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REGULAR ARTICLE

Which Aspects of Positive Affect Are Related to Mortality? Results From a General Population Longitudinal Study

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Abstract

Background Previous research has shown a link between low positive affect and mortality, but questions remain about how positive affect is related to mortality and how this differs by gender and age.

Purpose To investigate the relationships between positive affect, negative affect, and mortality in a general population sample, and to examine whether these relationships were related to age, sex, or cause-specific mortality.

Methods We used data from 5,554 Norwegian participants aged 47–49 and 71–74 years who completed the Positive and Negative Affect Schedule (PANAS) and also provided data on demographics, health behaviors, and physical health as part of the Hordaland Health Study. The primary outcome was mortality after an average follow-up period of 16.5 years.

Results Participants in the lowest positive affect tertile had a near twofold increased mortality risk, compared to those in the highest positive affect tertile. This association was driven primarily by the PANAS "active" item and persisted, even after controlling for activity-related confounds and other positive affect items. No significant associations were found between negative affect and mortality. The relationship between positive affect and mortality was not significantly attenuated by age or sex. Although low positive affect was associated with an increased risk of mortality, it was not related to a specific cause of death.

Conclusions Low positive affect was significantly associated with mortality risk. The relationship was driven by the PANAS active item and not associated with cause-specific mortality. Findings suggest future research should examine the association between feeling inactive, sedentary behavior, and subsequent mortality.

Keywords Positive affect • Negative affect • Mortality • Longitudinal study • PANAS

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Introduction

There has been recent interest in the role of positive affect in predicting future health. A consistent finding in the literature is the relationship between positive affect and future mortality [1]. In multiple studies, researchers have found that healthy adults with high levels of positive affect have longer life expectancies than those with low levels of positive affect [2–5]. Although the perception in the longevity literature is that this connection is robust, there are discrepancies in the survival literature, where studies frequently find that in some diseases and with some positive measures, greater positive affect is associated with shortened disease survival time or a null effect [6–9]. Thus, there is a clear need to further explore the positive affect–mortality connection.

Of central importance is the issue of what *type* of positive affect is responsible for survival effects. Positive affect can be defined broadly as an affective state or trait reflecting pleasurable engagement with the environment, and includes feelings of joy, excitement, or enthusiasm [10]. With well-validated measures, positive affect typically includes multiple affective subcomponents that may influence health and physiology differentially. Positive affect does not include cognitively oriented traits, such as life satisfaction or optimism. Studies have shown many different positive measures to be both correlated and associated with health (for reviews, see [11, 12]), the pathways by which they influence health may be different from one another [1, 13]. Because of this, there is a need for researchers to try and isolate the "active ingredients" responsible for effects in multifaceted measures.

Unfortunately, to date, most studies of positive affect and longevity have not addressed this issue and instead focus on dispositional constructs, either alone or in combination with positive affect items (e.g., [14–16]). This inconsistency and lack of attention to "active ingredients" could create noise in our understanding of the associations between positive affect and health, given that they assess different components of positivity with possibly different behavioral and physiological correlates [13].

Of those few studies that do contrast different types of positive affect, there is growing evidence that higher arousal positive affect items (e.g., feelings of vigor and excitement) could in fact be driving the relationship between positive affect and mortality. For example, studies have shown that it is mid- to high-arousal positive affect that predicts reduced objective rhinovirus infection upon experimental exposure [17] and it is high-arousal positive affect not lower arousal positive affect measures (e.g., feelings of calm and happiness) that predicts extended life span [4] and survival post heart failure (e.g., vigor but not satisfaction; [18]). Furthermore, many studies that *only* assess high-energy positive affect states and traits like vitality also find health benefits [19, 20]. Identification of the specific items within a scale that predict mortality would help identify what may be linking positive affect to mortality and might resolve some of the mixed findings in the health literature, since it is possible that null or reverse findings may be due to the incorrect subtypes of affect being assessed.

Researchers have also raised the possibility that positive affect generally, and high-arousal positive affect in particular, may in itself be a de facto marker of health or be associated with other variables associated with health outcomes, such as exercise or lower rates of sedentary behavior [13, 21]. When individuals report feeling vigorous, active, and enthusiastic, this may be tapping into some aspect of their health, physical fitness, and general energy availability. This is especially relevant given a recent large study showing that a one-item happiness item did not predict mortality after numerous health and health behavior measures (among other factors) were controlled [22].

Another important measurement issue is the relation of negative affect to mortality and how that fits into the positive affect–mortality literature. Much has been made of the possibility that any benefit of positive affect on health may simply be due to the lack of negative affect, and therefore there is a call for researchers testing positive affect to control for the effects of negative affect in their analyses [21]. Unfortunately, this can be a difficult task because many positive affect and negative affect scales are highly correlated, creating issues of multicollinearity in analyses. One solution to this problem is to utilize scales that are specifically designed for the statistical independence of negative affect and positive affect (via item choice), such as the Positive and Negative Affect Schedule (PANAS) [23]. The PANAS has the advantage of the positive and negative affect scales being designed to be statistically unrelated, rather than ends of the same scale. This enables the different contributions of negative and positive affect to be examined. However, in order to achieve orthogonal scales, the PANAS positive affect measure does not include typical positive affect items such as happy and cheerful, and instead uses other items that reflect higher levels of arousal such as active, strong, interested, and excited. This has raised the possibility that the high-arousal PANAS positive affect items be associated with other variables associated with health outcomes, such as exercise or, in the case of low scores, sedentary behavior [4, 13, 21].

A further gap in the literature is to examine the type of disease-related mortality that is most strongly associated with positive affect. That is, does positive affect predict mortality similarly for different types of disease-related mortality, such as cancer and cardiovascular disease, or is the effect strongest in one type of disease? Data on this question may also provide some indications about what may be driving the positive affect–mortality association. At this point, there is strong supporting evidence from the cardiovascular area that positive affect seems to play a prognostic role in predicting mortality from coronary heart disease [12]; thus, this may be the disease most closely tied to positive affect in comparison to other causes of death. Unfortunately, few studies have examined the association between positive affect and specific cause of death in the same study, creating an important gap to improve our understanding of the types of health

outcomes most tied to positive affectivity. Most other diseases have been examined in only a handful of studies, frequently with measures that are not singularly assessing positive affect such as for stroke [24], diabetes [25], and AIDS [26].

It is well established in the emotions literature that men and women report, perceive, and experience emotion differently [27–30]; however, there has been very little work on whether gender moderates the effect of positive affect on mortality or on whether there are different aspects of positive affect that predict mortality for men as opposed to women. The role of age has also been rarely addressed. Although it has been suggested that positive affect may be especially critical in older age health processes [31], to date, it has not been tested whether this heightened positive affect associated with older age is tied to greater health-related benefits or whether the benefits are more present for those in their middle age, a group that has been relatively understudied in mortality and emotion research.

Thus, there are several goals for the current study. First, to test the hypothesis that low positive affect will be associated with mortality in a large general population sample followed for a period of 14 years and to further investigate whether the effect of positive affect is independent of the role of negative affect. We also sought to examine which components of positive affect are the most predictive of death and whether this points to the possible role of a third variable explaining this association. Next, we investigated whether any effects of positive affect on mortality are stronger for older age groups and for males. Finally, based on previous research, we also tested the hypothesis that positive affect will be most closely associated with death from cardiovascular disease rather than cancer or all-cause mortality.

Methods

Procedure

Participants were drawn from the Hordaland Health Study, a large population-based study of 18,044 individuals living in Hordaland County in Western Norway. The Hordaland Health Study was a collaboration between the National Health Screening Service, the University of Bergen and local health authorities. The Hordaland Health Study was carried out in 1997–1999 and included participants living in the city of Bergen and its surroundings. The Hordaland Health Study included two age cohorts: the "younger group," included participants aged 47–49 years, while the "older group" included participants aged 71–74 years. A total of 9,187 men and women born between 1925–1927 and 1950–1951 were eligible, and 7,074 (77%) signed the informed consent. Baseline data for the current study were collected by questionnaires and a clinical examination. Self-administered questionnaires provided information on sociodemographical factors and mental and physical health. Further details on the sample and data collection have been published elsewhere [32, 33]. In all, 5,554 persons provided valid data on the variables of interest, and thus constitute the study population. There were no significant differences on age, sex, or education between the 7,074 eligible participants and the 5,554 participants who comprised the final study sample.

Measures

Demographic, health behavior, and medical diagnoses

Baseline demographic data included age, sex, and level of education, which was classified into four categories ranging from less than 7 years of schooling up to at least 4 years of higher education at college/university. We also included data on marital/cohabitant status, smoking (number of cigarettes smoked daily), and weekly level of exercise: (i) none or easy physical activity 1 hr/week, (ii) moderate physical activity 1 to 2 hr/week, or (iii) hard physical activity more than 2 hr/week. Alcohol consumption was categorized according to weekly number of self-reported alcohol units (none, 1–2 units/week, 3–4 units/week, or ≥5 units/week). Participants were also asked: "Do you have or have you had (one or more of the following)": myocardial infarction, diabetes, stroke, or angina. In addition, the physical examination included measurements of height and weight (body mass index; BMI: kg/m^2), and blood pressure.

Positive and negative affect

The PANAS is a 20-item questionnaire that comprises two subscales, one that measures positive affect and the other that measures negative affect [23]. The positive affect scale includes the terms "interested," "alert," "enthusiastic," "excited," "proud," "inspired," "strong," "active," and "attentive," while the negative affect scale contains the terms "irritable," "hostile," "distressed," "ashamed," "upset," "jittery," "nervous," "guilty," and "afraid." Participants are instructed to rate the extent to which they *usually* experience each emotion, rated on a 5-point scale from "very little" (coded as 1) to "very much" (coded as 5). Two sum scores, one for each scale, are calculated with higher scores representing greater affect on the respective subscale. For purposes of the present study, the sum scores were divided into tertiles separately in the older and younger participants. The Cronbach's alpha for the positive affect and negative affect subscales in the current study was 0.85 and 0.83, respectively.

Mortality

The primary outcome of the present study was mortality from any cause as registered by the Norwegian Cause of Death Registry at the end of January 2016 (average follow-up: 16.5 years). This registry is kept by Statistics Norway and includes information on date and cause of death (i.e., cancer related, cardiovascular related, or other) for all deceased persons registered as residents in Norway at the time of death [34]. Cause-specific mortality was examined as a secondary outcome. The official cause of death statistics are based on death certificates provided by registered physicians and are prepared in accordance with the International Classification of Diseases. Norway implemented the 10th revision of International Classification of Diseases in 1996. Death certificates are run through a semiautomatic coding program that selects the underlying cause of death according to the rules set by the World Health Organization. To ensure that the Cause of Death Registry provides valid data, the diagnoses on the death certificate are examined and controlled to check that they are plausible for a person of the specified age or sex. Cardiovascular mortality was defined as deaths with the mention anywhere on the death certificate of ICD-10 codes "Diseases of the circulatory system" (I00–I99). Cancer mortality was defined as deaths with the mention anywhere on the death certificate of International Classification of Diseases version 10 codes Neoplasms (C00–C97).

Statistical Analysis

IBM SPSS Statistics 23 for Mac (SPSS Inc., Chicago, IL) and STATA/SE 13.1 were used for all analyses. Cox proportional hazards models were computed to assess the effect of positive and negative affect on all-cause and cause-specific mortality, both unadjusted and adjusting for potential confounders. The following variables were included as potential confounders: age cohort, gender, education, marital/cohabitant status, smoking, physical exercise, alcohol consumption, BMI, systolic blood pressure, myocardial infarction, angina, stroke, and diabetes. Analyses were stratified by age cohort and gender. Participants were followed from the date of participation in Hordaland Health Study (1997–1999) to their death or the end of the follow-up period (January 31, 2016), at which point they were censored. Results are presented as hazard ratios (HRs) with 95% confidence intervals (95% CIs). We evaluated the proportional hazard assumption by inspecting the log minus log plots stratified on the level for each covariate and found no major deviation from a proportional hazard using the "collin" command in STATA, and all values were well within the recommended limits [35]. Visual inspection of plots showed no sign of a curvilinear association between PANAS scores and mortality. For the descriptive statistics in Tables 1 and 2, missing data were handled using listwise deletion. Missing responses in the included variables ranged from 0% (sociodemographical variables) to 18.5% (PANAS). Little's MCAR test in SPSS showed that the data were not missing completely at random ($ps < .001$). Multiple missing imputation procedures in SPSS, using the automatic imputation method with 20 imputation procedures, were employed for these variables before the main regression analyses were conducted. Each of the imputed data sets was analyzed and the results were combined to produce estimates and CIs. As a sensitivity analysis, the main Cox regression models were repeated excluding the "active" item from positive affect total score.

Ethics

The study protocol was approved by the Regional Committee for Medical and Health Research Ethics of Western Norway, whose directives are based on the Declaration of Helsinki. Written consent was obtained from all subjects included in this study.

Results

Sample Characteristics

Baseline demographic and clinical characteristics according to scores on the PANAS are presented in Table 1. Low positive affect score was more prevalent among older participants, women, less educated participants, and among alcohol abstainers and those with low physical activity. Low positive affect was also significantly associated with higher systolic blood pressure, and self-reported myocardial infarction, angina, stroke, and diabetes. A similar pattern of associations were also observed in the reverse direction for the negative affect scale, but the associations were generally not as pronounced (see Table 1 for details).

Positive Affect and All-Cause Mortality

During the follow-up period from 1997–1999 through January 2016, 1,626/5,564 (29.2%) of the sample died, of whom 756/3,167 (23.9%) were female and 870/2,558 (34.0%) were male. In the unadjusted analyses, participants scoring in the lowest tertile (<33th percentile) on the positive affect subscale had a twofold increase in mortality (HR = 1.79; 95% CI: 1.42–2.25; Table 2) compared to the highest tertile (>66th percentile). Adjusting for confounding factors (age cohort, gender, education, marital/cohabitant status, smoking, physical exercise, alcohol consumption, BMI, systolic blood pressure, myocardial infarction, angina, stroke,

Table 1 Baseline Demographic and Clinical Characteristics According to Positive and Negative Affect Tertile in the Hordaland Health Study, Norway, 1997–1999

	PANAS: positive affect				PANAS: negative affect			
	Lower tertile (n = 1,629)	Middle tertile (n = 1,915)	Upper tertile (n = 2,181)	p-Value*	Lower tertile (n = 1,741)	Middle tertile (n = 2,137)	Upper tertile (n = 1,836)	p-Value
Age group				<.001				.140
47–49	40.5%	54.8%	62.5%		53.3%	55.3%	52.2%	
71–74	59.5%	45.2%	37.5%		46.7%	44.7%	47.8%	
Sex				.010				<.001
Men	45.4%	46.8%	42.2%		47.4%	46.7%	40.0%	
Women	54.6%	53.2%	57.8%		52.6%	53.3%	60.0%	
Living with partner (yes)	66.9%	74.9%	75.6%	<.001	26.1%	25.3%	30.3%	.001
Education				<.001				<.001
Compulsory	44.0%	30.8%	23.1%		30.9%	28.4%	36.3%	
High school	37.7%	42.2%	39.8%		41.5%	40.9%	37.4%	
College/university (1–3 years)	9.8%	14.1%	17.1%		14.0%	15.3%	12.4%	
College/university (4+ years)	8.5%	13.0%	20.0%		13.6%	15.4%	13.8%	
Number of daily smoked cigarettes	1.74	1.75	1.77	.265	1.74	1.78	1.74	<.001
Physical activity				<.001				.039
No or easy	56.1%	38.6%	56.1%		41.3%	40.2%	43.5%	
Moderate	37.3%	49.1%	50.1%		45.5%	46.7%	46.0%	
Heavy	6.6%	12.2%	16.5%		13.2%	13.1%	10.4%	
Alcohol consumption				<.001				.284
0 units/week	41.1%	29.4%	26.4%		32.9%	29.8%	32.0%	
1–2 units/week	16.5%	16.4%	16.9%		17.1%	17.2%	15.4%	
3–4 units/week	12.7%	15.2%	15.4%		14.4%	15.1%	14.1%	
≥5 units/week	29.8%	39.0%	41.3%		35.6%	37.9%	38.4%	
Body mass index				.048				.045
<25	46.1%	44.3%	46.3%		43.2%	45.4%	47.6%	
25–30	41.1%	44.9%	43.4%		44.2%	43.8%	41.9%	
>30	12.8%	10.9%	10.3%		12.7%	10.7%	10.5%	
Systolic blood pressure	138.3	136.44	135.5	<.001	136.7	136.6	135.1	.033
Myocardial infarction	6.3%	4.8%	3.5%	<.001	4.2%	5.1%	5.0%	.432
Angina	8.4%	6.4%	3.9%	<.001	4.5%	5.9%	7.5%	.001
Stroke	3.6%	1.7%	1.8%	<.001	2.6%	1.6%	2.7%	.043
Diabetes	4.5%	3.3%	2.3%	.001	3.2%	3.3%	3.4%	.943

*p-Values are based on Pearson chi-square tests or ANOVAs. Note that values are based on the non-imputed data set. PANAS = Positive and Negative Affect Schedule.

and diabetes) reduced the strength of association, but the effect of low positive affect remained significant in the adjusted model (HR = 1.38; 95% CI: 1.12–1.71; see Table 3 for details). As a sensitivity analysis, we also adjusted for the negative affect scale in the regression model, but this did not change the strength of the associations (data not shown). A positive affect score in the middle tertile was not associated with increased mortality risk.

When stratifying the analyses by sex, we found few gender differences. As depicted in Fig. 1, the effect of positive affect on mortality risk was somewhat higher for participants in the younger cohort (aged 47–49: unadjusted HR = 1.85; 95% CI: 1.14–3.00) for the lowest positive affect tertile) compared to participants aged 71–74 years (HR = 1.35; 95% CI: 1.15–1.60), but this interaction was not statistically significant (p = .212). Also, no significant associations were found between

Table 2 Number and Cause of Deaths in Men and Women Stratified by PANAS Tertile Scores

	PANAS: positive affect				PANAS: negative affect			
	Lower tertile % (*n*)	Middle tertile % (*n*)	Upper tertile % (*n*)	*p*-Value*	Lower tertile % (*n*)	Middle tertile % (*n*)	Upper tertile % (*n*)	*p*-Value
All								
Any cause of death	38.5% (626)	26.8% (514)	22.3% (486)	<.001	27.9% (485)	27.5% (587)	30.1% (552)	.160
CVD death	9.2% (150)	6.7% (128)	5.8% (127)	<.001	7.2% (126)	7.4% (159)	6.6% (121)	.564
Cancer death	11.4% (185)	7.7% (148)	7.5% (163)	<.001	8.4% (147)	8.1% (174)	9.5% (175)	.275
Other	17.9% (291)	12.4% (238)	9.0% (196)	<.001	12.2% (212)	11.9% (254)	13.9% (256)	.119
Women								
Any cause of death	33.3% (296)	22.1% (225)	18.7% (235)	<.001	22.5% (206)	23.3% (266)	25.4% (280)	.281
CVD death	7.4% (66)	5.5% (56)	4.3% (54)	.007	5.0% (46)	6.4% (73)	5.1% (56)	.283
Cancer death	9.9% (88)	6.1% (62)	6.6% (83)	.003	7.2% (66)	6.9% (79)	8.1% (89)	.563
Other	16.0% (142)	10.5% (107)	7.8% (98)	<.001	10.3% (94)	10.0% (114)	12.3% (135)	.183
Men								
Any cause of death	44.6% (330)	32.2% (289)	27.3% (251)		33.8% (279)	32.2% (321)	37.1% (272)	.105
CVD death	11.4% (84)	8.0% (72)	7.9% (73)	.025	9.7%(80)	8.6% (86)	8.9% (65)	.720
Cancer death	13.1% (97)	9.6% (86)	8.7% (80)	.009	9.8% (81)	9.5% (95)	11.7% (86)	.293
Other	20.1% (149)	14.6% (131)	10.6% (98)	<.001	14.3% (118)	14.0% (140)	16.5% (121)	.320

*p-Values are based on Pearson chi-square tests. Note that values are based on the non-imputed data set. CVD = cardiovascular disease; PANAS = Positive and Negative Affect Schedule.

Table 3 Unadjusted and Fully Adjusted Hazard Ratios (HRs) of All-Cause Mortality Risk Associated With Positive and Negative Affect (PANAS), Stratified by Sex and Age Group

	Positive affect				Negative affect	
	Unadjusted model		Adjusted model[a]		Unadjusted model	
Score on PANAS factors	HR	95% CI	HR	95% CI	HR	95% CI
Total sample						
Lower tertile	1.79***	1.42–2.25	1.38**	1.12–1.71	1.00	Ref
Middle tertile	1.24	0.84–1.81	1.15	0.80–1.63	0.94	0.80–1.09
Higher tertile	1.00	–	1.00	–	0.92	0.80–1.05
Men						
Lower tertile	1.77***	1.40–2.24	1.29*	1.03–1.62	1.00	Ref
Middle tertile	1.20	0.83–1.72	0.99	0.83–1.20	0.91	0.76–1.09
Higher tertile	1.00	–	1.00	–	0.88	0.73–1.06
Women						
Lower tertile	1.78***	1.34–2.37	1.31*	1.01–1.71	1.00	Ref
Middle tertile	1.24	0.82–1.89	1.15	0.75–1.77	0.92	0.73–1.15
Higher tertile	1.00	–	1.00	–	0.91	0.75–1.11

Cox regression analyses are based on a multiple imputed data set.

[a]Adjusted for age cohort, education, marital/cohabitant status, smoking, physical exercise, alcohol consumption, body mass index, systolic blood pressure, myocardial infarction, angina, stroke, and diabetes.

*$p < .05$; **$p < .01$; ***$p < .001$.

negative affect and mortality, including in separate analyses for men and women. Similarly, consideration of the younger versus older sample did not reveal any specific predictive effects of negative affect.

Specific Positive Affect Items and Mortality

We explored the association between positive affect and subsequent mortality in a series of Cox regressions to

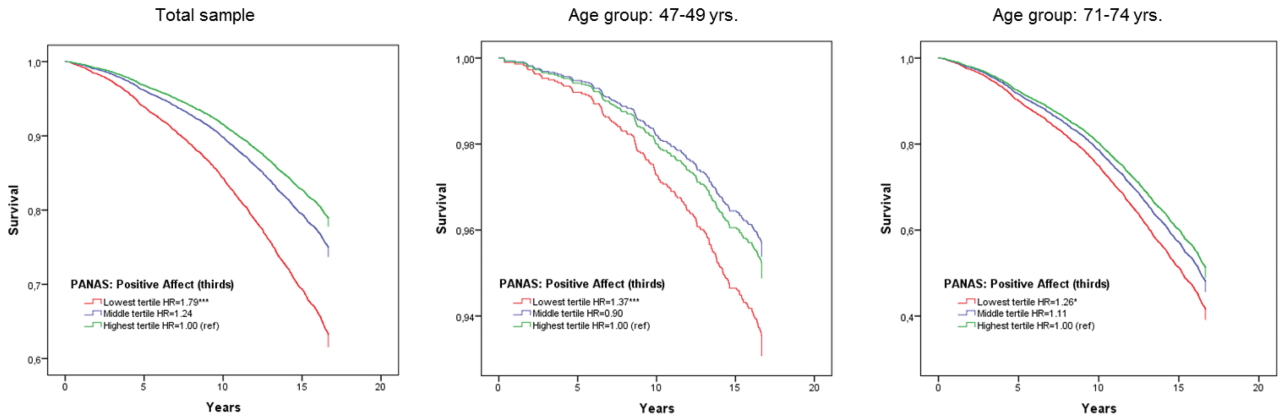

Fig. 1. Kaplan–Meier survival curves by PANAS positive affect percentiles in the total sample and stratified by age group (crude analyses). Note: Cox regression analyses are based on a multiple imputed data set. PANAS = Positive and Negative Affect Schedule.

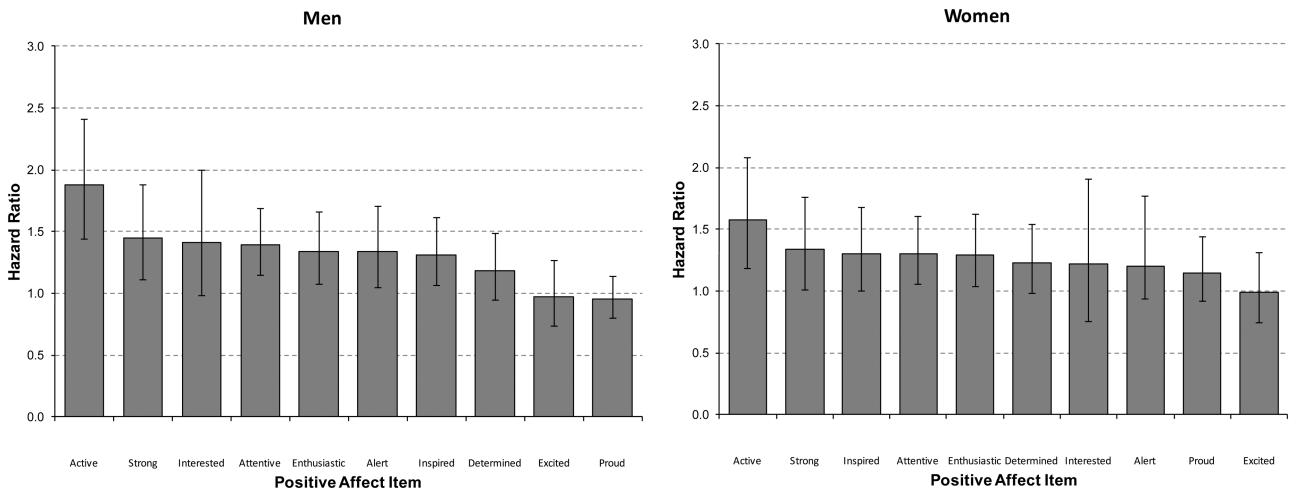

Fig. 2. Fully adjusted hazard ratios (HRs) of all-cause mortality risk associated with single items on the positive affect (PA) subscale of PANAS stratified by sex. Item scores are dichotomized comparing "very little" or "little" with "much" or "very much." Error bars represent 95% confidence intervals. Note: Cox regression analyses are based on a multiple imputed data set. PANAS = Positive and Negative Affect Schedule.

examine the effect of each specific positive affect item. As shown in Fig. 2, a low score on the item "active" in the positive affect subscale was most predictive of mortality for both men and women, with a much stronger association with mortality than any of the other nine PANAS items. To examine the unique association between the "active" item and all-cause mortality, we additionally adjusted for all other positive affect items in the Cox regressions. These analyses showed that scoring low on the "active" item remained a significant risk factor for death, in both female (HR = 1.58; 95% CI: 1.30–1.89) and male participants (HR = 1.82; 95% CI: 1.51–2.20).

We also examined the association between individual PANAS items and baseline health behaviors, previous diagnoses of myocardial infarction, diabetes, or stroke, BMI, systolic blood pressure, and education. As can be seen from the supplementary tables, the PANAS "active" item is the most strongly associated with exercise, smoking, and BMI in the total sample and these associations tend to be slightly stronger in the younger cohort.

Sensitivity Analyses

To further explore the nature of the association between positive affect and mortality, we repeated the regression analyses excluding the "active" item from the positive affect sum score. These analyses showed that participants scoring in the lowest tertile on this modified positive affect subscale still had a significant increase in mortality in the fully adjusted analyses (adj. HR = 1.17; 95% CI: 1.01–1.36). When stratifying the analyses by sex, the effect on mortality was only statistically significant in women (adj. HR = 1.25; 95% CI: 1.01–1.56), not men (adj. HR = 1.11; 95% CI: 0.91–1.35).

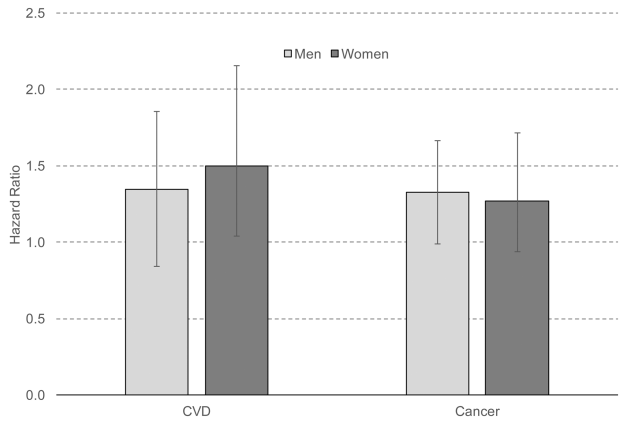

Fig. 3. Fully adjusted hazard ratios (HRs) by the most common causes of death associated with scoring low (lowest tertile) on the positive affect (PA) subscale (reference: upper tertile). Error bars represent 95% confidence intervals. Note: Cox regression analyses are based on a multiple imputed data set.

Cause-Specific Analyses

Although the sample size in the current study prevented a more detailed analysis of cause of death, fully adjusted analyses showed that scoring low on positive affect was equally strong associated with cardiovascular disease deaths and cancer deaths. Also, no significant differences were observed between men and women (see Fig. 3).

Discussion

In this study using two age groups from a Norwegian general population sample followed for 17 years, we found low positive affect to be strongly associated with mortality. Participants scoring in the lowest tertile of the PANAS positive affect subscale had a near twofold increase in mortality over the follow-up period, compared to participants in the highest tertile of positive affect. Although this relationship was attenuated somewhat after controlling for health behavior, medical diagnoses, age, BMI, and blood pressure, low positive affect was still associated with a 38% increased risk of mortality. We did not find any significant effects for negative affect on mortality. The relationship between positive affect and mortality was not significantly stronger in the younger than the older cohort. Looking at the type of death, we found that the impact of low positive affect was equally strong for death from cardiovascular disease and from cancer. Further examination of the positive affect items revealed that a low score on the positive affect item "active" had by far the strongest association with mortality in both male and female participants. Removing the item "active" from the positive affect scale reduced the association between positive affect and mortality for men but not for women.

The association between low positive affect and mortality is consistent with other research findings. The review by Chida and Steptoe found that both state and trait positive measures were associated with longer life duration in studies of healthy and physically ill populations, and that this effect was independent of negative affect [1]. Also, a recent study of over 3,000 individuals that assessed positive affect using ecological momentary assessment over a single day, rather than the traditional questionnaire approach, found a graduated association of positive affect with survival with low levels of positive affect being associated with the highest risk of death [36]. There is also strong supporting evidence from the general population and cardiovascular literature that positive affect seems to play a particularly important prognostic role in predicting mortality from coronary heart disease [19, 37, 38].

Our data did not show any significant associations between negative affect and mortality. Although it is often assumed that because negative emotions are often accompanied by adverse physiological consequences, these effects over time may impact adversely on disease processes. However, many other longitudinal studies have also not demonstrated a relationship between negative affect and mortality [39]. For example, a prospective study of older Mexican Americans found low positive affect was associated with poorer functional status and survival; however, negative affect had no significant impact [40]. Similar findings are reported in other longitudinal studies [41, 42]. However, many studies have not assessed both positive and negative affect and it is possible that some of the past associations between negative affect and disease may be driven by low positive affect, given the high correlation between the two variables.

Why is low positive affect associated with mortality and what mechanisms may underlie this association? To date, there has been very little work testing *how* low positive affect could affect mortality. It has been speculated that lower positive affect could lead to poorer health behavior, less supportive social networks, and more negative social interactions. These in turn could result in worse health on their own, as well as an increased impact of stressful events on the body, resulting in worsening health [13]. We tested some of these possible mechanisms by controlling for a number of possible baseline confounds (age, gender, education, smoking, physical exercise, BMI, somatic diagnoses, and blood pressure), and though they reduced the association somewhat, low positive affect was still associated with mortality, even when these variables were included in the analysis. It is possible, then, that other mediators unexamined in this data set could also be possibly responsible for the positive affect–health connection, such as inflammation or neuroendocrine functioning, [43, 44]. An alternative methodological argument is that positive affect measurement is confounded with positive health and individuals' positive affect ratings. According to this view, positive

affect items reflecting higher energy are in fact just markers of perceived health that are not controlled by baseline measures of physical health and fitness. For example, differences in positive energy may reflect differences in restorative behaviors such as sleep or even reflect not feeling physically well [45].

Our data show the PANAS item "active" to be the most predictive of mortality. It is important to consider what it means to say that one feels very slightly or not at all active? A literal interpretation would be that perhaps these individuals had a greater propensity to be sedentary over the follow-up. We now know from large epidemiological studies that sedentary behavior is strongly associated with mortality and, in particular, death from cardiovascular disease [46–48]. Given the restricted data available in this epidemiological study, we are unable to directly assess activity and exercise levels over the follow-up period but we believe that this is something that researchers interested in the link between positive affect and mortality should examine more closely in the future. The sensitivity analysis conducted with the item "active" removed points to there being a possible gender effect with this item being more associated with mortality in men than women. The strength of the association of active points to the fact that more work needs to be done to demonstrate that the association between low positive affect and mortality is not simply due to an association with sedentary behavior.

The finding that feeling "active" is what provides longevity benefit from positive affect is in contrast to other researchers who have posited that the association between positive affect and health outcomes is due to the fact that positive emotions build cognitive strength and creativity and thus make high positive affect individuals more resilient to stressful events [49, 50]. The general focus of positive psychology interventions has been on other types of positive emotions like gratitude, happiness, and life meaning. This study points to feelings of energy and activity as critical to the health–positive affect connection and point to a possible different and more energy-based focus for future interventions.

The study has a number of strengths including a large sample size and a comprehensive follow-up through the Norwegian Cause of Death Registry, made possible through linkage using the personal identification number unique to each Norwegian resident. The study also used an established and validated measure of positive affect, which allowed examination of the unique contribution of positive affect and negative affect and was able to look at the relationship between the individual items of the PANAS and mortality. The study also assessed a number of possible confounding variables at baseline. It should, however, be noted that other potentially important factors were not included in the specific set of questionnaires used in the Hordaland Health Study, such as other measures of positive affect, previous medical diagnoses, social support, depression, or diet. Related to this, the items assessing medical diagnoses were based on self-report, and thus not validated by hospital or medical records. Another limitation is the items assessing health behavior were single items and the measurement of physical activity did not separate between actual time spent doing the activity and the level of strenuousness involved.

It is also important to note that the study is also limited by the restriction of the sample to two age cohorts, which may restrict the generalizability of the findings to other age groups. The measurement of exercise level at baseline is also restricted by being classified into three categories, with a much smaller proportion of participants in the top (strenuous exercise) category. Bearing these limitations in mind, this study has shown low positive affect being strongly associated with future mortality. Our analysis of the individual items of the PANAS scale suggests that how active people feel is the most important component in this relationship. The results further suggest that the association between feeling inactive and sedentary behavior should be more closely examined as a possible explanation for the link between low positive affect and mortality in future research.

Supplementary Material

Supplementary material is available at *Annals of Behavioral Medicine* online.

Compliance with Ethical Standards Statements

Authors' Statement of Conflict of Interest and Adherence to Ethical Standards Keith J. Petrie, Sarah D. Pressman, James W. Pennebaker, Simon Øverland, Grethe S. Tell, and Børge Sivertsen declare that they have no conflict of interests. All procedures, including the informed consent process, were conducted in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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