Does Positive Affect Influence Health?

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This review highlights consistent patterns in the literature associating positive affect (PA) and physical health. However, it also raises serious conceptual and methodological reservations. Evidence suggests an association of trait PA and lower morbidity and of state and trait PA and decreased symptoms and pain. Trait PA is also associated with increased longevity among older community-dwelling individuals. The literature on PA and surviving serious illness is inconsistent. Experimentally inducing intense bouts of activated state PA triggers short-term rises in physiological arousal and associated (potentially harmful) effects on immune, cardiovascular, and pulmonary function. However, arousing effects of state PA are not generally found in naturalistic ambulatory studies in which bouts of PA are typically less intense and often associated with health protective responses. A theoretical framework to guide further study is proposed.

Keywords: positive affect, mortality, morbidity, health, emotions

A cheerful heart is good medicine.—Proverbs 17:22

Self-help books, popular magazines, and Sunday newspaper supplements have suggested for years that positive affect (PA) can improve people's health. However, this hypothesis has been relatively ignored in research on psychological predictors of health. For example, a search of PsycINFO revealed that there are over 20 times more studies on depression and health than there are on happiness and health. Although the recent interest in "positive psychology" has focused attention on the potential benefits of positive feelings (e.g., Seligman & Csikszentmihalyi, 2000), there has been little critical discussion of the evidence linking PA to physical health. In this article, we review the literature examining the association between measures of PA and markers of physical health status, examine the conceptual and methodological weaknesses in the existing literature, and discuss how PA could get "under the skin" to influence health.

PA

We define *PA* as the feelings that reflect a level of pleasurable engagement with the environment (Clark, Watson, & Leeka, 1989)

such as happiness, joy, excitement, enthusiasm, and contentment. These can be brief, longer lasting, or more stable traitlike feelings. Although some use the terms *affect*, *mood*, and *emotion* to distinguish duration, these uses are not applied consistently in the literature, and thus we use these terms interchangeably. We, however, distinguish between studies using measures that assess more stable disposition-like PA, which we refer to as *trait PA*, and those measuring or manipulating relatively short-term bouts of positive emotions, which we refer to as *state PA*.

To date, reviews examining associations between positive psychological constructs and health outcomes have been broad in scope, including traits such as self-esteem, extraversion, purpose, mastery, and optimism along with PA (Lyubomirsky, King, & Diener, 2005; Ryff, 2003; Salovey, Rothman, Detweiler, & Steward, 2000; Zautra, 2003). Hence, it has been difficult to separate the social and cognitive content of these measures from the unique effect of positive emotions on health. In the current review, we include only studies using measures that contain items that assess PA. Within these studies, we distinguish between those using more or less "pure" measures of affect and those using measures containing other components that might influence health in an attempt to separate potential effects of affect from related constructs.

An issue of contention in the emotion literature is whether PA and negative affect (NA) are bipolar extremes of the same scale or orthogonal factors. Evidence exists for both camps of thought (e.g., Bradburn, 1969; Diener & Emmons, 1984; Watson, Clark, & Tellegen, 1988). Variables thought to influence whether NA and PA are independent include whether frequency or intensity is assessed, the types of items included in the scales, and the length of time covered by the measure (e.g., Diener & Emmons, 1984; Diener, Larsen, Levine, & Emmons, 1985; Watson, 1988b). This issue is relevant here because there is a vast literature showing associations between NA and disease (see, e.g., reviews by Booth-Kewley & Friedman, 1987; Herbert & Cohen, 1993a; Krantz & McCeney, 2002). If PA and NA are bipolar ends of the same construct, benefits of PA may merely reflect the absence of NA rather than the presence of positive feelings. Alternatively, should

the two be mutually independent, PA could provide benefits independent of NA levels. As we examine each study, we consider whether there is evidence supporting an independent contribution of PA to health. However, it is worth noting that studies of NA and health typically do not control for PA, leaving the interpretation of that literature in regard to valence ambiguous.

Although there is much debate regarding the structure of affect (Ekman, 1992; Izard, 1977; Larsen & Diener, 1992; Russell, 1980; Tomkins, 1963; Watson & Tellegen, 1985), when not conceptualized as basic, separate emotions, it has frequently been conceptualized according to a circumplex structure. In this model, affect exists on two dimensions: one describing positive versus negative valence (e.g., happy vs. sad), and one delineating activation levels (e.g., aroused vs. unaroused) (Russell, 1980). Affect can be described by where it falls on this two-dimensional plane (e.g., excitement is high activation–positive valence; contentment is low activation–positive valence). Many emotion theorists have argued that these two dimensions are not sufficient to properly distinguish between emotions (e.g., Larsen & Diener, 1992); however, this approach is attractive to health researchers who equate affective activation with physiological arousal, which is thought to be a primary pathway through which emotions may influence health (Cohen, Kessler, & Underwood Gordon, 1997; Krantz, Glass, Contrada, & Miller, 1981). In this context, the circumplex allows the prediction of differential effects of activated (e.g., joy) and unactivated (e.g., contentment) positive emotions. Although there may be other constructs that could exist on the circumplex such as locus of control, depth of feeling, and approach–avoidance (see discussion in Russell, 1978), these approaches are not easily applied to the existing literature. Consequently, we focus only on the dimensions of valence and activation–arousal as the nature of the research warrants.

Measures of PA

The majority of the studies we review use self-reported ratings of different mood items to assess PA. A commonly used measure is the positive mood scale from the Positive and Negative Affect Schedule (PANAS; Watson et al., 1988). The PANAS was developed so that positive and negative factors would emerge as orthogonal dimensions (separate 10-item scales) rather than bipolar ends of the same scale. In this model, high PA is a state of high energy and concentration (e.g., attentive, interested, alert, enthusiastic), whereas NA is a state of general distress (e.g., guilty, hostile, irritable). The authors suggested that because of the independence of their scales, these items are pure markers of NA and PA. However, the PANAS PA scale includes adjectives that are not typical mood items, such as *strong*, *determined*, and *active* (Larsen & Diener, 1992), and excludes low-activated moods such as calm, content, and relaxed as well as many common PA adjectives such as *happy*, *cheerful*, and *joyful*. The PANAS allows an investigator to indicate the time frame when considering the experience of the affect items (i.e., ranging from "current states" to "general feelings"). In most cases, the time frame assessed by the authors of the reviewed studies examined general (trait) feelings rather than current state.

In its original form, the Profile of Mood States scale (POMS; McNair, Lorr, & Droppleman, 1971) included only a single subscale assessing PA—vigor (items include *cheerful*, *active*, *lively*,

alert, and *energetic*), whereas there are four subscales assessing NA—*depression*, *anger*, *fatigue*, *tension–confusion*. Each item is rated on a 0–5 scale (0 = *not at all accurate*, 5 = *extremely accurate*) according to how much the adjective reflects how a respondent generally feels. Again, there is a strong component of activation in the PA (vigor) measure as in the PANAS PA subscale.

Another measure of PA has used four positively worded items from the Center for Epidemiological Studies Depression Scale (CES-D; Radloff, 1977). These four items load on a single PA factor (Sheehan, Fifield, Reisine, & Tennen, 1995). They include ratings of how much the participants enjoy life, the extent to which they feel hopeful about the future, their happiness, and how good they are as compared with other individuals. Although this scale includes a component of PA (happiness, enjoyment), it also taps optimism and self-esteem. When considering studies using this measure, we mention their limitations in regard to representing pure PA.

Additional measures used in the literature include other multiple-item affect adjective scales, single-item scales, observer-rated PA, participant-rated happiness on a visual analog scale (a bipolar line from *very unhappy* to *very happy*), and counts of emotional words in written material. Because the majority of these are used in only one reviewed study, these techniques are described within the reviews of studies in which they were used.

For the purposes of this review, we classify self-report PA instruments that ask about "current mood" or mood in "the last day" as measures of state PA. Studies that asked about one's "general mood" or mood over the "last few weeks" or longer we classify as having measured trait PA. We consider the few cases in which measures assessed affect over the "last week" more ambiguous in this regard. Because trait affect is a relatively stable characteristic of a person, we assume that whatever effects it might have on behavior or physiology may be sustained over a long period of time. Consequently, trait PA is more likely to influence disease outcomes where underlying processes often take a long time to develop, like risk for the onset of chronic diseases or mortality. In contrast, we expect that state PA is more likely to influence the progression of ongoing disease processes or the occurrence of disease "events" (attacks) in persons with chronic underlying diseases such as asthma or coronary heart disease.

Finally, most of the studies reviewed in this article used self-report questionnaires to assess PA. Do these measures provide valid and reliable assessments of affect? Acceptable psychometrics for the most commonly used PA self-report scales in the review have been established—for example, for the PANAS (Crawford & Henry, 2004; Watson et al., 1988), for the POMS (McNair et al., 1971; Norcross, Guadagnoli, & Prochaska, 1984), and for the CES-D (Sheehan et al., 1995). There is more general evidence about the validity of self-reported adjectives as a measure of affect as well. For example, one study (Sandvik, Diener, & Seidlitz, 1993) found convergence between a self-report questionnaire, interview ratings, peer reports, average daily ratings of pleasant to unpleasant moods, and memory for pleasant minus unpleasant events. Another (Cohen, Doyle, Turner, Alper, & Skoner, 2003) found that self-reports of trait PA were highly correlated with the average of daily interviews collected over a 3-week period. Furthermore, other studies have provided evidence for discriminative validity, finding that self-reported PA was not contaminated by

social desirability (Diener, Sandvik, Pavot, & Gallagher, 1991) or more global evaluations of life satisfaction (Lucas, Diener, & Suh, 1996).

There are a number of positive psychological concepts that are viewed by many as synonymous with PA. These include life satisfaction, quality of life (QOL), and subjective well-being (SWB). However, most scales measuring these constructs are complex and multifaceted with PA either not directly assessed or representing a very small percentage of the total items (e.g., Diener, 1984; McDowell & Newell, 1996; Weisman, 1979). For this reason, we included only those studies in which the measures include PA items and caution the reader that these scales are rarely measures of pure PA and are typically confounded with NA measures. Moreover, we limited inclusion of prospective studies to those in which the predictor scales did not include self-reported health or functional status measures as part of the aggregate because this confounds the outcome and the predictor. This resulted in the exclusion of most of the prospective studies of QOL on health (primarily on survival). We also excluded studies in which the authors reported assessing PA but did not provide enough information for us to determine the nature of the specific PA items.

Inducing PA

A number of methods were used to induce positive moods in the experimental studies of mood and health. A widely used method, the Velten mood induction (Velten, 1968), involved reading silently then aloud a list of statements (e.g., "I am elated about things") and trying to feel the suggested mood. Other mood inductions in the lab included imagining previous positive events; listening to positive music; making facial expressions; and watching films or reading stories, sometimes being asked to get involved in the story and the feelings expressed. A meta-analysis of the association between these methods and self-reported moods suggested that the film–story methods (with or without being asked to get involved with the feelings) produced the strongest effect (.53 to .73) whereas facial expression was the weakest manipulation with an effect size of approximately .19 (Westermann, Spies, Sthul, & Hesse, 1996). These procedures are effective in inducing changes in mood that typically last for 10 to 15 min (e.g., Frost & Green, 1982).

In order to ensure that manipulations differ as intended and that the emotion of interest is induced, manipulation checks in which participants report their mood after the induction are standard. Studies lacking such checks can be difficult to interpret, especially when results differ from study hypotheses. Studies should also include an emotionally neutral but interesting condition to control for diurnal variations, passage of time, and factors associated with the manipulation itself (e.g., distraction). Furthermore, conditions examining the induction of other types of emotion (e.g., NA or differing types of PA) are beneficial to determine whether influences are due to valence, arousal, or specific emotions. Some studies also use too few participants to provide sufficient power. Although we include all studies in the tables, we limit discussion to studies with sample sizes greater than 10.

Scope and Organization of the Review

Medline and PsycINFO were surveyed using keywords drawn from commonly used instruments with PA subscales (see earlier discussion of scales) as well as from an exhaustive list of physical health outcomes generated by the authors (e.g., *mortality, morbidity, cancer, illness, infection, upper respiratory infection, cardiovascular disease*, and so on) as well as physiological markers (e.g., *heart rate* [HR], *blood pressure* [BP], *immunity, cortisol, epinephrine* [epi]). Searches were conducted by crossing terms between each PA adjective and the varying physiological outcomes. Reference sections of the reviewed publications were also combed for additional related articles.

PA terms included *happy, cheerful, joy, vigor, excited, elated, enthusiastic, interest, content, amused, humor, calm, relaxed, satisfied, positive affect*, and *positive emotions*. Because there is some debate as to whether calm and relaxed are PA or low NA (e.g., Watson et al., 1988), we have limited inclusion of studies using these affects to those that also included other, less controversial PA components, and those purposefully manipulating PA, but not, for example, relaxation interventions designed to reduce stress. Studies examining affect "about something" (e.g., "How happy are you about being pregnant?") or that assessed life quality without any items tapping affective response were not included. Experimental studies using comedic stimuli (e.g., funny movies) were included in the review, despite the fact that some of these studies were designed to evaluate the effects of humor and did not specifically measure affect. Studies looking at sense of humor or the occurrence of laughter were not included (for a comprehensive review of humor and health, see R. A. Martin, 2001).

As our dependent measures of physical health status, we focused on studies of morbidity, mortality, and survival as well as indicators of disease progression and severity. We also reviewed studies of changes in the functioning of the cardiovascular, endocrine, and immune systems because influences on these systems are proposed as potential mediators of the effects of PA on health. On the other hand, we did not review physiological changes with less clear etiological relevance to objective health outcomes, such as changes in respiration, skin conductance, or brain activity in healthy populations.

Finally, we consider the association of PA and self-reported health outcomes but place less emphasis on this literature. This is because the thresholds for labeling physiological states as symptoms, for reporting symptoms to others, and for seeking medical care all vary with affect (Cohen & Williamson, 1991; Mechanic, 1972; Pennebaker, 1982; Watson & Pennebaker, 1989). Most relevant here is that individuals high in trait PA respond to illness by reporting fewer and less severe symptoms when objective markers of disease are held constant (Cohen et al., 2003). Hence, associations of PA and these self-report measures often reflect cognitive biases in perceiving, reporting, and acting on physical sensations rather than underlying pathology.

We also chose to place greater emphasis on studies meeting minimal design criteria. Cross-sectional correlations between PA and health may be attributed to PA's influencing health, but they may also reflect health status causing changes in affect (reverse causation) or third (spurious) variables causing changes in both affect and health. Due to these interpretational problems, we only briefly consider cross-sectional studies of PA and health. For this

reason, this review focuses on prospective and experimental studies of health. Prospective designs allow us to eliminate the interpretation that health influences PA because they examine changes in health as a function of positive feelings measured prior to the changes. Well-conducted experiments allow elimination of both reverse causation and spurious relations, resulting in the unambiguous inference that PA influences health.

Studies are organized based on the primary outcome type: mortality, morbidity, survival, disease severity and physical functioning, self-reported health outcomes, and physiological systems. To provide greater detail than presented in the text, the review includes corresponding tables with lists of all studies that were located in the literature review. The exceptions are cross-sectional studies that are summarized in the text but not included in tables. Next, conceptual models of how PA influences health are presented along with evidence of associations between PA and theorized pathways. We end with a summary of the evidence and recommendations for future research on PA and health.

Review

Mortality

Mortality studies are prospective studies of defined populations (e.g., communities or countries) where PA is assessed at the onset of the study and participants are followed for a specified number of years. At the end of the study, the investigators identify who is still living. (Two of the reported studies focused on the number of years survived during the follow-up period [longevity] instead of mortality rate at the end of follow-up). Either the populations are chosen because they are healthy at the onset of the study, or health is assessed at baseline and statistically controlled when predicting mortality. These studies often focus on older populations (at baseline) because shorter follow-ups are associated with greater mortality rates. Table 1 summarizes the PA and mortality studies.

Most of the studies of PA and mortality have been done in older (average age over 60) community-residing samples. Although unanimously supportive of an association between PA and lower mortality rates, each of these studies has its own limitation in either conceptualization or methodology.

A 2-year prospective study of 65- to 99-year-old Mexican Americans (Ostir, Markides, Black, & Goodwin, 2000) used the PA items from the CES-D. Those with higher PA at baseline were half as likely (odds ratio [OR] = 0.53) to die during the 2-year follow-up as compared with those with low levels of PA. This finding remained after controlling for baseline medical conditions (heart problems, stroke, cancer, diabetes, and arthritis); body mass index (BMI); smoking and drinking status; sociodemographic characteristics (including age); and importantly, levels of NA. Recall that the CES-D PA scale includes items reflecting self-esteem and optimism as well as two PA questions.

B. R. Levy, Slade, Kunkel, and Kasl (2002) studied 660 participants (mean age = 63) who completed the Attitudes Toward Aging subscale (Liang & Bollen, 1983; based on Lawton, 1975) and were followed for 23 years to assess longevity. PA items in the scale included "I am as happy now as I was when I was younger" and "I have as much pep as I did last year," but there were also three questions tapping whether their lives in general (not specifically affect related) were getting worse or better. Those with more

positive self-perceptions of aging at baseline lived 7½ years longer than those with less positive perceptions (those above vs. below the mean). This advantage remained after age, sex, socioeconomic status, and baseline functional health status (e.g., walk a half mile, walk up stairs) were included as covariates (risk ratio [RR] = 0.90). Self-rated health was also assessed as a control but was not associated with mortality.

Maier and Smith (1999) examined how SWB influenced mortality in a sample of older individuals (70–103 years old). SWB was a composite of the PANAS PA and NA scales (trait) and scales assessing agitation, life satisfaction, and satisfaction with aging (Lawton, 1975). Lower levels of well-being (i.e., lower satisfaction, lower PA, higher NA) were associated with increased mortality risk, even after controlling for age, sociodemographic characteristics, baseline health assessed by clinical exam, and self-rated health ($\chi^2 = 11.2$, $p < .05$). Of the SWB subscales, lower PA, dissatisfaction with aging, and dissatisfaction with life were each associated with increased hazard of dying; however, when control factors were entered, only dissatisfaction with aging predicted mortality outcomes (RR = 1.16).

A study of community-dwelling older individuals ages 65 to 98 examined whether self-rated happiness (*quite unhappy* to *very happy*) or self-rated emotional status (*feel quite gloomy* to *feel quite cheerful*) were associated with mortality at a 3-year follow-up (Kawamoto & Doi, 2002). Greater PA as assessed by both factors was associated with decreased mortality when each was examined separately. When the two were entered into a logistic regression with demographics, history of fall, self-rated health, activity in community, and habit of exercise, only the self-rated emotional status was retained (OR = 1.01, $p = .055$) along with age, gender, and physical function (activities of daily living; ADL). Although other assessments of health at baseline were associated with mortality (e.g., self-rated health, medical history, medication use), these did not enter the final model nor were they statistically controlled.

Parker, Thorslund, and Nordstrom (1992) studied a Swedish community-based sample ages 75 to 84 and a mixed community and institution sample ages 85 and over. They addressed whether life satisfaction ("How happy are you with life in general?" rated from *very happy* to *unhappy*) prospectively predicted mortality. Measures of baseline health including self-reported health and symptoms and nurse evaluations of somatic and mental status were not predictive of mortality for either sample. For the community-based sample, happiness with life emerged as a predictor of longer life even after controlling for nurse's baseline evaluation of participant's abilities to perform daily tasks (ADL) and self-rated mobility (OR = 4.5 for those less than very happy with their lives). Life satisfaction was not associated with mortality in the community–institutionalized sample that was 85 and older.

Longevity was assessed in a 15-year follow-up of a sample of older adults using an interview measure of PA (Palmore, 1969). Variables assessed at baseline that were strongly associated with longevity included health status based on a physical exam, activities, attitudes, and socioeconomic status. However, interviewer-assessed happiness had the highest correlation with longevity, with happier people living longer. Unfortunately, baseline physical functioning was only covaried out of happiness in a subanalysis of men 70 and over, so only this analysis was truly prospective.

Table 1
Summary of Positive Affect (PA) and Mortality Findings

Study	Participants	Follow-up	PA measure (state–trait)	Was PA associated with longevity?	Could NA play a role in this association?
Danner et al. (2001)	180 nuns entering convent (mean age = 22)	~60 years	Emotion words in autobiography (suggestive of trait)	Increased longevity	No
Friedman et al. (1993)	1,178 children (~11 years)	65 years	Parent and teacher assessed cheerfulness–optimism (trait)	Decreased longevity	No
Janoff-Bulman and Marshall, (1982)	30 nursing home residents (mean age = 75.4)	2.5 years	Well-being (happiness, satisfaction, interest, disappointment; trait)	Decreased longevity	Yes (both PA and NA in scale)
Kaplan and Camacho (1983)	6,928 members of the general population (ages 16–94)	9 years	Two questions: general positive morale–feelings and happiness (trait)	No effect	No effect
Kawamoto and Doi (2002)	2,274 noninstitutionalized older individuals (ages 65–78, mean age = 73)	3 years	Happiness and emotional status (gloomy to cheerful; trait)	Increased longevity	Yes (bimodal PA–NA scale)
Koivumaa-Honkanen et al. (2000)	22,461 Finnish twins (ages 18–64)	20 years	Life satisfaction (trait)	Increased longevity (driven by influence on men)	Yes (bimodal PA–NA scale)
Koivumaa-Honkanen et al. (2001)	29,173 Finnish twins (ages 18–64)	20 years	Life satisfaction (trait)	Increased longevity (outcome was death by suicide)	Yes (bimodal PA–NA scale)
B. R. Levy et al. (2002)	660 noninstitutionalized older individuals (ages 50 and older, mean age = 63)	23 years	Positive self-perceptions relating to aging (trait)	Increased longevity	No, items are not bimodal
Maier and Smith (1999)	516 noninstitutionalized older individuals (ages 70–103, mean age = 85)	3–6 years	Subjective well-being (PANAS, PGCMS; trait)	Increased longevity	No, items are not bimodal
O'Connor and Vallerand (1998)	129 institutionalized older individuals (mean age = 80.5)	4 years	Life satisfaction (trait)	No effect	No effect
Ostir et al. (2000)	2,282 noninstitutionalized older individuals (ages 65–99)	2 years	PA items from CES-D (1 week; trait)	Increased longevity	Not reported
Palmore (1969)	268 older individuals (institutionalized and not; ages 60–94)	15 years	Interviewer-assessed happiness (Is person satisfied with life situation?; trait)	Increased longevity	Not assessed
Parker et al. (1992)	421 noninstitutionalized older individuals (161 were ages 75–84 and 260 were 85 and older)	4 years	Life satisfaction (trait)	Increased longevity (for the younger group)	Yes (bimodal from happy to unhappy with life)
Stones et al. (1989)	156 institutionalized older individuals (mean age = 79.6)	5 years	Two questions: average happiness now and over past month (state and trait)	Decreased longevity	No
Zuckerman et al. (1984)	400 older individuals (ages 62 and older)	2 years	Interviewer-assessed happiness (state)	Increased longevity	Yes (bimodal PA–NA scale)

Note. NA = negative affect; PANAS = Positive and Negative Affect Schedule; PGCMS = Philadelphia Geriatric Center Morale Scale; CES-D = Center for Epidemiological Studies Depression Scale.

Another study that assessed happiness by interview involved a sample of poor older Americans. Baseline happiness–sadness was rated on a 5-point scale (Zuckerman, Kasl, & Ostfeld, 1984). Lower levels of happiness (and therefore higher levels of sadness due to the bipolar measure) were associated with an increased risk of mortality 2 years later (RR = 1.92), even after controlling for sociodemographic variables (sex, race, age, education, income, marital status) and baseline physical health status as assessed by history of chronic illness. However, additional analyses indicated that lower levels of happiness increased risk of mortality only for those in poor health at baseline.

The evidence from the two studies of seniors institutionalized in nursing homes looks quite different from that found for those residing in the community. In the first study, a multifaceted well-being scale was administered at baseline to a group of 30 nursing home residents with a mean age of 75.4 (Janoff-Bulman & Marshall, 1982). The association between well-being and longevity was examined over a 2½-year follow-up controlling for a social worker's rating of their health at baseline. Perceived well-being, assessed with five items measuring happiness, life and daily satisfaction, loss of interest in people, and disappointment, predicted mortality but was associated with increased likelihood of death. Another study similarly examined whether ratings of happiness were associated with longevity in older nursing home residents with a mean age of 79.6 (Stones, Dornan, & Kozma, 1989). A happiness score was formed by aggregating how happy participants reported they were "now" and "over the last month" on a 1–7 scale. Again, higher levels of happiness were associated with increased likelihood of mortality over the 5-year follow-up (explained 1.2%–2%).

Two studies have examined the influence of PA on mortality in community samples with a broad age range at baseline. The association of life satisfaction on mortality over 20 years was examined in an initially healthy sample (excluded if they had chronic illness at baseline) of 18- to 64-year-old Finnish adults (Koivumaa-Honkanen et al., 2000). This study used a life satisfaction index that included measures of interest in life (1 = *very interesting*, 5 = *very boring*), happiness (1 = *very happy*, 5 = *very sad*), ease of living, and degree of loneliness (interest and happiness are considered components of PA). Lower levels of life satisfaction were associated with greater all-cause mortality even after adjusting for age, marital status, social class, smoking, and alcohol status (RR = 1.27). When causes of mortality were broken down, the association between life satisfaction and mortality was found for deaths attributable to disease, injury, and suicides (Koivumaa-Honkanen et al., 2001).

In contrast, another community study with a broad age range at baseline found no association between PA and mortality. Kaplan and Camacho (1983) examined the influence of psychological functioning on mortality over 9 years in a sample of 16- to 94-year-olds in Alameda County, California. Included in psychological functioning were single-item measures of happiness (how happy the individual is: *very or pretty* or *not too*) and morale (positive and negative feelings; high morale was a score of 4–9 on a 9-point scale), as well as measures of depression and anomie. None of these variables were associated with mortality.

The remaining two studies used rather unique samples. In the first, autobiographies written by nuns in their early 20s were coded for emotion words (Danner, Snowdon, & Friesen, 2001). The greater the number of positive emotion words and sentences containing positive emotion words, the lower was the age- and education-adjusted mortality assessed approximately 60 years later. In contrast, the number of negative emotions reported was not associated with mortality. In the second, H. S. Friedman et al. (1993) predicted longevity in the Terman sample of gifted children whose mean age was 11 at baseline. PA in this study was reported not by the children themselves but by a parent and a teacher who rated the perceived sense of humor as well as the cheerfulness and optimism of the child. Greater childhood cheerfulness predicted greater mortality over a 65-year follow-up (RR = 1.3) net of sex, year of birth, and intelligence.

Discussion of Mortality Findings

Overall, the evidence for the association between PA and mortality is most consistent in studies of community-residing older individuals. Seven studies have found that greater PA was associated with lower mortality rates (Kawamoto & Doi, 2002; Lawton, 1975; B. R. Levy et al., 2002; Palmore, 1969; Parker et al., 1992; Ostir et al., 2000; Zuckerman et al., 1984). Although an eighth study (Maier & Smith, 1999) also found an association, it did not hold up when demographic and baseline health controls were added to the equation. These results suggest the possibility that PA is of special importance to the well-being of healthy persons over 55. Although impressive in aggregate, there are limitations to this work. Many of the scales used in these studies included items other than those assessing pure affect, and only one of the seven excluded NA as an alternative explanation (Ostir et al., 2000). Two others used bipolar scales with an NA adjective on one end and a PA adjective on the other (e.g., sadness–happiness) (Kawamoto & Doi, 2002; Zuckerman et al., 1984), and the remaining four studies did not include NA measures.

The validity of a mortality study is dependent on the adequacy of the baseline measure of health. Inadequate measurement (and hence inadequate control) would allow the possibility that being healthier at baseline contributed both to greater PA at baseline and to subsequent longevity. It is difficult to judge adequacy of baseline health measures, but one could argue that accurate assessment is particularly difficult in samples of older individuals. Moreover, some PA adjectives such as *active*, *alert*, *energetic*, and *full of pep* (e.g., see measures in B. R. Levy et al., 2002; Maier & Smith, 1999) might directly tap perceived health, a predictor of mortality above and beyond objective health assessments (Idler & Benyamini, 1997). To the extent that PA measures are actually markers of perceived health, it is possible that the association between PA and mortality may be attributable to existing medical conditions at baseline, or even emerging subclinical illness. It is noteworthy that perceived health was controlled for (or not associated with mortality) in three of these studies (B. R. Levy et al., 2002; Maier & Smith, 1999; Parker et al., 1992) with the PA association reduced below significance in only one (Maier & Smith, 1999).

In contrast to studies on community-residing older individuals, the two studies of institutionalized older individuals (Janoff-Bulman & Marshall, 1982; Stones et al., 1989) both found greater PA to be associated with higher rates of mortality. This association may occur because "healthy" institutionalized older individuals (there was no exclusion for those with chronic illnesses) are not healthy in the same sense as healthy community residents, and

hence these studies might better be categorized as survival studies (see the *Survival* section) than mortality studies. As noted later, there is some reason to think that excessive happiness may constitute a risk for ill persons. Alternatively, there is evidence that older individuals who are demanding, aggressive, and narcissistic are most likely to survive relocation to nursing homes (B. F. Turner, Tobin, & Lieberman, 1972). Low PA may reflect reactance and a fighting spirit (rather than happiness and satisfaction) in a situation of lost control.

The remaining three studies examined populations other than older individuals. Danner et al.'s (2001) study of mortality in nuns was based on ratings of their happiness when they were in their early 20s. Like the community-residing older individuals, there was an association of PA and lower rates of subsequent mortality in this group. Koivumaa-Honkanen et al. (2000, 2001) similarly found greater PA associated with lower mortality in a Swedish community sample with a broad age range. In contrast, Kaplan and Camacho's (1983) analysis of a United States community sample with a broad range of ages found no association. It would be interesting to stratify the results by age in the community studies including broad age ranges. It is, of course, possible that the PA–mortality association is stronger or occurs only in older participants.

Finally, H. S. Friedman et al. (1993) found that PA as assessed in gifted children was associated with higher rates of adult mortality. The authors suggested that this may occur because these extremely optimistic and cheerful individuals may underestimate dangers, take few precautions in risky situations, or fail to follow medical advice, resulting in poorer health outcomes (Martin et al., 2002). Previous research has indeed shown that happy, healthy individuals perceive themselves as less vulnerable to future negative health outcomes (Salovey & Birnbaum, 1989). Of interest, those at risk in the H. S. Friedman et al. (1993) study scored at the highest (*extremely happy*) range of the scale in contrast to those with lower scores which averaged in the *very happy* range. It is possible that it is the extremity of this response that put them at risk. It is also possible that the influence of PA is dependent on age, setting negative health trajectories in early life but positive ones in later life. This is consistent with the evidence for the positive associations of PA and mortality in community samples of older individuals. It may be that benefits of PA are primarily associated with the traditional causes of mortality in older individuals (e.g., heart disease, cancer) and less so with accidents, violence, and other significant causes of death in early life.

Morbidity

Not surprisingly, people who have serious diseases often report lower levels of PA than do healthy controls, and PA declines when disease severity increases. For example, patients with Lyme disease (Elkins, Pollina, Scheffer, & Krupp, 1999), lupus (Pfeiffer & Wetstone, 1988), polio, spinal cord injury (Kemp & Krause, 1999), gastrointestinal cancer (Hornquist, Hansson, Akerlind, & Larsson, 1992), hypertension (Knox, Svensson, Waller, & Theorell, 1988), hypotension (Jorm, 2001), fibromyalgia (Celiker & Borman, 2001), arthritis (Celiker & Borman, 2001; Germano & Cummins, 2001), and cold sores (Logan, Lutgendorf, Hartwig, Lilly, & Berberich, 1998) reported lower PA than healthy control samples. Increased Alzheimer's severity is similarly correlated with de-

creased expression of interest and pleasure (Albert et al., 1996), and those with disease associated with disability or pain report lower PA than those without pain or disability (S. Evans et al., 1998; Jang, Mortimer, Haley, & Graves, 2004). Finally, increasing numbers of chronic medical conditions are also correlated with lower PA in a sample of older individuals (Jelicic & Kempen, 1999). Likewise, there is a large literature looking at the levels of QOL in those with varying disease such as HIV/AIDS, cancer, arthritis, and heart disease (see reviews by Benito-León, Manuel Morales, Rivera-Navarro, & Mitchell, 2003; Botteman, Pashos, Hauser, Laskin, & Redaelli, 2003; Eton & Lepore, 2002; Huang, Wartella, Kreutzer, Broaddus, & Lyckholm, 2001; Luscombe, 2000; Shumaker & Czajkowski, 1993). As with the more pure PA scales, those with serious diseases typically have lower QOL than normative samples (e.g., Burgoyne & Saunders, 2001; Germano & Cummins, 2001; Hays et al., 2000; Nair, 2000). It is, however, likely that reports of lower PA and QOL in those suffering from disease, pain, and disability are primarily attributable to the influence of the disease on PA rather than the influence of PA on disease. Interestingly, although PA may decrease in response to the onset of serious physical illness, there is some evidence of adaptation, wherein PA returns to levels equivalent to those reported by healthy persons in those who have been ill for some time (e.g., Riis et al., 2005).

Studies of the relations between PA and the subsequent onset of disease require the selection of a healthy population or statistical control for individual health status at baseline. Participants are followed for a specific time period during which they are monitored for the onset of the disease under consideration. Although the health outcomes and PA measures in this literature are diverse, these studies have virtually unanimously found that PA was associated with less risk of illness and injury and generally better health. Table 2 summarizes the prospective morbidity studies.

Ostir, Markides, Peek, and Goodwin (2001) were interested in whether the absence of PA was associated with future occurrence of stroke in a population of healthy seniors (65 years old and older). Using the PA subscale of the CES-D, they found that lower PA at baseline was associated with a greater risk of stroke incidence over a 6-year follow-up (RR = 0.74) and that the relation was strongest in men. This association held after adjusting for age, income, education, marital status, BMI, systolic BP, smoking status, and history of heart attack or diabetes. The NA subscale was not associated with stroke occurrence, nor did controlling for NA reduce the association of PA with stroke.

Middleton and Byrd (1996) were interested in what factors predicted relapse and hospital readmission in a group of 121 patients with cardiovascular disease, ages 55 and older, who had previously been hospitalized for a heart problem. At baseline, happiness was measured by the combined score (PA minus NA) on an Affect Balance Scale (Bradburn, 1969). This 10-item scale depicts PA (5 items) and NA (5 items) as independent components, in this case with a time frame covering the last few weeks. Questions were answered with true or false, for example, "During the past few weeks did you feel particularly excited or interested in something?" After 90 days, 71 participants had experienced at least one unplanned readmission to the hospital. Happiness predicted rehospitalization after controlling for chronic illnesses other than heart disease, length of initial stay, perceived health, hope for

Table 2
Summary of Positive Affect (PA) and Prospective Morbidity Findings

Study	Participants	Follow-up	PA measure (state–trait)	Outcome	Was PA associated with health?	Could NA play a role in this association?
Cohen et al. (2003)	334 members of general population (ages 18–54)	~1 month	Positive emotional style: average six interviews (vigor/well-being/calm; trait)	Colds and symptoms	Yes (fewer colds)	No
Klonoff-Cohen et al. (2001)	151 women at a fertility clinic (mean age = 36.8)	In vitro fertilization success–birth	PANAS (acute and general; state and trait)	Pregnancy outcomes	Yes (some improved pregnancy outcomes)	Yes
Koivumaa-Honkanen et al. (2000)	22,461 Finnish twins (ages 18–64)	20 years	Life satisfaction (trait)	Injury	Yes (fewer injuries)	Yes (bimodal PA–NA scale)
Middleton and Byrd (1996)	121 individuals with cardiovascular disease (ages 55+)	90 days	Happiness (trait)	Hospital readmission	Yes (decreased readmission)	Yes (happiness is PA minus NA)
Ostir et al. (2001)	4,162 noninstitutionalized older individuals (ages 65 and up)	6 years	PA items from CES-D (1 week; trait)	Stroke	Yes (fewer strokes)	No
A. M. Smith et al. (1997)	86 male high school hockey players (ages 15–18)	1 season	Vigor from "Incredibly Short POMS" (trait)	Injury	Yes (fewer injuries)	No

Note. PANAS = Positive and Negative Affect Schedule; NA = negative affect; CES-D = Center for Epidemiological Studies Depression Scale; POMS = Profile of Mood States.

the future, and ADLs. There were no analyses separating PA and NA.

PA has also been shown to be protective against the occurrence of infectious illness in healthy (passed thorough physical exam) adults. Cohen et al. (2003) phone interviewed 334 volunteers, ages 18 to 55, seven times over a 3-week period. For each interview, participants rated how accurately each of nine positive and nine negative adjectives described how they felt over the last day. Examples of PA items include *lively*, *energetic*, *happy*, *cheerful*, *at ease*, and *calm*. Examples of NA items include *sad*, *depressed*, *nervous*, and *hostile*. Daily mood scores (sum of 9 respective adjectives) were calculated and averaged across the 7 days to create summary measures of trait PA (termed *positive emotional style* by the authors) and NA (termed *negative emotional style*). Subsequently, participants were exposed to one of two viruses that cause a common cold. Those with high levels of PA were less likely to develop a cold when exposed to the virus (OR = 2.9, comparing bottom to top tertile). This relationship remained after controlling for age, sex, immunity (baseline antibody to the experimental virus), education, and NA.

A. M. Smith, Stuart, Wiese-Bjornstal, and Gunnon (1997) were interested in how psychosocial factors, including general mood, might influence injury occurrence in a sample of high school hockey players. Using a shortened version of the POMS, they found that individuals reporting high levels of vigor prior to hockey season had a lowered risk of injury. Having high levels of fatigue was correlated with higher risk of injury, but depression, anger, and confusion were not. Unfortunately, the authors did not control for NA when examining the association between vigor and injury. Injury was also an outcome in the previously discussed 20-year prospective study of healthy (without chronic illness) Finnish adults ages 18 to 64 (Koivumaa-Honkanen et al., 2000). They found that lower levels of life satisfaction (with one half of the scale assessing happiness and interest) were associated with an increased probability of general injuries (age-adjusted OR = 3.01). As discussed in the mortality section, they were also associated with the number of injuries resulting in death (age-adjusted OR = 2.97). As noted earlier, limitations of the PA measure make it difficult to determine whether the association is attributable to NA, PA, or some other component of the scale (i.e., loneliness, satisfaction).

Klonoff-Cohen, Chu, Natarajan, and Sieber (2001) studied whether affect (assessed by PANAS) was associated with pregnancy or live birth delivery rate in healthy women (mean age = 36.8) undergoing in vitro fertilization or gamete intrafallopian transfer. Higher levels of state PA assessed just prior to that pregnancy-induction procedure were associated with a lower risk of an unsuccessful ("no live birth") delivery (RR = 0.093). However, trait PA assessed prior to the procedure was not associated with this outcome. This study did not test for independent effects of PA and NA. Because NA was associated with a higher risk of live birth failure as well as several of the other birth outcomes, it is again unclear whether PA was the working ingredient in this correlation.

Finally, Valkamo and colleagues, in two separate studies, examined whether life satisfaction (as described earlier in Koivumaa-Honkanen et al., 2000) assessed when individuals with chest pain entered the hospital was associated with their coronary artery disease diagnosis (Valkamo, Hintikka, Niskanen, & Viinamaki,

2001; Valkamo et al., 2003). They found no association between life satisfaction and the existence of a serious blockage or the treatment method that was chosen in either study. However, assessing life satisfaction during a time of extreme threat (i.e., checking into the hospital for a surgical–diagnostic procedure) may not provide an accurate assessment of satisfaction leading up to the potential pathology and hence makes these results difficult to interpret.

Discussion of Morbidity Findings

Both cross-sectional and prospective studies of PA and illness virtually unanimously support an association between higher PA and health. The more critical (in regard to the hypothesis that PA is the causal factor) prospective morbidity studies found benefits of trait PA in conditions as diverse as stroke, rehospitalization for coronary problems, the common cold, and accidents. Three of these studies either controlled for NA or assessed NA variables and found no influence on outcomes (Cohen et al., 2003; Ostir et al., 2001; A. M. Smith et al., 1997). One (Middleton & Byrd, 1996) used a measure that confounded PA and NA. Additional work with replications within disease, repeated use of the same measurement techniques, and control for the potential role of NA would strengthen this literature considerably. Even with these caveats, the near unanimity of results supporting a beneficial association of PA and morbidity is impressive.

Survival

Survival studies are prospective studies of groups of people with serious (often fatal) illnesses. They are basically mortality studies of people who are sick. PA (usually state) is assessed at the onset of the study (patients already diagnosed with the illness), and participants are followed for some defined period of time. Either patients are selected for a specific stage of disease, or severity of disease at baseline is controlled for in the analysis. At the end of the study, the investigators identify who is still living. There are relatively few of these studies, and they are mixed in terms of PA's predicting survival. Table 3 summarizes the PA and survival studies.

A study by Moskowitz (2003) used the four PA items from the CES-D to predict survival in patients with AIDS (ages 25–53). Data over approximately 7.5 years revealed that PA (and not NA) was associated with an increased likelihood of survival (RR = 0.86) when control variables (e.g., baseline markers of illness progression and medication) were accounted for.

Another study examined survival in 356 individuals 10 years after coronary angioplasty (van Domburg, Pedersen, van den Brand, & Erdman, 2001). The researchers used the Heart Patients Psychological Questionnaire (Erdman, 1982). The questionnaire included a 12-item subscale assessing a well-being component (e.g., "I feel happy") and other subscales measuring inhibition, despondency, and disability. The well-being score was related to lower mortality prior to adjustment ($\chi^2 = 5$, $p < .02$); however, this finding did not withstand controlling for baseline measures of medical history and health.

Several studies examined whether PA is associated with survival in a variety of patients with cancer. Only one found a beneficial effect of state (current) PA. In this study, S. M. Levy,

Lee, Bagley, and Lippman (1988) examined predictors of survival time in a 3.5-year follow-up of patients with first recurrent breast cancer. They assessed PA at baseline with the Derogatis (1975) Affects Balance Scale. The scale consists of four positive (joy, contentment, affection, vigor) and four negative (anxiety, guilt, depression, hostility) 5-item subscales. Apart from medical assessments (e.g., longer disease-free interval, physician's prognosis, fewer metastatic sites), baseline joy was the only predictor of longer survival (survival hazards model with biological variables: $\beta = -.46$, $p < .01$). Negative mood was associated with shorter survival; however, it was not as potent as PA and did not enter the most powerful statistical model.

Another study examined survival time in patients with advanced malignant disease (e.g., unresectable pancreatic cancer, gastric cancer, lung cancer, colorectal cancer, glioma) with a median expected survival time of 1 year (Cassileth, Lusk, Miller, Brown, & Miller, 1985). In this case, none of a number of psychological and social measures including general life satisfaction (assessed by eight questions) were associated with survival.

The remaining two cancer studies found evidence for negative effects of PA. Derogatis, Abeloff, and Melisaratos (1979) contrasted patients with metastatic breast cancer who survived less than 1 year (short-term survivors) to those who survived a year or longer (long-term survivors). The Derogatis Affects Balance Scale (see earlier description) was administered at baseline to assess current mood. Long-term survivors had a lower affect balance, indicating a mood balance that was shifted toward higher NA and lower (but not significantly so) PA. A final cancer study examined happiness and survival time in a group of patients with early stage melanoma (J. E. Brown, Butow, Culjak, Coates, & Dunn, 2000). They also found that shorter survival duration was associated with elevated baseline levels of general positive mood as assessed by a 1- to 100-mm line scale anchored by *my mood is miserable* at one end and *happy* at the other.

Another study indicating negative effects of PA on survival examined happiness as a predictor of 4-year survival in patients with end-stage renal disease (Devins et al., 1990). Happiness was assessed by the Atkinson (1978) Life Happiness Rating Scale, a bidirectional index ranging from *very unhappy* (1) to *very happy* (11) with 5 indicating an *even mixture of unhappiness and happiness*. When all factors were entered in a forward stepwise fashion, happiness was the only psychosocial factor to step in (immediately after organ dysfunction ratings and age), revealing that higher levels of life happiness were related to shorter survival times. Upon closer examination, the researchers noted that 95 of the 97 participants indicated happiness levels of 5 or above (an even mixture). This suggests that longer survival was associated with even mixtures of happiness and sadness (more neutral moods), whereas mortality was associated with high levels of only happiness.

Finally, several studies have examined the predictive value of QOL in survival in a manner that at least separates mental health (including affect) from physical health, although most of these mental health subscales confound NA, and social and cognitive factors with PA. Survival after open heart surgery was benefited by the energy (pep and vigor) component of PA (Chocron et al., 2000), but not by a summary mental health score that collapsed across energy, positive–negative emotions, and social functioning (Rumsfeld et al., 1999). Another heart disease study examined the

Table 3
Summary of Positive Affect (PA) and Survival Findings

Study	Participants	Follow-up	PA measure (state–trait)	Was PA associated with survival?	Could NA play a role in this association?
J. E. Brown et al. (2000)	426 patients with early melanoma (mean age = 57)	5 years	General mood from miserable to happy (on 1 = to 100-mm line scale; state)	Shorter survival	Yes (bimodal PA–NA scale)
Cassileth et al. (1985)	204 patients with inoperable cancer (mean age = 60.3)	5 years	Life satisfaction (trait)	No effect	No
Chocron et al. (2000)	215 patients receiving open heart surgery (mean age = 65)	3 years	Energy section of the Nottingham Health Profile questionnaire (trait; Hunt et al., 1980)	Energy was associated with better survival	Yes (low energy could be NA)
Derogatis et al. (1979)	35 patients with breast cancer	~3 years	Derogatis Affects Balance Scale (state)	Shorter for those with lower Affects Balance Scores (high NA and low PA)	More NA is associated with longer survival
Devins et al. (1990)	97 patients with renal disease (ages 16–79)	4 years	Life happiness from very unhappy to very happy (trait)	Shorter survival if too happy	Yes (bimodal PA–NA scale)
Kalantar-Zadeh et al. (2001)	65 outpatients receiving chronic dialysis (mean age = 54.5)	1 year	SF-36 (Ware et al., 1993) mental health subcomponent (happy, calm, nervous, down in the dumps, downhearted) and vitality component (pep, energy, tired, worn out; trait)	No effect for mental health; marginal survival benefit with high vitality ($p = .09$)	Yes (tired and worn out in vitality scale; NA confounded in mental health)
Konstam et al. (1996)	5,025 patients with congestive heart failure (ages 21–80)	3 years	Vigor and life satisfaction (trait)	Vigor was associated with improved survival; satisfaction was marginally beneficial ($p = .057$)	No
S. M. Levy et al. (1988)	36 patients with breast cancer (mean age = 52)	3.5 years	Derogatis Affects Balance Scale (state)	Improved survival	Not as strong as PA
Moskowitz (2003)	407 men who were HIV+ (ages 25–53)	7.5 years	PA items from CES-D (1-week; trait)	Improved survival	No
Parkerson and Gutman (2000)	103 patients receiving hemodyalisis (mean age = 62.6)	1 year	SF-36 (Ware et al., 1993; trait)	No effect	Yes (all scales confounded with PA and NA)
Rumsfeld et al. (1999)	2,480 patients with coronary artery bypass (mean age = 63)	6 months	SF-36 (Ware et al., 1993) mental component (vitality, mental health, social and emotional function; trait)	No effect	Yes (NA–PA combined)
van Domburg et al. (2001)	356 patients with heart disease (mean age = 60)	10 years	Heart Patients Psychological Questionnaire (one component measures well-being; trait)	No effect of well-being component	No effect

Note. NA = negative affect; CES-D = Center for Epidemiological Studies Depression Scale.

association between QOL and survival in patients with symptoms of congestive heart failure (Konstam et al., 1996). Although the vigor and life satisfaction components of QOL were associated with decreased all-cause mortality over 3 years (ps were .001 and .057 respectively), activities of daily living, perceived health and social function were stronger predictors when all factors were entered together. Patients receiving hemodialysis (typically at the end stage of renal disease) similarly did not benefit from QOL in terms of their survival (Parkerson & Gutman, 2000), although energy may have played some role in the health of these patients because vitality (pep and vigor) was marginally ($p = .09$) related to longer survival in one study (Kalantar-Zadeh, Kopple, Block, & Humphreys, 2001) and fewer hospital visits in the other (Parkerson & Gutman, 2000).

Discussion of Survival Findings

There is too little consistency across the few existing survival studies to draw any conclusions. However, there is a pattern of results suggesting a hypothesis. It appears that those with "end stage" disease (Derogatis et al., 1979; Devins et al., 1990) and diseases with high short-term mortality rates—patients with melanoma (J. E. Brown et al., 2000)—were harmed by high levels of PA, whereas those with diseases (or disease stages) with longer term expectations for living, where adherence to medical regimens and other behavioral factors (e.g., exercise, better sleep) could play a role, were benefited by PA (S. M. Levy et al., 1988; Moscovitz, 2003) or unaffected (van Domburg et al., 2001). The QOL literature, though difficult to interpret because of the multifacet measures, showed similar effects, wherein QOL was not beneficial for patients with end-stage renal disease (Kalantar-Zadeh et al., 2001; Parkerson & Gutman, 2000) nor for those recovering from serious surgery (Rumsfeld et al., 1999). There is, however, some suggestion that mental vigor and pep may help in some fashion (e.g., Chocron et al., 2000; Konstram et al., 1996).

It is possible that high levels of PA in populations with serious illness are harmful. They are associated with underreporting of symptoms and hence could result in inaccurate tracking of disease progression and consequent incorrect disease treatment. Similarly, patients high in PA may be overoptimistic and consequently not follow their treatment regimens or take their illness seriously. It may be that reporting excessively high levels of PA when confronting a life threatening disease is a sign of maladaptive coping, inappropriate illness behavior, denial, or even emotional suppression, whereas reporting an even balance of emotions is an indication of facing the reality of the situation, taking their illness seriously, and not suppressing felt emotions. Or it may be that persons with serious illness who are high in PA are more likely to choose to live the remainder of their lives without suffering the pain and invasiveness of indicated treatment regimens.

It is also possible that in studies of serious and end-stage diseases, the absolute level of PA or the balance between PA and NA may be more important than simply having more PA. Recall that in one study, the majority of patients reported a relatively even balance of NA and PA, and that it was the patients who were out of balance (i.e., reporting very high levels of PA relative to NA) who had the lowest survival rates (Devins et al., 1990). In another study (Derogatis et al., 1979), patients with breast cancer who had

longer survival did not have absolute low levels of PA; they simply had lower levels than those who lived for under 1 year.

Finally, it may be that in those cases in which PA was neither beneficial nor harmful, some patients are too far along in their illness progression for affect to play an important role. For example, if tumor cells are already in the millions and replicating at a high rate, or the kidney has already failed, it is difficult to imagine how emotions could play a strong role at this point in the disease process.

Markers of Disease Severity and Physical Functioning

A number of studies examined associations between PA and markers of physiological functioning in ill or older populations. These include both experimental and naturalistic prospective studies. Table 4 summarizes the PA and severity–function studies. The majority of these studies examined the effects of changes in mood on pulmonary function in individuals with asthma.

Asthma. In general, NA and stress are associated with reductions in pulmonary function (reviewed in Wright, Rodriguez, & Cohen, 1998). Although less attention has been paid to PA, in the laboratory, induced PA has been generally found to reduce pulmonary function as well. This suggests a valence-nonspecific response in the airway. However, studies conducted in natural settings suggest that state PA is associated with improved pulmonary function.

In a laboratory study of adults with mild and moderate asthma, Ritz, Steptoe, DeWilde, and Costa (2000) found that both positive (happy, content, elation) and negative (anxiety, anger, depression) mood-inducing movie excerpts resulted in poorer pulmonary function (respiratory resistance; measured by forced oscillation) as compared with neutral movie clips. Although the decreases in pulmonary function seen in this study were not clinically significant, they do indicate that strong positive emotional arousal in individuals with asthma may place them at risk. Of interest, this research group has also found evidence of the same changes in pulmonary function with PA and NA in participants who did not have asthma; however, the health implications of this are likely negligible (Ritz, George, & Dahme, 2000; Ritz, Steptoe, et al., 2000).

In another study of adults with asthma (mean age = ~ 27), Ritz, Claussen, and Dahme (2001) manipulated mood with happy pictures and self-referent Velten statements (e.g., "I'm pleased that most people are so friendly to me") as well as similar depressive stimuli. In this case, pulmonary function was also generally worse after both happy and depressed mood inductions; however, there were only significant decreases in function with depressive stimuli.

Florin, Freudenberg, and Hollaender (1985) similarly examined physiological reactions to positive and negative emotional stimuli in 7.5- to 12-year-old children with bronchial asthma and in healthy matched controls. Each child was exposed to a pleasant, funny film and a stress-inducing task. Similar to the studies described earlier, pulmonary function (assessed as forced expiratory volume; FEV) decreased under both experimental conditions. The healthy controls showed no changes in forced expiration in response to these manipulations.

In a study of children with moderate to severe asthma, ages 8 to 17, positive emotion induction did not influence levels of pulmonary function but did change variability of response. Miller and

Table 4
Summary of Positive Affect (PA) and Its Associations With Disease Severity and Physical Function (in Prospective and Experimental Studies)

Study	Participants	Follow-up/study type	PA measure (state–trait)	Outcome	Was PA associated with health markers?	Could NA play a role in this association?
Affleck et al. (2000)	48 individuals with moderate–severe asthma (mean age = 42.1)	21 days (ambulatory)	Items from circumplex (e.g., peppy, happy, calm; state)	PEF	Yes (higher PEF for peppy and active)	Yes (assessed with bipolar mood vector)
Apter et al. (1997)	21 individuals with moderate–severe asthma (mean age = 43.4)	21 days (ambulatory)	Naturalistic mood report (state)	PEF	Yes (higher PEF)	No
Cassileth et al. (1985)	155 patients with Stage I–II breast cancer (mean age = 52.2)	5 years	Life satisfaction (trait)	Recurrence	No effect	No effect
Florin et al. (1985)	36 control vs. individuals with asthma (ages 7.5–12)	Pre–post induction test	Mood induction with comedic film (state; facial expression in response to movie assessed)	Forced expiratory volume	No	NA was associated with reduced expiratory volume
Gabbay et al. (1996)	63 patients with coronary artery disease (mean age = 62.6)	24–48 hr (ambulatory)	Happiness (state)	Silent ischemia	No effect	Anger was associated with increased likelihood of ischemia
Gullette et al. (1997)	132 patients with coronary artery disease (mean age = 59)	48 hr (ambulatory)	Happiness (state)	Silent ischemia	No effect	NA was associated with increased likelihood of ischemia
Houghton et al. (2002)	20 patients with irritable bowel syndrome (ages 17–64)	Pre–post induction test	Hypnosis induced happiness and relaxation (state)	Balloon distension pain	Relaxation decreased pain, whereas happiness had marginal benefit	No
Hyland (1990)	10 individuals with mild–moderate asthma (ages 19–59)	15 days (ambulatory)	PANAS (current mood; state)	PEF	PA was associated with higher peak flow in 3 participants (others null)	No
Liangas et al. (2003)	21 children with mild–severe asthma (mean age = 10)	30 days (ambulatory)	Recording occasions that child displayed mirth (excitement, laughing; state)	PEF and symptoms of asthma	No—on some occasions mirth caused asthmatic symptoms and a decrease in PEF	No
Miller and Wood (1997)	24 individuals with moderate–severe asthma (ages 8–17)	Pre–post induction test	Induction with happy film segments (MC; state)	Oxygen saturation–HR variability	Yes (more stability in pulmonary function with happy scene)	No
Ostir et al. (2002)	240 patients poststroke, hip fracture, or myocardial infarction (ages 65 and up)	1 year postevent	PA items from CES-D (1 week; trait)	Mobility and function	Yes (better function)	PA was only beneficial when NA (depression) was low
Ritz et al. (2001)	40 control vs. individuals with asthma (mean age = 27.3)	Pre–during–post induction test	Mood induction with pictures and self-referent statements (MC; state)	Respiratory resistance	No	NA was associated with increased resistance
Ritz and Steptoe (2000)	40 control vs. individuals with asthma (mean age = 30.1)	Lab induction + 3 weeks (ambulatory)	Induction with film (MC) and natural mood (elated, happy, calm, content; state)	Peak flow and expiratory volume	No	NA was associated with reduced flow and volume
Ritz, Steptoe, et al. (2000)	48 control vs. individuals with asthma (ages 20–48)	Pre–during–post induction test	Mood induction with happy and content film segments (MC; state)	Respiratory resistance	No	NA was associated with increased resistance

Table 4 (*continued*)

Study	Participants	Follow-up/study type	PA measure (state–trait)	Outcome	Was PA associated with health markers?	Could NA play a role in this association?
Steptoe and Holmes (1985)	7 individuals with asthma (ages 18–25)	Ambulatory over 20 days	Ambulatory with three visual analogue scales: calm–angry, relaxed–tense, elated–depressed (state)	PEF	Variable: 2 participants showed benefit of PA on PEF; 3 showed NA benefit	Yes (bipolar scales)
Whorwell et al. (1992)	18 patients with irritable bowel syndrome (ages 20–48)	Hypnosis	Hypnosis-induced mood (state)	Colonic motility	Relaxation decreased motility, whereas happiness was marginal; excitement was not beneficial	No

Note. PEF = peak expiratory flow; NA = negative affect; PANAS = Positive and Negative Affect Schedule; MC = manipulation check administered; CES-D = Center for Epidemiological Studies Depression Scale.

Wood (1997) examined how induction of happiness, sadness, and a mixture of those emotions (with different segments of the movie *E.T.: The Extraterrestrial*) influenced oxygen saturation in the blood and autonomic function. Oxygen saturation is an indirect measure of pulmonary function and was used in this study instead of respiratory resistance because researchers did not want to interrupt the flow of the movie. The happy scene resulted in less variability in oxygen saturation than the sad and happy–sad mix scenes; however, it was not different from the neutral scene (film credits) in terms of its oxygen saturation, nor were total levels of oxygen significantly different between all scenes. These findings indicate that happiness may be associated with greater stability in oxygen levels in individuals, but not overall levels. It is, however, important to note that the scene used to invoke happiness also involved a great deal of relief (boy discovers that E.T. is not actually dead), which may be different in terms of arousal and valence than a pure happiness manipulation.

Naturalistic studies of PA and lung function tell a somewhat different story. In a prospective study, Apter et al. (1997) monitored pulmonary function (peak expiratory flow rate; PEF) and mood items (based on the circumplex model) three times daily over a 21-day period in 21 adults with moderate to severe asthma. Participants rated 20 mood adjectives according to their presence in the past 30 min (0 = *not at all*, 6 = *very much*) including pleasant mood (*happy, cheerful*), unpleasant mood (*sad, blue*), active mood (*active, lively*), and passive mood (*quiet, passive*) as well as combinations for each category of active–passive and pleasant–unpleasant (e.g., passive–pleasant = calm; active–unpleasant = anxious). Pleasant mood was the only mood variable associated with PEF at the next time point (lagged analyses). Specifically, more pleasant mood predicted better pulmonary function.

There are also several concurrent (same-day) analyses of ambulatory studies of mood and pulmonary function in individuals with asthma (see Table 4). Hyland (1990) monitored mood and PEF in 10 adults with asthma for 15 days. He reported that 3 of the 10 participants with asthma showed increases in PEF on days with more positive moods, and another 3 showed a trend in the same direction. In another 21-day study, Affleck et al. (2000) also found increases in PEF with increased arousal and pleasant arousal (pep) and also showed that positive valence is associated with fewer asthmatic symptoms, even when PEF levels are controlled. A divergent outcome arose out of a 24-day study of 7 male adults with mild asthma by Steptoe and Holmes (1985). They found that PEF was correlated with mood across days in 6 of the 7 participants but that the directionality varied among them (i.e., 3 showed higher PEF with negative states, 2 showed higher PEF with positive states, and 1 showed decreased PEF with negative).

In a 21-day study of adults with mild to moderate asthma, Ritz and Steptoe (2000) found that there was a decrease in pulmonary function as assessed by FEV on the occasions that participants reported their most extreme levels of positive and negative moods. They also found that these effects may be attributable to high levels of self-reported arousal (low calm) during those extreme moods. Interestingly, they found that PA-elicited pulmonary function in the laboratory and PA-associated function in a field study were not correlated. This questions the extent to which the laboratory model is representative of real-world response.

A final study found evidence for mirth-triggered asthma (Gayrard, 1978). A survey of children with mild to severe asthma revealed that approximately 34% of the children had experienced asthma as a result of a gleeful stimulus. The author also had children with asthma record asthmatic symptoms and PEF over 30 days. Results showed that mirthful events (e.g., funny movies) were often associated with triggering asthmatic symptoms and resulted in a decrease of PEF to approximately 65% of baseline levels.

Overall, in the laboratory studies of individuals with asthma, acute states of arousal, whether associated with PA or NA, appear to be the key component associated with worsening of pulmonary outcomes. In contrast, naturalistic studies typically (but not always) have found that state PA was associated with improved pulmonary function. This discrepancy suggests that the laboratory paradigm may not be a good model of what happens in the real world. This may be because many of the laboratory manipulations induced more intense and arousing emotions than most day-to-day fluctuations assessed in the naturalistic studies. In fact, when analysis of naturalistic mood focused only on more extreme levels of PA, the results were consistent with those of most laboratory studies (Gayrard, 1978; Ritz & Steptoe, 2000). As noted in the *Survival* section, the association between state PA and some outcomes may be curvilinear, with small to moderate changes improving outcomes but truly intense emotions having detrimental effects associated with arousal. It is also possible that differences in results from the laboratory and field are attributable to differing methods of assessing pulmonary function. Because peak flow measurements taken in the field are inaccurate if participants do not blow into the peak flow meter "as hard as they can," it is possible that affect might influence the outcome through its impact on adherence to the measurement regimen (see Affleck et al., 2003)—for example, those low in PA not trying as hard as those with higher PA.

Irritable bowel syndrome (IBS). One study examined how colonic motility (a measure of pressure in the colon) is influenced by hypnotic induction of excitement, anger, and happiness in 18 adult patients (Whorwell, Houghton, Taylor, & Maxton, 1992). Hypnosis on its own resulted in decreased colonic motility, likely because of the relaxation, sometimes considered an unactivated positive state, naturally induced by hypnosis. Excitement (activated pleasant mood), on the other hand, was associated with increased colonic motility relative to the controlled hypnotized state, but not the same degree of increase as was observed in anger induction. By contrast, happiness was associated with decreased colonic motility as compared with the prehypnotic state, but it was not significantly different from the neutral, relaxed hypnotic state. In sum, whereas general relaxation had benefits for motility in the bowel, excitement resulted in worsened motility, and happiness had no effect. Because IBS inflammation and occurrence is strongly associated with the occurrence of stress and NA (see Searle & Bennett, 2001, for a review), it makes sense that relaxation would show benefits.

Ischemia in patients with coronary artery disease. Two studies monitored patients with coronary artery disease for 24 to 48 hr and examined whether ambulatory mood changes were associated with silent ischemia (Gabbay et al., 1996; Gullette et al., 1997). A heart attack (myocardial infarction) occurs when the heart muscle is deprived of oxygen, resulting in the death of heart tissue. *Silent*

ischemia is an inadequate supply of blood flow and oxygen available to heart tissue without any chest pain. Silent ischemia is a way of looking at oxygen deprivation that occurs much more often than heart attacks and may provide a model for determining emotional (and other) triggers relevant to coronary artery disease. In both cases, positive emotions were not related to the occurrence of ischemia, but negative emotions such as anger, anxiety, and frustration were associated with its future occurrence.

Physical function. A small group of studies examined the associations between PA and decreases in functional status in older individuals and function and recovery in those with disease. Two cross-sectional studies found that lower life satisfaction is associated with an increased likelihood of requiring nursing home care and being more frail (Finlayson, 2002; Strawbridge, Shema, Balfour, Higby, & Kaplan, 1998). On the other hand, a third (Revenson & Felton, 1989) found that happiness was not associated with changes in self-reported physical limitations–disability in a group of patients with rheumatoid arthritis (RA); however, NA was.

A prospective study of a 65- to 99-year-old Mexican American cohort we described in the mortality section (Ostir et al., 2000) also examined whether baseline affect was associated with functional status and mobility over a 2-year follow-up. The authors found that low levels of PA at baseline were associated with decreased walking speed in a timed 8-ft (approximately 2.4-m) walking test as well as a decrease in the ability to engage in daily living activities (e.g., bathing, feeding oneself). The influence of NA in this case was not reported.

In sum, this is a very small and varied literature, and it is not possible draw any conclusions. However, there is a suggestion that outcomes subject to motivation or self-report bias (e.g., function and self-reported limitations and disabilities) were susceptible to positive PA influences.

Discussion of PA and Disease Severity and Physical Functioning

There are several very different outcomes represented here, and other than the asthma work, not enough evidence exists in any single area to draw any sweeping conclusions. Overall, the data suggests the possibility that associations between PA and outcomes vary with the extremity of the affective response, probably through effects on arousal level. The most extreme affect was most likely to have a detrimental effect. It is also consistent with the possibility that PA is associated with improvement on outcomes that are subject to motivation or self-report bias.

Self-Reported Health Outcomes

Physical symptoms. The reporting of physical symptoms partly reflects underlying disease, but such reports are also influenced by psychological states and traits of patients (Cohen & Williamson, 1991; Mechanic, 1977; Pennebaker, 1983). Individuals with high state and trait NA report more symptoms than one would expect from their underlying disease (Cohen et al., 1995; Watson & Pennebaker, 1989), and individuals high in trait PA report fewer and less severe symptoms when objective markers of disease are held constant (Cohen et al., 2003). Higher trait levels of PA and SWB have been associated with fewer symptoms and better self-reported health among patients with Lyme disease (El-

kins et al., 1999), lupus (Grootscholten et al., 1988), multiple sclerosis (Gatten, Brookings, & Bolton, 1993), coronary artery disease (Sullivan, LaCroix, Russo, & Walker, 2001), upper respiratory infection (Cohen et al., 2003; Takkouche, Regueira, & Gestal-Otero, 2001), older individuals (Brissette, Leventhal, & Leventhal, 2003; Edwards & Klemmack, 1973; Palmore & Luikart, 1972; Spreitzer & Snyder, 1974), as well as among hospital inpatients and outpatients for a variety of illnesses (e.g., De Gucht, Fischler, & Heiser, 2004; Kvaal & Patodia, 2000; Schneider et al., 2003). In general, those with mild illnesses (i.e., allergic disorder) are not less happy or more dissatisfied (trait) than healthy individuals (Roysamb et al., 2003).

There is also evidence for an association of trait PA and perceived health and symptom reporting in healthy populations. A meta-analysis on subjective well-being and self-reported health found an average correlation between happiness and health of .32 (Okun, Stock, Haring, & Witter, 1984). More recent cross-sectional analyses have similarly reported better perceived health and fewer symptoms in those with high trait PA (Roysamb et al., 2003; Takkouche et al., 2001). However, Watson and Pennebaker (1989) found little association between trait PA and symptom reporting (i.e., one of six samples showed a negative association between PA and symptoms). State PA has also typically been associated with the report of fewer symptoms in healthy individuals (Benyamini, Idler, Leventhal, & Leventhal, 2000; Casten, Lawton, Winter, Kleban, & Sando, 1997; Watson, 1988a).

Experimental evidence suggests that inducing state PA in both healthy (Croyle & Uretsky, 1987; Salovey & Birnbaum, 1989) and mildly ill (Salovey & Birnbaum, 1989) individuals results in more favorable self-evaluations of health as compared with those induced to feel NA and versus a neutral control condition in the Salovey and Birnbaum study. Finally, prospective evidence also reveals that PA measures predict better self-reported health and fewer symptoms prospectively in older individuals for both state and trait PA (state: Benyamini et al., 2000; trait: Hirdes & Forbes, 1993) and those with upper respiratory infections for trait PA (Cohen et al., 2003). Although these data are provocative, many of these studies also found NA to be associated with greater symptom reporting and poorer self-reported health, begging the question of which component is responsible for the found effects. However, there is some evidence that PA effects on self-reported health are independent of and stronger than those of NA (Benyamini et al., 2000; Cohen et al., 2003; Pettit, Kline, Gencoz, Gencoz, & Joiner, 2001).

Pain. There is a large literature on the impact of NA on reports of pain (see Riley, 1999, for a review) but a relatively smaller one on PA effects. Pain, like symptoms, is a perception of a bodily state that is subject to affect-elicited self-report biases (e.g., Pennebaker, 1982; Salovey & Birnbaum, 1989). Not surprisingly, in populations with disease, self-reported pain has frequently been correlated with lower levels of state and trait PA. For example, traitlike measures of PA have been associated with less pain in patients with cancer (Guadagnoli & Mor, 1989), fibromyalgia (Potter, Zautra, & Reich, 2000; Zautra, Johnson, & Davis, in press) and in patients with RA (Potter et al., 2000; Zautra et al., in press) as well as in hospital inpatients (Kvaal & Patodia, 2000). State PA has similarly been associated with less pain in patients with cancer (Guadagnoli & Mor, 1989) and in patients with sickle-cell disease (Gil et al., 2003, 2004) as well as in healthy populations (Casten et

al., 1997). This cross-sectional evidence, however, may be attributable to the experience of pain changing perceptions of PA. Supportive evidence for PA's influencing pain is found in experimental studies (see Table 5). PA induced via a wide array of strategies (e.g., imagery, film, audiotape, verbal statements, memory recreation) resulted in less reported pain sensitivity and more pain tolerance (see the list of studies in Table 5) with the exception of a study that found no effect of positive imagery on pain threshold (Scott & Barber, 1977). Other support comes from a prospective study showing that PA report among patients with RA and fibromyalgia was associated with less pain report over the following week (Zautra et al., in press).

The majority of these studies also reported that NA is associated with decreased pain tolerance; however, in some cases, it was associated with analgesic effects similar to those of PA (e.g., Zillmann, de Wied, King-Jablonski, & Jenzowsky, 1996). Although a good number of the experimental studies did not use manipulation checks, the consistency of the relation across multiple studies is impressive. Again, because pain is a perception, evidence linking PA to the report of less pain might be partly or wholly attributable to psychological as opposed to physiological changes. In fact, a common explanation for the PA–pain association is that the affect acts as a distractor (e.g., McCaul & Malott, 1984). Although, as we discuss later, PA may be associated with the release of endogenous opioids, providing a potential physiological mechanisms for analgesia.

Discussion of PA and Self-Reported Health

In sum, there is considerable evidence linking PA to reports of fewer symptoms, less pain, and better health. These outcomes have practical importance, but there is reason to think that this association may be driven primarily by PA influences on how people perceive their bodies rather than by affect-elicited changes in physiological processes (Cohen & Williamson, 1991; Mechanic, 1977; Pennebaker, 1982).

Physiological Systems Associated With Health

Cardiovascular function. Increases in cardiovascular activity support increased physical output by bringing oxygen and nutrients to tissues and carrying waste products away. Temporary increases in BP and HR are a natural and normal response to current demands and expectancies and function to support behaviors that are typically associated with specific emotions, for example, fight and flight. However, recurrent or prolonged activation of the cardiovascular system can result in levels of response that have the potential of influencing health outcomes (Krantz et al., 1981). For example, they may put persons at risk for stroke and coronary heart disease (e.g., Blascovich & Katkin, 1993) and alter (usually suppress) immune functions such as the efficient division of white blood cells in response to an infectious challenge (Rabin, Cohen, Ganguli, Lysle, & Cunnick, 1989). Consequently, PA could contribute to health to the extent it is associated with changes in basal levels of cardiovascular response. In addition, changes in state PA and associated acute changes in cardiovascular response could also be important for those with chronic underlying diseases where short-term emotions may trigger an "event" such as an asthma or heart "attack." In general, lower (within norms)

Table 5
Summary of Experimental and Prospective studies of Positive Affect (PA) and Pain

Study	Participants	PA measurement–induction (state–trait)	Manipulation checks: control sessions	Pain type	Relevant findings
Adams and McGuire (1986)	20 older individuals in a long-term facility with chronic pain	Humorous movie (state)	No; nonhumorous movie	Self-reported pain	Humorous film was associated with decreased pain report and decreased pain medication
Alden et al. (2001)	50 undergraduates	Pleasant imagery (state)	Yes; no imagery condition	Cold pressor	Positive imagery was associated with lower pain ratings and longer tolerance
Avia and Kanfer (1980)	79 female undergraduates	Pleasant imagery (state)	No; control session	Cold pressor	PA was associated with increased pain tolerance
Bruehl et al. (1993)	80 male students (mean age = 20)	Positive emotion induction (state)	No; two control sessions	Finger pressor	PA was associated with lower pain reports
Chaves and Barber (1974)	120 female undergraduates	Pleasant imagery (state)	No; no imagery condition	Finger pressor	Positive imagery was associated with less self-reported pain
Clum et al. (1982)	119 undergraduates	Pleasant imagery (state)	No; no treatment control	Pressure-induced discomfort (arm cuff)	Pleasant imagery was associated with reduced pain report
Cogan et al. (1987; Experiment 1)	40 undergraduates	Laughter- or relaxation-inducing audio narrative (state)	No; dull narrative or no tape	Pressure-induced discomfort (arm cuff)	Higher discomfort threshold was associated with laughter and relaxation conditions
Cogan et al. (1987; Experiment 2)	20 female undergraduates	Laughter-inducing narrative or interesting or uninteresting narrative audiotape (state)	No; control session (no intervention)	Pressure-induced discomfort (arm cuff)	Laughter-inducing condition was associated with increased discomfort thresholds
Gil et al. (2003)	37 young adults with sickle-cell disease (ages 13–17)	Ambulatory (up to 6 months; state)		Self-reported pain	Positive mood was associated with lower same-day pain, but not subsequent-day pain; pain was associated with lower subsequent positive mood (next day)
Gil et al. (2004)	41 adults with sickle-cell disease	Ambulatory (~91 days; state)		Self-reported pain	Positive mood was associated with lower same- and subsequent-day pain
Hertel and Hekmat (1994)	30 undergraduates	Pleasant imagery (state)	No; no imagery condition	Cold pressor	Positive imagery was associated with increased pain tolerance from pre- to posttest
Horan and Dellinger (1974)	36 undergraduates	Pleasant imagery (state)	No; no imagery condition	Cold pressor	Positive imagery was associated with increased pain tolerance vs. control
Hudak et al. (1991)	31 undergraduates	Humorous video (state)	No; nonhumorous video	Electric stimulation	Humor group had higher thresholds for discomfort than no-humor group
Meagher et al. (2001)	70 undergraduates (mean age = 19.4)	Pleasant slides (nurturant and erotic; state)	Yes; neutral slides	Cold pressor	Erotic (pleasant and arousing) slides associated with reduced pain sensitivity (increased self-reported pain intensity and unpleasantness threshold) in men; no effect on tolerance
Morgan and Horstman (1978)	47 male adults	Baseline POMS (vigor; trait)		Finger pressor	Vigor was inversely associated with pain report
Pickett and Clum (1982)	59 patients post gallbladder surgery (ages 40–68)	Pleasant imagery (state)	No; no-treatment control	Surgical pain ratings (pain questionnaire and a rating of pain at its worst)	Pleasant imagery treatment was associated with lowest "pain at its worst" scores vs. no-treatment group
Rosenbaum (1980)	40 rural community members	Pleasant imagery (state)	No; no imagery condition	Cold pressor	Pleasant imagery was associated with longer tolerance to pain
Scott and Barber (1977)	80 undergraduates	Pleasant imagery (state)	No; no imagery condition	Cold pressor and finger pressor	No effect

Table 5 (continued)

Study	Participants	PA measurement–induction (state–trait)	Manipulation checks: control sessions	Pain type	Relevant findings
Stevens et al. (1989)	40 undergraduates (mean age = 19.6)	Pleasant imagery (high- and low-arousal conditions; state)	No; no	Finger pressor	PA was associated with increased pain tolerance (vs. NA); no effect of imagery intensity
Weaver and Zillmann (1994)	72 undergraduates	Comedic film clip (state)	No; neutral film clip	Cold pressor	PA was associated with increased pain tolerance for men but not women
Weisenberg et al. (1998)	200 healthy participants (ages 18–36)	Humorous movie (state)	Yes; neutral film clip	Cold pressor	Humorous film was associated with increased pain tolerance
Worthington and Shumate (1981)	96 female undergraduates	Pleasant imagery (state)	No; no imagery condition	Cold pressor	Pleasant imagery was associated with longer tolerance and less self-reported pain
Zautra et al. (in press)	124 women with fibormyalgia or osteoarthritis	Weekly mood assessments with the PANAS (state)		Self-reported weekly pain	Weekly PA was associated with less pain in the following week
Zelman et al. (1991)	65 students and hospital workers	Velten mood induction (state)	Yes; neutral condition	Cold pressor	PA was associated with increased pain tolerance
Zillman et al. (1993)	100 undergraduates	Comedic film clip (state)	Yes; neutral film clip	Arm cuff–pressure	PA was associated with increased pain threshold
Zillman et al. (1996)	72 male undergraduates	Positive movie clips (state)	Yes; control condition	Arm cuff–pressure	Pain sensitivity diminished with PA was compared with control

Note. POMS = Profile of Mood States; NA = negative affect.

levels of cardiovascular response are assumed to be health promoting whereas higher ones have the potential to constitute a health risk. The direction of response to be expected under elevated PA is not entirely clear. For example, the circumplex model of emotion suggests that activated emotions such as excitement and joy would be associated with increases in HR and BP. In contrast, low-activation emotions such as feelings of calm and pleasantness would be associated with a quiescent response or a dampening of cardiovascular response. Studies of PA and its hemodynamic correlates are listed in Table 6.

Most studies of PA and cardiovascular response are experimental studies in which (state) PA is manipulated in the laboratory. Because of the relatively large number of studies, we limit the following discussion to only those that meet minimal design criteria. Specifically, we considered mood manipulation studies that included manipulation checks, positive and negative emotions, and a reasonable sample size (more than 10 participants). Of the 16 studies fitting these criteria, 10 found that activated positive emotions (e.g., happiness, joy, euphoria) were associated with increased HR and/or BP when compared with baseline or a mood-neutral control (Ekman, Levenson, & Friesen, 1983; Futterman, Kemeny, Shapiro, & Fahey, 1994; Knapp et al., 1992; Neumann & Waldstein, 2001; Prkachin, Williams-Avery, Zwaal, & Mills, 1999; G. E. Schwartz, Weinberger, & Singer, 1981; Sinha, Lovallo, & Parsons, 1992; Waldstein et al., 2000; Witvliet & Vrana, 1995; Yogo, Hama, Yogo, & Matsuyama, 1995). Of interest, of those studies showing increases in cardiovascular response, all used some kind of active PA manipulation such as the use of personally relevant stimuli (e.g., recall events from the past, emotional scripts). Those studies not showing the increase typically entailed passive inductions of PA, for example, inducting mood with music and movies (Christie & Friedman, 2004; Fredrickson, Mancuso, Branigan, & Tugade, 2000; Gendolla & Krusken, 2001a, 2001b). It is likely that increased cardiovascular response was found in the active manipulations because they induced greater feelings of arousal, whereas more passive ones did not.

There is also a small experimental literature that manipulates state PA by having participants take on emotional facial expressions associated with happiness. This manipulation typically, but not always, results in self-reported happiness. In all of these studies the facial manipulation of happiness resulted in increased HR (Boiten, 1996; Ekman et al., 1983; Hess, Kappas, McHugo, Lanzetta, & Kleck, 1992; Levenson, Ekman, & Friesen, 1990; Levenson, Ekman, Heider, & Friesen, 1992). However, the increase in HR elicited by the PA manipulation is typically smaller than that elicited by taking on the facial expression associated with anger and fear. Emoting peacefulness via facial expression was associated with a decrease in HR (Hess et al., 1992).

Five naturalistic ambulatory studies examined the association between daily PA and cardiovascular responses on the same day. Four of the five showed state (daily) PA to be associated with increased BP, but there was no association with HR (Gellman et al., 1990; Jacob et al., 1999; J. E. Schwartz, Warren, & Pickering, 1994; Shapiro, Jamner, & Goldstein, 1997). The fifth study (James, Yee, Harshfield, Blank, & Pickering, 1986) did not find that PA increased BP; however, self-reported emotional arousal was associated with BP increases. In all cases, anxiety and anger were associated with larger increases in cardiovascular response than PA.

Table 6

Summary of Positive Affect (PA) and Cardiovascular Function

Study	Participants	Design and independent PA measures (state–trait)	Manipulation checks; control sessions	Dependent measures	Relevant findings
Bacon et al. (2004)	135 patients with coronary artery disease	Ambulatory (48 hr) with assessments every 20 min (happy and relaxed; state)	N/A	HRV	Higher NA was associated with decreases in HF and LF power; high PA was related to an increase in LF power
Boiten (1996)	50 male adults	Facial manipulation task to express happiness, sadness, fear, anger, surprise, disgust, and neutral state (state)	Manipulation check; control (neutral) session	HR	Anger, fear, and sadness were associated with the largest increases in HR followed by a smaller increase via happiness expression
Brosschot and Thayer (2003)	33 members of the general population (mean age = 29,18)	Ambulatory over 1 day with eight hourly evaluations; eight valence and arousal ratings (state)	N/A	HR at eight time points	Cardiovascular activation was shorter after positive emotions than after negative emotions (decelerated 2.14 BPM after positive and increased 1.06 BPM after negative)
Catipovic-Veselica et al. (1999)	114 inpatients with unstable angina and myocardial infarction (mean age = 53.8)	Reported eight basic emotions at hospital entry; positive were gregarious–joy and trust–acceptance (trait)	N/A	HRV and HR over 24 hr	No association between HR and emotion; trust–acceptance was associated with higher HRV in those with unstable angina and non-Q-wave MI, and inversely related to gregariousness–joy; NA was typically associated with HRV decrease in this group (e.g., sadness)
Christie and Friedman (2004)	34 healthy undergraduates (mean age = 18.7)	Mood induction; film clips eliciting amusement and contentment vs. anger, fear, sad, neutral (state)	Manipulation check; neutral control	MAP, SBP, DBP, heart period, MSD	Anger decrease greater than all emotions for MSD
Ekman et al. (1983)	16 emotion researchers and actors (adults)	Mood induction with facial expression or recollecting and reliving a happy situation from past (vs. fear, anger, sadness, disgust, surprise; state)	Rated intensity for recollection; no control	HR	HR increased more in anger and fear conditions than in happiness
Frazier et al. (2004)	56 healthy undergraduates (mean age = 19.1)	Mood induction with three positive film segments and neutral and sad segments (state)	Manipulation check; neutral control	RSA, IBI	RSA decrease was associated with both positive and negative films, but not neutral; IBI showed biggest increase in association to negative stimulus, whereas positive was similar to neutral
Fredrickson and Levenson (1998; Study 1)	60 female undergraduates	Mood induction; contentment- and amusement-inducing films following a fear-inducing film (also sad induction; state)	Manipulation check; neutral control	Heart period, pulse transmission time to ear, pulse transmission time to finger, finger pulse amplitude (aggregated)	Contentment and amusement were associated with faster return to prefilm basal levels of cardiovascular activation than neutral or sadness-inducing films
Fredrickson and Levenson (1998; Study 2)	72 males and females (ages 20–35)	Whether participant spontaneously smiled during a sad film clip (state)	No manipulation check; no control	Heart period, pulse transmission time to ear, pulse transmission time to finger, finger pulse amplitude (aggregated)	Those who smiled at least once had a 20-s-faster recovery than those who did not

Table 6 (continued)

Study	Participants	Design and independent PA measures (state–trait)	Manipulation checks; control sessions	Dependent measures	Relevant findings
Fredrickson et al. (2000; Study 1)	170 undergraduates (ages 19–22)	Mood induction; videos inducing amusement and contentment vs. sad or neutral (state)	Manipulation check; neutral control	HR, finger pulse amplitude, pulse transmission times to finger and ear, DBP, SBP (aggregate score created)	Amusement- and contentment-film participants recovered to basal cardiovascular activation faster than those with sadness or neutral inductions
Fredrickson et al. (2000; Study 2)	185 undergraduates (ages 19–22)	Mood induction; videos inducing amusement and contentment vs. sad or neutral (state)	Manipulation check; neutral control	HR, finger pulse amplitude, pulse transmission times to finger and ear, DBP, SBP (aggregate score created)	Cardiovascular responses to four films were minimal and not significantly different from each other and barely different from BL contentment: slight decrease in FPA and slight SBP increase; cry film resulted in slight decrease in HR and FPA and increase in SBP; in post hoc analyses, FPA and SBP distinguished the cry film from other films but only in certain subgroups (e.g., stronger in women)
Futterman et al. (1994)	14 male actors (mean age = 35)	Five separate mood inductions on separate days; induced high-arousal PA (euphoric happiness) and low-arousal PA (relaxed happiness) by reading scenarios and using personal memories (also high–low arousal NA; state)	Manipulation check; no control session	HR (throughout each period)	HR increased with mood induction irrespective of affect
Gellman et al. (1990)	131 individuals with normotensive and mild hypertensive status (mean age = 34.6)	Ambulatory; 1 day of mood collection on PA (smiling and happy) and NA (tense, angry, annoyed, upset; state)	N/A	SBP and DBP	Significant increases in SBP and DBP were seen with both NA and PA after posture was controlled (mood effects when sitting but not standing)
Gendolla and Krusken (2001a)	56 students (mean age = 24)	Mood induction; positive music vs. sad, slow music (state)	Manipulation check; no control session	BP and HR change with positive–negative task following induction	No manipulation effect (during music)
Gendolla and Krusken (2001b)	60 students (mean age = 23)	Mood induction; positive music vs. sad, slow music (state)	Manipulation check; no control session	BP change with manipulation and with positive–negative task following induction	No manipulation effect (during music)
Gendolla and Krusken (2002)	26 healthy undergraduates (mean age = 23)	Mood induction; happiness induced with comedic film (state)	Manipulation check; no control session	HR, SBP, DBP	No significant effect of PA- or NA-inducing films on HR, SBP, or DBP; however, for DBP, NA caused an NS increase whereas PA resulted in a decrease, and for HR, decrease with NA and no change in PA
Harrison et al. (2000)	30 healthy undergraduates (mean age = 21)	Mood induction; excitement- and humor-inducing films vs. neutral (state)	Manipulation check; neutral control	SBP, DBP, HR, CO, PEP, TPR	Excitement was associated with increases in SBP (marginal), HR and CO, PEP shortening, and TPR increase with all films. Humor was associated with decreased CO and lengthened PEP

(table continues)

Table 6 (*continued*)

Study	Participants	Design and independent PA measures (state–trait)	Manipulation checks; control sessions	Dependent measures	Relevant findings
Hess et al. (1992)	27 female undergraduates	Mood induction; asked to "feel an emotion, facially emote an emotion, or to feel and facially show an emotion" (high- and low-arousal PA and NA; state)	Manipulation check; no control session	HR	Happiness was associated with an increase in HR, whereas peacefulness was associated with a decrease in HR; strongest effects were seen when participants were asked to "feel and show" the emotion
Hubert and de Jong-Meyer (1990)	12 participants with general anxiety and 12 without (ages 20–40)	Mood induction; joy-inducing film clip vs. suspense-inducing film (state)	Manipulation check; no control session	HR	No change in HR for positive condition, whereas there was a temporary decrease for the negative condition
Hubert and de Jong-Meyer (1991)	20 male undergraduates (mean age = 22.7)	Mood induction; joy-inducing film clip vs. suspense-inducing film (state)	Manipulation check; no control session	HR	No HR effect
Jacob et al. (1999)	69 male adults with and without borderline hypertension (mean age = 37) and a validation sample of 85 male students (mean age = 21.6)	Ambulatory; 4 separate days of 24-hr monitoring with a circumplex-based mood rating system: valence and arousal (state)	N/A	BP monitor at fixed 30-min intervals (SBP, DBP, HR)	Elation–happiness resulted in an increase of BP 1.5/0.80 mmHg and anxious–annoyed increased 2.8/2.2 mmHg; HR similar but less pronounced; anxious vs. happy was not significant for SBP and HR but was significant ($p < .05$) or DBP
James et al. (1986)	90 patients with borderline hypertension (ages 16–70)	Ambulatory 24 hr with sample every 15 min; happiness rated from 1 (*low*) to 10 (*high*) at each BP assessment (also anger and anxiety; state)	N/A	SBP, DBP	On average, pressure reported during anger and anxiety was higher than that for happiness; happy score intensity was inversely associated with SBP; anxiety intensity was positively correlated with DBP; emotional arousal was associated with increased SBP and DBP independent of posture and location
Knapp et al. (1992)	20 members of the campus community (ages 18–30)	Two mood induction sessions on different days + 1 training day; induction with recall of positive personal event and event reenactment, also negative event (state)	Manipulation check; no control session	SBP, DBP, HR	SBP increased with negative induction but not positive; DBP and HR increased with both PA and NA inductions but was more pronounced in NA
Laidlaw et al. (1994)	7 healthy volunteers (ages 23–47)	Correlational during eight sessions over 8 days; self-report with POMS vigor and Brief Mood Ratings (several bipolar scales loading onto two factors: lively–listless and stressed–tranquil; state)	N/A	SBP, DBP	POMS vigor was associated with SBP increase but not DBP or pulse (anger, depression, and tension showed the same relationship with SBP and no relation with DBP); Lively–listless, factor was associated with increased SBP and decreased pulse whereas the stress–tranquil factor was correlated with SBP and pulse increases

Table 6 (*continued*)

Study	Participants	Design and independent PA measures (state–trait)	Manipulation checks; control sessions	Dependent measures	Relevant findings
Laidlaw et al. (1996)	38 healthy participants (mean age = 39.2)	Mood manipulation with screening, control, and intervention sessions; hypnosis to induce relaxation and the feeling of a pleasant day, and self-report of POMS items and Brief Mood Ratings irritable–peaceful factor and lively–listless factor (state)	Manipulation check and baseline control session	SBP, DBP assessed after hypnosis period, mood report, and allergen test	BP was not correlated with emotion variables
Levenson et al. (1990)	16 actors and emotion researchers; 16 college students; 30 members of the general population	Facial muscle configuration for various emotions: happiness, anger, sadness, fear, surprise, disgust (state)	Manipulation check (self-reported emotion); no control session	HR	Anger, fear, and sadness expression were associated with the largest increase in HR; happiness produced a small increase in HR, but it was significantly smaller than anger and fear; the specificity of the autonomic response was increased when the correct emotion was self-reported and when the facial expression was more accurate
Levenson et al. (1992)	46 Minangkabau of west Sumatra (ages 16–27)	Facial muscle configuration for various emotions: happiness, anger, sadness, fear, surprise, disgust (state)	Manipulation check (self-reported emotion); no control session	HR	Anger, fear, and sadness expression produced the largest increase in HR; happiness produced a small increase in HR, but it was significantly smaller than anger; the specificity of the autonomic response was increased when the correct emotion was self-reported and when the facial expression was more accurate
McCraty et al. (1995)	24 healthy participants (mean age = 39)	Mood induction with freeze-frame method of consciously disengaging from negative and focusing on the heart, focus on feeling appreciation or similar positive emotions toward someone vs. anger induction (state)	No manipulation check; no control but BL levels of autonomic activity assessed	HR, HRV, power spectral density	Anger was associated with increase in LF power but not HF. Appreciation–PA was associated with increases in both; LF–HF ratio increased with anger but was unchanged with PA; MF increased with both PA and NA
McCraty et al. (1996)	10 healthy participants (mean age = 41)	Mood induction with music (rock, New Age, and designer calm-yet-energetic-alertness–inducing music); also included self-induced positive emotional states (appreciation) vs. no self-induction (state)	No manipulation check; no control but BL levels of autonomic activity assessed	HRV, power spectral density	Calm–energetic music and self-induced PA were associated with increased autonomic activity (no change with other music); there was an increase in HRV during appreciation session and calm–alert music with appreciation session; there was an increase in LF and MF power during appreciation and calm music

(*table continues*)

Table 6 (*continued*)

Study	Participants	Design and independent PA measures (state–trait)	Manipulation checks; control sessions	Dependent measures	Relevant findings
McCraty et al. (1998)	45 experimental participants and 15 controls (mean age = 38)	Longitudinal (1 month); mood induction with freeze-frame method (disengaging from negative and focusing on the heart, focus on positive emotions; state)	Checked for changes in mood after 1 month of training; nontreatment control group	HRV	Training was associated with greater heart rate variability during performance of technique in 80% of participants and an increase in coherence of HRV pattern in 80% of participants after 1 month of training
Miller and Wood (1997)	24 children with asthma and behavioral and emotional problems (ages 8–17)	Mood induction by watching full-length feature film; measured happy/relief-inducing movie scene vs. sad scene and happy–sad mixed scene 2 min each (state)	Manipulation check (reported emotion); movie credits were the control	HRV, HR	Sad scene (followed by mixed) was correlated with the biggest increase in HRV vs. happy and neutral; sad and mixed scenes were also associated with biggest HR increase vs. happy scene
Neumann and Waldstein (2001)	42 healthy undergraduates (mean age = 19.45)	Mood induction of joy and relaxation (high–low positive valence) induced with personally relevant recall task (state)	Manipulation check; no control session	SBP, DBP, HR, PEP, stroke index, cardiac index, TPR	BP, HR, and TPR increase was associated with all emotions, whereas SI decreased; in addition, SBP was higher for negatively valenced tasks (anger and sadness); PEP lengthened more was associated with low-arousal conditions (relaxation and sadness)
Pollock et al. (1979)	8 healthy men (ages 19–31)	Correlational (eight separate samples); POMS scale (trait)	N/A	SBP, DBP, HR	No association between vigor and BP or HR, but depression and tension were positively correlated with HR and DBP, and anger was positively associated with HR
Prkachin et al. (1999)	43 undergraduates with high affect intensity	Mood induction; happiness based on an intense personal event from participant's past (state)	Manipulation check; neutral trial	SBP, DBP, HR, SV, TPR, CO	SBP was greater during negative than positive inductions; DBP and HR were low in the happy condition and SV was highest, but nonsignificant
Provost and Gouin-Decarie (1979)	40 infants (9- and 12-month-olds)	Mood induction; interest induction (exploration) and joy induction (reunion with mother and help with a new toy; state)	Mood verified by observers; control session	HR	Negative-inducing situations were associated with increases in HR (anger, distress), whereas positive situations (interest and joy) were associated with a small nonsignificant deceleration in HR
Santibanez and Bloch (1986)	10 patients with anxiety, 12 drama students, and 12 undergraduates (ages 18–45)	Mood induction with storytelling and experience reliving of joy–laughter and other emotions; hypnosis mood induction in undergraduate group (state)	No manipulation check; no control session	HR	HR increased most in joy–laughter condition (similar to erotic love); all emotions were associated with an increase (NA and PA) except for tenderness–love
Schmidt et al. (2003)	167 infants (ages 3–12 months)	Mood induction; used classical musical pieces to induce joy, fear, and sadness (state)	No manipulation check; no control session	HR	No difference between any of the emotions and HR

Table 6 (continued)

Study	Participants	Design and independent PA measures (state–trait)	Manipulation checks; control sessions	Dependent measures	Relevant findings
G. E. Schwartz et al. (1981)	32 healthy undergraduates	Mood manipulation (six trials); personal situations that evoke happiness followed by vivid recreation while sitting and while exercising vs. fear, anger, sadness, relaxation, control (state)	Manipulation check; control session	HR, SBP, DBP	For HR and SBP, all emotions were higher than neutral control; for DBP, PA was no different from control; for HR, fear and anger produced a bigger increase than happiness
J. E. Schwartz et al. (1994)	246 participants with normotensive and patients with minor hypertensive status (ages 30–66)	Ambulatory monitoring (24 hr); self-report of the presence of excitement and happiness at BP assessment; 10 total NA and PA adjectives (state)	N/A	HR, SBP, DBP	Anger resulted in the biggest SBP and DBP changes followed by excitement and happiness (smaller increases)
Shapiro et al. (2001)	203 premenopausal female nurses (mean age = 37.7)	Ambulatory monitoring (4 days of 24 hr monitoring); self-report of 10 mood words, PA: happy, alert, in control (state)	N/A	HR, SBP, DBP	NA resulted in a graded d increase in SBP, DBP, and HR, but there was no impact of intensity of happiness on these variables except for a very small association with DBP; the presence of high happiness during high anxiety counteracted effects on DBP
Sinha et al. (1992)	27 healthy men (ages 21–35)	Mood induction (four sessions); self-referent emotion scripts for joyful emotions vs. three negatives, one action, and 1 neutral script (state)	No manipulation check; control session	HR, SBP, DBP, SV, CO, PEP, PVR, LVET	Sadness and joy were similar in their effects: intermediate changes in SV, SBP, PEP, LVET, HR, and SBP; the only significant difference between joy and neutral was PVR; anger had the greatest HR and DBP increases
Stemmler (1989)	42 female medical students (mean age = 23)	Mood induction; happiness induced by giving participants positive feedback about previous work and bonus money (state)	Manipulation check; control session	HR, PTT, finger pulse amplitude	Happiness was not different from the control session, although it was discriminable from the fear and anger conditions
Stembach (1962)	10 children (mean age = 8)	Mood induction; movie scenes where child self-rated it as "funniest" (made them feel happiest) and "nicest" (also saddest, scariest) (state)	Yes (used self-ratings to choose when to assess cardio measures); no control	HR, finger pulse volume	There was a lack of consistency in response for HR and finger pulse
Theorell et al (1974)	34 patients with ischemic heart disease (mean age = 63)	Clinical interview over 2 years of positive–negative emotional response to life events (i.e., rushed, excited happy vs. sad, passive, depressed; average trait response)	N/A	HR and mean velocity–cardiac force from ballistocardiogram	Mean velocity–maximum force development of the heart was higher during arousal–excited states than during withdrawn–sad states; HR was lower in withdrawn state vs. aroused state (less sensitive measure)

(table continues)

Table 6 (*continued*)

Study	Participants	Design and independent PA measures (state–trait)	Manipulation checks; control sessions	Dependent measures	Relevant findings
Uchiyama (1992)	6 male undergraduates (18–19 years old)	Mood induction in the laboratory by telling individuals that they had heart disease (surprise), getting angry at participant (anger, contempt), and giving reward–telling truth about study (joy; state)	Manipulation check; control session at start	HR, SBP, DBP	Situations differed in HR (HR highest in NA situation vs. others)
Uchiyama (1990)	10 undergraduate students	Mood induction with four films inducing either joy, fear, sadness, or anger (state)	Check emotions by using self-ratings to choose when to assess cardiovascular measures; no control session	HR, SBP, DBP	Joy was negatively associated with HR and was significantly smaller in BP vs. the negative emotions
Waldstein et al. (2000)	30 healthy undergraduates (mean age = 23.9)	Mood induction; happiness-inducing film followed by personally relevant recall of happy event and imagination of event (vs. negative; state)	Manipulation check; no control session	HR, SBP, DBP	Happy film was associated with a decrease in SBP and HR and a slight increase in DBP; recall and imagery were associated with elevations in all three parameters; the patterns were similar in NA
Warner and Strowman (1995)	70 healthy undergraduates	Approximately 1 hr of conversation with a stranger; PA rated with PANAS and positive conversation items from Warner et al. (1987): relaxed, friendly, natural, confident, involved, pleasant, happy, in charge, enthusiastic (state)	N/A	SBP, DBP	PA composite score of PANAS and Warner adjectives was associated with greater BP elevations, whereas NA was not associated with BP
Witvliet and Vrana (1995)	48 undergraduates	Mood induction with 12 sentences describing 3 situations from each circumplex quadrant; PA (joy, pleasant–relaxed) vs. NA (fear and sadness; state)	Manipulation check; no control session	HR	HR was higher during high-arousal emotions (joy and fear) than during low-arousal emotions (no valence effect)
Yogo et al. (1995)	24 female undergraduates	Mood induction with standard emotion-inducing scripts (joy, anger, neutral) and personalized scripts for same emotions ~2 min of imagery (state)	Manipulation check; control session	SBP, DBP	Main effect of emotion increasing SBP and DBP vs. neutral state; personal scripts had higher BP responses than standard script; joy produced greater SBP response than anger

Note. BP = blood pressure; CO = cardiac output; DBP = diastolic blood pressure; HF = high frequency power, HR = heart rate; HRV = heart rate variability; IBI = interbeat interval; LF = low frequency power; LVET = left ventricular ejection time; MAP = mean arterial pressure; MF = medium frequency power; MSD = mean success difference in heart period; NA = negative affect; PA = positive affect; PEP = pre-ejection period; PTT = pulse transmission time; PVR = pulmonary vascular resistance; RSA = respiratory sinus arrhythmia; SV = stroke volume; TPR = total peripheral resistance.

Finally, there are a number of ambulatory and PA-manipulating laboratory experimental studies that assessed HR variability (HRV) in order to examine the contribution of parasympathetic (the arousal dampening system) activation to PA-elicited change in cardiovascular response. In general, evidence suggests that PA may be associated with the control of parasympathetic activation; however, the direction of the PA influence on cardiovascular response varied across studies with some finding activation of this arousal dampening system (Bacon et al., 2004; Christie & Friedman, 2004; McCraty, Atkinson, Rein, & Watkins, 1996; McCraty, Atkinson, Tiller, Rein, & Watkins, 1995; McCraty, Barrios-Choplin, Rozman, Atkinson, & Watkins, 1998) and others decreases in the arousal dampening effects (vagal withdrawal; Catipovic-Veselica et al., 1999; Frazier, Strauss, & Steinhauer, 2004). Vagal withdrawal may be a function of mood activation because it occurred with joy and gregariousness but not trust and acceptance in the Catipovic-Veselica et al. study, and with a happy movie induction in undergraduates in the Frazier et al. study. A single study of undergraduate students (Christie & Friedman, 2004) found no effect of induced PA on HRV. It may be that PA is associated with deeper and slower breathing (i.e., lower respiratory rate and greater respiratory volume), both of which can directly increase HRV.

Overall, it appears that arousal plays a key role in the association between state PA and cardiovascular function. Highly activated positive emotions in both experimental (HR and BP) and correlational studies (BP only) were associated with increases in cardiovascular response. These increases, however, were typically of a smaller magnitude than those of activated negative emotions such as anger. Sadness and other less activated emotions were, however, less differentiated from PA (see Table 6). Furthermore, the evidence suggests that PA may be associated with the activation and withdrawal of the system that dampens sympathetic nervous system (SNS) response (the parasympathetic nervous system; PNS).

Endocrine function. A well-known conduit that could influence a spectrum of diseases is the emotionally provoked release of pituitary and adrenal hormones. As with cardiovascular function, these hormones rise and fall in response to daily challenges but can constitute a potential risk for disease when they are elevated for a prolonged period or when their diurnal rhythms are disrupted by emotional fluctuations. Hormone dysregulation can influence many physiological systems including the alteration of both immune and cardiovascular function. Numerous studies have suggested that hormones such as epi, norepinephrine (norepi), ACTH, cortisol, growth hormone, and prolactin are responsive to emotions. These factors can all drive quantitative and qualitative changes in immune and cardiovascular function and may, in turn, play a role in health outcomes. Table 7 summarizes the studies relating PA to endocrine function.

Most of the studies listed in the table have examined the influence of mood induction or ambulatory mood evaluations on acute changes in cortisol levels (both salivary and plasma). Cortisol is a hypothalamic pituitary–adrenocortical hormone that regulates metabolic and immune processes (Sheridan, Dobbs, Brown, & Zwilling, 1994) that are potentially important in autoimmune disease, infectious diseases, diabetes, wound recovery, and some cancers. In general, one might expect cortisol levels to be lower with increased PA. However,

cortisol is highly responsive to stress and arousal (e.g., Kirschbaum & Hellhammer, 1989); therefore, in cases of very aroused PA (e.g., excitement), we might expect increases in this hormone.

Laboratory studies in which PA was induced have typically found a decrease or no change in cortisol. For example, Hubert and de Jong-Meyer (1990, 1991) have found that inducing joy or suspense via film induction was associated with decreases in cortisol. Others have reported that inducing happiness was associated with decreased cortisol levels, whereas inducing NA increased cortisol (Berk et al., 1989; Black & Friedman, 1968; Buchanan, al'Absi, & Lovallo, 1999; Codispoti et al., 2003; Zachariae et al., 1991). Similarly, a study using repeated laboratory inductions showed that a technique that promoted positive emotional states resulted in decreased cortisol levels 1 month later (McCraty et al., 1998). Another study found that watching a comedic performance resulted in decreased cortisol levels in patients with RA, but not in healthy controls (Yoshino, Fujimori, & Kohda, 1996). Other studies found no effect of happiness induction on cortisol response in healthy individuals, even though anxiety and fear inductions increased cortisol levels (Berk et al., 1989; Black & Friedman, 1968; Buchanan et al., 1999; Codispoti et al., 2003; Zachariae et al., 1991). A single study found no effect of either PA or NA (induced by music) on cortisol levels (Clark, Iversen, & Goodwin, 2001). However, in this case the last sample was only 10 min after the end of induction, which is not enough time to mount a peak cortisol response—a 20- to 30-min period is typically necessary. All of these studies used more passive inductions such as watching humorous films, listening to music, or looking at pictures, which may account for the cortisol decrease.

Four of the experimental studies found that PA was associated with increased cortisol. Specifically, inducing happiness resulted in the same increase in cortisol as inducing guilt or sadness in students and members of the college community (Hucklebridge et al., 2000); inducing elation resulted in the same increase as inducing sadness in female actresses and students (W. A. Brown, Sirota, Niaura, & Engebretson, 1993); inducing either euphoric or relaxed happiness in actors resulted in the same elevated levels as inducing agitated or anhedonic depression (Futterman et al., 1994); and inducing amusement resulted in an increase in cortisol as compared with a neutral stimulus (Hubert, Moller, & de Jong-Meyer, 1993). Three of these four had participants draw on personal experiences and memories to induce the mood as one component of the manipulation (W. A. Brown et al., 1993; Futterman et al., 1994; Hucklebridge et al., 2000), and two used actors as participants (W. A. Brown et al., 1993; Futterman et al., 1994). Use of these more self-relevant and engaging manipulations may elicit increased levels of arousal not found in the more passive manipulations discussed earlier.

Studies of cortisol levels in the natural environment support an association between trait PA and lower cortisol levels, although there is mixed evidence in regard to an association with state PA. Here, we included studies with reasonable sample sizes (20 or more). Studies of normal populations collecting multiple measures over days or weeks generally found that higher trait (Cohen et al., 2003; Polk, Cohen, Doyle, Skoner, & Kirschbaum, 2005) and state PA (Kugler & Kalveram, 1987; Polk et al., 2005) were associated with lower levels of cortisol. However, three studies found no associations between state PA and cortisol response (Ryff, Singer,

Table 7
Summary of Positive Affect (PA) and Endocrine Function

Study	Participants	Design and independent PA measures (state–trait)	Manipulation checks; control sessions	Dependent measures	Relevant findings
Berk et al. (1989)	10 healthy men (mean age = 27)	Mood manipulation; humorous video (state)	No manipulation check; control session	Plasma CORT, ACTH, Beta endorphin, epi, norepi, dopamine catabolite (dopac), prolactin, growth hormone	The humorous video was associated with decreases in CORT, dopac, epi, growth hormone
Black and Friedman (1968)	2 out of 8 hypnotized participants (age not reported)	Mood induction; direct hypnotic suggestion of emotion (state)	Manipulation check; no neutral control	CORT (plasma)	No association between happiness andCORT (decreases in a similar manner to natural decrease in, afternoon) as compared with anxiety and fear, which were associated with a CORT increase
W. A. Brown et al. (1993)	10 female students (mean age = 23.2), 12 female student controls (mean age = 20.8), and 16 female actors (mean age = 22.5)	Mood induction (two different sessions); Velten mood induction method (self-referent statements) to increase elation vs. sadness (state)	Manipulation check; no neutral control	Plasma CORT and growth hormone sampled every 15 min	Both sadness and elation manipulations resulted in increased CORT; there was some indication that changes in mood during elation condition were associated with growth hormone (changes nonsignificant, $p > .05$)
Buchanan et al. (1999)	30 young men (mean age = 24)	Mood induction; humorous video vs. stressful speech task (state)	Manipulation checks; control sessions	Salivary CORT at baseline and 30 min (just after induction)	CORT decreased with humorous video and increased with stress task; no effect on CORT from neutral session
Clark et al. (2001)	22 participants; 11 with and 11 without hypomania symptoms (mean age = 21)	Mood induction; positive music piece vs. negative (state)	Manipulation check; no neutral control session	Salivary CORT sampled at 0, 10, 15, 20 min; mood induction from 3–10 min	No main effect of mood induction condition (NA or PA)
Codispoti et al. (2003)	10 healthy men (mean age = 24.9)	Mood induction (3 days); International Affective Picture System (positive pictures of erotic stimuli; state)	Manipulation check; control session	Blood drawn at BL, after 30 min, after 30-min picture session for norepi, epi, prolactin, CORT, ACTH	Norepi and ACTH increased with NA and decreased with neutral, with PA in the middle (greater than neutral); CORT increased more with negative vs. neutral and pleasant conditions; prolactin increased with PA and decreased with NA
Cohen et al. (2003)	334 members of the general population (mean age = 28.8)	Prospective; positive emotional style sampled over one month (average score of vigor, well-being, and calm subscales; trait)	N/A	Salivary CORT sampled at 1830, 2230 1st night; next morning at 0545, 0615, 0645, and hourly between 0800 and 1600; epi and norepi from 24-hr urine sample	Positive emotional style was associated with lower levels of epi and norepi as well as lower CORT production (AUC; $p < .06$)
Futterman et al. (1994)	14 male actors (mean age = 35)	Five separate mood inductions on separate days; induced high-arousal PA (euphoric happiness) and low-arousal PA (relaxed happiness) by reading scenarios and using personal memories (also high–low arousal NA; state)	Manipulation check; no neutral control	CORT (plasma) drawn at 20 min after BL period, after 20-min mood induction, and after 20-min recovery	Inducing PA or NA resulted in CORT remaining at baseline levels, whereas neutral state was associated with a decrease over time

Table 7 (*continued*)

Study	Participants	Design and independent PA measures (state–trait)	Manipulation checks; control sessions	Dependent measures	Relevant findings
Hubert and de Jong-Meyer (1990)	12 participants with general anxiety and 12 without (mean age = 20–40)	Mood induction (on 2 days); joy-inducing film clip vs. suspense inducing film (state)	Manipulation check; no neutral control	Pre session 15 min BL, 0-, 15-, 30-, 45-, and 60-min salivary CORT	There was no condition effect on CORT (declines across time for both conditions)
Hubert and de Jong-Meyer (1991)	20 male undergraduates (mean age = 22.7)	Mood induction (on 2 days); joy-inducing film clip vs. suspense inducing film (state)	Manipulation check; no neutral control	Presession 15 min BL, 0-, 15-, 30-, and 45-min salivary CORT	There was no difference in CORT between the suspenseful and pleasant movies (both decreased from premanipulation levels)
Hubert et al. (1993)	52 male volunteers (ages 19–31)	Mood induction; amusement-inducing film vs. neutral (state)	Manipulation check; neutral control	Pre session, 20, 40, 60, 80, 100, 120, 140, 160 min postonset salivary CORT	Amusement-inducing film was associated with a significant increase in CORT vs. the neutral film; self-reported funniness and interest levels of the film were correlated with CORT levels
Hucklebridge et al. (2000)	19 female students (mean age = 19.7) and 41 male and female campus community members (mean age = 19.9)	Study 1: Mood induction on 2 different days; self-reflected very happy vs. guilty (using life experience); Study 2: happy music vs. sad music (state)	Manipulation check for self-reflection but not for music previously validated); no control group	No. 1 baseline salivary CORT, 10 min postrecall) and 30 min posttask; No. 2 (baseline and 30 min after music)	CORT increased with both mood manipulation tasks, but there was no valence differentiation
Kugler and Kalveram (1987)	22 healthy participants (ages 17–28)	Longitudinal ambulatory mood ratings of cheerfulness at 9 a.m. 1 p.m., 5 p.m. and other mood items (state)	N/A	Salivary CORT drawn at 9 a.m., 1 p.m., and 5 p.m.	Low cheerfulness was associated with higher daily levels of CORT; no negative items were associated with CORT levels
Logan et al. (1998)	10 healthy participants with a history of herpes labialis (cold sores; ages 20–40)	Longitudinal (3 months); daily mood report with bipolar scales: content–discontent, depressive (happy–unhappy and hopeful–hopeless), secure–insecure, calm (anxious–relaxed and uptight–calm), hateful–loving (state)	N/A	Serum epi	No association between mood type and EPI
McCraty et al. (1998)	45 healthy adults in intervention and 15 controls (mean age = 38)	Longitudinal (1 month); mood induction with freeze-frame method (disengaging from negative and focusing on the heart, focus on positive emotions; state)	Checked for changes in emotions after 1 month of training; control group	Salivary cortisol sampled 4 times over a day (pre- and postintervention)	There was a 23% decrease in cortisol levels in the intervention group
Polk et al. (2005)	334 members of the general population (mean age = 28.8)	Prospective; positive emotional style sampled over 1 month (average score) of vigor (lively, full of pep, energetic), well-being (happy, pleased, cheerful), calm (at ease, calm, relaxed; trait and state)	N/A	CORT sampled (salivary) at 1830, 2230 1st night; next morning at 0545, 0615, 0645, and hourly between 0800 and 1600	Higher trait PA was associated with lower waking-day CORT concentration; there was a sex interaction where by men with low trait PA had less CORT decrease in the afternoon–evening whereas women had lower morning rise; state PA but not NA was associated with decreased CORT production in women

(*table continues*)

Table 7 (continued)

Study	Participants	Design and independent PA measures (state–trait)	Manipulation checks; control sessions	Dependent measures	Relevant findings
Pollock et al. (1979)	8 healthy men (ages 19–31)	Cross-sectional (three separate samples); POMS scale (trait)	N/A	Leutenizing hormone, prolactin, testosterone, ADCH, CORT (serum) sampling-timing unknown but all collected between 8 a.m. and 9:30 a.m.	No association between POMS factors and these measures
Ryff et al. (2004)	135 older women (ages 61–91)	Cross-sectional; PANAS, MASQ happy, cheerful, optimistic, looking forward to things, having fun (in the past week; trait)	N/A	Three saliva samples per day 30 min post wake up, 30 m in before lunch, 30 min before bed)—averaged over 4 days—one blood draw during overnight stay for epi–norepi	No association between emotion measures and CORT
Smyth et al. (1998)	120 members of the general population (mean age = 38.7)	Ambulatory (2 days): PA items asked six times per day (between 8 a.m. and 9 p.m.): happy, joyful, enjoyment–fun, pleased (+5 NA items; state)	N/A	Six salivary CORT samples taken 20 min after each mood assessment	PA was associated with lower CORT levels, whereas NA was associated with higher levels
Szczepanski et al. (1997)	101 employed women (ages 20–60)	Ambulatory: self-report of 14 mood states were collected over 2 days (three mood factors studied: pressured, distressed, and contented; state)	N/A	Urinary norepi, epi, CORT collected at three time periods (overnight, daytime, evening) over 2 workdays	Contentment (satisfied, thoughtful, excited, calm) was not associated with the neurohormonal parameters
Van Eck et al. (1996)	87 high- and low-stress white-collar workers (mean age = 42.1)	Ambulatory (5 days with 10 samples per day): 7 PA items: cheerful, satisfied, relaxed, energetic, self-assured, concentrated, enthusiastic (state)	N/A	10 salivary CORT samples per day approximately 90 min apart between 8 a.m. and 10 p.m.	No association between PA and CORT levels
Yoshino et al. (1996)	26 women with rheumatoid arthritis and 31 healthy women	Mood induction with 3-hr performance of "Rakugo"(Japanese comedy–storytelling)	No manipulation check; no control	CORT, epi, norepi, corticotropin releasing factor, corticotrophin, B endorphin, dopamine (serum)	CORT decreased in patients with rheumatoid arthritis after PA stimulus, but healthy participants did not show a significant change
Zachariae et al. (1991)	11 hypnotizable undergraduates	Mood induction; hypnotized to feel happiness and well-being (vs. anger and depression; state)	Manipulation check; no neutral control	Serum CORT, norepi epi	CORT decreased with happiness, whereas norepi increased

Note. CORT = cortisol; epi = epinephrine; norepi = norepinephrine; NA = negative affect; N/A = not applicable; BL = baseline; AUC = area under the curve; POMS = Profile of Mood States; ADCH = adrenocorticotropin hormone; PANAS = Positive and Negative Affect Schedule; MASQ = Mood and Anxiety Symptom Questionnaire (Watson et al., 1995).

& Dienberg Love, 2004; Szczepanski et al., 1997; van Eck, Berkhof, Nicolson, & Sulon, 1996).

Of the studies looking at endocrine parameters other than cortisol, several naturalistic studies examined epi and norepi, other "stress" hormones that act to increase blood flow and cardiovascular activity. Both high state (Berk et al., 1989; Codispoti et al., 2003) and trait PA (Cohen et al., 2003) were associated with lower levels of epi and norepi. Two studies found no association between state PA and epi nor norepi (Ryff et al., 2004; Szczepanski et al., 1997). These are the same studies that found no association with cortisol.

Finally, one experimental study found higher norepi levels when happiness was induced (Zachariae et al., 1991) as compared with levels when depression and anger were induced. Similarly, an amusement-inducing funny movie increased epi and norepi significantly, as did aggression- and anxiety-provoking movies; however, the anxiety increases were the most marked (Levi, 1965). In contrast, a study of patients with RA and controls watching a performance of comedic Japanese storytelling ("Rakugo") found no impact on epi or nepi in controls postperformance; however, there was no manipulation check, making the emotional state of these participants unclear (Yoshino et al., 1996).

Dopac, a precursor to the catecholamine dopamine (and therefore a precursor to epi and norepi) also decreases with the induction of PA (Berk et al., 1989), whereas ACTH, which stimulates the adrenal cortex to produce cortisol, showed no increase with PA induction (Berk et al., 1989; Codispoti et al., 2003). Finally, PA is also associated with increases in prolactin (Codispoti et al., 2003) and growth hormone (Berk et al., 1989; W. A. Brown et al., 1993). Increases in both of these hormones are thought to be conducive to better health.

In summary, PA manipulations in laboratory studies may vary in terms of their effects on endocrine response based on the specific mood being manipulated and on the extent to which the manipulation itself engages the participant or requires active behavioral response. In contrast, field studies are generally (put sporadically) supportive of both trait and state PA associations with more quiescent and sometimes lower levels of stress hormones and higher levels of other hormones whose rises are thought to play a positive role in health.

Immunologic function. PA may get "under the skin" to influence immunity via the aforementioned hormones and their ability to bind to white blood cell receptors and have regulatory effects on distribution and function (Ader, Felten, & Cohen, 2001; Rabin et al., 1989). It may also act directly on immunity via sympathetic fibers that descend from the brain to the primary and secondary lymphoid tissues (e.g., thymus and lymph nodes). The fibers release a variety of substances that can influence immune response by binding to receptors on white blood cells as well (Ader et al., 2001; Rabin, 1999). There have been a number of experimental and correlational studies examining the associations between immune function and PA (see Table 8).

Secretory immunoglobulin A (SIgA), a type of antibody and the main immunological defense of mucosal surfaces, is frequently assessed in psychological studies because it can be measured noninvasively in saliva with little discomfort to the participant. All nine of the studies assessing total (antibodies to all antigens) SIgA in response to a positive mood induction (e.g., movies, music, self-referent statements) showed increases (Dillon, Minchoff, & Baker, 1985; Hucklebridge et al., 2000; Labott, Ahleman, Wolever, & Martin, 1990; Lambert & Lambert, 1995; Lefcourt, Davidson-Katz, & Kueneman, 1990; McClelland & Cheriff, 1997; McCraty et al., 1996; Njus, Nitschke, & Bryant, 1996; Perera, Sabin, Nelson, & Lowe, 1998). Of the two studies that induced both PA and NA, both found that SIgA increased regardless of valence (Hucklebridge et al., 2000; Njus et al., 1996). Plasma IgA has also been shown to increase with positive mood induction as have the levels of two other types of plasma antibodies IgG and IgM (Berk, Felten, Tan, Bittman, & Westengard, 2001).

Of particular note are two ambulatory studies that examined the association between daily PA and the immune system's ability to produce SIgA antibody to a specific immune stimulant (rabbit albumin) administered repeatedly (by pill) on each day of the study. In both studies, PA was related to higher levels of the production of specific antibody to the stimulant (Stone, Cox, Valdimarsdottir, Jandorf, & Neale, 1987; Stone et al., 1994). A single ambulatory study of total SIgA found no association between PA and SIgA (P. Evans, Bristow, Hucklebridge, Clow, & Walters, 1993).

There is a small literature on PA and cellular immune response. PA is clearly associated with alteration in cellular response, but the relationship does not appear to be a simple one. Inducing acute PA increases the numbers of different peripheral white blood cell populations (Berk et al., 2001; Futterman et al., 1994; Futterman, Kemeny, Shapiro, Polonsky, & Fahey, 1992; Logan et al., 1998; Valdimarsdottir & Bovbjerg, 1997). However, there are exceptions, where no differences were found with PA induction (Knapp et al., 1992; Logan et al., 1998). These increases in cell populations are the same as found in response to laboratory stress and are thought to be driven primarily by elevated SNS activation (Herbert & Cohen, 1993b; Segerstrom & Miller, 2004). The effect of inducing PA on a measure of cellular immune function (response of cells to stimulation) has received little attention. One study reported that induced PA increased proliferation to the mitogen phytohemagglutinin (PHA) (Futterman et al., 1994), whereas others reported mixed evidence (one of two concentrations) for a small decrease in PHA-elicited response with acute PA (Knapp et al., 1992).

Cytokines are chemical messengers that different cells of the immune system use to communicate with one another. In most cases, increases or decreases in production of specific cytokines are difficult to interpret in regard to health implications because it is regulation (release of the appropriate amount of cytokine given a specific demand) that is of greatest importance for an efficient immune response. Some evidence suggests that PA mood induction increases some cytokines, specifically, interleukin (IL)-2 and IL-3, and decreases tumor necrosis factor alpha (Mittwoch-Jaffe, Shalit, Srendi, & Yehuda, 1995). Another study found that after participants watched a comedic performance, IL-6 decreased in patients with RA and interferon-gamma decreased in both RA and control participants. IL-6 is a sensitive marker of inflammatory processes in the body, and higher levels are usually considered to be a sign of underlying disease processes; therefore, a decrease in patients with RA may in fact be a marker of at least a short-term beneficial effect on the expression of this ongoing inflammatory disease. In contrast, trait PA was not associated with circulating levels of IL-6 in healthy older women (Ryff et al., 2004).

Table 8
Summary of Positive Affect (PA) and Immune Function

Study	Participants	Design and independent PA measures (state–trait)	Manipulation checks; control sessions	Dependent measures	Relevant findings
Berk et al (2001)	52 healthy men (mean age = 27)	Mood induction; humorous film stimulus (state)	None	NK activity; Ig A, G, M, T cells, B cells, IFN gamma, leukocyte populations from 10 min prestimulus (up to 12 hr post)	Humorous video was associated with increases in NK cell activity, IgG, A, M, activated T cells, cytotoxic T cells, NK numbers, B cells, helper and noncommitted T cells, helper–suppressor T ratio (marginal), IFN gamma, and total leukocytes, as well as lympho cytes and granulocytes
Dillon et al. (1985)	10 students (mean age = 22.9)	Mood induction; humorous film stimulus (state)	Rated funniness; control session	SIgA	SIgA was greater after humorous video vs. control and baseline
P. Evans et al. (1993)	12 undergraduates (age ~ 20)	Longitudinal (2 weeks' ambulatory monitoring); Nowlis Mood Adjective Checklist items: playful, elated, energetic, kindly, leisurely, concentrating (state)	N/A	SIgA	Within-subject analysis showed higher SIgA levels on days with negative mood
Futterman et al. (1992)	5 actors (ages 25–38)	Mood induction; improvisational monologues drawing on personal experiences (happy, depressed, anxious; state)	Manipulation checks; control (neutral) session	NK cell activity, CD56 NK cells, CD57 large granular lymphocytes, T cells (total, helper, cytotoxic)	There was more immune fluctuation (combined) for affect inductions vs. neutral condition and more fluctuation in aroused conditions (happy, anxious) than unaroused condition (depression, neutral); descriptive data due to small sample size
Futterman et al. (1994)	14 male actors (mean age = 35)	Five separate mood inductions on separate days; induced high-arousal PA (euphoric happiness) and low-arousal PA (relaxed happiness) by reading scenarios and using personal memories (also for high/low arousal NA; state)	Manipulation check; no neutral control	NK cell cytotoxicity, lymphocyte proliferation to PHA, number of NK cells, large granular lymphocytes and T cells (helper/inducer and suppressor)	All mood states were associated with NK cell percentage and activity; response to PHA mitogen increased after positive moods and decreased after negative moods
Harrison et al. (2000)	30 undergraduates (mean age = 21)	Mood induction; humor- and excitement-inducing films (state)	Manipulation check; control session	SIgA at 2 min post each film	No association between condition and SIgA
Hucklebridge et al. (2000)	19 female undergraduates (mean age = 19.7) and 41 male and female undergraduates (mean age = 19.9)	Study 1: Mood induction (40-min session on 2 different days); self-reflected (very happy vs. guilty) life experience; Study 2: Happy music vs. sad music (state)	Manipulation check for self-reflection but not for music (previously validated)	No. 1 baseline SIgA, 10 min (postrecall) and 30 min posttask; No. 2 BL and 30 min (after music); no control	SIgA increased with both manipulations regardless of valence, but there was a trend for a more pronounced elevation to occur only in happy mood; separate analyses showed only a happy effect for the self-reflection experiment
Knapp et al. (1992)	20 members of the campus community (ages 18–30)	Two 2.5-hr mood induction sessions on different days and 1 training day; induction with recall of positive personal event and event reenactment (also negative event; state)	Manipulation check; no control	Lymphocyte proliferation in response to PHA, ConA, and PWM; NK cell activity, T cell subsets	PHA-stimulated proliferation decreased for both PA and NA inductions (ConA decreased with NA only)
Labott et al. (1990)	39 women (mean age = 21.6)	Mood induction with a humorous (and sad) videotape (28 min each; state)	Manipulation check; neutral control condition	SIgA	Humorous stimuli were associated with improved immunity (higher SIgA)

Table 8 (*continued*)

Study	Participants	Design and independent PA measures (state–trait)	Manipulation checks; control sessions	Dependent measures	Relevant findings
Lambert and Lambert (1995)	39 fifth-grade students	Mood induction; humorous program	No manipulation check; nonhumorous presentation	SIgA	SIgA increased in the humorous group but not in the nonhumorous group
Logan et al. (1998)	10 healthy subjects with a history of herpes labialis (cold sores; ages 20–40)	Longitudinal (3 months); daily report with bipolar scales: content–discontent, depressive (happy–unhappy and hopeful–hopeless), secure–insecure, calm score (anxious–relaxed uptight–calm), hateful–loving; also Affect Intensity Measure (trait)	N/A	Blood drawn once per week for T lymphocytes and NK cells	Content–discontent correlated with elevated NK cells (more content) the week prior to cold sore outbreak and higher CD8+; the depressed composite (low happy–hopeful) was associated with lower CD8+
Marsland et al. (in press)	84 healthy graduate students (mean age = 24)	Vaccination study; PA measured after first two inoculations but before third; assessed with lively, full-of-pep, energetic, happy, pleased, cheerful, at-ease, calm and relaxed (trait)	N/A	Antibody response to Hepatitis B vaccination	Trait PA was associated with higher levels of antibody production, and this effect was relatively independent of both NA and closely related constructs such as optimism and extraversion
McCraty et al. (1996)	10 healthy participants (mean age = 41)	Mood induction with music (rock, New Age, and designer calm-yet-energetic-alertness-inducing music); also self-induced positive emotional states vs. not appreciation (state)	No manipulation check; no control but used BL levels of SIgA	SIgA	SIgA increased by 55% with calm–alert music while, whereas appreciation produced a 50% increase; simultaneous calm–alert music and appreciation produced a 141% increase
Moss et al. (1989)	10 healthy participants (mean age = 24.1)	Longitudinal (4 weeks) with weekly mood questionnaires and blood draws; PA assessed with POMS (trait)	N/A	NK cell cytotoxicity	There was no correlation between any mood item (NA or PA) and NK cytotoxicity
Mittwoch-Jaffe et al. (1995)	123 undergraduates (mean age = 23.4)	Mood induction; humorous film stimulus (state)	Manipulation check; no control session	IL-1B, IL-2, IL-3, IL-6, TNF-alpha	Positive mood induction resulted in decreased TNF, increased IL2, and increased IL3
Njus et al. (1996)	50 undergraduates	Mood induction; writing about humorous or negative film (state)	Manipulation check; writing session control	Salivary IgA drawn prevideo, postessay, 1 hr after postessay and next day at same time	Participants who wrote about positive or negative movies had increased SIgA as compared with mundane writers
Perera et al. (1998)	16 undergraduates (mean age = 25)	Mood induction; watching a humorous video or a nonhumorous neutral video (state)	Manipulation check (ratings of funnliness); neutral control session	SIgA and salivary lysozyme	Both salivary lysozyme and SIgA increased significantly with humorous video

(*table continues*)

Table 8 (*continued*)

Study	Participants	Design and independent PA measures (state–trait)	Manipulation checks; control sessions	Dependent measures	Relevant findings
Ryff et al. (2004)	135 older women (ages 61–91)	Cross-sectional (four days of mood report on PANAS general affect) and short form of Watson MASQ (happy, cheerful, optimistic, having fun over past week); also Ryff eudaimonic well-being scale (e.g., relations, mastery, growth; state and trait)	One blood draw during overnight stay	IL-6	No association between hedonic (emotion) measures and immunity, but eudaimonic factors (high life purpose) were correlated with lower IL-6
Stone et al. (1987)	30 dental students (mean age = 24.5)	Longitudinal (4 weeks ambulatory data collection); Nowtis Mood Adjectives collected daily (state)	N/A	SIgA in response to daily challenge of rabbit albumin	SIgA response was higher on days with high positive mood and lower on days with elevated negative mood
Stone et al. (1994)	96 adults (mean age = 42)	Longitudinal (12 weeks ambulatory data collection); PANAS collected daily (state)	N/A	SIgA in response to daily challenge of rabbit albumin	SIgA was higher on days with high PA and lower on days with high NA
Valdimarsdottir and Bovbjerg (1997)	48 healthy women (mean age = 38.8)	Cross-sectional, 2 days of mood report, POMS adjectives from factor analysis by Guadagnoli and Mor (1989; state)	Not relevant	NK cell activity	PA was associated with increases in NK cell activity, whereas NA was associated with decreases; there was a significant interaction where by PA was only beneficial when some NA was present (buffering)
Yoshino et al (1996)	26 women with rheumatoid arthritis and 31 healthy women	Mood induction with 3-hr performance of "Rakugo" (Japanese comedy–storytelling; state)	No manipulation check; no control	Substance P, CD4/CD8 ratio, NK cell activity, IL-6, IFN-γ	Comedic performance was associated with a decrease in IL-6 in patients with rheumatoid arthritis and a decrease in IFN-γ in both samples
Zachariae et al. (1991)	11 hypnotizable undergraduates	Mood induction; hypnotized to feel happiness and well-being vs. anger and depression induction (state)	Manipulation check; no control	Monocyte chemotaxis	Chemotactic index was higher after a happy–relaxed state was induced vs. both baseline and NA states

Note. NK = natural killer; Ig = immunoglobulin; IFN = interferon; N/A = not applicable; SIg = salivary immunoglobulin; PHA = phytohemagglutinin; ConA = concavalin A; PWM = pokeweed mitogen; NA = negative affect; POMS = Profile of Mood States; TFN = tumor necrosis factor; PANAS = Positive and Negative Affect Schedule; MASQ = Mood and Anxiety Symptom Questionnaire; IL = interleukin.

Several studies have examined whether PA reduces allergic reaction (wheal size in Type I hypersensitivity) in response to allergen or histamine exposure in allergic participants. A reduction in allergic response was found when pleasantness and relaxation were induced by hypnosis (Laidlaw, Booth, & Large, 1996) and when humor was induced by a movie (Kimata, 2001). However, Zachariae, Jorgensen, Egekvist, and Bjerring (2001) failed to find an influence of hypnotically induced happiness (nor anger and sadness) on allergic response as assessed by wheal size.

In a correlational study, Laidlaw, Booth, and Large (1994) found that those reporting more liveliness (bipolar liveliness–listless factor) and vigor (from POMS) had smaller allergy responses. They also found that greater liveliness and vigor were associated with lesser responses to higher concentrations of the allergen. Feelings of peacefulness assessed at baseline (on a bipolar peaceful–irritable scale) were related to less skin reactivity in the Laidlaw et al. (1996) study described earlier.

In sum, PA inductions in the laboratory were generally associated with acute quantitative and qualitative changes in immune response. The implications of most of these changes for health are not clear; however, the ability to produce these responses is seen as adaptive. Induced PA was, however, associated with a more interpretable immune outcome, a lesser allergic skin response. There is also evidence from field studies that both trait and state PA are associated with elevated SIgA levels, although there are only a smattering of studies of the association of PA and other immune outcomes in naturalistic environments.

How Could PA Influence Health?

The studies we have reviewed have generally been atheoretical in approach. Their reasons for using specific measures, or using state or trait affect measures, were unspecified, and the possible mechanisms through which PA would get under the skin were generally unstipulated and untested. To help provide a framework for understanding this literature and for planning future studies, we propose two models representing plausible pathways linking PA to health outcomes. The mechanisms we propose are meant to be general in nature and to potentially encompass disease incidence (onset), recurrence, severity, and recovery. The first addresses the direct effects of PA on behavior and physiological systems. The second proposes that it is psychological stress that triggers behavioral and physiological responses inimical to health, and PA influences health because it aids people in coping with stressful events (stress buffering). The models we present indicate paths moving in only one causal direction, from PA to health. Alternative paths are excluded for the sake of simplicity. Their exclusion is not intended to imply hypotheses about their existence.

The Main (Direct) Effect Model

In general, the main effect model best fits the idea that it is trait (or at least enduring state) PA that influences health outcomes. This is because the emotion has to last long enough to influence proposed mediating behaviors or physiological responses in a manner that would create a long-term risk. The exception would be a situation in which an acute arousing positive emotional experience triggers an event in an ongoing pathological process, for example, asthma or coronary heart disease. Thus, we expect trait PA to be associated with better health outcomes, and extreme "arousing" state PA to potentially be associated with the triggering of events in underlying diseases.

Health practices. As indicated in Figure 1, PA may directly influence health via changes in health practices. Higher state and trait PA have been associated with better behaviors such as improved sleep quality in both healthy samples and samples of people with narcolepsy (Bardwell, Berry, Ancoli-Israel, & Dimsdale, 1999; Fosse, Stickgold, & Hobson, 2002), more exercise (Ryff et al., 2004; Watson, 1988a), and more intake of dietary zinc (Cohen et al., 2003). However, one study failed to find differences between health practices reported by very happy individuals and those reported by less happy participants (Diener & Seligman, 2002). Better sleep, exercise, and diet have all been associated with lower risk for morbidity and mortality (e.g., Berkman & Breslow, 1983; Cohen, Tyrrell, Russell, Jarvis, & Smith, 1993; Luoto, Prattala, Uutela, & Puska, 1998; Wingard, Berkman, & Brand, 1994) and with more positive immune and cardiovascular profiles (Kiecolt-Glaser & Glaser, 1988). PA might also increase adherence to medical regimens among patients, resulting in less severe illness, faster recovery, and longer survival.

Autonomic nervous system activation. PA could also alter people's disease susceptibility via the dampening of SNS activity, decreasing HR, BP, and blood concentrations of the hormones epi and norepi. In fact, our review suggested that trait PA was generally associated with lower levels of epi and norepi. In contrast, PA inductions that involved more activated emotions or used active and engaging induction techniques generally result in increases in these markers of SNS response. This is consistent with the argument that extreme positive emotional experiences may trigger disease events, particularly among persons with underlying chronic illnesses.

Changes in cardiovascular response that have often been attributed to SNS activation might also be caused by PA-induced changes in PNS response. The PNS operates as a feedback system with the opposite effect of SNS activity. Hence, changes in the activation of this system could have effects similar to (but opposite of) those of the SNS. As discussed earlier, it is plausible that increases in PA would activate this control system, reducing cardiovascular response. However, at present it appears that under some conditions (possibly extreme positive emotional experiences), PA may result in downregulating this system and hence upregulating cardiovascular response.

Hypothalamic–pituitary–adrenal (HPA) axis activation. Another potential pathway by which PA might influence health outcomes is via hormones released by the HPA axis in response to affect. Regulation of cortisol is important in many physiological outcomes such as immune and inflammatory diseases. As indicated earlier, cortisol has been shown to decrease following the experimental induction of positive moods and with increasing levels of trait PA. Two other hormones, oxytocin and growth hormone, are thought to increase under PA, although there is little evidence for PA associations with these hormones at this time (Berk et al., 1989; R. A. Turner, Altemus, Enos, Cooper, & McGuinness, 1999; R. A. Turner et al., 2002). Increased concentrations of oxytocin decrease cortisol and BP, and growth hormone plays an important role in physical development and growth.

Endogenous opioids. PA could influence the opioid system via its influence on behaviors such as exercise and laughter (e.g.,
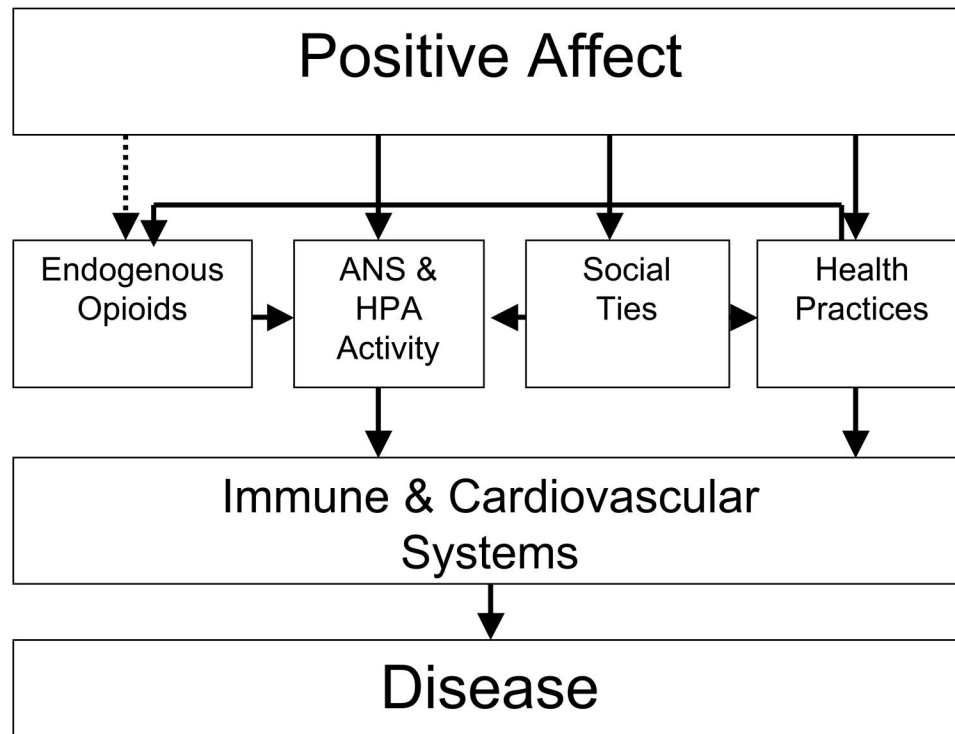
Figure 1. Main effect model showing behavioral and biological pathways linking positive affect (PA) to the onset or progression of physical disease. For brevity, the model indicates paths moving in only one causal direction (PA to disease). The dashed line indicates a theorized pathway without supporting evidence. ANS = autonomic nervous system; HPA = hypothalamic–pituitary–adrenal axis.

Harte, Eifert, & Smith, 1995; Martin, 2002; Pedersen & Hoffman-Goetz, 2000; Wildmann, Kruger, Schmole, Niemann, & Matthaei, 1986) or through general emotional activation (Gerra et al., 1996, 1998). Endogenous opioids may influence health by diminishing autonomic and endocrine activity (see Drolet et al., 2001, for a review) that might otherwise pose risks for health (see earlier discussion) or by altering immune function (see McCarthy, Wetzel, Sliker, Eisenstein, & Rogers, 2001, for a review). They may also be especially important in explaining the link between PA and pain response because opioids act to blunt the distressing, affective component of pain (see Drolet et al., 2001, for a review).

Immune function. As reviewed earlier, PA has also been associated with changes in immune function, another potential pathway to health (see Figure 1), although the exact nature of the relation is not entirely clear from the literature. Induced PA generally causes changes in circulating white blood cells and rises in SIgA antibody that are the same as those found in response to laboratory stress, suggesting a general arousal associated effect. However, there are other PA-induced effects that are provocative, including a reduction in allergic response, and a reduced inflammatory response in patients with RA.

Social factors. Prospective community studies found that social isolation is associated with increased risk of morbidity and mortality and that increased engagement in social network activities is associated with decreased risk (for reviews, see Cohen, 2004; House, Landis, & Umberson, 1988). Furthermore, social support is beneficial to survival from life-threatening illnesses

(Berkman, 1995; Helgeson, Fritz, & Cohen, 1998; Seeman, 1996) and is associated with improved immune outcomes (Cohen, 1988; Uchino, Cacioppo, & Kiecolt-Glaser, 1996). We believe that one major pathway by which trait PA might influence good health is via one's social networks and the health benefits associated with them. Persons who report more PA socialize more often and maintain more and higher quality social ties (e.g., Berry, Willingham, & Thayer, 2000; Diener & Seligman, 2002; Nelson, 1990; Lyubomirsky, King, & Diener, in press; Watson, 1988a; Watson, Clark, McIntyre, & Hamaker, 1992). PA may result in more and closer social contacts because PA facilitates approach behavior (e.g., R. J. Davidson, 1992) and because others are drawn to form attachments with pleasant individuals.

The Stress-Buffering Model of PA Influences on Health

As an alternative to the direct effect model, PA may influence health primarily through its ability to ameliorate the potentially pathogenic influences of stressful life events. This hypothesis is consistent with Fredrickson's (1998) "broaden and build" theory of positive emotions. She suggested that positive emotions encourage exploration and creativity and result in the building of social, intellectual, and physical resources via interactions and exploration (e.g., juvenile play) by broadening action tendencies. Similarly, Salovey and colleagues (2000) suggested that positive emotions generate psychological resources by promoting resilience, endurance, and optimism. Although the positive emotions themselves

may be short-lived, these resources are long lasting and may be drawn upon in moments of need, for example, when one is challenged by stressful events. The existence of these resources should facilitate coping and psychological resilience. Furthermore, there is evidence that PA is associated with more creative problem solving (see the discussion in Ashby, Isen, & Turken, 1999), which may too resolve stressors more quickly and result in health benefits.

Alternately, A. W. Smith and Baum (2003) suggested that PA may encourage restorative activities such as sleep, exercise, relaxation, vacation, and spending time in natural environments. In turn, these activities are thought to help reduce both stress appraisals and negative affective responses to stress. They also argued that positive emotions may protect persons from negative responses to stress through the release of endogenous opioids. As discussed earlier, endogenous opioids diminish autonomic and endocrine responses that are often triggered by stress.

Our model (see Figure 2) shows PA playing an important role at several points in the stress response. First of all, it is plausible that individuals high in PA experience less stress in their environment. For example, they are less likely to be involved in social conflicts. Moreover, when potential stressors are encountered, the social resources that are associated with PA help redefine (reduce) the potential for harm and bolster perceived ability to cope with imposed demands.

Alternatively PA may facilitate recovery from stress-related activation. To date, studies have found that inducing amusement or contentment following a stressful or fearful stimulus results in a faster return to baseline levels of cardiovascular reactivity as does

spontaneous smiling during a sadness-inducing stimulus (Fredrickson & Levenson, 1998; Fredrickson et al., 2000). In line with this, ambulatory studies have shown that HR increases last a shorter period after PA versus NA (Brosschot & Thayer, 2003) and that high happiness occurring naturally during a period of high anxiety counteracts BP increases that occur in the absence of happiness (Shapiro, Jamner, Goldstein, & Delfino, 2001). Similarly, there is some evidence of PA's buffering the negative immune impact of ambulatory negative mood in a study showing an interaction between positive and negative mood in predicting natural killer cell activity (Valdimarsdottir & Bovbjerg, 1997).

Finally, although we have avoided relaxation interventions in the review because they are not specifically designed to increase PA, they are relevant to stress reduction and may result in the cultivation of positive emotions either unintentionally or purposefully (Fredrickson et al., 2000). For example, studies have found that individuals with a history of coronary problems were able to reduce BP response to stress after relaxation training (e.g., Carson, Hathaway, Tuohey, & McKay, 1988; Gatchel, Gaffney, & Smith, 1986), suggesting that there may be future health benefits for these individuals. Whether the benefit is due to positive emotions or physiological muscle relaxation effects remains to be seen.

Discussion

We sought to determine whether PA contributes to physical health, with an emphasis on evidence from prospective and experimental studies. Overall, this is a heterogeneous literature in regard to measurement of PA, methodologies, outcomes, and results. It
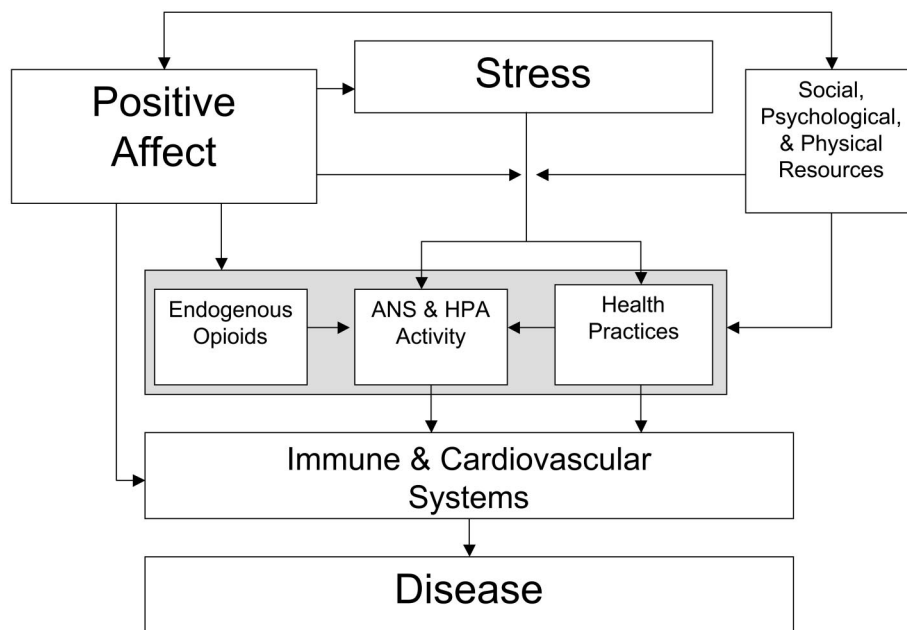

Figure 2. Stress-buffering model showing behavioral and biological pathways linking stress to disease onset or progression and indicating places in the process where positive affect (PA) may buffer the effects of stress. For simplicity, the model shows paths moving in only one direction (PA to disease). The dashed line indicates a theorized pathway without supporting evidence. The light gray box that contains several factors with PA pointing to the outside of the box indicates that PA influences all of those factors. ANS = autonomic nervous system; HPA = hypothalamic–pituitary–adrenal axis.

does not unequivocally indicate that PA is beneficial for health but instead suggests a more differentiated view of when PA matters. The patterns in the literature that we present next are tempered by the fact that the literature is atheoretical in nature and suffers from some serious conceptual and methodological problems that must be addressed in order to provide more definitive evidence.

What Health Outcomes Are Associated With Trait PA?

Literatures on morbidity, symptoms, and pain provide evidence for the benefits of trait PA. Evidence for lower mortality rates with greater trait PA is also consistent in studies of community-dwelling older individuals over the age of 60, but inconsistency and too few studies make it difficult to conclude anything about PA and mortality in other populations at this time. The evidence from literatures on severity and physical functioning is scattered. The pattern of the severity data (asthma and IBS) does, however, suggest the possibility that associations between PA and outcomes may vary with the extremity of the affective response, probably through its effects on arousal level.

As discussed earlier, associations of trait PA and self-report measures of health are likely, at least in part, attributable to PA's effects on perception and decision making (bias in the reporting of symptoms and pain as well as in seeking medical care). In contrast, trait PA associations with more objective health outcomes such as morbidity and mortality may be attributable to a range of behavioral, social, and physiological mechanisms discussed earlier.

Trait PA is thought to be a stable characteristic of the individual that is relatively impervious to manipulation. Even powerful positive events (e.g., winning a lottery) do not alter average mood levels for very long (Brickman, Coates, & Janoff-Bulman, 1978). Moreover, 44% to 52% of the variance in happiness is associated with genetic variation (Lykken & Tellegen, 1996), further suggesting the potential difficulty in manipulating levels.

What Health Outcomes Are Associated With State PA?

Survival.   There are too few studies of survival from life-threatening illness to conclude anything at this time. However, there is a pattern of results suggesting that those with diseases with high short-term mortality rates were harmed by high levels of PA, whereas those with diseases (or disease stages) with longer term expectations for living, where adherence to medical regimens and other behavioral factors (e.g., exercise, better sleep) could play a role, were benefited or unaffected by PA. High levels of PA in seriously ill populations could be harmful because they are associated with the underreporting of symptoms or overoptimistic expectations, both which could result in failure to seek medical care or to adhere to physician advice. In the case of the few QOL studies, positive emotions were not consistently associated with survival, although there is some evidence that energy (or the vigor and pep components of PA) was associated with a greater probability of surviving.

PA, physiological systems, and disease-related events.   Affect induced by PA manipulations in the laboratory usually last for several minutes. Those that involved high-activated emotions such as joy or excitement, or those that were personally engaging or required active behavioral responses, produced increases in markers of physiological arousal such as BP, HR, epi, and norepi. They also triggered arousal-associated effects such as increased numbers of circulating immune cells, increased levels of SIgA, greater colonic motility for patients with IBS, and poorer pulmonary function in patients with asthma. These results are in the same direction, but were usually of a lesser magnitude, than those found when negative moods such as anger and anxiety were induced. However, when PA inductions involved low-activated emotions such as calm or content, or when manipulations were passive in character, for example, when induced via movies or hypnosis, they generally produced very small increases in cardiovascular response and small decreases in cortisol response. The decrease in cortisol may have been associated with the relaxing–calming (antistress) aspect of the manipulations.

State PA in naturalistic studies lasted from minutes to a day. These studies provided mixed results and were a little difficult to parse. For example, the evidence is generally supportive of a PA-associated increase in BP but, at the same time, with more quiescent and often lower levels of stress hormones (epi, norepi, and cortisol) and higher levels of SIgA—an antibody that protects against respiratory illness. With regard to disease outcomes, state PA was typically associated with improved pulmonary function (peak flow) in individuals with asthma but was not associated with silent ischemia in persons with coronary heart disease.

Why the difference between the lab and the field? This is possibly because PA states as intense as those manipulated in the laboratory have a low base rate over a period of days or weeks (the time frame of the ambulatory studies that were conducted). Consequently, most PA assessed in these studies was probably more moderate and not intense enough to trigger physiological arousal and its associated effects on "events" for patients with chronically illness. In fact, in a single study that monitored for only "extreme moods," researchers found that there was a decrease in pulmonary function associated with both positive and negative moods (Ritz & Steptoe, 2000). Of interest, they also found that PA-elicited pulmonary function in the laboratory and PA-associated function in a field study were not correlated.

Combining the lab and naturalistic studies, it is likely that extreme rises in PA may act to increase physiological arousal and hence exacerbate an underlying disease process or increase risk of arousal-related events in persons with underlying disease states. In contrast, moderate levels of PA may be associated with more positive outcomes, possibly by acting as stress buffers. However, testing this assertion will require ambulatory measures more sensitive to affect magnitude, and studies that follow participants for longer periods of time so that they can detect low-base-rate events. It is noteworthy that even though a study may be adequate to detect effects of rises in negative emotions, it may not be adequate to detect the effects of rises in positive emotions where arousal-eliciting response is less common.

Self-reported health.   There is considerable evidence for associations between state PA and self-reported health outcomes. Experimental studies have found induced PA results in reporting fewer symptoms, less pain sensitivity, and more pain tolerance in both healthy participants and those with illness. Naturalistic studies have similarly found lesser reports of symptoms and pain in populations with illness, and although not as consistently, in healthy populations as well. As discussed elsewhere in this article, PA effects on self-reported health outcomes are likely attributable, in part, to affect influences on perceptions and judgments.

Are There Specific Positive Moods–Emotions That Influence Health?

Aggregation versus specificity. Is it important to distinguish between happiness, contentment, elation, joy, and other positive emotions, or do these affects cluster close enough in experience or in the manner by which they influence health that they should be treated as an aggregate? Few of the studies we reviewed explicitly compared different positive emotions or compared individual emotions to a PA aggregate. Overall, both aggregate and single-affect measures predicted health outcomes. Measuring happiness alone was the only single emotion used in multiple prospective studies. Despite the narrowness of this measure, happiness was associated with decreased mortality and increased longevity in four out of six studies, as well as with a decreased likelihood of hospital readmittance for patients with heart disease. Although happiness measures were not associated with survival benefits in populations with illness, other PA measures were similarly ambiguous in their survival effects. In sum, the evidence suggests that happiness is probably an important positive emotion for health. However, because little research has examined the effect of other single-emotion scales, it is unclear whether it has any unique properties in this regard.

Clearly, there is a need for future studies to compare individual emotions as well as compare single emotions to a PA aggregate. However, evidence that many people are insensitive to individual moods and report similarly responses across moods within a single valence (e.g., Feldman, 1995) raises questions about the potential importance of individual emotions.

High versus low activation. To the extent that activated emotions were associated with physiological (SNS or HPA-axis) arousal, they had the potential to influence health outcomes. For example, acute activated emotions (e.g., excitement) worsened asthma and IBS symptoms (at least in the laboratory) and were often associated with the same immune and cardiovascular changes as negative emotions, although not to the same extent. In contrast, studies that induced unactivated emotions such as calm and relaxed as well as those manipulating activated emotions with passive, less arousing PA manipulations had benefits for a number of immune and neuroendocrine parameters. Naturally occurring energy and vigor, however, appeared beneficial in some of the survival, severity, and morbidity studies. Future studies examining activated and unactivated components of affect separately in different populations (healthy and ill) could help to tease apart when arousal is beneficial to health and when it is detrimental.

Can Too Much PA Be Harmful to One's Health?

There are many hints in the existing literature that there are conditions under which PA is harmful to health. The few studies of institutionalized older individuals showed higher rates of mortality with higher rates of PA. This is possibly attributable to the unique characteristics of institutionalization. Suggestive evidence was also found on the associations of trait PA with mortality and survival and of state PA with asthma exacerbation. In H. S. Friedman et al.'s (1993) study of middle- to upper-middle-class, highly intelligent children, those with greater mortality risk had "extremely high" levels of PA. In studies of chronic or terminal illness, extremely elevated PA or too much PA relative to NA was associated with lower rates of survival. Finally, in laboratory studies of arousing PA and a naturalistic study focusing on extreme PA responses (Ritz & Steptoe, 2000), PA was associated with poorer pulmonary function.

It is possible that there is a curvilinear relationship between PA and health with risk decreasing as one moves from low to moderately high levels of PA, but increasing as one reaches extremely high levels. Moderate levels of PA may act as stress buffers, dampening potential arousal of daily hassles or even major stressful life events. Excessively high levels of PA may result in underestimating potential threats and the adoption of inappropriate coping strategies. In the case of the survival studies, this might include denial of the seriousness of disease and failure to adhere to medical advice. In fact, previous research has shown that individuals in positive mood states perceive themselves as less vulnerable to undesirable health conditions (see Salovey et al., 2000, for a review). Furthermore, when excessive, PA-elicited arousal may trigger disease-related events in persons with underlying chronic illnesses such as cardiovascular disease and asthma. This could occur through either arousal-triggered changes in health behaviors (e.g., more smoking, more alcohol consumption, or less exercise) or through activation of the SNS and HPA axis as found in exposure to stressful events.

This argument may not play out for psychological outcomes where recent work indicated that being very happy is not dysfunctional (Diener & Seligman, 2002; E. T. Friedman, Schwartz, & Haaga, 2002). However, studies of physical health have not generally considered scaling PA in relation to normal (average) levels within and between individuals, an approach that would help in comparing levels across studies and answering the question of whether existing associations between PA and health are linear or curvilinear.

Are There Alternative Explanations for PA Associations With Health?

PA or NA? Many of the studies we reviewed leave room for the possibility that NA is responsible for the apparent association between PA and health. This clearly creates a problem for interpreting some of the literature reviewed in this article. However, it is important to consider that in the well-accepted literature on negative emotions such as hostility, anger, and depression and health, there are virtually no attempts to account for the potential confound with positive emotions. This is especially relevant given that depression, which has been frequently associated with poor physical health outcomes (for reviews, see Irwin, 2002; Rugulies, 2002), is thought to be characterized by a combination of high levels of NA and low levels of PA (Watson & Clark, 1995). Given that several studies in the current review have found that the PA component of the CES-D depression scale was more powerful than (and independent of) the NA component (e.g., Moskowitz, 2003), it may be that previous supposed depression–health evidence is to some extent indicative of PA effects. We do not wish to imply that either NA or PA is the more important factor in physical health, only that they cannot be studied in isolation. Clearly, measures and statistical analyses that take into account the potential interdependence of NA and PA are essential for understanding the role of affect valence in health.

As mentioned earlier, the relation between PA and NA differs depending on the time frame (Diener & Emmons, 1984). The strongest negative correlation between the two types of affect occurs when acute emotional responses are reported, whereas the correlation decreases as the reporting time frame increases. Hence, measures of PA and NA aggregated over long periods tend to be relatively independent of one another. The studies we reviewed on PA and mortality and morbidity virtually unanimously assessed PA according to how the participants typically felt for several weeks or longer. This suggests that despite many studies not controlling for NA, because PA is relatively independent of NA over longer periods, NA levels are less likely to be responsible for these associations. Consistent with this argument, of the prospective studies showing benefits of trait PA on objective health that specifically included a control for NA, none found that including NA resulted in a loss of association between PA and health (Cohen et al., 2003; Moskowitz, 2003; Ostir et al., 2000, 2001).

Differences in underlying neurological activation for trait PA and NA suggest that there are fundamental differences in how the brain represents these traits. These differences may similarly imply differences in the direction and manner that they influence health. For example, PA-associated activations occur primarily in the left frontal cortex, whereas NA occurs in the right frontal cortex (J. M. Davidson, 1995; R. J. Davidson, Jackson, & Kalin, 2000; Harmon-Jones & Allen, 1998). Incidentally, left prefrontal cortex (PA-like) activation is also associated with improved immune function (R. J. Davidson, Coe, Dolski, & Donzella, 1999; R. J. Davidson et al., 2003; Kang et al., 1991). Neurotransmitters may also respond differently to PA than to NA. For example, trait PA was associated with increased serotonergic function after controlling for NA (Flory, Manuck, Matthews, & Muldoon, 2004).

Is PA confounded with physical health?   It is possible that measures of responses to *vigor* and related adjectives such as *active*, *alert*, and *energetic* (e.g., PANAS, POMS, and QOL measures) are markers of perceived health. Because perceived health predicts mortality over and above physician-rated health (see Idler & Benyamini, 1997, for a review), it is possible that correlations between PA and health outcomes (even prospective analyses controlling for objective baseline health assessments) occur merely because these "high-energy" PA adjectives are actually assessing perceived health. Of the mortality studies reporting higher PA associated with lower mortality risk, three controlled for perceived health. PA associations with longevity were maintained in two (B. R. Levy et al., 2002; Parker et al., 1992). Moreover, the possibility that some PA measures may tap perceived health does not provide an explanation for the associations between PA scales without a vigor component and morbidity and mortality (e.g., Koivumaa-Honkanen et al., 2000; Ostir et al., 2000, 2001; Palmore, 1969; Zuckerman et al., 1984). Especially relevant is the work by Cohen and colleagues (2003) showing that the three PA subcomponents (vigor, calm, and well-being) showed similar associations with susceptibility to verified upper respiratory illness. However, it does suggest benefits of assessing multiple individual dimensions of PA (see PANAS-X; Watson & Clark, 1994) and including controls for perceived as well as objective health status at the onset of studies of affect (whether PA or NA) as a predictor of morbidity and mortality.

Closely related concepts.   There are a number of psychological constructs that are closely tied to trait PA that might be responsible (act as third or spurious factors) for associations between PA and health in the correlational studies. Obvious alternatives include optimism, extraversion, personal control, purpose, and self-esteem. These constructs are typically moderately correlated with PA (e.g., rs = .17 to .54 for extraversion; Burger & Caldwell, 2000; De Neve & Cooper, 1998; Hills & Argyle, 2001; and rs = .45 to .75 for optimism; Chang, Maydeu-Olivares, & D'Zurilla, 1997; Hills & Argyle, 2001; Roysamb & Strype, 2002). The problem in discriminating between the effects of these social and cognitive constructs and that of PA is compounded by the inclusion of items tapping these concepts in "PA" scales used in some of the studies. One approach to clarify such results would be to separately examine the predictability of items or subscales that assess each factor (including pure PA). However, the greatest clarity would result from the inclusion of psychometrically valid instruments assessing these alternative constructs in studies of PA and health with analyses examining the independence of PA's contribution. For example, a recent study from our own laboratory found that trait PA predicted greater production of antibody in response to an immunization even after controlling for NA, extraversion, and optimism (Marsland, Cohen, Rabin, & Manuck, 2005). However, it is not unlikely that some of these closely related psychological constructs are intrinsically confounded with PA and that it might ultimately be impossible to clearly differentiate their effects.

Alexithymia.   Another potential confounder of the relationship between PA and health is *alexithymia*—an impairment of the identification, processing, and verbal expression of feelings. It is possible that persons low in PA actually have alexithymia. Alexithymia has been associated with psychiatric disorders such as depression (Honkalampi, Hintikka, Tanskanen, Lehtonen, & Viinamaki, 2000), panic disorder (Iancu, Dannon, Poreh, Lepkifker, & Grunhaus, 2001), eating disorders (Cochrane, Brewerton, Wilson, & Hodges, 1993), and posttraumatic stress disorder (Cochrane et al., 1993; Honkalampi et al., 2000; Iancu et al., 2001; Sondergaard & Theorell, 2004). It has also been associated with adverse health behaviors such as poor nutrition, greater alcohol and drug use, and a more sedentary lifestyle (e.g., Helmers & Mente, 1999), and in one study, it was associated with an increased risk for mortality (Kauhanen, Kaplan, Cohen, Julkunen, & Salonen, 1996).

Heredity.   Trait PA effects are particularly sensitive to alternative genetic explanations. To the extent that there is a genetic basis to the positive affective component of personality, those components might also influence the production of proteins that play a role in disease susceptibility.

Are There Other Methodological Weaknesses in This Literature?

Correlational studies.   As we have noted in the course of this review, common problems in the correlational literature include a lack of specific directional hypotheses; insufficient power (small sample sizes); and the use of many statistical tests, leaving the door open for Type I error. Because not all of these studies are focused on answering the questions about PA and health outlined in this article, analytic models are often inadequate to that task (e.g., inadequate control variables). This literature also relies totally on self-reported adjective scales. Studies using multichannel PA assessments, for example, adding peer report and the coding of nonverbal behavior (e.g., facial expressions) to self-reports, would

be less subject to reporting biases (Diener et al., 1991). Assessment of trait affect in this literature is also virtually always based on a single point of assessment. Such summary judgments can be disproportionately influenced by brief peak moods (Fredrickson & Kahneman, 1993), and studies that sample mood at several time points across a longer period (e.g., Cohen et al., 2003) would provide a better estimate of the experience of emotion. Sampling across multiple time points also allows investigators to distinguish the effects of deviation from the mean, peak emotional experiences, and emotion frequency versus average intensity (see Stone & Shiffman, 1994, on ecological momentary assessments). Finally, in ambulatory studies, the base rate of more extreme, arousing PA is quite low, making these studies insensitive to potential effects of arousing emotions. This might be addressed by monitoring participants for longer periods and by obtaining better assessments of mood intensity.

Experimental studies. Many of the experimental studies failed to assess whether the experimental manipulations succeeded in influencing the desired emotions. In addition, the degree to which a mood manipulation elicits arousal is a key issue. We found that manipulations that involved active participation or were particularly engaging to the participant typically elicited arousal-related effects, whereas more passive manipulations failed to do so. This suggests the necessity to more clearly distinguish effects of the mode of manipulation from the effects of a specific mood.

File-drawer bias. There is the possibility that there is a "file-drawer" bias to publish studies that demonstrate positive effects of PA on health. This may occur for two reasons. The first is the standard argument that the probability of publication is increased by statistical significance so that published studies do not represent the population of studies conducted (Rosenthal, 1991). The second is that the beneficial effect of PA has become an accepted belief in our culture. Such a bias may similarly result in a failure to publish disconfirming evidence.

What Are the Potential Pathways Linking PA to Health?

This literature is noteworthy with regard to the lack of tests of theoretical models that address how PA may influence health. Our own speculations about such pathways were described earlier in this article. Likely mediators such as health practices, stronger social networks, more positive and fewer negative interactions, and frequency of stressful events should be measured and tested in future studies. The potential that PA operates as a stress buffer (Fredrickson 1998), influencing the intensity of and recovery from stressful events, is also an area for future study.

Conclusions

Overall, we consider this literature provocative but not definitive. It does not unequivocally indicate that PA is beneficial for health but instead suggests a more differentiated view of when PA may have positive, negative, or no effects. It is a patchwork that we have brought together to gain a preliminary idea of what is known and begs for more sophisticated studies addressing the theoretical and methodological issues raised in this review.

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