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Maintaining Healthy Behavior: A Prospective Study of Psychological Well-Being and Physical Activity

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Abstract

Background—Although higher psychological well-being has been linked with a range of positive biological processes and health outcomes, the prospective association between psychological well-being and physical activity among older adults has been understudied.

Purpose—We tested whether higher baseline psychological well-being predicted higher levels of physical activity over time.

Methods—Prospective data were from the English Longitudinal Study of Ageing, a nationally representative sample of English adults over the age of 50. Our sample included 9,986 adults who were assessed up to six times across an average of 11 years.

Results—After adjusting for sociodemographic factors, each standard deviation increase in baseline psychological well-being was associated with higher median physical activity in linear regression models that examined physical activity across all six waves (β=0.20; 95% confidence interval [CI]: 0.18–0.21) and in linear mixed effect models that examined repeated measures of physical activity over the entire follow-up period (β=0.20; 95% CI: 0.19–0.21). Further, higher baseline psychological well-being was associated with a slower rate of decline in physical activity among people who were active at baseline (hazard ratio [HR]=0.79, 95% CI: 0.76–0.82) and increasing physical activity among people who were inactive at baseline (HR=1.28, 95% CI: 1.22–1.35). Findings were maintained after adjusting for baseline health status and depression.

Conclusions—Psychological well-being was independently associated with attaining and maintaining higher physical activity levels over 11 years, suggesting that it may be a valuable target for interventions aimed at helping older adults acquire more physical activity.

Keywords

psychological well-being; physical activity; exercise; epidemiology; health psychology

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Introduction

Physical activity is a key health behavior linked to enhanced physical functioning and cardiometabolic health, as well as reduced risk of several leading causes of death including cancer and heart disease [1–4]. A recent consensus report written by the four Chief Medical Officers of the United Kingdom (U.K.) advised people to increase physical activity levels due to its health-enhancing effects, as well as its potential role in reducing health care costs [5]. However, according to the British Heart Foundation, relatively few older adults in all four countries within the U.K. meet physical activity recommendations and these numbers worsen substantially after age 75 [6]. For example, in England, only 55% of men and women ages 55-64 meet recommended levels, and this drops to 36% of men and 18% of women in ages ≥75 [6]. In the next 20 years, the number of people in the U.K. aged ≥60 is projected to increase by nearly 50% [7]; further, the burden of chronic disease rises swiftly with age [8]. In combination, these age-related forces will likely result in poorer population health and exert an ever-increasing upward pressure on health care costs. Given research suggesting that initiating and sustaining recommended levels of physical activity can have substantial health benefits even if initiation does not occur until older adulthood, interventions that increase population levels of physical activity may provide one approach for reducing the projected burden of poor health [9]. Because rates of physical activity are moderate among middle-aged adults and seem to drop as people age, a key challenge is to identify not only modifiable factors that reduce the likelihood of declining activity levels, but also factors that contribute to the initiation and maintenance of physical activity as people age.

Research suggests that psychological factors can impact the likelihood that individuals either meet or fail to meet recommended levels of physical activity. For example, one study followed individuals for eight years and found that those with higher baseline anxiety or depression were less likely to meet recommended physical activity levels initially and also over time [10]. Beyond psychological distress, a growing body of prospective research also shows that psychological well-being (e.g., life satisfaction, optimism, positive affect, and purpose in life) is independently associated with a wide range of enhanced physical health outcomes [11–14]. Psychological well-being is a multidimensional construct encompassing unique factors that do not simply reflect the absence of distress, but rather represent the positive feelings, cognitions, and strategies of individuals who function well in their life and evaluate their life favorably [12,15]. Various studies have demonstrated that different facets of psychological well-being are prospectively associated with reduced risk of cardiovascular disease, cognitive decline, and mortality [11–14,16]. However, the underlying pathways that link psychological well-being with better health outcomes are unclear. Investigators have speculated that physical activity may be one mechanism behind these associations [12]. Psychological well-being may promote physical activity by buffering the negative effects of stress exposure as well as by influencing other key psychological processes that affect whether individuals engage in physical activity. Individuals with high stress exposure often develop chronic psychological distress [17], which in turn is associated with decreased physical activity [10]. Psychological well-being may blunt the deteriorative effects of stress exposure because it fosters resilience (e.g., accelerated recovery from stressors experienced throughout the day). As an example, experimental studies have demonstrated that one component of psychological well-being—positive affect—leads to accelerated cardiovascular recovery after exposure to stressful stimuli [18,19]. Psychological well-being may also lead to higher physical activity via a number of additional processes. For example, people with higher psychological well-being levels expect and seek favorable life outcomes, and as a result they are more likely to persist at goals, plan for future challenges, and cope effectively with difficulties [20]. Thus, psychological well-being may lead to higher physical activity levels because it influences key psychological processes that impact whether individuals engage in physical activity such as: goal setting, self-efficacy, motivation, self-regulation, and perceptions of risk [1,21,22].

Although previous studies have reported positive associations between psychological well-being and physical activity [23–25], the majority have been cross-sectional. However, for physical activity to act as an explanatory factor in the association between psychological well-being and improved health, assessment of psychological well-being must precede assessment of physical activity. To date, most longitudinal evidence has shown that physical activity may lead to enhanced psychological well-being, but evidence for the reverse is lacking or limited in five key ways [26–32]. First, some studies used data from specific subpopulations (e.g., adolescents, college students) or patient groups (e.g., people with coronary heart disease) and we do not know if results from these studies generalize to healthy populations or older adults (among whom activity levels tend to decrease). Second, most studies did not account for depression or other types of psychological distress; given prior work linking higher symptoms of depression and anxiety with lower levels of physical activity [10], we cannot determine if effects of psychological well-being are independent of distress. Third, some studies used measures of psychological well-being that have not been psychometrically evaluated, while others used single item measures that may be unreliable. Fourth, some studies assessed only leisure-time physical activity, even though physical activity performed at work can be substantial, especially in some professions. Fifth, many studies had short follow-up times (<12 months) and could not examine changes in physical activity or assess whether levels improved or declined over time. Lengthy follow-up is important given the difficulty of not only initiating, but also maintaining physical activity over time.

Thus, it remains unclear if psychological well-being is prospectively related to physical activity, especially among older adults. The present study examined whether psychological well-being serves as a health asset by enhancing the likelihood that individuals meet recommended levels of physical activity. Using data from the English Longitudinal Study of Ageing (ELSA), we tested the hypothesis that older adults with higher baseline levels of psychological well-being would engage in more physical activity over time. We also hypothesized that higher baseline psychological well-being would be associated with reduced likelihood of declining physical activity levels among people who were initially active, and increased likelihood of initiating or increasing physical activity levels among people who were initially inactive. Based on prior work we identified relevant covariates for consideration including sociodemographic factors, initial health status, and depression.

Methods

Study Population

Data were from the ELSA cohort, an ongoing and nationally representative panel study of community-dwelling English adults aged 50 and older. The core sample was drawn from households who participated in the Health Survey for England during 1998, 1999, and 2001. Individuals were eligible for ELSA if they were part of the Health Survey for England and aged ≥50 on April 1, 2002 when the first wave of ELSA started. Since its inception, ELSA respondents have been surveyed every two years. A total of 11,392 people participated in Wave 1 of ELSA (2002–03). Follow-up interviews took place in 2004–05 (Wave 2), 2006–07 (Wave 3), 2008–09 (Wave 4), 2010–11 (Wave 5), and 2012-13 (Wave 6). The current study considered Wave 1 as baseline and included individuals who participated in at least Wave 1 and also contributed physical activity data in at least one additional follow-up wave; individuals who joined ELSA in later waves were excluded from our analyses. Respondents were also excluded if they had missing data on baseline psychological well-being (> half items in the well-being scale were missing; n = 1,232) or on any covariates (n=170), or no data on physical activity in any of the waves (n = 4), yielding a final analytic sample of 9,986. Compared to respondents who were excluded from analyses because of missing data, those who were included were younger, more likely to be men and White, and had higher education and incomes; however, they did not differ on psychological well-being. Ethical approval was obtained from the Multicentre Research and Ethics Committee and all respondents provided written informed consent. More detailed information about ELSA can be found elsewhere [33].

Measures

Psychological Well-Being—Psychological well-being was assessed at baseline and all subsequent waves using the CASP-19, which was specifically developed to capture multiple domains of psychological well-being in older adults [34]. Items for the CASP-19 were created based on the theoretical framework that four core needs must be met for humans to achieve psychological well-being, including: control, autonomy, self-realization, and pleasure. Respondents were asked to use 4-point Likert scales to rate the degree to which they endorsed statements such as: "I look forward to each day" and "I feel that my life has meaning." Two items were removed from the scale because they conceptually overlapped with physical health, which could confound results. The two excluded items were: "My age prevents me from doing the things I would like to" and "My health stops me from doing things I want to do." Some respondents only partially completed the well-being items. If respondents completed at least 9 of the 17 items, their missing values were imputed with the mean value of non-missing items, resulting in 811 respondents (8.12%) with imputed CASP-17 values [35]. Among those with imputed values, the majority (79%) were missing only one or two items. To create an overall well-being score, negatively worded items were reverse scored and all 17 items were summed, with higher scores reflecting higher well-being, or the extent to which all 4 core needs are met. The CASP-19 has demonstrated good construct validity in ELSA and other samples [34,36], and the modified CASP-17 demonstrated high internal consistency reliability in this study (*Cronbach's* $\alpha = 0.86$). CASP-17 scores were standardized (M = 0, SD = 1) to facilitate interpretation and comparison of effect sizes across studies. Additionally, we created psychological well-being tertiles based on the distribution of scores to evaluate possible discontinuous effects. Mean well-being scores by tertile were: 29.7 (low), 39.7 (medium), and 45.8 (high).

Physical Activity Measurement—At all waves, respondents were asked about the frequency and intensity of their physical activity at work and during leisure time. The questions were from the Health Survey for England and the European Prospective Investigation into Cancer and Nutrition (EPIC) Short Physical Activity Questionnaire [37,38], and have been validated against information collected through accelerometer and heart rate monitor data [9,37]. For example, one study validated the physical activity questionnaire by asking 116 ELSA respondents to wear objective accelerometry devices for seven consecutive days. Self-reported physical activity data and the accelerometry data were correlated (Spearman's $r = 0.21$, $p = 0.02$). Although the correlation was modest, it is similar to associations found for physical activity instruments commonly used in large epidemiologic studies [37].

Responses were categorized by ELSA data managers into four rank ordered categories (sedentary = 1, low = 2, moderate = 3, and high = 4) to reflect classifications used in the Allied Dunbar Survey of Fitness [39]. Categories were defined as follows: *Sedentary* (not working or sedentary occupation, engages in mild exercise 1–3 times a month or less with no moderate or vigorous activity); *Low* (standing occupation, engages in moderate leisure-time exercise once a week or less and no vigorous activity; OR engages in mild leisure-time activity at least 1–3 times a month, moderate activity once a week or less and no vigorous activity; OR has a sedentary or no occupation and engages in moderate leisure-time activity once a week or 1–3 times a month, with no vigorous activity); *Moderate* (does physical work; OR engages in moderate leisure-time activity more than once a week; OR engages in vigorous activity once a week to 1–3 times a month); *High* (heavy manual work or vigorous leisure activity more than once a week). Given that these levels of physical activity were normally distributed at each wave of assessment we treated this ordinal variable as a continuous measure in analyses [40].

Covariates—Covariates included sociodemographic factors, health status, and depression. All covariates were assessed at baseline (Wave 1). Sociodemographic covariates included age (in years), sex (men, women), race (White, non-White), education (University degree, higher education but no University degree, A level [exam-centered qualification for people wanting to enter University], O level [a national-level school exam taken at age 16 for people who want to leave the school system; no equivalent exam exists in the United States], less than O level), and total weekly income (in pounds). Health status was assessed by evaluating the presence or absence of self-reported doctor diagnosis on eight medical conditions: (1) chronic lung disease, (2) asthma, (3) arthritis, (4) osteoporosis, (5) cancer/malignant tumor (excluding minor skin cancers), (6) Parkinson's disease, (7) Alzheimer's disease, or dementia/other serious memory impairment, and (8) cardiovascular conditions including angina, heart attack, congestive heart failure, or stroke. A binary variable was created to indicate having no chronic conditions versus one or more. Depression was assessed by self-report of a doctor's diagnosis of depression (yes, no).

Statistical Analysis

Associations between psychological well-being and physical activity were evaluated in several ways. First, linear regression was used to examine if baseline psychological well-being was associated with an individual's median physical activity levels across the entire follow-up period. Second, generalized linear mixed effect models were used to analyze the association between baseline psychological well-being and repeated assessments of physical activity levels in each respondent over time. This analytic approach accounts for correlations among repeated measures across time within each subject, as well as variability between subjects. It also has the ability to handle unequally spaced intervals between observations. Coefficients for these models were estimated using maximum likelihood and a compound symmetry structure was used for the covariance matrix [41]. Third, Cox proportional hazards models were used to examine the likelihood of declining into sedentary or low physical activity levels among participants who reported moderate or high physical activity at baseline. A fourth set of similar Cox proportional hazard models examined the likelihood of taking up moderate or high physical activity among people who were sedentary or had low physical activity at baseline. In both of these Cox proportional hazard models, baseline psychological well-being was used in order to assess whether initial levels of well-being were associated with the likelihood of declining or increasing physical activity levels over time.

For all analyses, several sets of models were tested. First, we evaluated a minimally-adjusted model that included age, gender, and race as covariates (Model 1). We then considered the impact of sequentially adding other potential confounders such as socioeconomic status (income and education; Model 2), health status (Model 3), and then depression (Model 4). Psychological well-being was first considered as a continuous and then a categorical variable (i.e., tertiles of psychological well-being).

The proportional hazards assumption for the Cox models was tested following Kleinbaum and Klein's recommendations (i.e., including interaction terms between time and covariates in models) [42]. Although psychological well-being violated the assumption of proportionality, three sensitivity analyses showed that the violation was not meaningful. First, we compared the original results to those that included a psychological well-being by time interaction and they were similar (Table S1). Second, we examined the interaction between psychological well-being and time (which was divided into three separate time periods) to evaluate how the association between psychological well-being and physical activity might differ across time. This analysis showed the associations were similar in all of the time periods (Table S2). Third, we visually inspected the Kaplan Meier survival curves and observed that psychological well-being's association did not substantially vary over time (Figure S1). Based on findings from these sensitivity analyses, we present the standard Cox model analyses.

Based on previous research and standard practice [10], we conducted several additional analyses to reduce potential concerns about associations in the reverse direction (i.e., more physical activity at baseline precedes and predicts higher levels of psychological well-being over time). First, we used linear regression to examine baseline psychological well-being's association with an individual's median physical activity levels across time using physical activity from only Waves 2-6 (excluding Wave 1 physical activity). Second, we used similar modeling techniques (generalized linear mixed effect models) that we used in the main analyses, but instead included baseline physical activity level (Wave 1) as the independent variable and repeated assessments of psychological well-being over time (Waves 1-6) as the dependent variable to examine if initial levels of physical activity are associated with subsequent levels of psychological well-being over time. If initial physical activity levels influence subsequent levels of psychological well-being, we would expect to see either that higher versus lower baseline levels of physical activity are associated with a more rapid rate of increase in psychological well-being over time, or with a slower rate of decline in psychological well-being over time.

All results reported in the current study used ELSA sampling weights to account for the complex multistage probability survey design, except for the linear mixed effect models (due to controversy about how such weights should be incorporated) [43]. All analyses in this study were run using SAS 9.4.

Results

Descriptive Statistics

The average age of respondents at study baseline was 63.7 years (SD = 10.6). Respondents were primarily women (55.7%) and tended to have less than an O level education (53.1%). Most respondents identified as White (97.7%) and a little more than half reported having any chronic condition at baseline (52.4%). Table 1 describes the distribution of covariates by tertile of psychological well-being; Figure 1 displays the mean level of physical activity at each wave by tertile of baseline psychological well-being. Physical activity levels were correlated across time (*r*s ranged from 0.52 to 0.61 across waves).

Psychological Well-Being and Median Physical Activity Across Time

Higher psychological well-being was associated with higher median physical activity across all waves after adjusting for sociodemographic factors (β=0.20; 95% confidence interval [CI]: 0.18–0.21), and findings persisted after adjusting for additional covariates (fully adjusted β=0.19, 95% CI: 0.17–0.20). Considering psychological well-being tertiles, we did not find evidence of a threshold or discontinuous effect, but rather a graded relationship. For example, compared to adults in the lowest psychological well-being tertile, those in the middle tertile had higher median physical activity (β=0.29; 95% CI: 0.25–0.32) and those in the highest tertile had the highest median physical activity levels (β=0.42; 95% CI: 0.38–0.45) after adjusting for demographics. These associations remained significant and of similar magnitude in models that adjusted for additional covariates, including depression.

Psychological Well-Being and Rate of Change in Physical Activity Over Time

Mixed models that adjusted for sociodemographic factors indicated that higher baseline psychological well-being was associated with higher physical activity at each time point during follow-up (β=0.20; 95% CI: 0.19–0.21). A main effect of time was also evident, such that physical activity levels decreased over time (β=−0.03; 95% CI: −0.03–−0.03). The interaction term indicating whether the rate of change in physical activity differed depending on level of psychological well-being was marginally significant, but in the direction opposite to expectations (β=−0.002; 95% CI: −0.004–−0.0001). Participants with higher versus lower initial levels of psychological well-being had a somewhat faster decline in physical activity over time. Findings in these models were largely unchanged after adjusting for the full set of covariates, including depression (Table 2).

A graded relationship was evident when considering main effects of tertiles of psychological well-being. Compared to participants in the lowest tertile of psychological well-being, those in the middle tertile had somewhat higher physical activity (β=0.28; 95% CI: 0.25–0.31), while those in the highest tertile had the highest physical activity levels (β=0.41; 95% CI: 0.38–0.45). Associations remained significant in models adjusting for all covariates. However, in this fully-adjusted model, the interaction term between tertiles of psychological well-being and time was not statistically significant (data not shown).

Psychological Well-Being and Likelihood of Changing Physical Activity Over the Follow-Up Period

Among 6,030 participants who engaged in moderate or high physical activity at baseline, 47.2% declined into sedentary or low physical activity over the 11-year follow-up. With each standard deviation increase in baseline psychological well-being, participants had up to a 23% reduced hazard of becoming sedentary or rarely engaging in physical activity (Table 3). Results using tertiles of psychological well-being were similar. Compared to those with the lowest levels of well-being, individuals with moderate well-being had 24% reduced hazard (fully adjusted HR= 0.76, 95% CI: 0.69–0.82) and those with the highest well-being had 33% reduced hazard (fully adjusted HR= 0.67, 95% CI: 0.61–0.73) of engaging in low levels of physical activity. Notably, all findings were maintained after adjusting for chronic conditions and depression. Considering the 3,956 participants who initially reported sedentary or low physical activity, each standard deviation increase in psychological well-being was associated with an increased likelihood of becoming more active over the follow-up period (fully adjusted HR=1.25, 95% CI: 1.19–1.32).

Additional Analyses

Findings from mixed models considering physical activity from only Waves 2-6 were highly similar to those that included physical activity from Waves 1-6 (change in parameter estimates was less than 5% across all models). Additional mixed models evaluated the possibility that physical activity drives subsequent levels of well-being rather than vice versa, but did not suggest this was likely. The main effect of physical activity was statistically significant such that higher baseline levels of physical activity were associated with higher levels of psychological well-being at each time point during follow-up (Table S3). A main effect of time was also evident whereby psychological well-being decreased over time. However, the interaction term evaluating whether the rate of change in psychological well-being differed depending on initial physical activity levels showed that psychological well-being in fact decreased somewhat faster over time among participants with higher baseline physical activity (although some associations did not reach statistical significance).

Discussion

This is the first study to examine whether psychological well-being is associated with more physical activity and changes in physical activity over time in a large sample of older adults with a substantial follow-up period. In this nationally representative sample of English adults ages ≥50, higher baseline psychological well-being was associated with higher median physical activity over a period of 11 years. Results remained strong even after adjusting for health status and depression, suggesting that the association is independent of these factors. Moreover, in two separate time-to-event analyses we found that higher baseline psychological well-being was beneficial for older adults regardless of whether they were initially physically active or inactive. Thus, among initially active adults, higher baseline well-being was associated with a lower likelihood of becoming less active. Among adults who were initially inactive, those with higher psychological well-being had a greater likelihood of becoming more active.

The association of interest was also robust to various sensitivity analyses. Evidence for an association between baseline physical activity and changes in psychological well-being over follow-up was limited. Results that excluded versus included Wave 1 physical activity were virtually identical, suggesting that physical activity at Wave 1 was unlikely to be associated with both psychological well-being at the outset and with subsequent levels of physical activity. Further, if baseline physical activity led to higher psychological well-being over time, we would expect that people with higher versus lower baseline physical activity would show either increases in psychological well-being over time, or a slower rate of decline in psychological well-being. However, findings did not reflect either of these patterns (and in fact hinted at regression to the mean with higher versus lower initial physical activity levels associated with greater declines in subsequent psychological well-being), suggesting that baseline physical activity did not strongly predict changes in psychological well-being during follow-up. Our findings may initially appear to contradict prior research linking baseline physical activity with higher subsequent psychological well-being. However, this may be due to differences in study design. Past research has either been experimental, with strong protocols for inducing physical activity [44], or observational studies that have primarily considered associations of baseline physical activity with median levels of psychological well-being over time; such analyses are functionally cross-sectional as they do not examine trends of psychological well-being over follow-up. Study designs that can examine effects on *changes* in psychological well-being over time are methodologically stronger for assessing whether physical activity levels precede and predict psychological well-being.

Somewhat surprisingly, higher psychological well-being was not associated with a slower rate of decline in physical activity over the follow-up period. Rather, participants with higher initial psychological well-being declined somewhat faster in physical activity. Given that levels of physical activity at baseline were substantially higher among those with higher psychological well-being, we speculate this counterintuitive finding may be explained by regression to the mean. Moreover, physical activity levels typically decline as people age (as demonstrated in Figure 1). Given that adults with initially lower psychological well-being also had lower levels of physical activity at the outset, there could be a floor effect; it may be difficult to detect rates of change among people who start with lower physical activity.

Results in the Context of Prior Research

Findings from this study may help explain the growing body of research that has linked psychological well-being with better health. For example, higher psychological well-being has been associated with reduced risk of chronic disease, for which physical activity is an important behavioral determinant [11,12,45–47]. Results from this study also fit within the context of the broader body of research demonstrating associations between psychological well-being and a wide set of healthier behaviors. For example, facets of well-being like life satisfaction have been linked with a higher likelihood of using preventive health screenings such as cholesterol tests, mammograms or x-rays, pap smears, and prostate exams [48]. However, few prior studies have assessed well-being's associations with changes in health behavior over time, particularly with regards to whether psychological well-being may help to maintain healthier behaviors throughout older adulthood.

Public health and health care professionals often have difficulty persuading adults to increase physical activity. Results from this study suggest that higher levels of psychological well-being may precede increased physical activity; therefore, it is possible that psychological well-being could be a novel target for prevention and intervention efforts. Three recent meta-analyses of randomized controlled trials demonstrate that psychological well-being is modifiable through interventions [49–51], some of which are specifically tailored for older adults [52,53]. Intervention strategies range from structured classroom-style instruction and activities to brief writing exercises about happy life events or best possible future outcomes. While some interventions are more time-intensive, others are relatively brief and may be incorporated into practice more easily. Studies suggest the effects of these interventions can last at least up to six months; whether they are effective over a longer period is yet to be determined as longer follow-up periods have not been examined. These interventions have shown that psychological well-being can be improved, which may translate into downstream benefits for general health outcomes and, more specifically, physical activity. Indeed, at least one study has suggested the effectiveness of targeting psychological well-being to improve physical activity. This was demonstrated in a randomized controlled trial with 242 people recruited immediately after percutaneous coronary intervention [54]. Individuals in both the control and intervention groups received patient education; however, those in the intervention group also completed exercises designed to enhance positive emotions and emphasize personal values. One year after initiating the intervention, participants in the intervention group were 1.7 times more likely to achieve physical activity goals compared to participants in the control group. Together with findings from the current study, this work suggests that psychological well-being may be a promising target for interventions seeking to increase physical activity.

Although past studies have shown that depression is associated with decreased physical activity [10], the current study provided little evidence that the associations between psychological well-being and physical activity are simply due to the absence of depression. In all analyses, the association between psychological well-being and physical activity was minimally changed after adjusting for depression. This finding adds to previous research showing that psychological well-being has unique associations with health-related outcomes, even after adjusting for psychological distress [12].

Limitations and Strengths

Our study has some limitations. Although participants were both men and women with a range of socioeconomic backgrounds, there were relatively few non-White participants. Future studies should reexamine these hypotheses with more diverse samples. Because both psychological well-being and physical activity were self-reported, self-report bias remains a possibility. However, participants were unaware of this study's hypotheses when completing the survey, psychological well-being levels were reported prior to repeated reports of physical activity levels, and physical activity items were validated against objective accelerometry and heart rate monitor data [9,37]. However, future studies may benefit from using objective measures of physical activity. Further, the analytic method used in this study did not directly assess a potential reciprocal association between psychological well-being and physical activity. However, concerns that findings are primarily due to reverse or mutual causation are mitigated by the null findings regarding baseline physical activity's association with subsequent well-being across time. Future studies could address this question using other analytic methods such as cross-panel models. In addition, confounding by unmeasured variables is always a limitation in observational research. However, findings were maintained after careful control for multiple sociodemographic variables, chronic conditions, and also depression.

The sizes of associations in this study were relatively small. However, similar to determinants of many disease outcomes, determinants of health behaviors are likely multifactorial and any one variable will likely contribute only modestly to such outcomes. For example, associations between blood pressure and mortality, smoking and mortality, or aspirin given to patients after myocardial infarction to increase survival are less than $r = 0.1$ [55]. However, these small effect sizes translate into meaningful changes in standard of care and policy because they can save many lives at the population level. A similar logic may apply to our findings, where small associations can translate into meaningful changes in physical activity when considered at the population level.

The small effect sizes may also be attributable to the limited range assessed by the physical activity variable with values ranging from 1-4; when comparing means levels of physical activity between the groups with high versus low psychological well-being, the mean difference in physical activity was approximately 0.5 on a 4-point scale, equivalent to approximately a 12.5% increase in level of physical activity. However, this is a clinically relevant improvement, as suggested by a recent study which found that among individuals engaging in low to moderate physical activity levels, each additional 15 minutes per week of physical activity was associated with a 4-14% reduction in all-cause mortality, depending on initial levels of physical activity [56]. Thus, an increase of 0.5 on our physical activity scale is roughly equivalent to the health benefits accrued from a 6-15% increase in time spent engaging in physical activity. Although small, these differences in physical activity represent important gradations. Further, some of the effects of well-being may be cumulative across a person's lifespan, which may further bolster the impact of relatively small effects. This study also has considerable strengths. Data were from a large, prospective, and nationally representative sample of English women and men over the age of 50. Further, ELSA is one of the few epidemiological studies with detailed information about psychological well-being, a broad set of potential risk factors, and repeated measures of physical activity over a long follow-up period. Therefore, we were able to adjust for appropriate covariates. Further, the primary exposure of psychological well-being was assessed with a psychometrically validated and widely used measure. Finally, the prospective nature of our data mitigates concerns that the associations reported in this study are attributable to an association in the reverse direction or retrospective reporting bias.

Implications

A recent report from the British Heart Foundation shows that a large percentage of older adults are falling short of physical activity recommendations [6]. Enhancing physical activity, even in late age, is associated with health benefits [9], and results from this study suggest that higher levels of psychological well-being are prospectively associated with increased physical activity. Further, randomized controlled trials have shown that psychological well-being can be altered [49–51]. Therefore, interventions that target psychological well-being may be a novel way of not only enhancing psychological health, but also increasing physical activity—which in turn could improve the physical health of a large segment of people who are moving into the ranks of an aging society.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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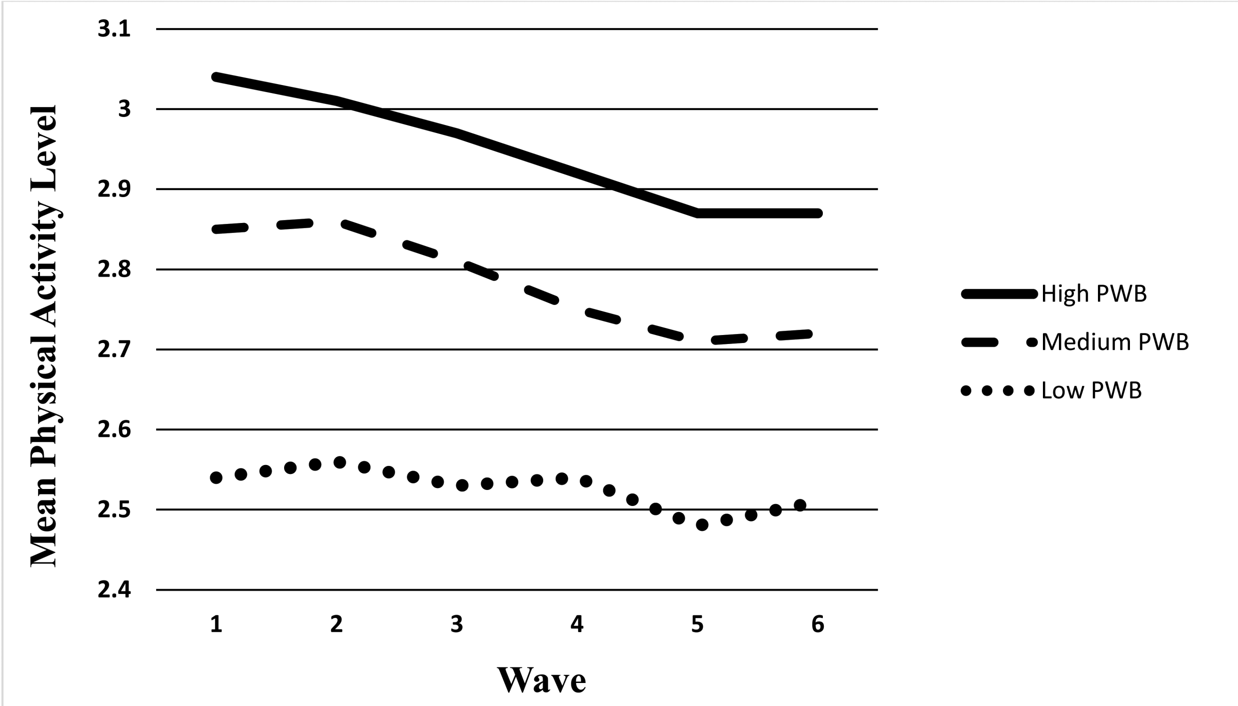

Figure 1.

Mean physical activity by tertile of psychological well-being (all participants, N=9,986).

Table 1

Distribution of respondent characteristics at baseline by level of psychological well-being.

	Psychological Well-Being			
	Low	Medium	High	
Characteristic	**n=3,294**	**n=3,097**	**n=3,595**	**p-value**
Psychological well-being, M (SD)	29.7 (5.86)	39.7 (1.69)	45.8 (2.19)	
Age, M (SD)	65.4 (10.7)	65.0 (9.87)	63.9 (9.26)	<.0001
Equivalized weekly income, M (SD)	216.4 (280.1)	253.7 (195.5)	302.5 (310.7)	<.0001
Sex				0.0206
Men	1542 (46.8)	1451 (46.9)	1581 (44.0)	
Women	1752 (53.2)	1646 (53.2)	2014 (56.0)	
Race				<.0001
White	3191 (96.9)	3036 (98.0)	3547 (98.7)	
Non-white	103 (3.13)	61 (1.97)	48 (1.34)	
Education				<.0001
University degree	248 (7.53)	325 (10.5)	567 (15.8)	
Higher education (no degree)	280 (8.50)	343 (11.1)	510 (14.2)	
A level	191 (5.80)	171 (5.52)	250 (6.95)	
O level	484 (14.7)	528 (17.1)	628 (17.5)	
Less than O level	2091 (63.5)	1730 (55.9)	1640 (45.6)	
Chronic conditions				<.0001
Yes	2164 (65.7)	1638 (52.9)	1574 (43.8)	
No	1130 (34.3)	1459 (47.1)	2021 (56.2)	
Depression				<.0001
Yes	326 (9.90)	120 (3.87)	93 (2.59)	
No	2968 (90.1)	2977 (96.1)	3502 (97.4)	

Table 2

Linear mixed effect models examining association between baseline psychological well-being and changes in physical activity over Waves 1-6 (N=9,986). Values are beta estimates (95% CI).‡

	Model 1	Model 2	Model 3	Model 4
Psychological well-being (per SD)	0.22 (0.20 – 0.23)*	0.20 (0.19 – 0.21)*	0.19 (0.17 – 0.20)*	0.19 (0.17 – 0.20)*
Time (per year)	−0.03 (−0.03 – −0.02)*	−0.03 (−0.03 – −0.03)*	−0.02 (−0.03 – −0.02)*	−0.02 (−0.03 – −0.02)*
Psychological well-being*Time	−0.002 (−0.004, 0.00004)†	−0.002 (−0.004, −0.0001)†	−0.002 (−0.003, 0.0003)†	−0.002 (−0.003, 0.0003)†
Age (per year)	−0.03 (−0.03 – −0.03)*	−0.03 (−0.03 – −0.03)*	−0.03 (−0.03 – −0.02)*	−0.03 (−0.03 – −0.02)*
Male sex	0.15 (0.13 – 0.18)*	0.13 (0.11 – 0.15)*	0.12 (0.10 – 0.14)*	0.12 (0.10 – 0.14)*
Non-white race	−0.18 (−0.26 – −0.09)*	−0.19 (−0.27 – −0.11)*	−0.19 (−0.27 – −0.11)*	−0.19 (−0.27 – −0.11)*
Income (per SD)		0.03 (0.01 – 0.04)*	0.02 (0.01 – 0.04)*	0.02 (0.01 – 0.04)*
Education at Wave 1				
University degree		0.24 (0.20 – 0.28)*	0.23 (0.19 – 0.27)*	0.23 (0.19 – 0.27)*
Higher education (no degree)		0.15 (0.12 – 0.19)*	0.15 (0.11 – 0.19)*	0.15 (0.11 – 0.19)*
A level		0.12 (0.07 – 0.17)*	0.12 (0.07 – 0.16)*	0.12 (0.07 – 0.16)*
O level		0.13 (0.09 – 0.16)*	0.12 (0.09 – 0.15)*	0.12 (0.09 – 0.15)*
Less than O level		Ref	Ref	Ref
Chronic conditions			−0.14 (−0.16 – −0.12)*	−0.14 (−0.16 – −0.12)*
Depression				0.002 (−0.05 – 0.05)

*p < 0.05

†p < 0.10

‡all variables were assessed at baseline

Table 3

Cox time-to-event analysis. Hazard ratio (95% CI) of becoming sedentary or having low physical activity among participants with moderate or high physical activity at baseline (N=6,030).‡

	Model 1	Model 2	Model 3	Model 4
Psychological well-being (per SD)	0.77 (0.74, 0.80)*	0.79 (0.76, 0.82)*	0.81 (0.78, 0.84)*	0.81 (0.78, 0.84)*
Age (per year)	1.05 (1.05, 1.06)*	1.05 (1.05, 1.05)*	1.05 (1.04, 1.05)*	1.05 (1.04, 1.05)*
Male sex	0.71 (0.67, 0.76)*	0.74 (0.70, 0.80)*	0.76 (0.72, 0.82)*	0.76 (0.72, 0.82)*
Non-white race	1.38 (1.05, 1.80)*	1.36 (1.04, 1.79)*	1.39 (1.05, 1.85)*	1.39 (1.05, 1.85)*
Income (per SD)		0.93 (0.86, 1.01)†	0.93 (0.86, 1.01)†	0.93 (0.86, 1.01)†
Education at Wave 1				
University degree		0.59 (0.51, 0.67)*	0.59 (0.51, 0.67)*	0.59 (0.51, 0.67)*
Higher education (no degree)		0.78 (0.70, 0.88)*	0.78 (0.70, 0.88)*	0.78 (0.70, 0.88)*
A level		0.84 (0.72, 0.99)*	0.85 (0.73, 1.00)†	0.85 (0.73, 1.00)†
O level		0.86 (0.78, 0.94)*	0.86 (0.79, 0.95)*	0.86 (0.79, 0.95)*
Less than O level		Ref	Ref	Ref
Chronic conditions			1.39 (1.29, 1.50)*	1.39 (1.29, 1.50)*
Depression				1.00 (0.85, 1.16)

* $p < 0.05$

† $p < 0.10$

‡ all variables were assessed at baseline