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RESEARCH PAPER

Effects of Happiness on All-Cause Mortality During 15 Years of Follow-Up: The Arnhem Elderly Study

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Abstract Positive psychological characteristics may be beneficial for physical health. However, prospective data on the effects of happiness on survival is scarce. In a population-based cohort study, the Arnhem Elderly Study, happiness was measured by two items, being: "I have many moments of happiness" and "I often laugh happily". In Cox proportional hazard models, happiness was analyzed as a predictor of 15 year all-cause mortality for 861 (85%) of 1,012 elderly subjects aged 65–85 years. Results showed that happiness was inversely associated with mortality (age- and sex-adjusted hazard ratio of 0.78 for happy subjects versus unhappy subjects; 95% confidence interval 0.64–0.95, $P = 0.01$ for trend), but that this relationship was no longer statistically significant after adjustment for physical activity and prevalent morbidity. Thus, happiness predicts for lower mortality, which may partly be mediated by more physical activity and lower morbidity.

Keywords Happiness · Longevity · Elderly subjects · Cohort study · Physical activity · Illnesses

1 Introduction

Most literature focuses on psychopathology rather than beneficial psychosocial characteristics (Pressman and Cohen 2005; Pitkala et al. 2004; Mossey and Shapiro 1982), although research concerning positive psychosocial characteristics gradually catches up (Giltay et al. 2004, 2006; Kubzansky et al. 2001, 2002; Ostir et al. 2000; Scheier et al. 1989; Zuckerman et al. 1984). Happiness is one of these positive characteristics that has already been subjected to research for its possible relation with desirable health outcomes

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(Deeg and Van Zonneveld 1989; Devins et al. 1990; Kawamoto and Doi 2002; Stones et al. 1989). Interest in the concept of happiness dates back to Ancient Greece when contemporary philosophers and society concentrated on a virtuous and dedicated life. As for the past century, different scholarly definitions of the happiness concept have been postulated (for an overview, see Veenhoven 1984). Veenhoven (1984) defines the construct of happiness as the degree to which an individual judges his or her life as a whole favorably.

Over time, investigators examined several happiness measures for their relation to longevity, both in healthy populations and in the institutionalized and ill. Most, but not all, studies found that these measures were positively associated with longevity. For example, Zuckerman et al. (1984) found that happiness ratings by trained interviewers predicted mortality risk for 398 poor elderly after controlling for gender and health status. A 20 year follow-up study on 22,461 Finnish adults reported an increased all-cause mortality rate for men who claimed to be dissatisfied with life when controlled for different sociodemographic characteristics (Koivumaa-Honkanen et al. 2000). Finally, within a study of 491 men and women, aged 75 and over, when controlled for age, gender and a comprehensive health measure, 10 year survival was positively associated to whether one is satisfied with life (Pitkala et al. 2004). However, Kawamoto and Doi (2002)arrived at a different conclusion. After controlling for age, gender, baseline health, marital status, economic status, social contacts and activity pattern, no relationship between self-rated happiness and survival was found during a 3 year follow-up period in 2,274 community-dwelling elderly people aged 65 and over.

Alternatively, the concept of happiness has also been operationalized by simply measuring happiness as such. Palmore (1969) asked 268 subjects who were aged between 60 and 94 about their level of happiness and found that self-reported happiness was inversely associated to mortality during 4 year follow-up (Palmore 1969). Within a national sample of widowed subjects who were followed up for 6 years, logistic regression analysis, controlling for age and sex, revealed that a lower level of happiness as rated by a qualified interviewer predicted early mortality for men in comparison to men of the same age in the general population (Bowling and Charlton 1987).

However, it is unclear which explanatory mechanisms could underlie the above mentioned associations. In an attempt to reduce possible confounding and reverse causation, investigators attempted to fit regression models to the data that adjusted both for sociodemographic and health indicators (Kawamoto and Doi 2002; Koivumaa-Honkanen et al. 2000). Yet, most of the earlier cited studies are rather conservative when it comes to including covariates. For example Palmore (1969) adjusted for none at all and Zuckerman et al. (1984) and Pitkala et al. (2004) only adjusted for a limited number of sociodemographic variables, i.e., sex, age and baseline health. In this respect, physical activity and prevalent morbidity may also be of importance. Physical activity seems to boost one's happiness level (Kawamoto and Doi 2002; Palmore 1969; Schnor et al. 2005) and is a strong protector against morbidity (Blair et al. 1989; Matthwes et al. 2007). Therefore it could be suggested that whether one judges his or her life favorably depends on the extend of one's physical activity, which may subsequently affect morbidity and life expectancy.

Thus longevity, physical activity and happiness appear to be interrelated, but the nature of this relationship remains unclear. The Arnhem Elderly Study, is a population-based cohort study that started in 1991–1992 with a mortality follow-up till 2006, offering the opportunity to assess longitudinally whether subjects reporting an increased overall experience of happiness live longer in comparison to their less happier counterparts. In a previous publication in this cohort, the effects were analyzed for dispositional optimism on

all-cause mortality, revealing a protective relationship between dispositional optimism and all-cause mortality in old age (Giltay et al. 2004). The present analysis however focused on subjective happiness experience and extends the duration of follow-up from 9 to 15 years. A difference in longevity is hypothesized in favor of the subjects considered to be more happy, whereby physical activity may fulfill a mediating role.

2 Methods

2.1 Study Population

The Arnhem Elderly Study is a population-based cohort study that was initiated in October 1991. In 1991–1992, Arnhem was a city of ~133,000 inhabitants in the eastern part of the Netherlands. A random sample of non-institutionalized elderly men and women was provided by the Municipal Register Office of Arnhem. These residents were living in 18 districts, covering a broad range of social economic status. A two-stage sampling procedure was applied since the first response was lower for the more elderly subjects as compared to other age groups, therefore the highest age group was enlarged during the second stage of sampling. Within six consecutive months data collection was finished. The random sample, stratified for gender and age, covered 1,793 non-institutionalized elderly residents. In total, 781 were excluded form the study due to institutionalization, moving to other places, mortality or non-participation. This resulted in a total target sample of 1,012 elderly (58%) aged 65–85 years of whom all agreed to be interviewed at baseline.

Follow-up on mortality and migration data was provided by municipal registries twice, at different time intervals. Migration resulted in the loss of one person at 9 year and 3 months follow-up that was completed in February 2001. The second follow-up survey wave on mortality and migration was completed in January 2007. Because of delayed or incomplete responses from local authorities, another 4 subjects were lost between 2001 and 2007. These 5 cases (0.5%) were censored at the last time-point of follow-up, leaving all-cause mortality data complete for the remaining 1,007 (99.5%) cases. Besides these 5 cases lost to follow-up, 74 (7.3%) cases were not included in the final analysis because a lag period of 2 years was applied to reduce the chance of reverse causation. Next, of the remaining 933 cases (92.2%), both of the happiness items were filled in by 896 (88.5%) respondents, resulting in an additional loss of 37 cases. Finally, as we only included those subjects with complete data on all the (co)variables of interest another 35 (3.5%) subjects were excluded from the analysis.The in total excluded 151 (14.9%) subjects were, when compared to the 861 (85.1%) included subjects more likely to be male ($P = 0.02$), less likely to live together as a married or unmarried couple ($P = 0.01$) and were slightly older (mean age 76.6 [±5.5] vs. 74.8 [±5.8] years; $P = 0.09$). No differences were found for education level. The study was approved by the ethical committee of Wageningen University (Wageningen, The Netherlands). Informed consent was obtained from all participants.

2.2 Questionnaire on Happiness

Between 1991 and 1992, at baseline, happiness was assessed by the Dutch Scale of Subjective Well-being for Older Persons (SSWO) developed by the Groningen University (Groningen, The Netherlands; Tempelman 1987). Interviews were conducted at the

subjects' residences by in total 23 trained interviewers. The research instrument originated from five existing scales that were considered to measure different components of subjective well-being on the basis of their content (Hermans and Van de Tak-ven 1973; de Jong-Gierveld 1980; Sanders 1977; Tempelman 1987; Wimmers and Van der Bom 1971). Factor analysis resulted in a 30 item questionnaire. The total sum score then indicates the general well-being experience of the elderly individual. Subsequent factor analysis on research data suggested 5 subscales: health (5 items; Cronbach $\alpha = 0.87$), self-respect (7 items; $\alpha = 0.73$), morale (6 items; $\alpha = 0.77$), optimism (7 items; $\alpha = 0.76$) and contacts (5 items; $\alpha = 0.65$), accounting for 48.1% of variance (Bosma 1988; Linschoten et al. 1988; 1993).

From the optimism subscale, 2 items were selected for their relation with the subjects' subjective happiness experience, thereby defining subjective happiness in this study ($r = 0.73$, $P < 0.01$). These items are: "I have many moments of happiness" and "I often laugh happily" (our translations from the Dutch sentences "Momenten dat ik me gelukkig voel heb ik vaak" and "Blij lachen doe ik vaak"). Responses were rated on a scale from '0' to '2' and the scores on both items were summed, whereby a higher score indicated higher levels of happiness. The linear-by-linear χ^2 association between the two happiness items was statistically significant ($P = 0.001$; with Cronbach's $\alpha = 0.60$). Within the current research sample, results on all 5 well-being subscales correlated significantly with the happiness score on the SSWO (r ranging from 0.33 to 0.73, $P < 0.01$).

Participants were ranked according to their happiness score and divided into three groups. Subjects reporting the lowest and highest possible sum scores on these two items were considered to be either unhappy (sum score 0, 1 or 2) or happy (sum score of 4), leaving a third group of respondents reporting neither to be explicitly unhappy nor to be explicitly happy on both the items. These subjects were considered to be moderately happy (sum score of 3), hence creating three in number most equal response groups ($n = 216$, 378, 267, respectively).

2.3 Physical Activity and Sociodemographic Characteristics

By means of standardized data collection, sociodemographic and behavioral characteristics were inventoried by trained interviewers at baseline. Physical activity was scored continuously according to a validated questionnaire for classifying activity levels of the elderly based on household activities, sporting activities and other leisure time activities. The test–retest reliability for this questionnaire was 0.89 as was determined by Spearman's correlation coefficient. Validity was assessed by repeated 24 h activity recalls and pedometer measurements, yielding Spearman's correlations of 0.78 and 0.73 for both methods, respectively (Voorrips et al. 1991).

Dichotomous variables were created for sex (i.e., men vs. women), marital status (i.e. living together as a married or unmarried couple vs. otherwise), educational level (i.e., college or university vs. otherwise) and socioeconomic status (i.e., housewives, unskilled and skilled workers and lower employees vs. small-business owners, employees and higher professions). For married or widowed women, socioeconomic status was classified according to that of the husband. Respondents' smoking behavior was categorized over three levels (i.e., current, former or non-smokers). Finally, an ordinal 6-point variable coded for the total number of chronic disorders and illnesses of the elderly (i.e., 0, 1, 2, 3, 4, or 5 or more from a list of 24; e.g., chronic venous leg ulcers, chronic gastric disease, chronic low back pain, rheumatic disease and cancer).

2.4 Statistical Analysis

The distribution of physical activity was positively skewed and required logarithmical transformation prior to statistical analyzes. Baseline characteristics for the included subjects according to happiness status were reported as numbers (percentage) or (geometric) means (±SD or 95% confidence interval [CI]). Potential differences in the distribution for these three groups on the baseline characteristics were analyzed by chi-squared test or analysis of variance (ANOVA).

Happiness was analyzed in relation to all-cause mortality for 861 subjects with complete data. First, the Kaplan–Meier method (Kaplan and Meier 1985) was used to examine crude all—cause mortality rates over the 3 different response groups, using a lag period of 2 years. Second, potential mediating or confounding variables were adjusted for in Cox proportional hazards models by incrementally including them as covariates. The associations of different levels of happiness and all—cause mortality were explored, by selecting the first group (i.e., unhappy) as the reference category (i.e., hazard ratio of 1.00). Differences in survival rate were represented by the relative survival ratios of the remaining two groups, i.e., 'moderately happy' and 'happy'. Third, to assess the relative impact for each covariate on the association between happiness levels and mortality, the formula as described by Lynch et al. (1996) is applied $(HR_{\text{model A}} - HR_{\text{model B}})/(HR_{\text{model A}} - 1)$, where model *A* is the unadjusted model and where model *B* includes the covariate. The software used was SPSS version 13.0 (SPSS Inc, Chicago, IL, USA).

3 Results

Subjects did not differ in sex, marital status, education, social economic status and smoking habits according to their level of happiness (Table 1). However, less happy subjects suffered from more chronic disorders and illnesses than their happier counterparts (median, 2.0 vs. median, 1.0, $P < 0.001$), were slightly older (mean age, 75.9 ± 5.6 vs. 74.5 ± 5.9 years; $P = 0.01$) and were less physically active ($P < 0.001$).

Crude survival according to the happiness sum scores were examined by a Kaplan–Meier curve (Fig. 1). Log-ranked test revealed that the cumulative survival rate within 15.2 years of follow-up differed significantly ($P = 0.006$) for the three groups that represent successive levels of subjective happiness, with lower levels of happiness predicting for shorter survival. Next, Cox Proportional Hazard models were applied to the data, incrementally adjusting for behavioral and sociodemographic covariates. The proportional hazard assumption was satisfied, using the log-minus-log graphical method for which continuous variables were provisionally categorized. As for the first and unadjusted model (i.e., model 1, Table 2), a significant difference in mortality hazard for the first and third happiness tertile was found. The statistical significance remained after adjusting for sex and age, and the subsequent additional adjustment for marital status, educational level and social economic status. The linear trend for hazard ratios over the three groups was not statistically significant for the models 4, 5 and 6 (Table 2).

Statistical significance was lost for the third response group (i.e., 'happy') versus the first response group (i.e., 'unhappy') after incrementally adjusting for total number of chronic disorders and illnesses and physical activity and smoking. Table 3 shows the relative impact of each covariate on the survival hazard ratio for the subjects considering themselves happy versus subjects considering themselves unhappy. The most notable relative impact on the association was found for physical activity (40% explained

Table 1 Baseline characteristics Arnhem Elderly Study according to the three subgroups of subjective happiness experience

Variable	Categories	Unhappy	Moderately happy	Happy	Test statistic[†]	*P* value
Sex	Female	119 (55.1%)	127 (47.6%)	205 (54.2%)	χ^2 (2) = 3.64	0.16
	Male	97 (44.9%)	140 (52.4%)	173 (45.8%)		
Age	–	75.9 (5.6)	74.5 (5.6)	74.5 (5.9)	F (1,860) = 4.64	0.01
Marital status	Living together	114 (52.8%)	165 (61.8%)	227 (60.1%)	χ^2 (2) = 4.47	0.11
	Otherwise	102 (47.2%)	102 (38.2%)	151 (39.9%)		
Educational level	College or University	44 (20.4%)	54 (20.2%)	67 (17.7%)	χ^2 (2) = 0.90	0.64
	Otherwise	172 (79.6%)	213 (79.8%)	311 (82.3%)		
Socioeconomic status[a]	Low	92 (42.6%)	101 (37.8%)	150 (39.7%)	χ^2 (2) = 1.14	0.57
	High	124 (57.4%)	166 (62.2%)	228 (60.3%)		
Smoking status	Current	55 (25.5%)	66 (24.7%)	75 (19.8%)	χ^2 (4) = 4.37	0.36
	Former	87 (40.3%)	109 (40.8%)	152 (40.2%)		
	Non-smoker	74 (34.4%)	92 (34.5%)	151 (39.9%)		
Number of chronic diseases	0	31 (14.4%)	60 (22.5%)	90 (23.8%)	χ^2 (10) = 35.63	<0.001
	1	42 (19.4%)	71 (26.6%)	121 (32.0%)		
	2	51 (23.6%)	56 (21.0%)	78 (20.6%)		
	3	48 (22.2%)	33 (12.4%)	48 (12.7%)		
	4	22 (10.2%)	28 (10.5%)	24 (6.3%)		
	5 or more	22 (10.2%)	19 (7.1%)	17 (4.5%)		
Physical activity[b]	–	1.72 (0.7)	1.94 (0.7)	2.14 (0.7)	F (1,860) = 24.81	<0.001

Data are *n* (%) or mean ± SD, when appropriate

[†] Chi-squared test and one way ANOVA *F* values (provided with accompanying degrees of freedom) were used to examine *P* values for independency for both categorical and numerical variables, respectively

[a] Socioeconomic status was defined as low for housewives, unskilled and skilled workers and lower employees, and as high for small-business owners, employees and higher professions. As for married or widowed women it was chosen to classify the socioeconomic status according to that of the husband

[b] Each activity was classified by intensity codes based on the net energetic costs of the activity

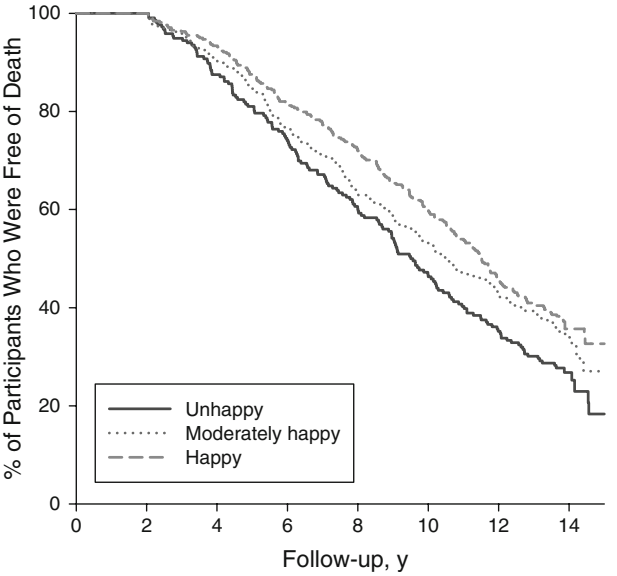

Fig. 1 Kaplan–Meier analysis of survival according to the happiness categories for 861 participants. The categories range from 'unhappy' to 'happy'. Compared to 'unhappy' subjects, those reporting to be 'happy' showed an increased survival rate ($P = 0.006$, by log-rank test)

Table 2 Hazard ratios for all-cause mortality according to the happiness tertiles in 861 men and women

Cox proportional hazard model	Tertiles			*P* value
	1 (reference)	2	3	
Model 1[a]	1.00	0.82 (0.66–1.01)	0.72 (0.59–0.88)	0.002
Model 2[b]	1.00	0.91 (0.74–1.13)	0.78 (0.64–0.95)	0.01
Model 3[c]	1.00	0.91 (0.73–1.12)	0.77 (0.63–0.95)	0.01
Model 4[d]	1.00	0.96 (0.77–1.19)	0.84 (0.68–1.03)	0.08
Model 5[e]	1.00	0.99 (0.80–1.23)	0.87 (0.71–1.07)	0.14
Model 6[f]	1.00	1.01 (0.81–1.26)	0.92 (0.75–1.14)	0.41

Data are presented as hazard ratio (95% confidence interval unless otherwise indicated. *P* values were determined by Cox proportional hazard analysis (linear term)

[a] Unadjusted

[b] Adjusted for sex and age

[c] Adjusted for sex, age, marital status, educational history and social economic status

[d] Adjusted for sex, age, marital status, educational history, social economic status and chronic disease

[e] Adjusted for sex, age, marital status, educational history, social economic status, chronic disease and smoking

[f] Adjusted for sex, age, marital status, educational history, social economic status, chronic disease, smoking and physical activity

variance), followed by age (18%) and total number of chronic disorders and illnesses (14%). As for other covariates, the current analyzes revealed that mediating effects on the association between happiness and mortality were less likely.

Table 3 Relative impact covariates on association happiness and mortality

Covariate	Survival hazard ratio[a]	Relative impact on association (%)[b]
No covariate (unadjusted)	0.72 (0.59–0.88)	–
Sex	0.72 (0.59–0.88)	0
Marital status	0.73 (0.60–0.89)	4
Educational history	0.71 (0.58–0.87)	−4
Socioeconomic status	0.72 (0.59–0.88)	0
Smoking status	0.73 (0.60–0.89)	4
Number of diseases	0.76 (0.62–0.93)	14
Age	0.77 (0.64–0.95)	18
Physical activity	0.83 (0.67–1.01)	40

[a] First response group, i.e., 'unhappy', functioned as reference category, i.e., a HR equal to 1. Survival hazard ratios were presented with 95% CI

[b] Relative impact of each covariate on the association between happiness and mortality was examined by the formula $(HR_{\text{model A}} - HR_{\text{model B}})/(HR_{\text{model A}} - 1)$, where model *A* is the unadjusted model and where model *B* includes the covariate (Lynch et al. 1996)

Since physical activity displayed the strongest impact on the association between happiness and longevity (Table 3) and adjustment for this covariate resulted in loss of statistical significance for the association (Table 2), the nature of this interrelationship between the three variables was examined more thoroughly. Within a multivariate model that adjusted for level of happiness, sex and age, a strong protective relationship with overall mortality for physical activity was found (HR 0.78; 95% CI: 0.69–0.88; $P < 0.001$). Thereby, the level of subjective happiness experience proved to be associated with physical activity as well (F [df] = 24.8 [2], $P < 0.01$).

Similar tendencies were found for the total number of chronic disorders and illnesses. For example, when controlled for level op happiness, sex and age, morbidity was a significant predictor for mortality (HR 1.17; 95% CI: 1.06–1.19; $P < 0.001$). However, subjective happiness experience was associated with the total number of chronic disorders and illnesses (F [df] = 14.0 [2], $P < 0.01$) as well.

4 Discussion

This prospective cohort study investigated the association between subjective happiness experiences and longevity. Increasing levels of happiness were found to predict a lower mortality rate during the follow-up period of up to 15 years in 861 elderly men and women. In other words, elderly subjects reporting increased levels of happiness lived longer than their less happier counterparts. This association remained statistically significant after adjusting for sex, age, marital status, education and socioeconomic status. However, adjustment for total number of chronic disease or illnesses and physical activity weakened the association. Further examination revealed that physical activity had the most substantial impact on the association between happiness and longevity.

However scare, prospective studies that examined the association between happiness and longevity found that happiness was inversely related to mortality (Bowling and Charlton 1987; Palmore 1969). Nevertheless, few of these studies investigated happiness

by directly asking their subjects for their individual experience of happiness (Palmore 1969). Yet, the current prospective study on happiness is rather unique in considering both subjective happiness experience as well as laughter as indicators of subjects' happiness. Aristotle equated happiness with virtue, Friedrich Nietzsche however brought laughter in relation with happiness and Charles Darwin (1872) explained laugher as a social expression of happiness. In an interesting study by Krolak-Salmon et al. (2006) the left presupplementary motor area of a normal psychologically and physically developed patient suffering from drug refractory epilepsy was electrically stimulated by a depth electrode contact. This stimulation elicited both laughter and the subjective experience of happiness for this patient. Another brain stimulation study found laughter and reported feelings of happiness to be interrelated as well (Arroyo et al. 1993). Due to this neurological correlates, the items inquiring subjective happiness experience and happy laughter were investigated for their association, which proved to be significant. Therefore both subjective happiness experience and happy laughter were considered to be valid markers when operationalizing happiness.

The current study is unique as well in the number of covariates that are adjusted for. For example Veenhoven (2006), found happiness to be associated with better objective health as well as longevity for healthy, non-institutionalized populations. However, none of these studies actually adjusted for all covariates that were taken into account in the current analysis.

A more healthy lifestyle might explain part of the relationship. Where clinical depression is a predecessor of health compromising behaviors (Breslau et al. 1998; Milligan et al. 1997), positive psychological characteristics are positively related to health behavior. We recently reported that dispositional optimism was associated with a healthy life style and dietary habits in 773 community-living men during 15 years of follow-up in a different elderly cohort (Giltay et al. 2007). As for the current study a similar mechanism might hold true. A tendency was found for happier subjects to smoke less and to be more physically active, the latter being a strong predictor of morbidity and mortality. For example physical actvity protected against cardiovascular disease and cancer in 10,224 men and 3,120 women, and a protective effect was already found for ordinary everyday activities (Matthwes et al. 2007; Menec 2003; Paffenbarger et al. 1994). In the present study, when adjusted for both physical activity and chronic disease in multivariable models, the strength of the initially significant association between happiness and longevity was significantly attenuated. In addition, subjective happiness experience was associated with physical activity and morbidity. Moreover, when controlled for subjective happiness experience, both physical activity and morbidity affected mortality as well. Together these findings comply with the criteria for a mediation effect as put forward by Baron and Kenny (1986). Therefore, there is some support for the hypothesis that physical activity and morbidity mediate the association between happiness and longevity (Baron and Kenny 1986; Judd and Kenny 1981).

Chronic somatic disorders may result in lower levels of happiness through the mental and physical discomfort and pain that inevitably accompanies morbidity (Anderson 2001; Skevington 1986; Von Roenn et al. 1993; Zeppetella et al. 2000) and are related to a shorter life expectancy, especially when the total number of chronic disorders and illnesses increases. For example, by means of assessing comorbid conditions of an age-stratified random sample of male and female patients aged 55–64 years, 65–74 years, and 75+ years, Yancik et al. (1998) found that morbidity was inversely related to survival. However, the considerably weakened strength of the association between happiness and mortality after adjustment for chronic disease, might suggest that morbidity is a confounder

in the present and previous studies. In several studies (Andersson 1996; Barefoot et al. 2000; Fisher 1995 Giltay et al. 2004, 2006a, b; Kubzansky et al. 2001) however, the association between positive psychological characteristics and health outcomes remained after taking comorbidity into account. Therefore, it seems unlikely that overt somatic illness explains the whole association. Another potential mechanism for the interrelationship between chronic disease, physical activity, happiness and longevity would be that a third factor not only affected mortality but also chronic disease, physical activity and happiness. By identifying possible markers that help to understand the effects of positive psychological characteristics on physical health outcomes, policy makers and authorities might find the present findings useful on both meso- and macro-level (Veenhoven 2006) with regard to further developing effective health care for the elderly population. It is already well-established that elderly health care programs should focus on the promotion of daily activities that may range from simple household activities to sport activities and the individual focus on happiness and the joyful aspects may help to effectively enhance its implementation. Further studies are however needed to establish whether the relationship between happiness and longevity is causal and whether physical activity and morbidity are mediating factors.

Some potential limitations of our study cannot be left unattended. First, external validity is limited as the Arnhem Elderly Study included white Dutch elderly participants. Second, this analysis is not independent of a previous analysis (Giltay et al. 2004) and partly reflects the protective effects of dispositional optimism on longevity. Third, information on cause-specific mortality is lacking. Finally, no unambiguous definition of happiness is currently used in epidemiologic research. Within the current study it can be discussed whether the concept of happy laughter represents a reliable and valid marker of structural happiness experience. Even though this item was accompanied by a satisfactory Cronbach's α and proving to be a valuable asset to the happiness subscale, it is not a direct indication of satisfaction with life which defines the construct of happiness (Veenhoven 1984). Continuous refinement and development of concepts and their measures are needed.

In conclusion, the results of the current study demonstrate that happiness is associated with longevity in community-dwelling elderly men and women, whereby physical activity is likely to fulfill a mediating role. Chronic disease may further explain the association. Future research will have to examine in more detail whether and through what mechanism happiness adds years to life.

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