# Being Happy and Becoming Happier as Independent Predictors of Physical Health and Mortality

Emily C. Willroth, PhD, Anthony D. Ong, PhD, Eileen K. Graham, PhD, and Daniel K. Mroczek, PhD



## ABSTRACT

**Objective:** The present study tested preregistered predictions regarding the prospective associations between level and change in subjective well-being (SWB) and physical health.

**Methods:** In two large longitudinal panel studies conducted in the United States ($N = 3294$) and Japan ($N = 657$), we used multilevel growth curve models to estimate level and change in components of SWB (i.e., life satisfaction, positive affect, and negative affect). Next, we used random intercepts and slopes to predict subsequent self-reported general health and number of chronic health conditions (in the United States and Japan) and mortality risk (in the United States).

**Results:** Greater life satisfaction, higher positive affect, and lower negative affect were associated with better health ($0.22 < |\beta$ values$| < 0.46$) and longer survival. Above and beyond SWB level, longitudinal increases in life satisfaction and positive affect and longitudinal decreases in negative affect were associated with better health ($0.06 < |\beta$ values$| < 0.20$). Moreover, all three SWB components independently predicted health, and life satisfaction and negative affect independently predicted survival. The preregistration and analysis scripts are available at osf.io/mz9gy.

**Conclusions:** The present findings suggest that being happy and becoming happier across time are independently associated with better physical health in the United States and Japan.

**Key words:** subjective well-being, affect, life satisfaction, physical health, mortality.

## INTRODUCTION

Happy people tend to live healthier, longer lives compared with unhappy people. Subjective well-being (SWB)—people's cognitive and affective evaluations of their lives (1)—is an important indicator of overall happiness and has been robustly linked to better physical health (for recent reviews, see Refs. (2,3)). However, several open questions remain. SWB comprises positive affect (PA), low negative affect (NA), and life satisfaction (LS) (4), but the unique associations of each component with physical health are poorly understood (3). Moreover, SWB is moderately stable across the life-span (5,6) but is also characterized by within-person change (7–10), yet little is known about the relationship between SWB change and physical health. In two longitudinal panel studies conducted in the United States and Japan, we examined *level* and *change* in components of SWB in relation to self-reported general health, number of chronic health conditions, and mortality risk.

### SWB Level and Physical Health

Higher SWB is theorized to confer benefits for physical health, by promoting positive health behaviors, directly influencing physiological processes (e.g., neuroendocrine, cardiovascular, and immune systems), and by buffering the harmful effects of stress on these physiological processes (1,11). Physical health also influences SWB, with better physical health leading to higher well-being and worse physical health leading to lower well-being (12). A large body of evidence has linked higher SWB with several aspects of general health, including less self-reported pain, fewer self-reported illness symptoms, and better self-reported health (e.g., Refs. (13,14)). In the US sample used in the present research, greater PA and lower NA have been prospectively linked with fewer chronic health conditions and better self-reported general health (15,16). SWB has also been associated with lower disease incidence, although evidence is more mixed. For example, SWB has been prospectively associated with lower risk for coronary heart disease (17) and cancer incidence (18) in some studies, but not in others (19,20). Despite mixed evidence and null associations within some chronic diseases, several studies have found that higher SWB is associated with reduced risk for arthritis (21), diabetes (for a review, see Ref. (22)), hypertension (e.g., Ref. (23)), stroke (e.g., Ref. (24)), and cold and flu viruses (e.g., Ref. (25)). Taken together, SWB seems to be protective against morbidity and disease prognosis, but associations differ across preexisting diseases states.

**HR** = hazard ratio, **LS** = life satisfaction, **MIDUS** = Midlife in the United States, **MIDJA** = Midlife in Japan Study, **NA** = negative affect, **PA** = positive affect, **SWB** = subjective well-being

SDC Supplemental Content

From the Department of Medical Social Sciences (Willroth, Graham, Mroczek), Feinberg School of Medicine, Northwestern University, Evanston, Illinois; Department of Human Development (Ong), Cornell University, Ithaca; Division of Geriatrics and Palliative Medicine (Ong), Weill Cornell Medical College, New York City, New York; and Department of Psychology (Mroczek), Northwestern University, Evanston, Illinois.

Address correspondence to Emily C. Willroth, PhD, Northwestern University, Hogan Biological Sciences Building 2127, Evanston, IL 60202. E-mail; emily.willroth@northwestern.edu

Received for publication December 15, 2019; revision received May 11, 2020.

DOI: 10.1097/PSY.0000000000000832

In addition, all three components of SWB are generally associated with lower mortality risk, especially in initially healthy populations (for reviews, see Refs. (26,27)). The protective effects of SWB have been found for PA (for a review, see Ref. (26)), low NA (e.g., Ref. (28)), and LS (e.g., Ref. (29)). In the US sample used in the present research, greater positive mental health (a composite of PA, LS, and other aspects of well-being) was associated with lower mortality risk in the first 10 years of follow-up (30). SWB has also been associated with reduced mortality in people who have been diagnosed with a disease (e.g., Refs. (31–33)); however, the associations tend to be smaller and findings are more mixed (26).

Previous research has shown that SWB is linked with physical health in Western and non-Western samples (e.g., Refs. (29,34)). However, there may be cultural differences in well-being–health links for specific types of well-being. For example, the relationship between NA and biological markers of health has been shown to differ in the United States compared with Japan, possibly because of culturally divergent beliefs about NA (35,36). Cultural differences in well-being-health links may also depend on the type of health outcome. For example, a study of 11 European countries found that well-being had weaker associations with self-reported health in less individualistic cultures; however, individualism did not moderate the link between well-being and all-cause mortality (37). Thus, it is important to examine the unique relationships between SWB components and multiple physical health outcomes across cultures.

### SWB Change and Physical Health

On average, SWB has been shown to change modestly across the life-span (7–10). Although age-related patterns of SWB have been observed (12,38), longitudinal changes in SWB seem to differ across well-being components and across individuals. A key unanswered question concerns how individual differences in SWB change are related to health outcomes. Although research on change in SWB and physical health is limited (2), a handful of studies have examined links between longitudinal characteristics of SWB and mortality. One study found a graded relationship between repeated assessments of enjoyment of life and mortality, such that the greater number of occasions on which participants reported enjoying their life, the lower their mortality risk (39). Similarly, greater stability in LS across time has been associated with lower mortality risk (40).

Indirect evidence for associations between longitudinal change in SWB and physical health also comes from research linking personality change to physical health. Personality—particularly extraversion and neuroticism—is one of the strongest predictors of SWB because, in part, of conceptual similarities and shared heritability between the two sets of constructs (41–44). Given that personality has been shown to explain approximately half of the variance in SWB (44), research on personality change and health associations may provide insight into SWB change and health associations. Longitudinal change in personality has been linked to several health outcomes, including self-rated health (45), health-related risk factors (46), and mortality (47). Thus, longitudinal change in SWB may be a key predictor of physical health as well.

### The Present Research

The present research used data from the Midlife in the United States (MIDUS) (48) and Midlife in Japan (MIDJA) (49) studies to examine the associations of SWB level and SWB change with self-reported general health, number of chronic health conditions, and mortality. This research builds on previous research in the MIDUS and MIDJA and tests several independent predictions. First, the present study examined associations between level and change in the three SWB components and physical health outcomes. We preregistered the following predictions. We predicted that higher PA, lower NA, and higher LS would be associated with better self-reported general health, fewer chronic health conditions, and lower mortality risk. Moreover, we predicted that greater longitudinal increases in PA, decreases in NA, and increases in LS would be associated with better self-reported general health, fewer chronic health conditions, and lower mortality risk.

Second, the study examined the *unique* associations of the three SWB components (i.e., PA, NA, and LS) with physical health outcomes, above and beyond one another. We did not make specific predictions regarding the unique associations of the three SWB components. Many studies of the links between PA and physical health have adjusted for NA (e.g., Ref. (50)). However, less is known about whether LS and affect have independent associations with health (3). The few studies that have examined LS with one or both affective components have produced conflicting results (e.g., Refs. (29,51)).

Third, we tested whether links between SWB and physical health differed in the United States (MIDUS) compared with Japan (MIDJA). We did not make specific predictions regarding similarities or differences between results in the MIDUS and MIDJA samples.

## METHODS

### Samples and Longitudinal Study Design

The MIDUS is a large publicly available data set aimed at collecting a representative sample of participants from the United States assessed during midlife (starting $N = 7108$ in MIDUS 1; age, 24–74 years at baseline). The MIDUS uses a longitudinal panel design in which participants complete comprehensive questionnaires about their well-being and health approximately every 9 years. In the present study, we used SWB data from MIDUS 1 (collected in 1995–1996), MIDUS 2 (collected in 2004–2006), and MIDUS 3 (2013–2015) to predict self-reported general health and chronic health conditions in MIDUS 3 and mortality through 2018. The MIDJA is a probability sample of Japanese adults (starting $N = 1027$ in MIDJA 1; age, 30–79 years at baseline) from the Tokyo metropolitan area. MIDJA participants completed the same questionnaires as MIDUS participants in 2008 (MIDJA 1) and in 2012 (MIDJA 2). In the present research, participants who had SWB data at one or more time points were included in mortality analyses ($N = 6462$ in MIDUS). Because we were interested in prospectively predicting self-reported general health and chronic health conditions, only participants with data in MIDUS 3 ($N = 3294$) or MIDJA 2 ($N = 657$) were included in the primary analyses for those outcome variables. Because of the large percentage of missingness for the analyses predicting general health and chronic health conditions, we also conducted sensitivity analyses using predictive mean matching in five imputed data sets using the mice package in R (52).

### Measures

Descriptive statistics are shown in Table 1.

#### *Positive Affect*

Participants were asked to rate how much of the time during the past 30 days they felt each of six PA items: cheerful, in good spirits, extremely happy,

**TABLE 1.** Participant Characteristics

| | MIDUS (Full Sample), Mean (SD) or *N*/% (Total *N*) | MIDUS (Sample With MIDUS 3 Data), Mean (SD) or *N*/% (Total *N*) | MIDJA (Sample With MIDJA 2 Data), Mean (SD) or *N*/% (Total *N*) |
|---|---|---|---|
| Age, y | 46.38 (12.98) (*n* = 7105) | 45.61 (11.41) (*n* = 3294) | 54.92 (13.58) (*n* = 657) |
| Male | 3440/48.41% (*n* = 7106) | 1484/45.05% (*n* = 3294) | 309/47.03% (*n* = 657) |
| Education | 5.25 (2.26) (*n* = 7095) | 5.73 (2.22) (*n* = 3290) | 5.05 (2.94) (*n* = 651) |
| Time 1 positive affect | 3.39 (0.73) (*n* = 6306) | 3.41 (0.70) (*n* = 3159) | 3.28 (0.77) (*n* = 654) |
| Time 1 negative affect | 1.54 (0.62) (*n* = 6299) | 1.51 (0.58) (*n* = 3159) | 1.66 (0.64) (*n* = 653) |
| Time 1 life satisfaction | 7.76 (1.63) (*n* = 6236) | 7.85 (1.48) (*n* = 3151) | 7.26 (2.02) (*n* = 657) |
| Time 2 positive affect | 3.43 (0.71) (*n* = 4023) | 3.45 (0.69) (*n* = 2895) | 3.26 (0.72) (*n* = 653) |
| Time 2 negative affect | 1.52 (0.58) (*n* = 4003) | 1.48 (0.54) (*n* = 2888) | 1.70 (0.64) (*n* = 649) |
| Time 2 life satisfaction | 7.88 (1.53) (*n* = 3987) | 7.94 (1.46) (*n* = 2875) | 7.36 (2.02) (*n* = 652) |
| Time 3 positive affect | 3.43 (0.72) (*n* = 2904) | 3.43 (0.72) (*n* = 2904) | — |
| Time 3 negative affect | 1.47 (0.58) (*n* = 2886) | 1.47 (0.58) (*n* = 2886) | — |
| Time 3 life satisfaction | 7.90 (1.60) (*n* = 2834) | 7.90 (1.60) (*n* = 2834) | — |
| General health | 7.33 (1.60) (*n* = 2912) | 7.33 (1.60) (*n* = 2912) | 7.23 (2.05) (*n* = 657) |
| Chronic conditions | 3.26 (3.15) (*n* = 2861) | 3.26 (3.15) (*n* = 2861) | 2.13 (1.88) (*n* = 657) |
| Mortality | 1302/20.05% (7108) | 1154/4.68% (*n* = 3294) | — |

MIDUS = Midlife in the United States; MIDJA = Midlife in Japan Study.

calm and peaceful, satisfied, and full of life. Response options ranged from 1 (all of the time) to 5 (none of the time). Responses were recoded such that higher values reflected greater experienced affect. Finally, a mean score was computed. Cronbach $\alpha$ ranged from .90 to .93 across time points and samples.

### Negative Affect

Participants were asked to rate how much of the time during the past 30 days they felt each of six NA items: so sad nothing could cheer you up, nervous, restless, nervous, everything was an effort, and worthless. Response options ranged from 1 (all of the time) to 5 (none of the time). Like with PA, responses were recoded such that higher values reflected greater experienced affect. Finally, a mean score was computed. Cronbach $\alpha$ ranged from .85 to .87 across time points and samples.

### Life Satisfaction

Participants rated their satisfaction with their lives overall on a scale from 0 (the worst possible) to 10 (the best possible). We preregistered that we would assess LS using a five-item composite measure. However, we later learned that the five-item measure includes satisfaction with one's health. To avoid including subjective health as both an independent and a dependent variable, we decided to deviate from the preregistration and use a single-item LS measure. Results using the full five-item measure are available at osf.io/frx4a.

### Subjective Well-Being

An SWB composite was formed from PA, NA, and LS variables. First, PA, NA, and LS were *z*-scored within time points. Next, NA was reverse-scored such that high values reflected greater SWB for all three indicators. Finally, a mean composite was calculated from *z*-scored PA, *z*-scored NA, and *z*-scored LS. Cronbach $\alpha$ ranged from .74 to .78 across time points and samples.

### Self-Reported General Health

Participants were asked "Using a scale from 0 to 10 where 0 means 'the worst possible health' and 10 means 'the best possible health,' how would you rate your health these days?"

### Chronic Health Conditions

Participants were asked to report any chronic health conditions that they experienced in the past 12 months.

### Mortality

Data on mortality were collected using several methods, including National Death Index reports conducted in 2006, 2009, and 2016; tracing; and longitudinal sample maintenance through October 2018. Survival time was calculated by subtracting the baseline interview month and year from the month and year of death.

### Covariates

Self-reported sex (male or female) was collected at baseline. Chronological age in years was computed by subtracting birthdate from the baseline interview date. Missing ages were found using a combination of public and proprietary databases. Education was assessed on a 12-point scale ranging from 1 (*no school/some grade school*) to 12 (*PhD, MD, JD, or other professional degree*) in MIDUS and an 8-point scale ranging from 1 (*8th grade graduate*) to 8 (*graduate school*) in MIDJA. For comparability across samples, both scales were converted to a 0–10 scale in Table 1.

## Analytic Strategy

The analytic strategy was preregistered (osf.io/ntqd7). All analyses were conducted in R version 3.6.1 and R Studio version 1.2.1335. We used the following R packages: nlme (53), survival (54), and survminer (55) to conduct primary analyses. First, we used four separate growth curve models to estimate level and change for SWB, PA, NA, and LS, respectively, within each sample. We modeled fixed and random effects for both intercept and slope, using time-in-study as the time metric, or temporal axis. Discrete time-in-study was modeled in years since baseline (MIDUS I/MIDJA I) and grand-mean-centered. Random intercepts and slopes were extracted and stored from each model for each participant. Next, the random intercepts and slopes from the growth curve models were used in subsequent regression models as predictors of physical health outcomes.

To predict self-reported general health and chronic health conditions (in MIDUS 3 and MIDJA 2), we used a separate regression model for each SWB component within each sample. In each model, SWB level and SWB

change were entered as predictors, and age, sex, and education were included as covariates. In a separate set of models, all six SWB predictors (PA level, PA change, NA level, NA change, LS level, and LS change) were entered as simultaneous predictors to evaluate the unique associations of each SWB component above and beyond the other components.

To predict mortality risk (in MIDUS only), we used a separate Cox regression model for each SWB component. Mortality risk was modeled as a function of mortality status (deceased or alive) and survival time (in months since MIDUS 1). Survival time was right-censored for participants who were still living in October 2018. In each model, SWB level and change were entered as predictors and age, sex, and education were included as covariates. In a separate model, all six SWB predictors (PA level, PA change, NA level, NA change, LS level, and LS change) were entered as simultaneous predictors to evaluate the unique associations of each SWB component above and beyond the other components.

## RESULTS

R code to reproduce all results is available at osf.io/mz9gy. Data are publicly available online at the Inter-university Consortium for Political and Social Research. Table S1, Supplemental Digital Content, http://links.lww.com/PSYMED/A641, shows zero-order correlations among study variables.

### SWB Growth Curve Models

Table S2, Supplemental Digital Content, http://links.lww.com/PSYMED/A641, shows fixed effects from growth curve models predicting level and change in the three SWB components from discrete time. On average, PA and LS increased and NA decreased in MIDUS. In MIDJA, we did not find evidence for group-level change in any of the SWB components, perhaps because of the shorter follow-up period.

### Self-Reported General Health

Table 2 displays standardized regression coefficients, *t* statistics, and 95% confidence intervals (CIs) from multiple regressions predicting self-reported general health from SWB level and change. Variance inflation factors were lower than 4 for all models, suggesting acceptable levels of multicollinearity.

In the model for PA, higher PA level (MIDUS: β = 0.34, 95% CI = 0.30–0.37; MIDJA: β = 0.40, 95% CI = 0.33–0.47) and greater increases in PA (MIDUS: β = 0.15, 95% CI = 0.11–0.18; MIDJA: β = 0.12, 95% CI = 0.05–0.19) were associated with better self-reported general health. In the model for NA, lower NA level (MIDUS: β = −0.33, 95% CI = −0.36 to −0.30; MIDJA: β = −0.36, 95% CI = −0.43 to −0.29) and greater decreases in NA (MIDUS: β = −0.16, 95% CI = −0.19 to −0.13; MIDJA: β = −0.14, 95% CI = −0.21 to −0.07) were associated with better self-reported general health. In the model for LS, higher LS level (MIDUS: β = 0.29, 95% CI = 0.26–0.33; MIDJA: β = 0.41, 95% CI = 0.34–0.48) and greater increases in LS (MIDUS: β = 0.16, 95% CI = 0.13–0.20; MIDJA: β = 0.20, 95% CI = 0.13–0.27) were associated with better self-reported general health. Effect sizes were large for PA, NA, and LS level. In contrast, effect sizes ranged from medium to small for PA, NA, and LS change (56).

When all three SWB components were included as simultaneous predictors in a single model, level and change in all three components were uniquely associated with better self-reported health in MIDUS. In MIDJA, PA level, NA level, LS level, NA change, and LS change remained unique predictors of self-reported health. We did not find evidence for unique associations between PA change and self-reported health in MIDJA (CIs contained 0).

### Chronic Health Conditions

Table 3 displays standardized regression coefficients, standard errors, *t* statistics, and 95% CIs from multiple regressions predicting number of chronic health conditions from SWB level and change. Variance inflation factors were lower than 4 for all models, suggesting acceptable levels of multicollinearity.

In the model for PA, lower PA level (MIDUS: β = −0.31, 95% CI = −0.33 to −0.27; MIDJA: β = −0.31, 95% CI = −0.38 to −0.23) and greater decreases in PA (MIDUS = −0.06, 95% CI = −0.10 to −0.03; MIDJA: β = −0.11, 95% CI = −0.18 to −0.03) were associated with more chronic health conditions. In the model for NA, higher NA level (MIDUS: β = 0.38, 95% CI = 0.35–0.42; MIDJA: β = 0.39, 95% CI = 0.32–0.46) and greater increases in NA (MIDUS: β = 0.12, 95% CI = 0.09–0.15; MIDJA: β = 0.13, 95% CI = 0.06–0.20) were associated with more chronic health conditions. In the model for LS, lower LS level (MIDUS: β = −0.22, 95% CI = −0.26 to −0.18; MIDJA: β = −0.26, 95% CI = −0.33 to −0.18) and greater decreases in LS (MIDUS: β = −0.10, 95% CI = −0.14 to −0.16; MIDJA: β = −0.13, 95% CI = −0.20 to −0.05) were associated with more chronic health conditions. Effect sizes were large for PA and NA level. In contrast, effect sizes ranged from medium to small for LS level and PA, NA, and LS change (56).

When all three SWB components were included as simultaneous predictors in a single model, lower PA level, higher NA level, greater increases in NA, and greater decreases in LS were uniquely associated with more chronic health conditions in both MIDUS and MIDJA. We did not find evidence for unique associations between PA change or LS level and chronic health conditions in MIDUS or MIDJA (CIs contained 0).

### Mortality

Table 4 displays hazard ratios (HRs; exponentiated coefficients), *z* statistics, and 95% CIs from Cox regressions predicting morality risk from SWB level and change. The associations between the scaled Schoenfeld residuals and time were statistically significant in all models, indicating that the proportional hazard assumption was violated. To correct this, we used the timeSplitter function in R to split time into 6-month intervals and added interactions between time and violating predictors in all models (57). After adding these interaction terms, the associations between the scaled Schoenfeld residuals and time were statistically nonsignificant, indicating that the proportional hazards assumption was met.

Note that two aspects of the time variable complicate the interpretation of the interaction terms reported in this section and shown in Table 4. First, the coefficient for SWB change reflects the associations of SWB change with mortality risk as the beginning of the study period (0 months). This is not a meaningful value because no SWB change could have occurred at 0 months. Instead, the coefficient for SWB change by time shows whether SWB change becomes associated with increasing or decreasing risk with each additional month. Interaction coefficients of 0.99 or smaller indicate that the predictor was increasingly protective across time, whereas interaction coefficients of 1.00 or greater indicate that the predictor was associated with increasing risk across time. Second,

**TABLE 2.** Regression Models Prospectively Predicting Self-Reported General Health

| | MIDUS | | | MIDJA | | |
|---|---|---|---|---|---|---|
| DV = General Health | $\beta$ | $t$ | 95% CI | $\beta$ | $t$ | 95% CI |
| SWB | | | | | | |
| SWB level | 0.41 | 24.78 | 0.38 to 0.44 | 0.46 | 13.30 | 0.39 to 0.53 |
| SWB change | 0.21 | 13.13 | 0.18 to 0.24 | 0.21 | 6.16 | 0.14 to 0.27 |
| PA | | | | | | |
| PA level | 0.34 | 19.39 | 0.30 to 0.37 | 0.40 | 10.69 | 0.32 to 0.47 |
| PA change | 0.15 | 8.84 | 0.11 to 0.18 | 0.12 | 3.24 | 0.05 to 0.19 |
| NA | | | | | | |
| NA level | −0.33 | 19.09 | −0.36 to −0.30 | −0.36 | 9.90 | −0.43 to −0.29 |
| NA change | −0.16 | 9.62 | −0.19 to −0.13 | −0.14 | 3.80 | −0.21 to −0.07 |
| LS | | | | | | |
| LS level | 0.29 | 14.91 | 0.26 to 0.33 | 0.41 | 11.49 | 0.34 to 0.48 |
| LS change | 0.16 | 8.71 | 0.13 to 0.20 | 0.20 | 5.79 | 0.13 to 0.27 |
| Unique associations | | | | | | |
| PA level | 0.14 | 5.59 | 0.09 to 0.18 | 0.14 | 2.92 | 0.05 to 0.24 |
| PA change | 0.07 | 3.56 | 0.03 to 0.10 | 0.01 | 0.32 | −0.06 to 0.09 |
| NA level | −0.12 | 5.47 | −0.17 to −0.08 | −0.18 | 4.32 | −0.26 to −0.10 |
| NA change | −0.10 | 5.69 | −0.14 to −0.07 | −0.09 | 2.57 | −0.17 to −0.02 |
| LS level | 0.17 | 6.99 | 0.12 to 0.22 | 0.24 | 5.07 | 0.15 to 0.33 |
| LS change | 0.10 | 4.87 | 0.06 to 0.14 | 0.17 | 4.67 | 0.10 to 0.24 |

Age, sex, and education were included as covariates.

DV = dependent variable; MIDUS = Midlife in the United States; MIDJA = Midlife in Japan Study; CI = confidence interval; SWB = subjective well-being; PA = positive affect; NA = negative affect; LS = life satisfaction.

**TABLE 3.** Regression Models Prospectively Predicting Number of Chronic Health Conditions

| | MIDUS | | | MIDJA | | |
|---|---|---|---|---|---|---|
| DV = Chronic Health Conditions | $\beta$ | $t$ | 95% CI | $\beta$ | $t$ | 95% CI |
| SWB | | | | | | |
| SWB level | −0.37 | 22.13 | −0.41 to −0.34 | −0.38 | 10.26 | −0.45 to −0.30 |
| SWB change | −0.12 | 7.71 | −0.16 to −0.09 | −0.16 | 4.56 | −0.23 to −0.09 |
| PA | | | | | | |
| PA level | −0.31 | 17.10 | −0.33 to −0.27 | −0.31 | 7.91 | −0.38 to −0.23 |
| PA change | −0.06 | 3.70 | −0.10 to −0.03 | −0.11 | 2.86 | −0.18 to −0.03 |
| NA | | | | | | |
| NA level | 0.38 | 22.91 | 0.35 to 0.42 | 0.39 | 10.88 | 0.32 to 0.46 |
| NA change | 0.12 | 7.45 | 0.09 to 0.15 | 0.13 | 3.65 | 0.06 to 0.20 |
| LS | | | | | | |
| LS level | −0.22 | 10.98 | −0.26 to −0.18 | −0.26 | 6.63 | −0.33 to −0.18 |
| LS change | −0.10 | 5.01 | −0.14 to −0.06 | −0.13 | 3.41 | −0.20 to −0.05 |
| Unique associations | | | | | | |
| PA level | −0.07 | 2.99 | −0.12 to −0.03 | −0.11 | 2.09 | −0.21 to −0.01 |
| PA change | 0.00 | 0.11 | −0.04 to 0.04 | −0.03 | 0.64 | −0.10 to 0.05 |
| NA level | 0.30 | 13.22 | 0.25 to 0.34 | 0.32 | 7.48 | 0.24 to 0.41 |
| NA change | 0.10 | 5.52 | 0.07 to 0.14 | 0.10 | 2.60 | 0.02 to 0.17 |
| LS level | −0.04 | 1.46 | −0.08 to 0.01 | −0.04 | 0.74 | −0.13 to 0.06 |
| LS change | −0.06 | 3.08 | −0.10 to −0.02 | −0.09 | 2.39 | −0.17 to −0.02 |

Age, sex, and education were included as covariates.

DV = dependent variable; MIDUS = Midlife in the United States; MIDJA = Midlife in Japan Study; CI = confidence interval; SWB = subjective well-being; PA = positive affect; NA = negative affect; LS = life satisfaction.

**TABLE 4.** Cox Regression Models Predicting Mortality Risk

| | MIDUS | | |
|---|---|---|---|
| DV = Mortality | HR | *z* | 95% CI |
| SWB | | | |
| SWB level | 0.79 | 3.91 | 0.71–0.89 |
| SWB change | 1.16 | 2.41 | 1.03–1.32 |
| SWB level by time | 1.00 | 0.35 | 0.99–1.00 |
| SWB change by time | 0.99 | 2.90 | 0.99–0.99 |
| PA | | | |
| PA level | 0.86 | 2.40 | 0.78–0.88 |
| PA change | 1.13 | 1.81 | 0.96–1.08 |
| PA level by time | 0.99 | 0.51 | 0.99–1.00 |
| PA change by time | 0.99 | 2.01 | 0.99–1.00 |
| NA | | | |
| NA level | 1.16 | 2.38 | 1.17–1.31 |
| NA change | 0.84 | 2.77 | 0.93–1.04 |
| NA level by time | 1.00 | 1.12 | 0.99–1.00 |
| NA change by time | 1.00 | 3.05 | 1.00–1.00 |
| LS | | | |
| LS level | 0.83 | 3.10 | 0.73–0.93 |
| LS change | 1.05 | 0.80 | 0.93–1.19 |
| LS level by time | 0.99 | 0.70 | 0.99–1.00 |
| LS change by time | 0.99 | 0.99 | 0.99–1.00 |
| Unique associations | | | |
| PA level | 1.02 | 0.38 | 0.94–1.10 |
| PA change | 0.99 | 0.19 | 0.93–1.06 |
| NA level | 1.17 | 4.26 | 1.09–1.25 |
| NA change | 0.86 | 2.49 | 0.76–0.97 |
| NA change by time | 1.00 | 2.81 | 1.00–1.00 |
| LS level | 0.85 | 4.75 | 0.80–0.91 |
| LS change | 0.99 | 0.25 | 0.94–1.05 |

Age, sex, and education were included as covariates.

DV = dependent variable; MIDUS = Midlife in the United States; HR = hazard ratio; CI = confidence interval; SWB = subjective well-being; PA = positive affect; NA = negative affect; LS = life satisfaction.

Time is in units of months. All other predictors are in standard deviation units. Interactions with time were included only for predictors that violated the proportional hazards assumption.

the time variable is in units of months (over a 282-month period), resulting in small coefficient values and CIs that are relatively uninformative at two decimal places for the interaction term. Instead, statistical significance at the $\alpha = .05$ level is indicated by a *z* statistic of 1.96 or larger.

In the model for PA, higher PA level (HR = 0.86, 95% CI = 0.78–0.88), but not PA change (HR = 1.13, 95% CI = 0.96–1.08), was associated with lower mortality risk. In the model for NA, higher NA level was associated with higher mortality risk (HR = 1.16, 95% CI = 1.17–1.32). In addition, there was an interaction between NA change and time (HR = 1.00, 95% CI = 1.00–1.00), such that increases in NA were associated with increasingly greater mortality risk across the study period. In the model for LS, higher LS level (HR = 0.83, 95% CI = 0.73,–0.93), but not LS change (HR = 1.05, 95% CI = 0.93–1.88), was associated with lower mortality risk. When all three SWB components were included as simultaneous predictors in a single model, the same pattern of results was observed with one exception. The association between PA level and mortality risk was no longer observed (i.e., the 95% CI contained 1).

## Sensitivity Analyses

We conducted four sets of sensitivity analyses. First, we repeated the analyses adjusting for time 1 health. Results were largely the same as those reported in primary analyses (Tables S3–S5, Supplemental Digital Content, http://links.lww.com/PSYMED/A641). Second, we repeated the analyses predicting self-reported general health and number of chronic health conditions using multiple imputation. Results were largely the same as those reported in primary analyses, with two exceptions (Tables S6–S7, http://links.lww.com/PSYMED/A641). When using multiple imputation, there was a modest unique association of LS level with chronic health conditions in MIDUS, which was not observed in primary analyses. Moreover, when using multiple imputation, there was not an association between PA level and chronic health conditions in MIDJA, which was observed in primary analyses.

Third, to evaluate the influence of outliers on results, we calculated DFBETAS, which indicates the difference between the regression coefficient estimated from all of the data and the regression coefficient estimated from all of the data minus one case. In line with our preregistration, we reran all of the analyses excluding cases with DFBETA values greater than 2/sqrt(*N*) for any of the SWB parameters (58). The pattern of results and magnitude of effect sizes were largely the same for models predicting self-reported general health and number of chronic health conditions when outliers were excluded (Tables S8 and S9, Supplemental Digital Content, http://links.lww.com/PSYMED/A641). When outliers were excluded, PA level was not associated with mortality at baseline but became increasingly protective across time. Likewise, NA level was not associated with mortality at baseline but became increasingly associated with greater risk across time. All other mortality results remained the same when outliers were excluded (Table S10, http://links.lww.com/PSYMED/A641).

Fourth, to examine whether the observed results were driven by changes in SWB near the end of life, we excluded participants who died during the follow-up period from the analyses predicting self-reported general health and number of chronic health conditions in MIDUS. The pattern of results and magnitude of effect sizes were largely the same when excluding participants close to the end of life (Tables S11 and S12, Supplemental Digital Content, http://links.lww.com/PSYMED/A641).

## Comparing Effect Sizes Across MIDUS and MIDJA Samples

Effect sizes were largely similar across MIDUS and MIDJA. In addition to evaluating the overall pattern of results, we examined whether the 95% CIs overlapped between the MIDUS and MIDJA samples. CIs did not overlap for the association of LS level with self-reported general health, indicating a statistically different effect size in the MIDUS compared with the MIDJA. The association between LS level and self-reported general health was slightly larger in MIDJA (95% CI = 0.34–0.48) compared with MIDUS (95% CI = 0.26–0.33); however, the effect size was large

in both samples. In sum, effect sizes were generally consistent across MIDUS and MIDJA.

## DISCUSSION

The present research offers evidence that higher SWB and longitudinal increases in SWB independently predict better physical health in the United States and Japan. In two longitudinal cohort studies, greater PA, lower NA, and higher LS were associated with better self-reported general health, fewer chronic health conditions, and lower mortality risk. Above and beyond SWB level, longitudinal increases in PA and LS and longitudinal decreases in NA were associated with better self-reported general health and fewer chronic health conditions. Across time, longitudinal increases in NA also became increasingly associated with higher mortality risk. These findings are consistent with previous research linking greater SWB to better physical health and longer survival (2). Extending previous research, the present findings suggest that increases in SWB across time independently predict better physical health, beyond SWB level.

SWB level had large associations with all three physical health outcomes. In contrast, the associations between SWB change and self-reported general health and number of chronic health conditions were generally medium to small, and there were limited associations between SWB change and mortality risk. The absence of an association between PA change and LS change with mortality risk may be explained by characteristics of the study design. Most participants with SWB data at the final time point were still alive at the end of follow-up. Additional research with a greater number of SWB measurements and/or a longer follow-up period is needed to provide a stronger test of the link between SWB change and mortality risk.

In addition to examining the simple associations between each SWB component on the one hand and physical health and mortality on the other hand, we also tested the unique associations of each SWB component with physical health and mortality, above and beyond the other SWB components. All three components had unique associations with self-reported general health and number of chronic health conditions, whereas only NA and LS had unique associations with mortality risk. This is generally consistent with previous research, which has found independent associations with positive aspects of well-being (LS and PA) and NA (11,25,29). The present findings build on this previous research by demonstrating independent associations of LS and PA above and beyond one another. These findings are also consistent with research on eudaimonic well-being (e.g., Ref. (59)), as well as research on optimism (e.g., Ref. (60)), which combines elements of both subjective and eudaimonic well-being (61). These related types of well-being have been associated with healthier life-styles (62), better physical health (63), and lower all-cause mortality (60).

Several limitations of the present research should be considered. First, SWB was only assessed at three measurement occasions in MIDUS and two measurement occasions in MIDJA. Additional time points may provide a more nuanced understanding of the relationship between SWB change and physical health, including associations with nonlinear change (38). Second, we assessed disease incidence as total number of chronic health conditions. Future research should compare associations between SWB change and the incidence of specific diseases, given heterogeneous findings in the literature across diseases (18). Third, this is an observational study, so strong causal conclusions cannot be drawn. It is possible that observed patterns result from reverse causality. However, associations between self-reported general health and number of chronic health conditions were largely maintained when excluding participants who died during the study period, arguing against the possibility that terminal decline processes led to lower SWB. Finally, PA and NA were assessed using a composite measure that did not distinguish between arousal level or discrete emotions, and LS was assessed using a single item. An important aim for future research will be to investigate whether certain discrete emotions or satisfaction with specific life domains drive the observed relationships between SWB and physical health (e.g., Ref. (64)).

## CONCLUSIONS

The present research replicated previous findings that happier people tend to have better physical health and longer survival. Extending our understanding of the happiness-health link, the present research found that becoming happier across time was independently associated with better physical health, above and beyond average happiness level. These results were observed in the United States and Japan, suggesting that both being happy and becoming happier are associated with health benefits across cultures.

*Source of Funding and Conflicts of Interest: The authors declare no conflicts of interest. The MIDUS has been supported by the John D. and Catherine T. MacArthur Foundation Research Network, and the National Institute on Aging (P01-AG020166, U19-AG051426). This work is also supported by three National Institute on Aging grants awarded to D.K.M. (R01-AG018436, R01-AG067622, R01-AG064006).*

## REFERENCES

1. Diener E. Subjective well-being. The science of happiness and a proposal for a national index. Am Psychol 2000;55:34–43.
2. Boehm JK. Living healthier and longer lives: subjective well-being's association with better health. In: Diener E, Oishi S, Tay L, editors. Handbook of Well-being. Salt Lake City, UT: DEF Publishers; 2018.
3. Cross MP, Hofschneider L, Grimm M, Pressman SD. Subjective well-being and physical health. In: Diener E, Oishi S, Tay L, editors. Handbook of Well-being. Salt Lake City, UT: DEF Publishers; 2018.
4. Diener E, Suh EM, Lucas RE, Smith HL. Subjective well-being: three decades of progress. Psychol Bull 1999;125:276–302.
5. Eid M, Diener E. Global judgments of subjective well-being: situational variability and long-term stability. Soc Indic Res 2004;65:245–77.
6. Lykken D, Tellegen A. Happiness is a stochastic phenomenon. Psychol Sci 1996; 7:186–9.
7. Baird BM, Lucas RE, Donnellan MB. Life satisfaction across the lifespan: findings from two nationally representative panel studies. Soc Indic Res 2010;99:183–203.
8. Lucas RE, Donnellan MB. How stable is happiness? Using the STARTS model to estimate the stability of LS. J Res Pers 2007;41:1091–8.
9. Sheldon KM, Lucas RE. Stability of Happiness: Theories and Evidence on Whether Happiness Can Change. New York: Elsevier; 2014.
10. Lansford JE. A lifespan perspective on subjective well-being. In: Diener E, Oishi S, Tay L, editors. Handbook of Well-Being. Salt Lake City, UT: DEF Publishers; 2018.
11. Ong AD. Pathways linking positive emotion and health in later life. Curr Dir Psychol Sci 2010;19:358–62.
12. Steptoe A, Deaton A, Stone AA. Subjective wellbeing, health, and ageing. Lancet 2015;385:640–8.
13. Pettit JW, Kline JP, Gencoz T, Gencoz F, Joiner TE Jr. Are happy people healthier? The specific role of PA in predicting self-reported health symptoms. J Res Pers 2001;35:521–36.
14. Zautra AJ, Johnson LM, Davis MC. Positive affect as a source of resilience for women in chronic pain. J Consult Clin Psychol 2005;73:212–20.
15. Assari S, Lankarani MM. Chronic medical conditions and negative affect: racial variation in reciprocal associations over time. Front Psych 2016;7:140.
16. Wiese CW, Chen ZJ, Tay L, Friedman EM, Rector JL. The role of affect on physical health over time: a cross-lagged panel analysis over 20 years. Appl Psychol Health Well Being 2019;11:202–22.

17. Davidson KW, Mostofsky E, Whang W. Don't worry, be happy: positive affect and reduced 10-year incident coronary heart disease: the Canadian Nova Scotia Health Survey. Eur Heart J 2010;31:1065–70.
18. Feller S, Teucher B, Kaaks R, Boeing H, Vigl M. Life satisfaction and risk of chronic diseases in the European Prospective Investigation into Cancer and Nutrition (EPIC)-Germany study. PLoS One 2013;8:e73462.
19. Freak-Poli R, Mirza SS, Franco OH, Ikram MA, Hofman A, Tiemeie H. Positive affect is not associated with incidence of cardiovascular disease: a population-based study of older persons. Prev Med 2015;74:14–20.
20. Bai A, Li H, Huang Y, Liu X, Gao Y, Wang P, Dai H, Song F, Hao X, Chen K. A survey of overall life satisfaction and its association with breast diseases in Chinese women. Cancer Med J 2016;5:111–9.
21. Okely JS, Cooper C, Gale CR. Wellbeing and arthritis incidence: the survey of health, ageing and retirement in Europe. Ann Behav Med 2016;50:419–26.
22. Celano CM, Beale EE, Moore SV, Wexler DJ, Huffman JC. Positive psychological characteristics in diabetes: a review. Curr Diab Rep 2013;13:917–29.
23. Trudel-Fitzgerald C, Boehm JK, Kivimaki M, Kubzansky LD. Taking the tension out of hypertension: a prospective study of psychological wellbeing and hypertension. J Hypertens 2014;32:1222–8.
24. Ostir GV, Markides KS, Peek MK, Goodwin JS. The association between emotional well-being and the incidence of stroke in older adults. Psychosom Med 2001;63:210–5.
25. Cohen S, Alper CM, Doyle WJ, Treanor JJ, Turner RB. Positive emotional style predicts resistance to illness after experimental exposure to rhinovirus or influenza A virus. Psychosom Med 2006;6:809–15.
26. Chida Y, Steptoe A. Positive psychological well-being and mortality: a quantitative review of prospective observational studies. Psychosom Med 2008;70:741–56.
27. Martin-Maria N, Miret M, Caballero FF, Rico-Uribe LA, Steptoe A, Chatterji S, Ayuso-Mateos JL. The impact of subjective well-being on mortality: a meta-analysis of longitudinal studies in the general population. Psychosom Med 2017;79:565–75.
28. Wilson RS, Boyle PA, Segawa E, Yu L, Begeny CT, Anagnos SE, Bennett DA. The influence of cognitive decline on well-being in old age. Psychol Aging 2013;28:304–13.
29. Collins AL, Glei DA, Goldman N. The role of life satisfaction and depressive symptoms in all-cause mortality. Psychol Aging 2009;24:696–702.
30. Keyes CL, Simoes EJ. To flourish or not: positive mental health and all-cause mortality. Am J Public Health 2012;102:2164–72.
31. DuBois CM, Lopez OV, Beale EE, Healy BC, Boehm JK, Huffman JC. Relationships between positive psychological constructs and health outcomes in patients with cardiovascular disease: a systematic review. Int J Cardiol 2015;195:265–80.
32. Moskowitz JT, Epel ES, Acree M. Positive affect uniquely predicts lower risk of mortality in people with diabetes. Health Psychol 2008;27:S73–82.
33. Cassileth BR, Lusk EJ, Miller DS, Brown LL, Miller C. Psychosocial correlates of survival in advanced malignant disease? NEJM 1985;312:1551–5.
34. Kimm H, Sull JW, Gombojav B, Yi SW, Ohrr H. Life satisfaction and mortality in elderly people: the Kangwha Cohort Study. BMC Public Health 2012;12:54.
35. Park J, Kitayama S, Miyamoto Y, Coe CL. Feeling bad is not always unhealthy: culture moderates the link between NA and diurnal cortisol profiles [published online April 22, 2019]. Emotion. doi:10.1037/emo0000605.
36. Kitayama S, Park J. Emotion and biological health: the socio-cultural moderation. Curr Opin Psychol 2017;17:99–105.
37. Okeley JA, Weiss A, Gale CR. The interaction between individualism and wellbeing in predicting mortality: Survey of Health Ageing and Retirement in Europe. J Behav Med 2018;41:1–11.
38. Blanchflower DG, Oswald AJ. Is well-being U-shaped over the life cycle? Soc Sci Med 2008;66:1733–49.
39. Zaninotto P, Wardle J, Steptoe A. Sustained enjoyment of life and mortality at older ages: analysis of the English Longitudinal Study of Ageing. BMJ 2016; 355:i6267.
40. Boehm JK, Winning A, Segerstrom S, Kubzansky LD. Variability modifies life satisfaction's association with mortality risk in older adults. Psychol Sci 2015;2: 1063–70.
41. Friedman HS. Neuroticism and health as individuals age. Pers Disord 2019;10: 25–32.
42. Anglim J, Horwood S, Smillie LD, Marrero RJ, Wood JK. Predicting psychological and subjective well-beingfrom personality: a meta-analysis. Psychol Bull 2020;146:279–323.
43. DeNeve KM, Cooper H. The happy personality: a meta-analysis of 137 personality traits and SWB. Psychol Bull 1998;124:197–229.
44. Steel P, Schmidt J, Shultz J. Refining the relationship between personality and subjective well-being. Psychol Bull 2018;134:138–61.
45. Turiano NA, Pitzer L, Armour C, Karlamangla A, Ryff CD, Mroczek DK. Personality trait level and change as predictors of health outcomes: findings from a national study of Americans (MIDUS). J Gerontol B Psychol Sci Soc Sci 2012; 67:4–12.
46. Siegler IC, Costa PT Jr., Brummet BH, Helms MJ, Barefoot JC, Williams RB, Dahlstrom WG, Kaplan BH, Vitaliano PP, Nichaman MZ, Day S, Rimer BK. Patterns of change in hostility from college to midlife in the UNC Alumni Heart Study predict high-risk status. Psychosom Med 2003;65:738–45.
47. Mroczek DK, Spiro A. Personality change influences mortality in older men. Psychol Sci 2007;18:371–6.
48. Brim OG, Baltes PB, Bumpass LL, Cleary PD, Featherman DL, Hazzard WR, Shweder RA. Midlife in the United States (MIDUS 1), 1995–1996. Ann Arbor, MI: Inter-university Consortium for Political and Social Research [distributor]. Available at: https://doi.org/10.3886/ICPSR02760.v18. Accessed September 9, 2019.
49. Ryff CD, Kitayam S, Karasawa M, Markus H, Kawakami N, Coe C. Survey of Midlife in Japan (MIDJA), April–September 2008. ICPSR30822-v3. Ann Arbor, MI: Inter-university Consortium for Political and Social Research [distributor]. Available at: http://doi.org/10.3886/ICPSR30822.v3. Accessed September 3, 2018.
50. Steptoe A, Wardle J. PA measured using ecological momentary assessment and survival in older men and women. Proc Natl Acad Sci U S A 2011;108:18244–8.
51. Gana K, Bailly N, Saada Y, Joulain M, Trouillet R, Hervé C, Alaphilippe D. Relationship between life satisfaction and physical health in older adults: a longitudinal test of crosslagged and simultaneous effects. Health Psychol 2013;32:896–904.
52. van Buuren S, Groothuis-Oudshoorn K. Mice: multivariate imputation by chained equations in R. J Stat Softw 2011;45:1–67.
53. Pinheiro J, Bates D, DebRoy S, Sarkar DR, Core Team. nlme: linear and nonlinear mixed effects models. R package version 3.1-140. 2019. Accessed December 1, 2019.
54. Therneau T. A package for survival analysis in S. Version 2.38. 2015. Available at: https://CRAN.R-project.org/package=survival. Accessed December 1, 2019.
55. Kassambara A, Kosinski M, Biecek P. survminer: drawing survival curves using 'ggplot2'. R package version 0.4.6. 2019. Available at: https://CRAN.R-project.org/package=survminer. Accessed December 1, 2019.
56. Funder DC, Ozer DJ. Evaluating effect size in psychological research: sense and nonsense. Adv Methods Pract Psychol Sci 2019;2:156–68.
57. Gordon M, Seifert R. Greg: regression helper functions. R package version 1.3.3. 2020. Available at: https://CRAN.R-project.org/package=Greg. Accessed December 1, 2019.
58. Belsley DA, Kuh E, Welsch RE. Regression diagnostics: identifying influential data and sources of collinearity. In: Wiley Series in Probability and Mathematical Statistics. New York: John Wiley & Sons; 1980.
59. Boyle PA, Barnes LL, Buchman AS, Bennett DA. Purpose in life is associated with mortality among community dwelling older persons. Psychosom Med 2009;71:574–9.
60. Rozanski A, Bavishi C, Kubzansky LD, Cohen R. Association of optimism with cardiovascular events and all-cause mortality: a systematic review and meta-analysis. JAMA Netw Open 2019;2:e1912200.
61. Boehm JK, Kubzansky LD. The heart's content: the association between positive psychological well-being and cardiovascular health. Psychol Bull 2012;138:655–91.
62. Bouchard LC, Carver CS, Mens MG, Scheier MF. Optimism, health, and well-being. In: Dunn DS, editor. Frontiers of Social Psychology. Positive Psychology: Established and Emerging Issues. Abingdon, UK, Routledge; 2017:112–30.
63. Trudel-Fitzgerald C, James P, Kim ES, Zevon ES, Grodstein F, Kubzansky LD. Prospective associations of happiness and optimism with lifestyle over up to two decades. Prev Med 2019;126:105754.
64. Petrie KJ, Pressman SD, Pennebaker JW, Overland S, Tell GS, Sivertsen B. Which aspects of positive affect are related to mortality? Results from a general population longitudinal study. Ann Behav Med 2018;52:571–81.