

The Protective Role of Positive Well-Being in Cardiovascular Disease: Review of Current Evidence, Mechanisms, and Clinical Implications

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Abstract Positive psychological aspects of well-being—including positive emotions, optimism, and life satisfaction—are increasingly considered to have protective roles for cardiovascular disease (CVD) and longevity. A rapidly-growing body of literature has linked positive well-being with better cardiovascular health, lower incidence of CVD in healthy populations, and reduced risk of adverse outcomes in patients with existing CVD. This review first examines evidence on the associations of positive well-being with CVD and mortality, focusing on recent epidemiological research as well as inconsistent findings. Next, an overview is provided of putative biological, behavioral, and stress-buffering mechanisms that may underlie the relationship between positive well-being and cardiovascular health. Key areas for future inquiry are discussed, in addition to emerging developments that capitalize on technological and methodological advancements. Promising initial results from randomized controlled trials suggest that efforts to target positive well-being may serve as valuable components of broader CVD management programs.

Keywords Positive affect · Well-being · Optimism · Cardiovascular disease · Mortality · Health behaviors

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Introduction

Decades of research have documented the role of negative psychological factors—including depression, anxiety, and hostility—in the development and progression of cardiovascular disease (CVD) [1–3]. By contrast, a rapidly-growing body of work has linked positive psychological characteristics with better health and longevity [4, 5], including lower levels of traditional CVD risk factors and decreased incidence of CVD [6]. Prospective investigations of patients with existing CVD have shown that greater positive well-being is associated with reduced risk of secondary cardiovascular events and mortality [67••]. As CVD remains the leading cause of death in the USA and worldwide [8], increasing attention is directed toward preventing CVD and promoting ideal cardiovascular health throughout the life course [9]. Positive well-being may serve as a modifiable protective factor that could reduce the burden of CVD through its potential influences on lifestyle behaviors and CVD-related biomarkers [6, 1011•].

The purpose of this review is to highlight the latest evidence relating positive well-being with cardiovascular outcomes, mortality, and CVD risk factors. Next, this article will provide an overview of putative biological, behavioral, and stress-buffering mechanisms. Gaps in current knowledge and areas of innovation will be examined, followed by a discussion of clinical implications. Due to the growing literature and recent developments on the topic of positive well-being and CVD, this review will primarily emphasize large-scale investigations from the past 5 years. For further reading, interested readers are advised to see other reviews on the associations of positive well-being with cardiovascular health [6], health outcomes in patients with established CVD [7••], and mortality [4].

What is positive well-being?

Positive well-being is defined as the presence of favorable emotional or cognitive psychological attributes, such as positive affect (i.e., positive emotions) and optimism. Well-being is not simply the absence of mental illness nor is it the opposite of negative psychological constructs such as depression [12]. Although positive and negative psychological factors are inversely correlated, positive well-being often remains independently predictive of subsequent health outcomes after accounting for depression or negative affect [10]. The study of well-being has traditionally revolved around two broad approaches [13]: *hedonia* is characterized by happiness, pleasure attainment, and life satisfaction [14], whereas *eudaimonia* is a deeper form of well-being concerned with meaning and the realization of an individual's true potential (e.g., purpose in life, personal growth) [12]. Other well-being constructs, such as optimism and emotional vitality, are associated with cardiovascular outcomes but are not strictly categorized as either *hedonia* or *eudaimonia* [6]. It should be noted that positive well-being is intertwined with related psychological and social factors, such as social support, that are also important for cardiovascular health and disease management [15]. This review will include studies that examine various well-being constructs.

Evidence relating positive well-being and CVD

Cardiovascular morbidity

A number of prospective cohort studies have linked positive well-being to lower risk of incident CVD. In the Whitehall II cohort of British civil servants, nearly 8000 middle-aged participants responded to questions regarding their optimism (i.e., positive expectations for one's future), emotional vitality (i.e., active engagement with the world, emotion regulation, and overall sense of well-being), and satisfaction with various life domains (e.g., job, family). Compared to those with low levels of emotional vitality or optimism, people with moderate and high levels of vitality or optimism had approximately 20–30 % reduced risk of incident coronary heart disease (CHD) 5 years later [16]. Greater satisfaction across life domains also predicted reduced CHD risk, particularly angina [17]. Similar results have been reported from nationally representative US samples, in which optimism predicted lower 4-year incidence of heart failure [18] and purpose in life was associated with reduced 4-year stroke risk among 6800 older adults in the Health and Retirement Study [19]. In the National Health and Nutrition Examination Survey, emotional vitality was predictive of reduced stroke risk across 16 years in over 6000 participants [20]. Furthermore, positive affect was protective against 10-year incident CHD in the Canadian Nova Scotia

Health Survey [21]. Importantly, the findings of these studies persisted after accounting for negative psychological characteristics (e.g., depression, anxiety, hostility) and biological and behavioral risk factors.

Among patients with existing CVD, those with greater positive well-being tend to have reduced risk of secondary events and better health behaviors. For example, greater purpose in life predicted lower risk of myocardial infarction across 2 years in participants with CHD [22]. In addition, positive affect was associated with reduced risk of myocardial infarction and death 2 years after percutaneous coronary intervention with stent implantation, whereas depression and anxiety were not predictive of clinical outcomes [23]. Several recent investigations have examined optimism and recovery among cardiac patients. Compared to pessimists, optimists were less likely to be rehospitalized and more likely to respond to depression treatment by 8 months after coronary artery bypass graft surgery [24]. Greater optimism (but not gratitude) after acute coronary syndrome was associated with lower rates of cardiac readmissions and more physical activity 6 months later; however, optimism and gratitude were unrelated to levels of inflammation or other prognostic biomarkers [25]. In another study, optimism predicted better physical health status, reduced depressive symptoms, and better health behaviors 12 months following acute coronary syndrome [26].

Mortality

Numerous investigations have demonstrated that positive well-being is associated with longevity in people with and without CVD [4–6]. In the English Longitudinal Study of Aging, nearly 3900 older men and women rated their current feelings of positive affect four times over the course of a single day. Participants in the highest tertile of positive affect (aggregated across assessments) had a 35 % reduction in mortality risk across 5 years compared to those with low positive affect, adjusting for negative affect, depressed mood, demographics, and health and behavioral indicators [27]. Also, life satisfaction has been shown to predict lower mortality risk in large cohorts of older adults from Australia [28], France [29], and Germany [30], spanning approximately 7 to 22 years of follow-up. However, several studies have found that the association between life satisfaction and longevity was eliminated after accounting for other indicators of positive well-being or psychosocial resources, including positive affect [29] and beliefs about having control over one's life [31]. In addition to positive affect and life satisfaction, eudaimonic well-being may be protective for longevity [32]. To illustrate, a recent national study of US adults found that people with greater purpose in life lived longer than their less-purposeful counterparts, independent of the influences of positive affect, negative affect, and positive social relationships [33].

CVD risk factors

It has been increasingly recognized that psychosocial and behavioral factors earlier in life can contribute to the development of CVD over the course of years to decades [9, 34]. Given the paramount importance of primary prevention, the American Heart Association (AHA) has called for an improvement in “cardiovascular health” as part of the AHA 2020 Impact Goals. The concept of cardiovascular health is defined by not only the absence of clinically manifest CVD but also the simultaneous presence of four optimal lifestyle behaviors (nonsmoking, physical activity, healthy diet, and normal body weight) and three favorable biomarker levels (optimal total cholesterol, blood pressure, and fasting blood glucose without drug treatment). A cross-sectional analysis of the Multi-Ethnic Study of Atherosclerosis demonstrated a graded association between optimism and cardiovascular health scores, whereby participants in the highest quartile of optimism had 92 % greater odds of ideal cardiovascular health compared to the least optimistic participants [35]. Longitudinal data from the Midlife in the United States Study revealed that life satisfaction and positive affect each predicted reduced risk for incident cardiometabolic conditions across 8–11 years, but only life satisfaction was prospectively associated with lower cardiometabolic risk scores [36]. Although studies have linked positive well-being to lower levels of individual CVD risk factors (e.g., hypertension, lipid profiles) [37, 38], whether positive well-being promotes overall cardiovascular health over time is less clear.

Inconsistent and null findings

Several recent large-scale studies have reported that positive well-being—specifically, positive affect—was not predictive of incident CVD and mortality [39, 41–43, 40]. Furthermore, several studies on positive affect and CVD have reported significant results for some health outcomes but not others [44, 45]. Notably, the Million Women Study obtained assessments of happiness, self-rated health, and health behaviors at baseline from 719,671 women in the UK and tracked them for an average of 9.6 years. The investigators concluded that happiness was not independently predictive of mortality after accounting for baseline self-rated health and behavioral factors [40]. However, it is possible that happiness has protective influences on physiological functioning and health behaviors, thereby leading to better general subjective health and reduced risk of mortality. Because health behaviors and general health are often thought to be part of the pathway linking psychological factors to mortality, researchers should be cautious about interpreting these factors as confounding variables versus potential mechanisms. Indeed, data from the Million Women Study showed that greater happiness was associated with lower risks of mortality due to CHD or to all causes, before adjustment for self-

rated health. Similar patterns were found for women’s reports of feeling relaxed, in control, and less stressed. These associations were attenuated to nonsignificance after including self-rated health to the models; whether self-rated health was in fact a confounder or a mediator is debatable. Future investigations would benefit from having repeated longitudinal assessments of positive well-being, biobehavioral mechanisms, and health outcomes to allow for an examination of temporal ordering and change over time.

Potential pathways linking positive well-being to CVD

Positive well-being is thought to influence CVD by (a) promoting adaptive physiological functioning, (b) motivating better health behaviors, and (c) buffering against the detrimental effects of stress on health [5, 6, 46, 47]. These three pathways are interrelated and not mutually exclusive. Moreover, the reversed causal direction (i.e., good health leading to positive well-being) is possible, as are reciprocal effects between positive well-being and health.

Physiological mechanisms

Compelling evidence suggests that trait positive affect is associated with better immune function and lower levels of inflammation [48]. In an experimental study, healthy adults were exposed by nasal drops to a cold or flu virus and monitored in quarantine [49]. Participants who had greater positive affect were more resistant to developing an upper respiratory illness and reported fewer symptoms, compared to those with less positive affect. Trait negative affect, on the other hand, was not predictive of susceptibility to colds. Similarly, trait positive affect has been linked to a greater antibody response to hepatitis B vaccination, whereas negative affect was unrelated to antibody response [50]. Cross-sectional studies show that positive well-being—including positive affect, purpose in life, and positive social relations—is associated with reduced inflammation in healthy adults [51–58] and in patients with heart failure [59], as well as lower in vitro production of cytokines in response to endotoxin stimulation [60]. In addition to psychological dispositions, positive activities and experiences in daily life are important for health [61]. Recent studies indicate that people who experience more daily positive events (e.g., having a pleasant conversation, spending time in nature) and who are involved in productive activities, particularly volunteering, tend to have lower levels of inflammation [62, 63].

The hypothalamic-pituitary-adrenal axis is considered to be a key pathway whereby stress and other psychosocial factors influence health. People with higher trait positive affect are more likely to show a steeper decrease in salivary cortisol

across the day, compared to those with lower positive affect [64, 65]. Steeper diurnal cortisol slopes, in turn, are associated with reduced cardiovascular morbidity and mortality [66, 67]. Some evidence suggests that positive affect is also associated with a less exaggerated increase in cortisol after waking (i.e., cortisol awakening response) [65, 68], as well as lower cortisol reactivity to acute laboratory stressors [69]. In addition, during moments when individuals are experiencing more positive affect—relative to their usual levels of positive affect—salivary cortisol levels are reduced [70]. However, other studies have reported no association or mixed results for positive affect and cortisol [71–73]. The complexities of assessing and analyzing cortisol [74], in addition to methodological differences (e.g., laboratory versus field research, within- versus between-person designs), make it difficult to draw conclusions regarding the role of positive well-being in diurnal cortisol patterns and cortisol reactivity to real-life stress.

Positive well-being may also have protective influences on cardiovascular function and cardiac autonomic control [5, 6]. In a study where older adults' emotions and blood pressure were assessed every day for 60 days, daily positive emotions counteracted the influence of negative emotions on systolic blood pressure [75]. The study also found that participants with higher levels of social connectedness tended to have elevated positive emotions and more rapid systolic blood pressure recovery from negative emotions, suggesting that socially connected people may be more adept than less-connected individuals at mobilizing positive emotions to regulate negative experiences. In another investigation, ratings of happiness aggregated across a single day were predictive of reduced ambulatory systolic blood pressure 3 years later, as well as lower ambulatory heart rate in men, independent of sociodemographics, negative affect, and other confounding variables [76]. Yet, despite the link between trait well-being and better cardiovascular function in the long-term, state or momentary positive emotions can provoke increased cardiovascular reactivity in the short-term [5, 77].

Behavioral mechanisms

People with higher positive well-being tend to have better health behaviors than those with lower well-being, possibly due to greater motivation and self-efficacy [78•], as well as the ability to adjust health-relevant goals and to cope with setbacks [79]. Positive dispositions—including optimism, life satisfaction, and purpose in life—are associated with a range of favorable health behaviors among older and younger adults, including nonsmoking, greater physical activity, better dietary patterns, and lower incidence of sleep disturbances [80–84]. For example, in a large sample of patients with CHD, higher positive affect at baseline was associated with greater physical activity, better sleep quality, more medication adherence, and nonsmoking 5 years later [11•]. Moreover, increases in positive affect across the 5-year period co-occurred with

improvements in health behaviors. In another study, patients hospitalized for an acute coronary syndrome were interviewed in the hospital and 3 months post-discharge [85]. Qualitative analyses of the interviews revealed that exercising and eating well-generated positive emotions (e.g., pride) and, conversely, positive attributes (e.g., optimism) prompted patients to engage in healthy behaviors. Likewise, a study of primary care patients showed that dispositional optimism and hope were associated with greater treatment adherence [83]. The literature on positive well-being and health behaviors is mostly cross-sectional, and few investigations to date have been conducted in patients with CVD or using longitudinal data. It therefore remains unclear whether positive well-being leads to better subsequent health behaviors or vice versa.

Stress-buffering effects

A number of theoretical models have been proposed to describe the benefits of positive well-being in the context of stress [46, 47, 86–89]. Positive well-being is thought to have multiple salutary effects during stress, such as attenuating inflammatory and cardiovascular responses to acute stressors [68, 90, 91], counteracting the physiological effects of negative emotions [75, 92], and promoting benefit-finding and adaptive coping skills [46, 86]. For example, people who maintain positive affect when faced with stressful situations in the laboratory [90] or in everyday life [93] tend to have lower levels of pro-inflammatory cytokines and reduced risk for mortality [94]. In a study of 564 patients with CVD, negative affect predicted increased risk of CVD-related hospitalizations and all-cause mortality across 3.4 years among patients with low positive affect [95••]. Patients with high positive affect, by contrast, were protected from the adverse health consequences of negative affect. Similarly, positive well-being has been shown to buffer against the detrimental influences of other forms of stress or adversity, including low socioeconomic status, on physiological dysregulation [96, 97].

Evaluation of mediational pathways

Despite abundant research linking positive well-being to physiological processes or health behaviors that are implicated in CVD, few investigations have explicitly tested mediational pathways. To date, these investigations indicate that the association between positive well-being and health outcomes may be largely attributable to better health behaviors [44••, 45, 98, 99]. In the Heart and Soul Study of over 1000 patients with stable CHD, a number of biological markers (e.g., heart rate variability, C-reactive protein, omega-3 fatty acids) and behavioral factors (e.g., physical activity, medication nonadherence, smoking) were tested as potential mediators linking positive affect to risk of all-cause mortality across 7 years [44••]. Physical activity was the most important

explanatory variable, resulting in a 30 % reduction in the strength of the association between positive affect and mortality. Consistent with this finding, physical activity mediated the relationship between positive affect and subsequent mortality risk in a large sample of CHD patients from Denmark [45] and in a population-based cohort of older adults from the Netherlands [98]. Likewise, emotional vitality predicted lower risk of incident CHD across 15 years in over 6000 participants in the National Health and Nutrition Examination Survey I [99]. Health behaviors—specifically, greater physical activity, nonsmoking, and moderate alcohol use—accounted for much of this association (27 %), with metabolic factors (diabetes, cholesterol, and body mass index) accounting for 16 %. Yet, the relationship between emotional vitality and incident CHD remained significant even after adjusting for health behaviors, metabolic factors, and other potential mediators and confounding variables, suggesting that additional pathways should be considered.

Areas of innovation

Methodological advances in the study of well-being

The most common methods for assessing positive well-being are by self-report in survey studies and by positive mood induction in laboratory studies. Psychologists have also utilized a range of other methods to capture well-being, including informant reports (i.e., surveying close friends or family), analysis of writing samples for positive affective content, and intensity of smiling in photographs (e.g., [100, 101]). Technological advancements, social media, and big data offer innovative ways to examine population-level trends in positive well-being and CVD. A recent study analyzed psychological language use in tens of millions of Twitter messages in relation to county-level CVD mortality across the USA [102•]. Counties where residents used more words reflecting positive experiences, engagement, and optimism (e.g., *wonderful*, *friends*, *opportunities*) had relatively lower rates of CVD mortality, whereas language patterns reflecting negative emotions were associated with greater CVD mortality risk. Interestingly, Twitter language use predicted cross-sectional CVD mortality risk better than did sociodemographics and other traditional indicators (e.g., smoking, diabetes, hypertension, obesity) at the county level, suggesting that novel approaches for capturing positive and negative psychological well-being can complement traditional methods for studying the epidemiology of CVD.

Much of the research on positive well-being and CVD has utilized trait measures of well-being, in which participants are asked to rate how they generally feel. Trait measures can differ from actual experiences because they are susceptible to memory biases and judgments or beliefs about how one's life is or

should be [103]. Rapidly-fluctuating phenomena—including emotions, thoughts, and behaviors—are perhaps best captured with repeated assessments as they unfold in daily life (e.g., using smartphones or daily Internet surveys) [104]. Because emotions and cognitions are presumed to have immediate effects on physiology, psychological experiences assessed in-the-moment may be more closely related to biomarkers than global assessments of well-being [104]. Indeed, some evidence indicates that momentary positive affect is more predictive of blood pressure, heart rate, immunity, and cortisol awakening response than trait positive affect [68, 105, 106]. Another advantage of utilizing repeated assessments in daily life is the ability to examine the temporal sequencing of events (e.g., direction of associations) and to reduce confounding by using participants as their own controls. This type of research design can reveal, for example, whether elevated positive emotions earlier in the day predict dietary choices, physical activity, and sleep behaviors later in the day, or whether good health behaviors precede upticks in positive emotions. Furthermore, repeated assessments of daily well-being can be paired with ambulatory measures of psychophysiology and with minimally-invasive methods (such as saliva and dried blood spot collection) for measuring CVD-relevant biomarkers in everyday life [107, 108]. These methodological advancements arising from mobile technologies, big data, and real-time assessments can move the field toward a better understanding of the contexts and mechanisms by which positive well-being shapes cardiovascular health.

Fluctuations in well-being and CVD

Positive well-being is dynamic and changing, not static. Nonetheless, too much variability may be a signal of instability or difficulty in regulating one's emotions; these fluctuations can be detrimental for mental and physical health, independent of a person's average level of well-being [109, 110]. In a study of approximately 4500 Australians, participants with higher variability in life satisfaction from year to year had increased mortality risk; yet, as expected, greater overall life satisfaction (averaged across years) was protective against mortality [28•]. On the other hand, variability in well-being can be adaptive when it reflects the ability to flexibly match one's emotions appropriately to situational demands [111]. The dynamic characteristics of positive well-being may have important implications for psychological adaptation and physical health, in addition to illuminating avenues for intervention.

Implications for measuring well-being in clinical practice

Considering these complexities of positive well-being, a key challenge lies in the assessment of positive well-being in clinical cardiology practice. Brief measures are commonly used in research, such as a single item about happiness [112, 113], the 6-

item Life Orientation Test-Revised for optimism [114], and the 10-item positive affect subscale of the Positive and Negative Affect Schedule [115]. However, these measures have not been validated for clinical use in cardiac patients. Mobile health applications provide a potential tool for measuring trait psychological and social well-being, in addition to monitoring changes in well-being. Further work is needed to develop and optimize brief, valid, and reliable measures of positive well-being for clinical use.

Clinical Implications

Despite the well-established link between psychological factors (particularly depression) and CVD, randomized trials of traditional depression treatments in CVD patients have demonstrated only modest improvements in depressive symptoms but no effects on cardiovascular outcomes [116–118]. Thus, novel approaches for improving psychological functioning should be considered. For example, programs focusing on exercise and comprehensive lifestyle changes (e.g., stress management training combined with cardiac rehabilitation) have been shown to improve mental and physical health [119–121]. Given the evidence linking positive well-being to better health outcomes, efforts to target positive well-being may serve as important components of broader CVD management programs. Positive psychology interventions that aim at cultivate positive thoughts, feelings, and behaviors are effective for enhancing well-being and ameliorating depressive symptoms [122, 123]. Randomized controlled trials of positive affect and self-affirmation interventions [78•], in combination with patient education, have shown clinically significant increases in physical activity among patients after percutaneous coronary intervention [124] and improvements in medication adherence among hypertensive African-Americans [125], compared with patient education alone. In a recent study, patients assigned to cardiac rehabilitation combined with a positive well-being program showed improvements in their emotional states and reduced hostility 8 weeks later, compared to the control group that participated in only cardiac rehabilitation [126]. Positive psychology interventions have also shown promising effects for improving biomarkers of inflammation and cortisol in a pilot trial of patients with recent coronary artery bypass graft surgery or percutaneous intervention, relative to a waitlist control group [127•]. While these initial results are encouraging, large-scale and well-controlled studies are needed to test whether positive psychology interventions can lead to clinically significant improvements in biological, behavioral, and CVD outcomes. Moreover, the effectiveness of positive psychology interventions compared to other psychological interventions (e.g., depression treatments, stress management) for cardiac populations remains unknown.

Conclusion

By and large, people are motivated to be happy and to lead purposeful, engaged lives. Among the many functions and benefits of positive well-being [87, 113], its salutary influences on cardiovascular health and longevity present opportunities for reducing the burden of CVD. Accumulating evidence from large-scale studies has demonstrated that positive well-being is protective against CVD risk factors, incident CVD, secondary cardiovascular events, and mortality [4, 6, 107•,]. The associations between positive well-being and CVD outcomes are perhaps largely mediated by better health behaviors (e.g., physical activity, sleep, diet, nonsmoking, and medication adherence) among people with greater well-being [11•, 80, 84]. Positive well-being is also linked to better immune, neuroendocrine, and cardiovascular functioning, in addition to reduced stress reactivity and adaptive coping skills. However, the literature has inconsistent findings and key gaps in knowledge, including a dearth of prospective studies on mechanistic pathways. Abundant opportunities exist to better understand the pathways and contexts underlying positive well-being, particularly by harnessing big data, employing ambulatory methodologies, and investigating dynamic characteristics of positive well-being. Interventions to enhance positive well-being or to sustain well-being in the face of stress may have the potential to promote favorable physiological functioning, optimal health behaviors, and downstream cardiovascular outcomes.

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Compliance with Ethical Standards

Conflict of Interest Nancy L. Sin declares that she has no conflict of interest.

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