories (0 = normal or lower, 1 = overweight, 2 = obese). The mixed ANOVA indicated a marginally significant effect of treatment, $F(2,138) = 2.66, p = .073$, partial- $\eta^2 = .04$. Exploring this pattern further, we ran a cumulative link mixed growth model, treating BMI category as an ordinal outcome. This test produced a statistically significant effect of Treatment on BMI over Time $b(se) = -4.00(1.10), p < .001$. Posthoc pairwise tests with Tukey corrections indicated a single significant effect, such that control participants' average BMI category increased significantly from baseline to post-test: Mean Difference (SE) = $.10(.03), t(72.2) = 3.36, p = .013$. Treatment participants, on the other hand, experienced no notable changes in BMI category. This pattern, then, cautiously suggests that feeling happier may play a protective role against gaining weight even over the challenging fall/winter season.

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Figure 4. After the happiness treatment, participants felt less sick, healthier, and more active, maintaining these improvements in health three months after the end of the intervention. Treatment participants also experienced a drop in blood pressure immediately after the intervention and no increase in weight risk category at follow-up. (compared to controls). Error bars are standard errors of the mean.

Discussion

Across a range of analyses and a variety of measures, we found evidence that increasing happiness through a PPI has causal effects on physical health in a sample drawn from a nonclinical population. Over the course of treatment, participants in the PPI reported fewer sick days across the course of treatment compared to controls; these treatment-related changes in sick days throughout the treatment phase were driven by (and preceded by) changes in subjective well-being. Following treatment, participants in the PPI, compared to controls, reported fewer days in which they felt sick or that their health interfered with normal activities and more days of feeling healthy and energetic in the assessments following the treatment phase. Right after the PPI, treatment participants demonstrated lower risk of cardiovascular disease as indicated by their blood pressure. And unlike control participants who gained weight, treatment participants' weight remained stable up to three months after treatment even though this period fell into the relatively less active winter season. Together, these findings provide the strongest evidence to date that psychological interventions exclusively designed to boost subjective well-being can have persistent causal effects on physical health—even in psychologically and physically healthy individuals.

Implications for Research and Practice

Our findings inform the basic science of happiness and carry implications for mental and physical health practitioners. Thus, though the notion that happiness begets health is well supported in general (Diener et al., 2017; Lyubomirsky et al., 2005), the current work fills a critical missing gap in the literature: experimental evidence from an RCT informed by best practices in clinical science, including deployment of an externally valid manipulation of

happiness, intention-to-treat analysis, acceptable attrition rate (< 20%), and consistent effects across complete-case and imputation analyses.

Beyond scientific research, the present work carries implications for healthcare providers, policy makers, and the future of medicine. By demonstrating the effects of happiness on health in a nonclinical community sample already in good general health, the present research dovetails with the increasing emphasis on and excitement about preventive healthcare across medicine (Barbot, 2012). In this approach, practitioners and policy makers aim to prevent the occurrence of disease, rather than only treat disease after onset, by targeting the healthy population via, for example, regular medical check-ups, immunizations, disease screenings, and dietary and activity recommendations. The toolbox used in preventative healthcare, however, is still largely limited to medical procedures and to interventions primarily focused on medically significant health behavior, such as diet or exercise (Damschroder et al., 2014; Lutes & Steinbaugh, 2010). The present research suggests that positive psychological science can greatly expand the toolbox of preventative medical science. Such a pathway—from positive psychological to clinical science—is notable from a historical perspective because ‘positive psychology’ emerged in reaction to the preoccupation in the medical and psychological sciences with treating rather than promoting health (Seligman & Csikszentmihalyi, 2000). Yet, as we have seen, rigorous causal evidence for the efficacy of PPIs in preventing disease in healthy individuals is hard to find in the literature. We hope that the present research would lay the foundation for a productive and mutually beneficial relationship—in research and practice—between positive psychological and clinical sciences.

Limitations and Future Directions

Despite using, CDC-recommended questionnaires of health and objective health indicators, the present research only lays the foundation for future research to use a much wider range of measures. Indeed, our two objective health indicators—blood pressure and BMI—were selected for their ease and affordability of measurement. As such, subsequent work building on this research ought to include a more comprehensive battery of physical health assessments, including a wider range of objective physiological indicators of physical health tested in large samples of participants. Additional indicators such as medical visit information and age of death can also be collected in future studies. Collaborations between medical and psychological researchers can be particularly fruitful in enhancing measurement.

Relatedly, as meaningful health differences may unfold slowly over time, rigorous assessment of physical health effects often entails extending follow-ups from months to years. Such longitudinal studies would also allow answering deep-standing theoretical questions about the connection between body and mind. Can a happiness intervention have cumulative effects on health across the lifespan through a positive feedback loop (Fredrickson & Losada, 2005)? Does the life stage of a happiness intervention—during childhood, in young adulthood, or middle age—moderate effects on health across a lifetime? Though early administration as part of a child’s education curriculum might set people on the right track for compounded health benefits over the life course, undertaking such an intervention in middle age and onward might be associated with greater agency and commitment (as people begin to realize that happiness needs to be actively practiced rather than achieved). In short, the present research raises more questions than it answers, thus revealing a fertile ground for future interdisciplinary collaborations.

Conclusion

Using an externally valid manipulation to boost happiness beyond the laboratory, the current work shows that happiness does lead to health, building new bridges between positive and clinical science. Happiness is good not only for the soul, but for the body as well.

Author Contributions

K Kushlev and S. Heintzelman contributed equally to the study design and implementation and the writing of this manuscript. Ed Diener served an advisory role throughout the research process.

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Notes

ⁱ Note that the indirect effect equals $a*b$, whereby path a equals the time by condition interaction on the mediator and path b equals the effect of the mediator on the outcome controlling for time; the signs of indirect effects for positive and for negative affect are both negative because the condition effect of time on positive affect is positive, whereas the conditional effect on negative affect is negative.

ⁱⁱ As MLMED is limited to conducting analyses assuming a Gaussian distribution, we also conducted these analyses on a normalized version of the days sick variable based on a Tukey transformation, where $\text{days}_{\text{transformed}} = \text{days}^{\lambda}$. These analyses produced an identical pattern of significance.