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Prospective associations of happiness and optimism with lifestyle over up to two decades

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ABSTRACT

Greater levels of psychological well-being are associated with reduced disease and mortality risk, and lifestyle habits may be potential mechanisms underlying these relationships. Prospective studies show that positive psychological factors enhance the likelihood of adopting specific health behaviors; yet, whether they promote the adoption of multiple healthy behaviors, which can have a multiplicative effect on disease and mortality risk compared to individual behaviors, is unknown. We investigated whether happiness and optimism were related to a healthy lifestyle (characterized by multiple health behaviors) over 10–22 years of follow-up; we also explored bidirectional associations, assessing if a healthy lifestyle at baseline was related to greater likelihood of experiencing higher happiness and optimism over time. Women reported levels of happiness in 1992 (N = 52,133) and optimism in 2004 (N = 36,802). Health-related behaviors (physical activity, body mass index, diet, alcohol and tobacco consumption) were self-reported and combined into a lifestyle score, every four years from baseline until 2014. Multivariable generalized estimating equations with a Poisson distribution were used. Women with moderate and higher (versus lower) happiness levels were more likely to report sustaining healthy lifestyles (RR = 1.18, CI = 1.11–1.25; RR = 1.39, CI = 1.32–1.46, respectively). In secondary analyses, the magnitude of the inverse association was somewhat smaller (likelihood of sustaining higher happiness levels for baseline healthy versus unhealthy lifestyle, RR = 1.11, CI = 1.10–1.12). Results were similar when considering optimism as the exposure and in other secondary analyses (e.g., across individual habits). While bidirectional associations are apparent, these findings suggest pursuing happiness and optimism as modifiable determinants of lifestyle deserves further consideration.

1. Introduction

Greater levels of psychological well-being (PWB), including optimism and life purpose, are associated with reduced disease and mortality risk (Boehm and Kubzansky, 2012; Martin-Maria et al., 2017), and lifestyle habits have been proposed as potential mechanisms. Behaviors like physical activity, diet, and alcohol/tobacco consumption tend to cluster (Spring et al., 2015), leading to a *lifestyle* that has a multiplicative effect on the likelihood of mortality compared to individual behaviors (Loef and Walach, 2012). To date, studies revealing associations between psychological factors and subsequent lifestyle have almost exclusively focused on the detrimental role of anxiety/depressive symptoms or medical populations (Murray et al., 2012; Trudel-Fitzgerald et al., 2018; Sin et al., 2015). Yet, whether PWB relates to lower likelihood of adverse outcomes by *promoting* a healthy lifestyle, in disease-free populations is unknown. Moreover, PWB is comprised of multiple dimensions (Boehm and Kubzansky, 2012) and whether each are similarly linked with lifestyle has not been assessed. Filling these knowledge gaps might broaden primary prevention strategies for targeting novel determinants. In fact, existing interventions,

Abbreviations: BMI, body mass index; CI, confidence interval; CV, coefficient of variation; GEE, generalized estimating equations; PWB, psychological well-being; RR, relative risk; SD, standard deviation

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including brief self-administered exercises, have been shown to increase PWB, including happiness (Bolier et al., 2013); such interventions may in turn help alleviate chronic disease burden (Spring et al., 2015; Van Cappellen et al., 2018) by potentially catalyzing improved lifestyle behaviors.

Numerous prospective epidemiological studies have evaluated whether PWB enhances the likelihood of adopting single health behaviors; these investigations mainly focused on optimism's potential role in smoking cessation/abstinence or physical activity over ≤6 years of follow-up, in non-medical samples (Progovac et al., 2017a; Hingle et al., 2014; Kim et al., 2016; Progovac et al., 2017b; Giltay et al., 2007; Haller, 2016; Baruth et al., 2011; Boehm et al., 2018a,b). Overall, results suggested higher optimism levels are related to greater likelihood of engaging in healthy behaviors. Findings were maintained after adjusting for not only conventional risk factors but also depressive symptoms, suggesting PWB may play a role beyond simply indicating the absence of distress. While this work is informative, it remains unclear whether i) optimism is associated with the adoption/maintenance of multiple concurrent health-related behaviors (hereafter, "lifestyle"), including physical activity, diet, alcohol/tobacco consumption, and weight, which synergistically impact morbidity and mortality (Loef and Walach, 2012); ii) other PWB dimensions, including happiness, may relate to future lifestyle; and iii) these relations persist over a decade and beyond. Of particular interest is whether PWB might be associated with greater ability to *sustain* a healthy lifestyle, rather than if it affects average lifestyle scores over time.

In the current study, we investigated whether happiness and optimism were related to subsequent healthy lifestyle over a 10–22 year follow-up period in disease-free women. We considered happiness as it is one of the most commonly assessed PWB indicators in epidemiologic and surveillance research. We hypothesized that higher baseline levels of happiness and optimism would relate to greater likelihood of sustaining a healthy lifestyle. Based on previous research (Progovac et al., 2017a; Hingle et al., 2014; Kim et al., 2016; Progovac et al., 2017b; Giltay et al., 2007; Haller, 2016; Baruth et al., 2011; Boehm et al., 2018a,b), we considered relevant covariates, including depression, previously identified as key potential confounders. While prior work has shown that favorable behaviors (e.g., physical activity, healthy diet) may also enhance PWB (White et al., 2017; Stevenson, 2017), to our knowledge no prospective study has evaluated potential bidirectionality between PWB dimensions and lifestyle. Thus, a secondary analysis assessed if healthy lifestyle at baseline was related to a greater likelihood of experiencing sustained higher PWB over time.

2. Methods

2.1. Participants

The Nurses' Health Study is an ongoing cohort comprised of 121,700 U.S. female nurses, aged 30–55 years at study inception in 1976 (Willett et al., 1987), who completed biennial questionnaires on lifestyle, medical history, and newly diagnosed medical conditions, with a follow-up rate of > 85% (Bao et al., 2016). As shown in Fig. 1, the present study excludes participants with missing baseline data on happiness or optimism, the health-related behaviors of interest, or relevant covariates (see Supplemental Table S1 for characteristics of eligible versus ineligible women). Those reporting cancer, diabetes, or heart disease at the time PWB indicators were queried were also excluded, as chronic conditions may affect health behaviors (Newsom et al., 2012), resulting in two analytic samples: $n_{happiness}$ = 52,133, $n_{optimism}$ = 36,802. The study protocol was approved by the institutional review board of Brigham and Women's Hospital.

2.2. Measures

2.2.1. Psychological well-being (PWB) dimensions

To assess happiness, the following item from the Medical Outcomes Study SF-36 (Ware and Sherbourne, 1992) was queried in 1992: "How much of the time during the last month have you been a happy person?" Women also responded to this item in 1996 and 2000; these data were used for the secondary analyses described below. Response options range from 1 "all the time" to 6 "none of the time," and were reversed-coded so that a higher score reflected higher happiness. While single-item PWB measures are somewhat limited, they have demonstrated predictive capacity with cardiometabolic-related outcomes, including behaviors and mortality (Boehm and Kubzansky, 2012; Baruth et al., 2011), and often perform similarly to multiple-item measures (Cheung and Lucas, 2014). In this sample, happiness scores were modestly stable across the three assessments (intra-class correlations coefficient [ICC] = 0.44). This finding is consistent with recent evidence from another study that used a similar happiness item and suggested that ~50% of the variance obtained was due to trait-like, stable processes (Hudson et al., 2017).

Optimism was assessed in 2004 using the 6-item Life Orientation Test-Revised (Scheier et al., 1994). It was also queried in 2008 and 2012, and these assessments were used for secondary analyses. This scale has good validity and reliability (Scheier et al., 1994). Using a 5-point Likert scale, women were asked the degree to which they agreed with statements like "In uncertain times, I usually expect the best." After reverse coding negatively worded items, all items were summed to create a composite score ranging from 6 to 30, with higher scores indicating higher optimism. Internal consistency (α = 0.78) in the optimism analytic sample (2004 baseline) and overall stability across the three assessments (ICC = 0.63) are moderate to high.

Happiness and optimism were first assessed at different times (1992 and 2004, respectively); therefore, the study baseline for each analytic sample was different. As both measures are available in each analytic sample, to assess the correlation between them, we considered happiness taken from 1992 in relation to optimism from 2004: $r_{happiness\ sample}$ = 0.32, $r_{optimism\ sample}$ = 0.33. To assess discontinuous or threshold effects, following other studies (Hingle et al., 2014; Kim et al., 2016) we created three categories of each PWB indicator based on the score distribution in their respective analytic sample. Similar to other cohorts (Boehm et al., 2015), most women in our sample reported higher happiness levels in 1992, resulting in unevenly distributed groups: low (14.62% of participants; score = 1–3), moderate (18.89%; score = 4), high (66.49%; score = 5–6). For 2004 optimism, scores were more evenly distributed: low (32.13% of participants; score = 6–23), moderate (30.96%; score = 24–27), high (36.90%; score = 28–30). To facilitate comparisons of effect size across indicators and studies, we also considered standardized PWB scores (M = 0, SD = 1).

2.2.2. Lifestyle score

The five health-related behaviors included in the lifestyle score were: physical activity, body mass index (BMI; a behavior-related factor), diet, alcohol and tobacco consumption. They were selected based on a lifestyle index of multiple health behaviors commonly used in prior studies (Trudel-Fitzgerald et al., 2018; Chiuve et al., 2008), as well as cancer and cardiovascular prevention guidelines (Kushi et al., 2012; Mosca et al., 2011). All individual behaviors were obtained via self-report at baseline (1992 or 2004), and every four years until 2014. We dichotomized each behavior according to whether women met recommended guidelines at each follow-up assessment (yes = 1, no = 0; see Text S1 for details about each cutpoint). Binary scores from each health behavior were then summed to create the lifestyle score, which ranges from 0 "least healthy" to 5 "most healthy" and was updated every four years. Because a score of 4 or 5 (healthy lifestyle) versus a score of 0–3 (unhealthy lifestyle) was associated with ~50% decreased

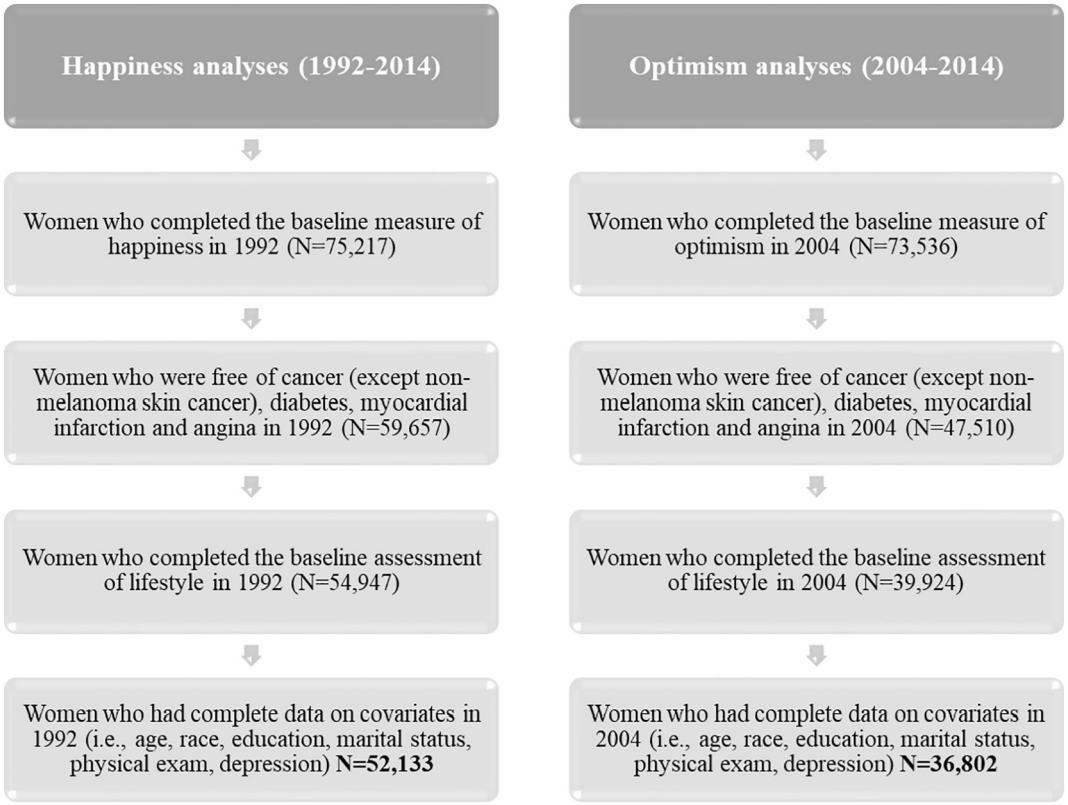

Fig. 1. Flowchart of the two analytic samples.

risk of stroke in this cohort (Chiuve et al., 2008) and 66% decreased risk of mortality in prior research (Loef and Walach, 2012), we defined a healthy lifestyle using this cutpoint (endorsing ≥4 healthy behaviors; yes/no). We further defined sustained healthy lifestyle as reporting a healthy lifestyle score at least twice over the study period, including the baseline assessment.

2.2.3. Covariates

Selected confounders and other covariates included age (continuous), race (White, non-White), marital status (married/in a relationship, divorced/separated/widowed), education level (registered nurse, bachelor, master's, doctorate), physical exam in the last two years (yes, no), as receiving advice from a clinician is associated with lifestyle changes (Rose et al., 2013), and depression status (i.e., antidepressant use or physician-diagnosed depression; yes, no). Age, marital status, and physical exam were self-reported at baseline for each analytic sample, whereas depression was obtained from the closest available assessment (happiness = 1996; optimism = 2004). Education and race were reported in 1992.

2.3. Statistical analysis

To characterize the degree of change in lifestyle over time, within-subject coefficients of variation (CVs) were computed (Hankinson et al., 1995). Associations of baseline happiness and optimism levels with likelihood of reporting a sustained healthy lifestyle over the follow-up period was evaluated using generalized estimating equations (GEE) which is robust to correlated observations; further a Poisson distribution was used to account for non-rare outcomes (Zou, 2004). In primary models we evaluated PWB dimensions as categorical variables (lower, moderate, higher levels) in relation to a sustained healthy lifestyle, with a test for linear trend. In additional models, continuous (standardized; per 1-SD) PWB variables were evaluated in relation to a sustained healthy lifestyle.

To leverage the information captured by the lifestyle scores more fully (i.e., ranging from 0 to 5) and assess change over time, we also considered categorical PWB indicators in relation to continuous lifestyle scores. In these models, a time × PWB interaction term was included to evaluate whether the rate of change in lifestyle scores over time differed depending on baseline PWB levels. All models controlled for age, race, marital status, education level, recent physical exam and depression.

We included secondary analyses. First, to explore the possible harmful role of extreme optimism on lifestyle, we modeled the likelihood of sustained healthy lifestyle for extremely high versus lower levels of optimism (extremely high = score of 30; 18.81% of the sample). Second, to account for women's habits at study initiation and reduce concerns about concurrent lifestyle habits influencing both PWB levels and subsequent likelihood of sustained healthy lifestyle, we stratified models by baseline lifestyle score (healthy versus unhealthy), and used the likelihood ratio test. Third, to evaluate whether associations were consistent across habits, we investigated the likelihood of sustaining a healthy level of each behavior (i.e., for at least two assessments) separately.

Finally, we considered the inverse association, namely whether baseline lifestyle scores (categorical = healthy/unhealthy; continuous = per 1-SD) were associated with the likelihood of reporting sustained higher (versus moderate/lower) levels of happiness or optimism, at least twice over the follow-up period. For these analyses, all available PWB time points in the cohort were leveraged, including baseline lifestyle and PWB scores (happiness = 1992; optimism = 2004) and follow-up assessments (happiness = 1996, 2000; optimism = 2008, 2012). Linear mixed models were also used to assess whether PWB levels over time differed by baseline lifestyle levels (healthy/unhealthy), and whether the rate of change in PWB levels varied based by baseline lifestyle levels. Due to missing data on follow-up PWB measures, these analyses were conducted in ≥95% of the main samples ($n_{happiness}$ = 50,652; $n_{optimism}$ = 35,043).

To address potential selection bias (see Table S1 for differences), person- and time-specific inverse probability weights were included in the models (Hernan et al., 2004). Specifically, the probability of participating at each time point was modeled based on the exposure and covariates of interest among each analytic sample, and a weight that corresponded to the inverse of the probability of participating was created. Since results from age-adjusted models were similar to fully-adjusted models, only the latter are presented. Analyses were conducted using SAS 9.4 with a two-sided *p*-value of 0.05.

3. Results

3.1. Baseline characteristics

At the 1992 happiness baseline, women were 57.81 years old on average (*SD* = 7.08; range = 45–72), mostly White (98.00%), married/in a relationship (82.92%), registered nurses (RN = 69.19%), reported a recent physical exam (87.37%) and not depressed (92.79%). The majority were non-smokers (86.45%), while nearly half had a healthy BMI (49.15%). Over one-third engaged in ≥150 min/week of moderate-to-vigorous physical activity (39.55%), whereas fewer drank on average 1 alcoholic drink/day (20.21%). Characteristics were comparable at the 2004 optimism baseline, with mean age = 68.70 years (*SD* = 6.83; range = 57–84). Table 1 shows the distribution of covariates and health behaviors across baseline PWB levels.

3.2. Relation of happiness with future lifestyle

Within individuals, lifestyle scores were stable over time, as indicated by the fairly low within-subject variance (CV = 0.30, confidence intervals: CI = 0.30–0.30). Almost a quarter of the sample (24.07%) reported sustaining a healthy lifestyle (≥2 healthy lifestyle scores) over the study duration and among those, most (88.28%) did so on two consecutive lifestyle assessments (e.g., maintained a healthy lifestyle score in 1996 and 2000). Compared to women with lower happiness (Fig. 2), those with moderate and higher levels were 18% and 39% more likely, respectively, to report sustaining a healthy lifestyle over time, after adjusting for covariates. A dose-response relationship was observed (*p*-trend ≤ 0.0001), whereby the likelihood of adopting a sustained healthy lifestyle increased monotonically as happiness levels did. A similar pattern was evident across all individual health behaviors (Table S2).

Findings were not altered substantially when evaluating happiness measured continuously (per 1-SD change) in relation to a sustained healthy lifestyle (relative risk: $RR_{1\text{-SD}} = 1.13$, CI = 1.11–1.15). Results were also maintained when evaluating associations of happiness levels in relation to continuous lifestyles scores over time, with higher happiness levels associated with healthier lifestyle scores at each time point. While lifestyle scores generally decreased over time, they decreased slightly more rapidly for those with elevated happiness levels ($p_{\text{interaction}} < 0.0001$; $\beta_{\text{moderate vs. lower happiness} \times \text{time}} = -0.001$, CI = −0.002, 0.001; $\beta_{\text{higher vs. lower happiness} \times \text{time}} = -0.006$, CI = −0.007, −0.005), perhaps because of regression to the mean. Stratified analyses by initial lifestyle levels yielded a stronger association among women with an initially unhealthy (versus healthy) lifestyle score (likelihood ratio test: $p_{\text{happiness} \times \text{baseline lifestyle}} < 0.0001$; Table S3).

3.3. Relation of optimism with future lifestyle

In the optimism analytic subsample, women's lifestyle scores were also stable across assessments (within-subject CV = 0.25, CI = 0.25–0.25); relatively few participants reported sustaining a healthy lifestyle (i.e., ≥2 healthy lifestyle scores; 15.66%), but among them, the majority (91.70%) did on two consecutive lifestyle assessments. As shown in Fig. 2, moderate and higher (versus lower) optimism levels at baseline were associated with 22% and 40% greater likelihood of reporting a sustained healthy lifestyle throughout follow-up. A dose-response association was evident (*p*-trend ≤ 0.0001) and similar patterns of association were observed for all individual behaviors (Table S2).

When considering optimism either as a continuous measure or at

Table 1
Age-standardized[a] distribution of covariates and health behaviors according to baseline happiness and optimism levels.

	Happiness (1992)[b]			Optimism (2004)[c]		
	Lower (*n* = 7622)	Moderate (*n* = 9848)	Higher (*n* = 34,663)	Lower (*n* = 11,826)	Moderate (n = 11,395)	Higher (*n* = 13,581)
Age, mean (SD)	56.42 (7.05)	57.29 (7.11)	58.27 (7.04)	69.36 (7.07)	68.88 (6.82)	67.97 (6.55)
Non-Hispanic White, %	97.94	97.47	98.15	98.21	97.96	98.19
RN degree, %	70.87	69.47	68.67	73.37	67.59	62.59
Married/in a relationship, %	79.29	82.18	83.94	70.61	72.69	74.27
Physical exam in the last 2 years	87.31	87.61	87.31	94.87	95.14	95.60
BMI in kg/m^2, mean (SD)	26.12 (5.19)	25.76 (4.80)	25.67 (4.71)	26.27 (5.20)	26.05 (4.97)	25.86 (4.78)
Current smoker, %	17.23	14.81	12.38	8.18	6.91	6.11
Former/never smoker, %	83.07	85.66	87.97	91.82	93.09	93.89
Cigarettes/day among smokers, mean (SD)	14.11 (9.84)	12.47 (9.09)	12.26 (9.21)	11.05 (8.59)	10.20 (7.73)	9.69 (7.40)
Physical activity in MET-hours/week, mean (SD)	2.06 (3.33)	2.47 (3.40)	3.05 (4.07)	2.15 (3.32)	2.56 (3.57)	2.91 (4.01)
Alcohol intake of 1 drink/day, %	16.88	19.51	21.14	20.09	22.79	24.38
AHEI Diet score[d], mean (SD)	47.14 (10.13)	47.88 (9.79)	48.83 (9.75)	53.75 (11.32)	55.36 (11.56)	56.95 (11.51)
Depressed (physician diagnosis or antidepressant use), %	17.04	8.49	4.60	17.61	10.64	7.50

BMI = body mass index; MET = metabolic equivalent of task; RN = registered nurses; SD = standard deviation.

[a] Values are means (SD) or percentages and are standardized to the age distribution of the study population (except age). Values of polytomous variables may not sum to 100% due to rounding.

[b] Due to a skewed distribution of happiness measured in 1992, participants were categorized into the following different groups: low (14.62% of participants; scores ranged from 1 to 3), moderate (18.89%; 4), high (66.49%; 5 to 6).

[c] For optimism, levels were more evenly distributed resulting in participants being categorized approximately into tertiles low (32.13% of participants; scores ranged from 6 to 23), moderate (30.96%; 24 to 27), high (36.90%; 28 to 30) in 2004.

[d] The AHEI diet score incorporates higher intake of vegetables, fruit, whole grains, nuts and legumes, long-chain (n-3) fatty acids, polyunsaturated fats; lower intake of sugar-sweetened beverages and fruit juice, red/processed meat, saturated fats, sodium. The score for each dietary component ranges from 0 (worst) to 10 (optimal), and then scores were summed.

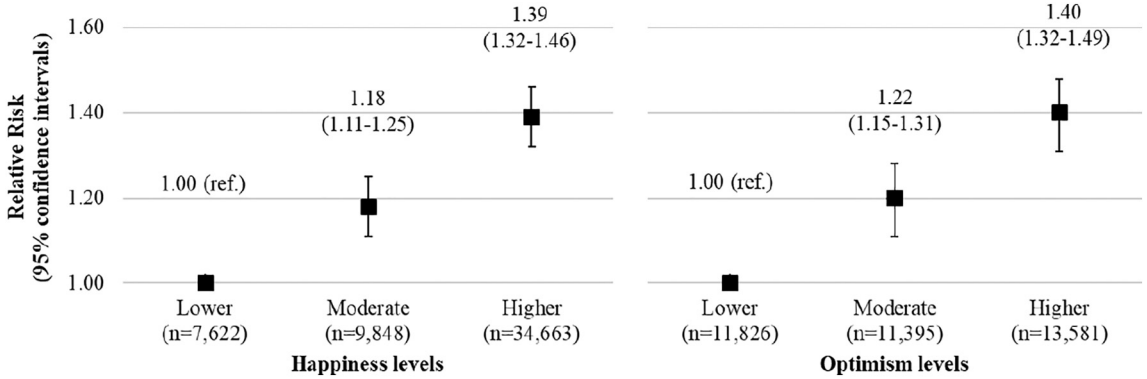

Fig. 2. Generalized estimating equations with a Poisson distribution evaluating the association[a] of baseline happiness (1992) and optimism (2004) levels with likelihood of reporting a sustained healthy lifestyle[b] over follow-up (until 2014).

[a]Fully-adjusted models, controlling for baseline age, race, marital status, education level, physical exam in the last 2 years, and depression.

[b]Dichotomized levels (healthy/unhealthy) of physical activity, diet, BMI, alcohol and tobacco consumption were summed to create the lifestyle score, ranging from 0 to 5 (most healthy) and updated at each follow-up assessment. The outcome was defined as reporting a healthy lifestyle score (i.e., ≥4 healthy behaviors) at least twice over the study period.

extremely high levels (versus lower optimism), the relationship with sustaining a healthy lifestyle was not substantially altered ($RR_{1\text{-}SD}$ = 1.16, CI = 1.13–1.19; $RR_{extreme\ high\ vs.\ lower}$ = 1.39, CI = 1.30–1.49). Findings were also comparable when considering categorical optimism with continuous lifestyle scores. As observed with the happiness results, lifestyle scores decreased somewhat more rapidly in women with elevated optimism levels ($p_{interaction} < 0.01$; $\beta_{moderate\ vs.\ lower\ optimism \times time} = -0.002$, CI = −0.004, 0.0002; $\beta_{higher\ vs.\ lower\ optimism \times time} = -0.004$, CI = −0.006, −0.002). In stratified models, estimates were stronger among women with an initially unhealthy (versus healthy) lifestyle score (likelihood ratio test: $p_{optimism \times baseline\ lifestyle} < 0.0001$; Table S3).

3.4. Relation of lifestyle with future levels of PWB

Compared to women with an unhealthy lifestyle at baseline, those with a healthy lifestyle were 11% more likely to report sustaining high happiness levels (RR = 1.11, CI = 1.10–1.12), and 26% more likely to report sustaining high optimism levels (RR = 1.26, CI = 1.22–1.31), after controlling for covariates. Continuous baseline lifestyle scores (per 1-SD) yielded similar relationships with likelihood of sustaining higher subsequent happiness and optimism levels ($RR_{happiness}$ = 1.06, CI = 1.06–1.07; $RR_{optimism}$ = 1.14, CI = 1.12–1.16). Further, investigating baseline lifestyle levels with continuous PWB scores at each follow-up assessments led to similar results. There was a slightly faster decline in happiness scores for women reporting healthy versus unhealthy lifestyle at baseline ($p_{interaction}$ = 0.0006; $\beta_{healthy\ vs.\ unhealthy\ lifestyle \times time} = -0.005$, CI = −0.007, −0.002), whereas no time × lifestyle interaction effect was noted with optimism ($p_{interaction} > 0.05$).

4. Discussion

This study investigated whether happiness and optimism levels were associated with subsequent likelihood of sustaining a healthy lifestyle over 10–22 years in middle-aged and older women. Compared to women with lower happiness and optimism levels, women with moderate levels were 18–22% more likely to report a healthy lifestyle at least twice throughout the study (with most of them being at two consecutive time assessments); the estimates were even stronger among women with higher happiness and optimism levels (i.e., 39–40%). A greater likelihood of reporting a sustained healthy lifestyle over time was also observed for every SD increase in both PWB dimensions, suggesting that even smaller improvements in happiness and optimism might potentially matter for lifestyle habits. Using prior findings from this cohort (Trudel-Fitzgerald et al., 2016), we estimate that the difference in lifestyle scores evident for higher versus lower PWB levels (up to 0.33 points) would translate into up to 5.35% decreased risk of stroke (see Text S2 for calculations). Overall, our results are consistent with previous findings on single behaviors assessed over shorter periods (Progovac et al., 2017a; Hingle et al., 2014; Kim et al., 2016; Progovac et al., 2017b; Giltay et al., 2007; Haller, 2016; Baruth et al., 2011; Boehm et al., 2018a,b). For instance, among women participating in the Women's Health Initiative observational study, those with higher versus lower optimism scores at study initiation had a three-fold increase (i.e., improvement) in AHEI diet scores from baseline to one year later (Hingle et al., 2014).

While happiness and optimism were assessed 12 years apart, which precludes formal comparison about within-person effects, it is notable that these modestly correlated constructs yielded comparable effect estimates for the likelihood of sustaining a healthy lifestyle. This may suggest that aspects of PWB common across the different dimensions are the critical factor driving associations of interest. In fact, an analogous phenomenon has been noted with psychological distress, whereby multiple dimensions like anger, anxiety, and depression often relate similarly with health outcomes (Suls, 2018; Suls and Bunde, 2005), and investigators have postulated that such associations could be explained by common rather than unique dimensions of psychological distress (Suls, 2018; Suls and Bunde, 2005). Or, it may be that PWB dimensions are somewhat exchangeable with regard to effects on lifestyle, perhaps in the way that different forms of physical activity may similarly affect health.

Consistent with prior studies evaluating the association of PWB with single behaviors (Progovac et al., 2017a; Hingle et al., 2014; Kim et al., 2016; Progovac et al., 2017b; Baruth et al., 2011), analyses revealed associations that were independent of traditional covariates and depression. In stratified analyses, relationships of happiness and optimism with future likelihood of sustaining a healthy lifestyle were obtained among women with initially unhealthy versus healthy lifestyle scores, potentially suggesting a greater role of PWB in *adopting* versus *maintaining* a healthy lifestyle. However, approximately 65%–77% of women with an initially healthy lifestyle maintained their favorable habits subsequent to baseline, which could also have reduced our capacity to detect relations in this subgroup. Moreover, although prior research has documented negative associations between extremely high optimism levels and health-related outcomes (Shepperd et al., 2015), we did not find evidence for such associations. Midlife and older female nurses, due to both their maturity and knowledge about health, may be less prone to systematic cognitive distortions about their own probability of encountering negative [health] events, a characteristic of

"unrealistic optimism" (Shepperd et al., 2015) that may be more common among younger adults or those who are not health professionals.

To our knowledge, no prospective study has specifically assessed the bidirectional associations between PWB and lifestyle. Our results revealed relationships in both directions; however, the lifestyle → PWB association was of equal or smaller magnitude than the PWB → lifestyle association, and due to data limitations, could only be evaluated over a shorter period (8 versus 10–22 years). Given efforts aimed at changing multiple behaviors have had limited success, especially in the long-term (Spring et al., 2015), our findings suggest that targeting PWB might prove to be a fruitful strategy for improving lifestyle. Accordingly, a recent conceptual model illustrates how targeting PWB as an upstream determinant may set in motion a cascade of positive changes, because subsequent concurrent healthy behaviors may in turn lead to greater PWB and, consequently, lower the risk of adverse health outcomes (Van Cappellen et al., 2018).

This study has some limitations. Since findings were from a sample of middle-aged and older health professionals free of chronic illnesses at baseline, investigating these associations among other populations is warranted. PWB levels might affect self-report of behaviors; however, participants were not aware of our study hypotheses. Self-reported habits may also be vulnerable to social desirability, which can lead to biased estimation of health behaviors (Hebert et al., 2002). Yet, even if absolute levels are not reported precisely, behaviors would likely still be categorized appropriately as either healthy/unhealthy. Lastly, the 1-item measure of happiness may not capture the construct comprehensively, although single items have been shown to perform similarly to multi-item measures in three large cohorts (Cheung and Lucas, 2014). To date, few epidemiologic studies have included PWB measures; while single items appear less-than-ideal, they may support further investment in multi-items measures for future research. Moreover, most women in our study reported a healthy lifestyle at two consecutive assessments; subsequent studies with more variability in lifestyle scores across assessments (e.g., alternating between healthy and unhealthy) should investigate whether PWB levels are associated with such variations. Strengths of the study include its prospective design over two decades, among a large and richly characterized sample. Additionally, repeated measures of both PWB and concurrent health behaviors allowed the investigation of bidirectionality between psychological and behavioral factors. To reduce concerns that initial lifestyle levels might affect both baseline PWB and subsequent lifestyle habits we conducted stratified analyses by baseline lifestyle levels. Lastly, the consideration of two PWB dimensions and a lifestyle composite also permitted a comprehensive perspective on how PWB indicators influence multiple habits that are synergistically involved in health.

5. Conclusion

Results from this study suggest that greater happiness and optimism levels might foster sustaining a healthy lifestyle over time, which could contribute to lower disease/mortality risk. It is noteworthy that elevated PWB may subsequently lead to the *adoption* of a healthy lifestyle even in women with initially unhealthy habits. Over the past 20 years, accumulating evidence has suggested that various interventions, from brief self-administered exercises to professionally-delivered psychotherapy, may increase diverse facets of PWB (Bolier et al., 2013). As most U.S. adults exhibit suboptimal levels of physical activity and weight, and a large proportion maintain a poor diet and smoking habits (World Health Organization, 2014), considering happiness and optimism as modifiable determinants of lifestyle deserves further consideration, particularly in clinical trials.

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Author contributions

CTF and LDK developed the study concept. CTF, FG, and LDK contributed to the study design. CTF performed the data analysis. CTF and LDK drafted the manuscript; all authors provided critical revisions and approved the final version of the manuscript for submission.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ypmed.2019.105754.

References

Bao, Y., Bertoia, M.L., Lenart, E.B., Stampfer, M.J., Willett, W.C., Speizer, F.E., et al., 2016. Origin, methods, and evolution of the three Nurses' Health Studies. Am. J. Public Health 106 (9), 1573–1581.
Baruth, M., Lee, D.C., Sui, X., Church, T.S., Marcus, B.H., Wilcox, S., et al., 2011. Emotional outlook on life predicts increases in physical activity among initially inactive men. Health Educ. Behav. 38 (2), 150–158.
Boehm, J.K., Kubzansky, L.D., 2012. The heart's content: the association between positive psychological well-being and cardiovascular health. Psychol. Bull. 138 (4), 655–691.
Boehm, J.K., Chen, Y., Williams, D.R., Ryff, C., Kubzansky, L.D., 2015. Unequally distributed psychological assets: are there social disparities in optimism, life satisfaction, and positive affect? PLoS One 10 (2), e0118066.
Boehm, J.K., Chen, Y., Koga, H., Mathur, M.B., Vie, L.L., Kubzansky, L.D., 2018a. Is optimism associated with healthier cardiovascular-related behavior? Meta-analyses of 3 health behaviors. Circ. Res. 122 (8), 1119–1134.
Boehm, J.K., Soo, J., Zevon, E.S., Chen, Y., Kim, E.S., Kubzansky, L.D., 2018b. Longitudinal associations between psychological well-being and the consumption of fruits and vegetables. Health Psychol. 37 (10), 959–967.
Bolier, L., Haverman, M., Westerhof, G.J., Riper, H., Smit, F., Bohlmeijer, E., 2013. Positive psychology interventions: a meta-analysis of randomized controlled studies. BMC Public Health 13, 119.
Cheung, F., Lucas, R.E., 2014. Assessing the validity of single-item life satisfaction measures: results from three large samples. Qual. Life Res. 23 (10), 2809–2818.
Chiuve, S.E., Rexrode, K.M., Spiegelman, D., Logroscino, G., Manson, J.E., Rimm, E.B., 2008. Primary prevention of stroke by healthy lifestyle. Circulation 118 (9), 947–954.
Giltay, E.J., Geleijnse, J.M., Zitman, F.G., Buijsse, B., Kromhout, D., 2007. Lifestyle and dietary correlates of dispositional optimism in men: the Zutphen Elderly Study. J. Psychosom. Res. 63 (5), 483–490.
Haller, C.S., 2016. Trajectories of smoking behavior as a function of mood and satisfaction with life: what matters most? J. Affect. Disord. 190, 407–413.
Hankinson, S.E., Manson, J.E., Spiegelman, D., Willett, W.C., Longcope, C., Speizer, F.E., 1995. Reproducibility of plasma hormone levels in postmenopausal women over a 2–3-year period. Cancer Epidemiol. Biomark. Prev. 4 (6), 649–654.
Hebert, J.R., Ebbeling, C.B., Matthews, C.E., Hurley, T.G., Ma, Y., Druker, S., et al., 2002. Systematic errors in middle-aged women's estimates of energy intake: comparing three self-report measures to total energy expenditure from doubly labeled water. Ann. Epidemiol. 12 (8), 577–586.
Hernan, M.A., Hernandez-Diaz, S., Robins, J.M., 2004. A structural approach to selection bias. Epidemiology 15 (5), 615–625.
Hingle, M.D., Wertheim, B.C., Tindle, H.A., Tinker, L., Seguin, R.A., Rosal, M.C., et al., 2014. Optimism and diet quality in the Women's Health Initiative. J. Acad. Nutr. Diet. 114 (7), 1036–1045.
Hudson, N.W., Lucas, R.E., Donnellan, M.B., 2017. Day-to-day affect is surprisingly stable: a two-year longitudinal study of well-being. Soc. Psychol. Personal. Sci. 8 (1), 45–54.
Kim, E.S., Kubzansky, L.D., Soo, J., Boehm, J.K., 2016. Maintaining healthy behavior: a prospective study of psychological well-being and physical activity. Ann. Behav. Med. 51 (3), 337–347.
Kushi, L.H., Doyle, C., McCullough, M., Rock, C.L., Demark-Wahnefried, W., Bandera, E.V., et al., 2012. American Cancer Society Guidelines on nutrition and physical activity for cancer prevention: reducing the risk of cancer with healthy food choices and physical activity. CA Cancer J. Clin. 62 (1), 30–67.
Loef, M., Walach, H., 2012. The combined effects of healthy lifestyle behaviors on all cause mortality: a systematic review and meta-analysis. Prev. Med. 55 (3), 163–170.
Martin-Maria, N., Miret, M., Caballero, F.F., Rico-Uribe, L.A., Steptoe, A., Chatterji, S.,

et al., 2017. The impact of subjective well-being on mortality: a meta-analysis of longitudinal studies in the general population. Psychosom. Med. 79 (5), 565–757.
Mosca, L., Benjamin, E.J., Berra, K., Bezanson, J.L., Dolor, R.J., Lloyd-Jones, D.M., et al., 2011. Effectiveness-based guidelines for the prevention of cardiovascular disease in women—2011 update: a guideline from the American Heart Association. J. Am. Coll. Cardiol. 57 (12), 1404–1423.
Murray, J., Craigs, C.L., Hill, K.M., Honey, S., House, A., 2012. A systematic review of patient reported factors associated with uptake and completion of cardiovascular lifestyle behaviour change. BMC Cardiovasc. Disord. 12, 120.
Newsom, J.T., Huguet, N., McCarthy, M.J., Ramage-Morin, P., Kaplan, M.S., Bernier, J., et al., 2012. Health behavior change following chronic illness in middle and later life. J. Gerontol. 67 (3), 279–288.
Progovac, A.M., Chang, Y.F., Chang, C.H., Matthews, K.A., Donohue, J.M., Scheier, M.F., et al., 2017a. Are optimism and cynical hostility associated with smoking cessation in older women? Ann. Behav. Med. 51 (4), 500–510.
Progovac, A.M., Donohue, J.M., Matthews, K.A., Chang, C.H., Habermann, E.B., Kuller, L.H., et al., 2017b. Optimism predicts sustained vigorous physical activity in post-menopausal women. Prev. Med. Rep. 8, 286–293.
Rose, S.A., Poynter, P.S., Anderson, J.W., Noar, S.M., Conigliaro, J., 2013. Physician weight loss advice and patient weight loss behavior change: a literature review and meta-analysis of survey data. Int. J. Obes. 37 (1), 118–128.
Scheier, M.F., Carver, C.S., Bridges, M.W., 1994. Distinguishing optimism from neuroticism (and trait anxiety, self-mastery, and self-esteem): a reevaluation of the Life Orientation Test. J. Pers. Soc. Psychol. 67 (6), 1063–1078.
Shepperd, J.A., Waters, E., Weinstein, N.D., Klein, W.M., 2015. A primer on unrealistic optimism. Curr. Dir. Psychol. Sci. 24 (3), 232–237.
Sin, N.L., Moskowitz, J.T., Whooley, M.A., 2015. Positive affect and health behaviors across 5 years in patients with coronary heart disease: the Heart and Soul Study. Psychosom. Med. 77 (9), 1058–1066.
Spring, B., King, A.C., Pagoto, S.L., Van Horn, L., Fisher, J.D., 2015. Fostering multiple healthy lifestyle behaviors for primary prevention of cancer. Am. Psychol. 70 (2), 75–90.
Stevenson, R.J., 2017. Psychological correlates of habitual diet in healthy adults. Psychol. Bull. 143 (1), 53–90.
Suls, J., 2018. Toxic affect: are anger, anxiety, and depression independent risk factors for cardiovascular disease? Emot. Rev. 10 (1), 6–17.
Suls, J., Bunde, J., 2005. Anger, anxiety, and depression as risk factors for cardiovascular disease: the problems and implications of overlapping affective dispositions. Psychol. Bull. 131 (2), 260–300.
Trudel-Fitzgerald, C., Tworoger, S.S., Poole, E.M., Williams, D.R., Kubzansky, L.D., 2016. Prospective changes in healthy lifestyle among midlife women: when psychological symptoms get in the way. Am. J. Prev. Med. 51 (3), 327–335.
Trudel-Fitzgerald, C., Tworoger, S.S., Poole, E.M., Zhang, X., Giovannucci, E.L., Meyerhardt, J.A., et al., 2018. Psychological symptoms and subsequent healthy lifestyle after a colorectal cancer diagnosis. Health Psychol. 37 (3), 207–217.
Van Cappellen, P., Rice, E.L., Catalino, L.I., Fredrickson, B.L., 2018. Positive affective processes underlie positive health behaviour change. Psychol. Health 33 (1), 77–97.
Ware Jr., J.E., Sherbourne, C.D., 1992. The MOS 36-item short-form health survey (SF-36). I. Conceptual framework and item selection. Med. Care 30 (6), 473–483.
White, R.L., Babic, M.J., Parker, P.D., Lubans, D.R., Astell-Burt, T., Lonsdale, C., 2017. Domain-specific physical activity and mental health: a meta-analysis. Am. J. Prev. Med. 52 (5), 653–666.
Willett, W.C., Green, A., Stampfer, M.J., Speizer, F.E., Colditz, G.A., Rosner, B., et al., 1987. Relative and absolute excess risks of coronary heart disease among women who smoke cigarettes. N. Engl. J. Med. 317 (21), 1303–1309.
World Health Organization, 2014. Global Status Report on Noncommunicable Diseases. World Health Organization, Geneva.
Zou, G., 2004. A modified Poisson regression approach to prospective studies with binary data. Am. J. Epidemiol. 159 (7), 702–706.