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Physical Behavior, Optimism and Positive Affect in Older Women

Author
Ryu, Rita Hana

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Physical Behavior, Optimism and Positive Affect in Older Women

A thesis submitted in partial satisfaction of the requirements
for the degree Master's degree

in

Public Health

by

Rita H. Ryu

Committee in charge:

Professor John Bellettiere, Chair
Professor Andrea Z. LaCroix
Professor Britta Larsen

2021

The thesis of Rita Ryu is approved, and it is acceptable in quality and form for publication on microfilm and electronically.

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DEDICATION

This study is dedicated to my late father Dr. Seh Man Ryu, PhD, and my mother Yumi Park Ryu, MS - both immigrated to pursue graduate degrees in the US. I hope their and my academic accomplishments inspire my children, Hana and Calvin, to pursue their dreams.

EPIGRAPH

Don’t let the perfect be the enemy of the good

-François-Marie Arouet

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ABSTRACT OF THE THESIS

Physical Behavior, Optimism and Positive Affect in Older Women

by

Rita H. Ryu

Master of Public Health

University of California San Diego, 2021

Professor John Bellettiere, Chair

Background Psychological well-being is closely linked to healthy aging in older women. Our study aims to elucidate inconsistencies in the literature on the relationships between physical behavior (physical activity and sedentary behavior) with optimism and positive affect using comprehensive, well-validated and objective measures in a large, diverse sample of older women.

Methods Our study of 4168 women (aged 63-99) with accelerometer-measured data from the Women's Health Initiative (WHI) study assessed associations of physical behavior (moderate-vigorous physical activity [MVPA], light physical activity [LPA], sitting time, and mean sitting bout duration) with optimism and positive affect using multiple linear regression models. Effect modification by age, race/ethnicity, multimorbidity, and social support was examined for all study associations.

Results In unadjusted models, positive associations for physical activity and negative associations for sedentary behaviors were present for both optimism and positive affect and associations were generally linear. In adjusted models, for every increased hour of MVPA, optimism increased by 0.4 score points [95% CI 0.2, 0.6, *p*-value <0.001] and positive affect increased by 0.6 score points [95% CI 0.2, 0.9, *p*-value=0.001]. For LPA, positive affect increased by 0.2 [95% CI 0.03, 0.33, *p*-value=0.02] and for sedentary behavior, a negative association existed for mean sitting bout duration and positive affect (β=-0.1, 95% CI -0.10, -0.02, *p*-value=0.002). Although there was not strong evidence of statistically significant interaction, differential effect estimates by age showed possible effect modification; all associations were stronger in women ≥80 years old compared to those <80 years old.

Conclusions Observed associations between physical behavior with optimism and positive affect were modest but robust over the average study period of one to two years. We recommend age-appropriate, attainable interventions that encourage older women to move more than they are currently. The known benefits of increased physical activity combined with the upward spiral effects of increased physical activity and improved well-being can ultimately improve many other aspects of this population's physical and psychosocial health.

INTRODUCTION

Women aged 65 years and older represent a large and growing population projected to exceed 50 million or 12.5% of the population in the United States (US) by 2060.[1] Women live longer, experience higher rates of morbidity, disability, depression, and anxiety compared to men.[2,3] Physical health and healthy aging are closely linked to psychological well-being, which includes eudaimonic (life satisfaction and functioning) and hedonic (high positive and low negative emotions) aspects of well-being.[4] Therefore, understanding factors that improve psychological well-being for the growing population of older women will be essential to reduce future health and economic burdens in the US. Although considerable research about psychological well-being exists, our study strives to extend the current knowledge on two particular aspects: (1) optimism – a "thinking" or eudaimonic component; and (2) positive affect – a hedonic component. Specifically, we aim to further understand the associations of intensity, duration, and patterns of physical behaviors (physical activity [PA] and sedentary behavior) with optimism and positive affect in older women and whether these relationships vary by age, race/ethnicity, comorbidities, and social support.

Optimism, defined as the expectation of positive future events, is associated with lower age-related morbidity and mortality in postmenopausal women.[5] Two recent, large longitudinal studies found significant associations between higher optimism and healthy aging, defined as good cognitive and physical function with no major chronic diseases,[6] in women, suggesting that the trait is not only related to longevity but also to improved health and functioning in older years.[7,8] Furthermore, studies show that higher levels of optimism are related to health-promoting behaviors including healthier diet and smoking behaviors in older women.[7,9]

Positive affect, described as the experience of pleasurable emotions, is a modifiable state that improves biological and psychological health.[10,11] Higher levels of positive affect have been associated with lower morbidity in older adults[12] and reduced levels of chronic pain in women.[13] According to Fredrickson's broaden-and-build theory, positive emotions create an upward spiral to boost wellness behaviors.[10] The supported mechanisms include the following: the "undo effect" of positive emotions which provides resources to regulate negative emotional experiences; "broadening" awareness which increases openness to behavioral options; and "building" trait resilience which is associated with improved life satisfaction.[10]

Strong evidence suggests that older adults with higher levels of PA experience lower rates of mortality, cardiovascular disease, some cancers and have higher cognitive function and physical functioning.[14] Independent of PA, longer sedentary time and bouts are also associated with higher risk of all-cause mortality and chronic diseases (cardiovascular disease, type 2 diabetes, and some cancers).[15-17] Additionally, studies have established the association between higher levels of exercise and higher optimism[9,18] and the effects of exercise on increases in positive affect;[19] however, the most commonly-used positive affect measures capture active, energetic states. Pressman confirmed that the overlap with these "active, energetic" items and self-reported exercise scales can lead to overstatement of the size of the associations.[20] Therefore, past research investigating the benefits of positive emotions on health may have been driven partially or primarily by physical activity, not emotion.[21] These issues highlight why the use of objectively-measured PA and positive affect measures without the high energy components are needed to advance our understanding.

Although it is well-established that more physical activity and less sedentary behavior reduce the risk for depression,[22-24] the relationships between physical behaviors with psychological well-being in older populations have generally been modest or null. Most studies with observed associations used constructed categories for optimism and positive affect (e.g. low vs high) and measured physical behavior through self-reported questionnaires, which tend to be inaccurate for light physical activity (LPA) and sedentary behavior because of recall difficulty.[25] A large Women's Health Initiative (WHI) study showed that highest compared to lowest baseline quartiles of optimism was predictive of higher self-reported recreational, vigorous activity (OR=1.15, 95% CI 1.06-1.24).[9] Another large study of older adults showed that higher levels of self-reported leisure time PA was associated with higher scores of a mental well-being measure, which included positive affect and optimism items, (Warwick-Edinburgh Wellbeing Scale [WEMWBS] scores 1.25 points higher, 95% CI=0.34, 2.16); however, the study found no association with accelerometer-measured PA at moderate or light levels of intensity.[26] Other studies of older adults observed small effect sizes between self-reported moderate-vigorous physical activity (MVPA) and positive affect[27-29] with one of the recent studies showing no association between self-reported physical behaviors and optimism.[28] A large study with accelerometer-measurement found a small positive relationship between life satisfaction and LPA ($p<0.001$), but not with MVPA,[30] and a randomized control trial observed contradictory findings – no associations between well-being measures and LPA, small positive associations with MVPA (r=0.19-0.22), and small negative associations with sedentary behavior (r=-0.09 to -0.16).[31] Elucidating the inconsistencies in the literature can deepen our understanding of the mechanisms between physical behaviors with optimism and positive affect and improve development of interventions for this population.

The objective of this cross-sectional study was to extend the current literature on the relationship of accelerometer-measured physical behavior (MVPA, LPA, sitting time, and mean sitting bout duration) with optimism and positive affect within the WHI Objectively Measured Physical Activity and Cardiovascular Health (OPACH) study. We hypothesized that higher levels of physical activity and lower levels sedentary behavior would be positively correlated with optimism and positive affect in older women.

METHODS

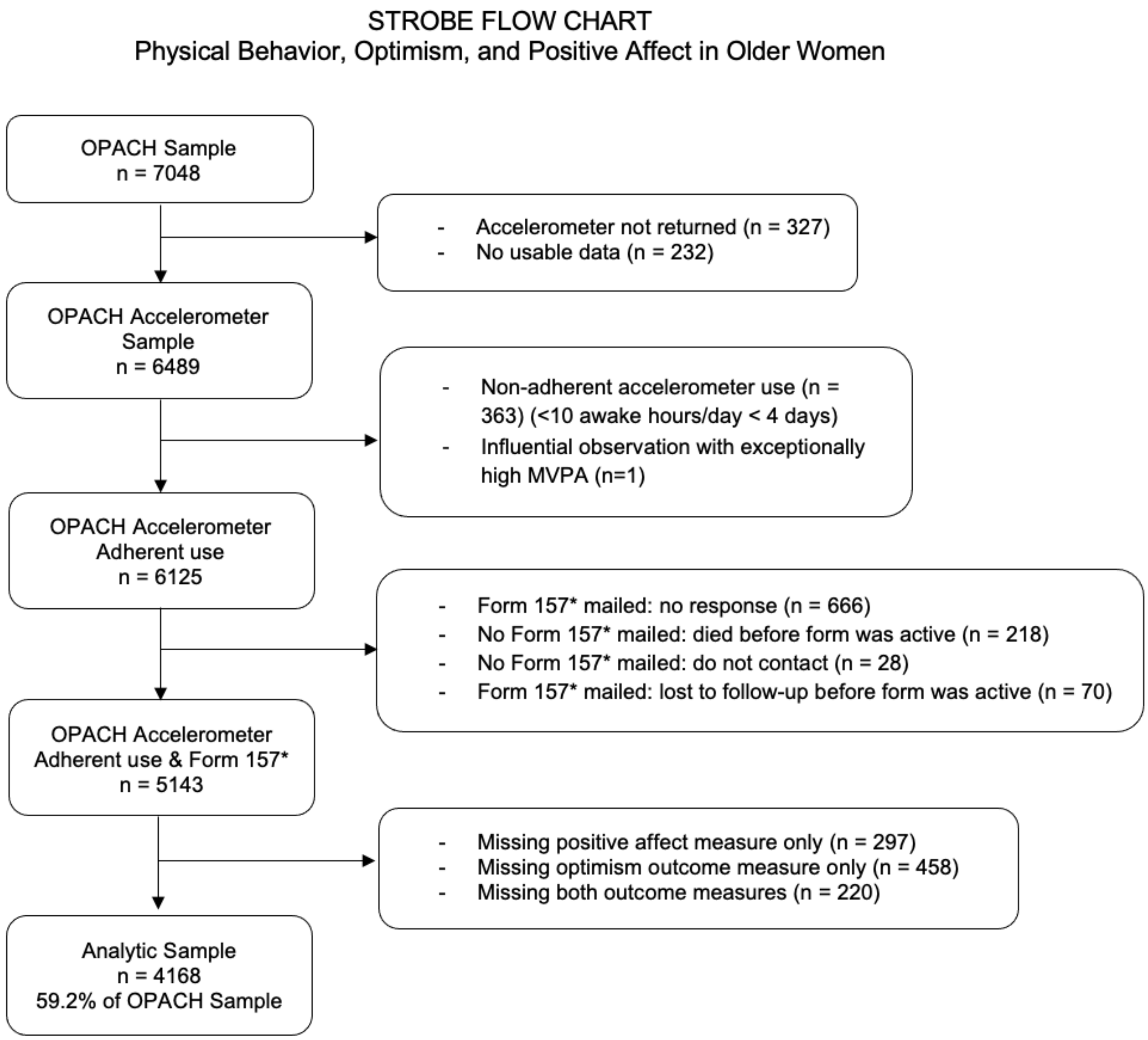
Study Description and Design

This cross-sectional investigation includes participants from the Objectively Measured Physical Activity and Cardiovascular Health (OPACH) Study, an ancillary study embedded within the Women's Health Initiative (WHI). Details about WHI have been extensively described.[32] Briefly, the WHI enrolled postmenopausal women, aged 50 to 79 years old, from 40 clinical sites across the US between 1993 and 1998.[32] The Long Life Study (LLS) was developed as part of the second WHI Extension Study to support healthy aging research and included an in-home assessment of height, weight, physical function, and other measures.[33] Non-Hispanic Black and Hispanic/Latina women were oversampled and comprise half the cohort of 7875 women. Participants from LLS were also invited to participate in OPACH at the time of consent. OPACH is a prospective study of accelerometer-measured physical activity (PA) and chronic disease outcomes that consented 7048 ambulatory, community-dwelling, WHI participants aged 63 to 99 years.[33]

From the OPACH study, 6489 women returned accelerometers with usable data; those with less than 4 days of 10 or more waking hours of wear time (n=363) and one with exceptionally high moderate-to-vigorous PA (n=1) were excluded. Additional exclusions came from participants who did not return the questionnaire (n=982) or returned a questionnaire with missing data for the outcome measures (n=975). See Figure 1 for more detail.

For the present study, 4168 participants with adherent accelerometer data and both outcome measures were included in analyses. The Fred Hutchinson Cancer Research Center institutional review board approved protocols for the Long Life Study and OPACH, and UC

San Diego's IRB approved subsequent OPACH data analyses. All women provided informed consent either in writing or orally by telephone. This report followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline.



* Form 157 questionnaire included optimism and positive affect outcome measures

Figure 1: Strobe flow chart: Physical activity, behavior, optimism, and positive affect in older women.

Measures

Exposure Measurement: Physical Behavior

Physical behavior measures included physical activity and sedentary behavior. Physical activity intensity and duration were operationalized with measures of moderate-to-vigorous physical activity (mean hours/day) and light physical activity (mean hours/day). Sedentary behavior duration and patterns were operationalized with measures of sitting time (mean hours/day) and mean sitting bout duration (minutes).

Physical Activity. Physical activity measures included moderate-to-vigorous (MVPA), light (LPA), and total PA. Between March 2012 to April 2014, the OPACH study provided an ActiGraph GT3X+ triaxial accelerometer (ActiGraph Corp; Pensacola, Florida) to be worn over the right hip 24 hours per day for 7 days, except when the device could be submerged in water (e.g. bathing, swimming),[33] and participants concurrently kept sleep logs of their in-bed and out-of-bed times each night. Accelerometer data were originally collected at 30 Hz and then integrated to 15-second epochs using the normal-frequency filter within ActiLife version 6 software (ActiGraphcorp.com). Accelerometer non-wear periods were identified and removed using the Choi algorithm.[34] Sleep time was removed using reported in-bed and out-of-bed times from sleep logs. Missing bedtimes were imputed using participant-specific mean times or, if all data were missing, the OPACH population mean.[35] Variation in PA time due to differences in accelerometer awake wear time was addressed using the residualized method.[36]

Accelerometers were calibrated specifically for older women in a separate laboratory study of 200 women from the same OPACH population.[37] MVPA defined as activity requiring 3.0 or more metabolic equivalents, was measured as the mean number of minutes per day with vector magnitude counts per 15-second epoch of at least 519. LPA was computed as the mean number of minutes per day with sufficient movement that the vector magnitude counts per 15-second epoch were between 19 and 518.[37] Total PA is the sum of MVPA and LPA. As recommended, PA measures were computed as the mean hours per day using data from days with 10 or more hours of awake wear time.[38]

Sedentary Behavior. Sedentary behavior included sitting time and sitting patterns (measured using the mean sitting bout duration). Sedentary behavior measures were computed using output from machine learning algorithms that were trained among older adults specifically to measure sitting behavior. These models were built on our previous work leveraging artificial intelligence along with concurrently collected pictures taken every 10 seconds and accelerometer data measured 30 times per second to identify sitting, standing, walking, riding a bike, and riding in a vehicle.[39] These early models were optimized for use among all adults,[40] further refined to specifically pinpoint transitions between sitting and standing that enable more accurate measurement of sitting patterns[41] and recently retrained using data from over 981 men and women. In a hold-out test sample of 421 adults, the new models exhibited an average sensitivity of 95.3% and specificity of 89.8% for predicting sitting time, when ground truth sitting time was measured using the current standard for ambulatory measurement of sitting (activPAL thigh-worn inclinometer; data not yet published but available upon request). From these data, the average amount of time spent sitting each day was be used to measure total sitting time computed as the mean hours per day. Consecutive minutes of sitting was classified as sitting bouts (with no minimum requirement and no tolerance) and the mean sitting bout duration was used to measure sitting accumulation patterns.

Outcome Measurement: Optimism and Positive Affect

Optimism. Optimism was assessed between August 2014-2015 using the Revised 6-item Life Orientation Test (LOT-R)[42,43] composed of six items relating to their expectations of the future (e.g. "I'm always hopeful about my future") scored on a five-point Likert scale from 1 "strongly disagree" to 5 "strongly agree." The 3 pessimism items were reverse-coded and all 6 items were summed to generate a summary score that ranged from 6 [low] to 30 [high], with higher scores indicating greater optimism. The scale initially yielded Cronbach's alpha of 0.78, test-retest reliability of 0.79 at 28 months, and good discriminant and convergent validity on a sample undergraduate students.[42] In populations of older post-menopausal women, psychometric assessments demonstrated good internal consistency (Cronback alpha=0.75)[7] and test-retest reliability (0.61 over a 4-year period).[44] Furthermore, a recent WHI study, which included this study's participants, also confirmed good reliability and validity (Cronbach alpha=0.79).[45]

Positive Affect. Positive Affect was measured between August 2014-2015 using the 9-item modified Differential Emotions Scale (mDES)[10] composed of past 24-hour intensity ratings for nine emotions (e.g. amusement, gratitude) scored on a five-point Likert scale from 1 "not at all" to 5 "very much." All rated items were summed to generate a summary score that ranged from 9 [low] to 45 [high], with higher scores indicating greater positive affect. Negative affect items of the mDES were not assessed in the WHI-OS. A recent mDES assessment successfully measured positive affect with good reliability and validity (Cronbach's alpha=0.9) in the WHI cohort.[45]

Covariates

Confounding, effect-modification, and mediating variables were identified *a priori* based on published literature. Self-reported covariates were measured at OPACH baseline or by the WHI questionnaire completed closest to and before the OPACH baseline.

Age at OPACH baseline was computed based on the first day of accelerometer wear. Other covariates were categorized as follows: race and/or ethnicity (Non-Hispanic White, Non-Hispanic Black, or Hispanic/Latina); highest level of education attained (≤high school, some college, or college graduate); current smoking (yes, no); alcohol use (never, <1 per week, 1-2 per week, 3-4 per week, 5-6 per week, everyday); live alone (yes, no), social support (Medical Outcomes Study (MOS): range 9 [low] – 45 [high]);[46] sleep disturbance (range 0 [low] – 20 [high]);[47] pain (SF-36 pain 2-item construct range 0– 100 [higher score indicates a more favorable health state with respect to pain]);[48] and depression symptoms (shortened version of the Center for Epidemiological Studies Depression Scale (CES-D): 0-1 range [higher score indicates a greater likelihood of depression] was dichotomized at 0.06.[49] Body mass index (BMI), calculated by dividing weight measured by a calibrated analog scale in kg by square of height in meters measured by a stadiometer. The Short Physical Performance Battery (SPPB),[50] a measure of lower extremity physical function, assessed through a series of objective physical tests of balance, gait speed, strength, and endurance[50] were obtained from in-home visits. Antidepressant use included 2012 current use of the following medication classes: tetracyclics, monoamine oxidase inhibitors (MAOIS), modified cyclics, selective serotonin reuptake inhibitors (SNRIS), tricyclic agents, and miscellaneous antidepressants.

Number of chronic conditions at OPACH baseline was characterized using outcomes ascertained by self-report and physician adjudication (0, 1, 2, 3+, or undetermined categories) including the following 11 chronic conditions that are recognized to be highly prevalent and burdensome to older women: cancer, cerebrovascular disease, cognitive impairment, cardiovascular disease, diabetes, frequent falls, chronic obstructive pulmonary disease, osteoarthritis, depression, urinary incontinence, and sensory impairment. Multimorbidity is defined as having at least two chronic conditions and has been operationalized as having two or more chronic conditions from the list of 11.[51] Given the high prevalence of multimorbidity in the population being studied (two-thirds of U.S. adults ≥65 and more than 80% of US adults ≥85)[52,53] and its association with lower functional status and quality of life, the absence or presence of multimorbidities was used for stratification and evaluation of effect modification.

Statistical Analyses

Descriptive data for baseline characteristics were examined and then summarized by quartiles of total PA. Differences by quartile of total PA were evaluated by analysis of variance (ANOVA) for continuous variables and chi-square tests for categorical variables.

To justify reporting single beta coefficients for the entire distribution, we tested linearity by overlaying smoothed conditional linear and polynomial regression models minimally adjusted for age and race/ethnicity with 95% CI bands on scatterplots for each association. Form, direction, strength, and the presence of outliers between the exposure and outcome variables were visually inspected.

Associations of physical behavior with optimism and positive affect were tested using multiple linear regression in models that were progressively adjusted as follows: Model 1 included age and race/ethnicity. Model 2 additionally adjusted for socio-economic and lifestyle behavior confounders: educational attainment, current smoking, and alcohol use. Model 3 was the main confounder-adjusted model and included Model 2 covariates and living alone, social support, sleep disturbance, and pain. In addition to Model 3 covariates, Model 4 includes the following measures, which we believe are potential mediators but could also be classified as confounders: BMI, number of chronic diseases, depression symptoms, antidepressant use, and SPPB. Although mediation analysis was not possible in this cross-sectional study, we adjusted for potential mediators to confirm whether non-mediating associations were present. To assess potential bias from missing covariate data, we generated results using multiple imputation by chained equations implemented with the MICE package in R based on 15 imputations and 30 iterations. Residual plots for linearity, constant variance, and normality were reviewed and variation inflation factors were assessed for multicollinearity—no strong evidence against using multiple linear regression was observed.

Effect modification was tested by including multiplicative interaction terms in the main model (Model 3) between the exposure and each potential effect modifier that was selected *a priori* based on literature: women <80 and ≥80 years old, race and/or ethnicity, social support <40 and ≥40 (median split), and multimorbidity status (no=0-1 and yes=2+ chronic conditions). For visualization of differential associations by subgroups, models were repeated, stratified by each potential modifier. All analyses were conducted in RStudio version 3.6.1 (RStudio, Inc. Boston, MA USA) and statistical tests were two-tailed with $\alpha=0.05$ and 95% confidence intervals.

Sensitivity Analyses

To assess potential selection bias, baseline characteristics were compared among the analytic sample (n=4168) and accelerometer-adherent participants who were missing outcome measures (n=1957) using analysis of variance (ANOVA) for continuous variables and chi-square tests for categorical variables. To assess potential for bias due to missing covariate data, multiple linear regression results generated by models using multiple imputation were compared to results generated with models using complete case analysis.

We evaluated whether the overall optimism score acted as single bipolar dimension or two separate dimensions by examining the LOT-R optimism and pessimism subscales as outcomes.[54,55] Results from multivariable linear regression models of physical behavior with each LOT-R subscale were compared to results from models in which the overall optimism score was the outcome.

RESULTS

Table 1 shows baseline characteristics for our sample of 4168 women [age range 63-99, mean = 78.1+/- 5.7 years] by quartile of time spent in total physical activity (PA). Approximately half the women (50.7%) self-identified as non-Hispanic White, 31.5% as non-Hispanic Black, and 17.8% as Hispanic/Latina. Women in the highest total PA quartile compared to those in the lowest were younger (76.1±6.1 vs 80.3±6.5 years) and less likely to be non-Hispanic White (40.5% vs 62.5%), non-drinkers (30.2% vs 39.5%) and live alone (38.0% vs 55.9%) compared to the women in the lowest quartiles of total PA. Those in the highest quartile also had fewer chronic conditions (66% vs 48% had less than 2), lower BMI (26.1 vs 30.3), higher physical function (SPPB scores 9.2 vs 7.6) and reported less relative pain (71.8 vs 62.3) and anti-depressant use (8.9% vs 14.7%).

Results from linear regression models are reported as single beta coefficients for the entire distribution after visual inspection showed that associations of physical behavior with optimism and positive affect were generally linear. For example, overlaying minimally adjusted linear and non-linear (polynomial with three knots) regression models resulted in overlapping 95% CI for each studied relationship (Figure 2). The scatterplots showed positive associations for MVPA (Pearson's correlation coefficient [$r_{optimism}$=0.11, $r_{positive\ affect}$=0.08]) and LPA and ($r_{optimism}$=0.04, $r_{positive\ affect}$=0.06) negative associations for sitting time ($r_{optimism}$= -0.04, $r_{positive\ affect}$= -0.05) and mean sitting bout duration ($r_{optimism}$= -0.05, $r_{positive\ affect}$= -0.07).

Table 1: Baseline characteristics by Quartile of Time Spent in Total Physical Activity (PA), Women's Health Initiative Objective Physical Activity and Cardiovascular Health Study (n=4168)

	Quartiles (Q) of Total Physical Activity[a] (hours/day)				
Characteristics	Q1 (n=1042)	Q2 (n=1042)	Q3 (n=1042)	Q4 (n=1042)	*p*-value
Total physical activity[a] (h/d), *mean (SD)*	3.8 (0.6)	5.2 (0.3)	6.1 (0.3)	7.6 (0.8)	NA
Age (years), *mean (SD)*	80.3 (6.5)	78.2 (6.5)	77.6 (6.5)	76.1 (6.1)	<0.001
Race/Ethnicity, *n (%)*					<0.001
Non-Hispanic White	651 (62.5)	536 (51.4)	501 (48.1)	424 (40.7)	
Non-Hispanic Black	277 (26.6)	342 (32.8)	335 (32.1)	361 (34.6)	
Hispanic/Latina	114 (10.9)	164 (15.7)	206 (19.8)	257 (24.7)	
Highest education, *n (%)*					0.07
High school or less	180 (17.4)	200 (19.4)	192 (18.6)	211 (20.3)	
Some college	425 (41)	398 (38.6)	364 (35.2)	373 (35.9)	
College graduate or more	431 (41.6)	432 (41.9)	479 (46.3)	455 (43.8)	
Current smoker, *n (%)*	37 (3.8)	25 (2.5)	25 (2.5)	19 (1.9)	0.07
Alcohol consumption, *n (%)*[b]					<0.001
Never	385 (39.5)	362 (36.7)	326 (32.6)	300 (30.2)	
<1 per week	358 (36.7)	369 (37.4)	357 (35.7)	327 (32.9)	
≥1 per week	232 (23.8)	255 (25.9)	316 (31.6)	367 (36.9)	
Live alone, *n (%)*	531 (55.9)	435 (45.3)	404 (42.5)	365 (38.0)	<0.001
Social support, *mean (SD)*	36.9 (7.8)	37.8 (7.7)	37.9 (7.5)	38 (7.4)	0.001
Sleep disturbance, *mean (SD)*	7.4 (4.7)	7.1 (4.7)	7.3 (4.7)	6.9 (4.5)	0.08
Pain[c], *mean (SD)*	62.3 (27.6)	65.2 (25.5)	68.4 (24.2)	71.8 (22.7)	<0.001
BMI (kg/m2), *mean (SD)*	30.3 (6.1)	28.8 (5.6)	27.4 (5.3)	26.1 (4.7)	<0.001
Chronic Conditions[d]					<0.001
0 or 1	493 (47.5)	562 (54)	575 (55.3)	683 (65.6)	
2 or 3+	545 (52.5)	478 (46)	464 (44.7)	358 (34.4)	
Depression symptoms[e], *n (%)*	60 (6.4)	54 (5.7)	55 (5.8)	46 (4.8)	0.52
Antidepressant use, *n (%)*	153 (14.7)	122 (11.7)	104 (10)	93 (8.9)	<0.001
Physical function (SPPB), *mean (SD)*	7.6 (2.6)	8.5 (2.3)	8.8 (2.2)	9.2 (2.2)	<0.001

Abbreviations: SD, standard deviation; NA, not applicable; BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); SPPB, short physical performance battery, WHI, Women's Health Initiative.

p-value: ANOVA for continuous variables and chi-squared for categorial variables.

[a]Adjusted for accelerometer awake wear time using residuals method. Total Physical Activity is the sum of Moderate-Vigorous Physical Activity and Light Physical Activity.

[b]Full variable categorization (never, <1/week, 1-2/week, 3-4/week, 5-6/week, everyday) used for models and p-values.

[c]Higher pain score indicates a more favorable health state in regards to pain.

[d]Sum of cancer, cerebrovascular disease, cognitive impairment, sensory impairment, cardiovascular disease, chronic obstructive pulmonary disease, diabetes, frequent falls, urinary incontinence, depression, and osteoarthritis. Full variable categorization (0, 1, 2, 3+) used for models and p-values.

[e]Shortened Center for Epidemiologic Studies Depression Scale (CES-D), ≥0.06 categorized as depression symptoms.

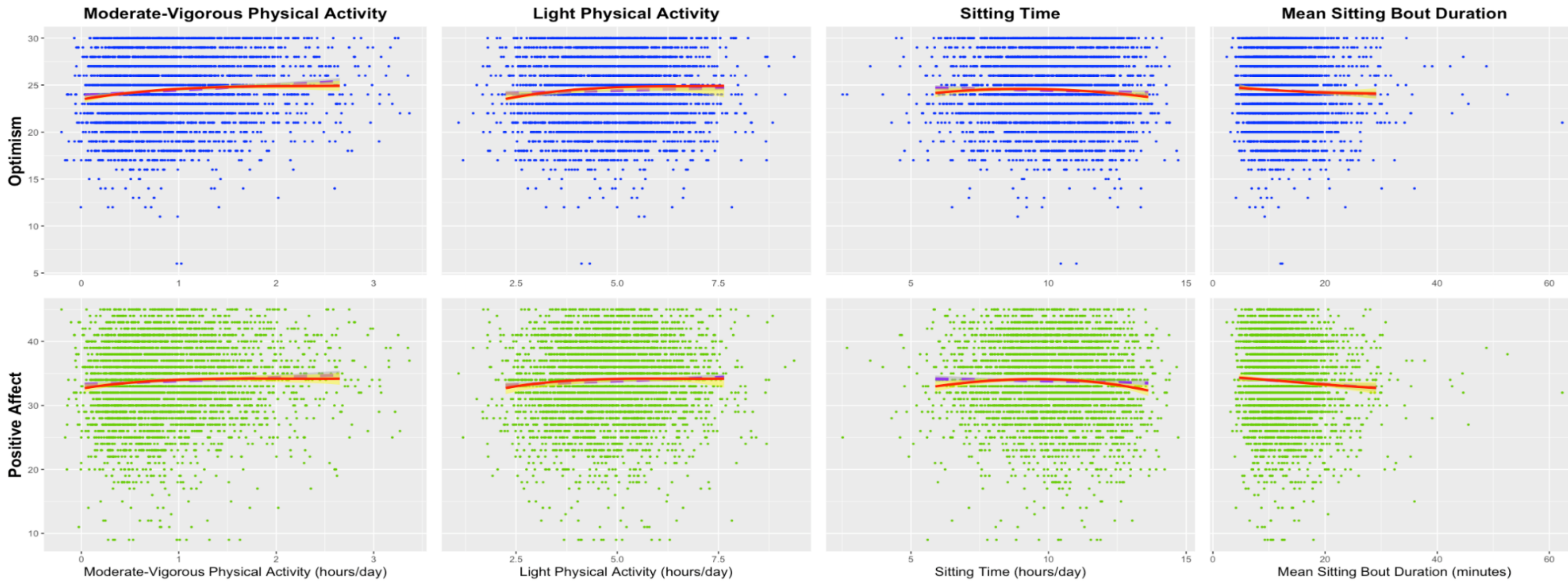


Figure 2: Association of physical behavior with optimism and positive affect. Scatterplots with smoothed conditional linear and polynomial regression models trimmed at the 1st and 99th percentiles with 95% CI bands. Models were minimally adjusted for age and race and/or ethnicity.

Table 2 provides detailed results from progressively adjusted multiple linear regression models for each physical behavior regressed on optimism and positive affect. In Model 1, adjusting for age and race/ethnicity, positive associations were observed for MVPA and LPA, and negative associations were observed for sitting time and mean sitting bout duration. MVPA (mean hours/day) associations were stronger than LPA (mean hours/day) associations for optimism with $\beta=0.6$ (95% CI 0.42-0.82, p-value<0.001) vs $\beta=0.1$ (95% CI 0.02-0.20, p-value=0.02) and positive affect with $\beta=0.7$ (95% CI 0.39-1.09, p-value<0.001) vs $\beta=0.2$ (95% CI 0.07-0.38, p-value=0.01) respectively. Except for moderate attenuation in the association between MVPA and optimism, associations between PA with both optimism and positive affect remained the same after additional Model 2 adjustments for educational attainment, smoking, and alcohol use. However, all associations were attenuated in the main confounder-adjusted Model 3 and the association between LPA and optimism was no longer statistically significant. In summary, for every increased hour of MVPA, optimism scores increased by 0.4 [95% CI 0.2,0.6, *p*-value <0.001] and positive affect scores increased by 0.6 [95% CI 0.2,0.9, *p*-value=0.001]. For every hour of increased LPA, positive affect increased by 0.2 [95% CI 0.03,0.33, *p*-value=0.02]. Further adjustment with covariates that were hypothesized to be potential mediators and/or confounders (Model 4) attenuated the relationship between MVPA and optimism. Model 4 adjustment resulted in minimal change to the beta coefficients for MVPA ($\beta=0.5$, 95% CI 0.16,0.85, *p*-value=0.004) and LPA ($\beta=0.2$, 95% CI 0.05,0.37, *p*-value=0.01) on positive affect.

Table 2: Association of Accelerometer-measured Physical Behavior with Optimism and Positive Affect among Women's Health Initiative Objective Physical Activity and Cardiovascular Health participants, 2012-14 (n=4168)[a]

	Moderate-Vigorous PA (hrs/day)			Light PA (hrs/day)			Sitting Time (hrs/day)			Mean Sitting Bout Duration*		
	β	95%CI	*p*-value	β	95%CI	*p*-value	β	95%CI	*p*-value	β	95%CI	*p*-value
OPTIMISM												
Model 1[b]	0.62	(0.42, 0.82)	<0.001	0.11	(0.02, 0.20)	0.02	-0.09	(-0.15, -0.02)	0.01	-0.03	(-0.05, -0.01)	0.01
Model 2[c]	0.53	(0.33, 0.73)	<0.001	0.11	(0.02, 0.20)	0.01	-0.08	(-0.15, -0.01)	0.02	-0.03	(-0.05, -0.01)	0.01
Model 3[d]	0.38	(0.19, 0.58)	<0.001	0.07	(-0.02, 0.16)	0.13	-0.03	(-0.10, 0.03)	0.30	-0.02	(-0.04, 0.01)	0.14
Model 4[e]	0.25	(0.05, 0.45)	0.01	0.01	(-0.08, 0.11)	0.76	0.02	(-0.05, 0.09)	0.60	0.00	(-0.02, 0.02)	0.89
POSITIVE AFFECT												
Model 1[b]	0.74	(0.39, 1.09)	<0.001	0.23	(0.07, 0.38)	0.01	-0.14	(-0.26, -0.03)	0.01	-0.07	(-0.11, -0.03)	<0.001
Model 2[c]	0.74	(0.39, 1.09)	<0.001	0.25	(0.09, 0.41)	0.00	-0.15	(-0.27, -0.04)	0.01	-0.08	(-0.11, -0.04)	<0.001
Model 3[d]	0.55	(0.21, 0.89)	0.001	0.18	(0.03, 0.33)	0.02	-0.09	(-0.20, 0.02)	0.10	-0.06	(-0.10, -0.02)	0.002
Model 4[e]	0.50	(0.16, 0.85)	0.004	0.21	(0.05, 0.37)	0.01	-0.09	(-0.21, 0.02)	0.12	-0.06	(-0.10, -0.02)	0.002

[a]Results were generated by models implemented using multiple imputation by chained equations to prevent covariate missing data bias.
[b]Model 1: age, race/ethnicity
[c]Model 2: Model 1 covariates, educational attainment, smoking, alcohol use
[d]Model 3 (Main model or confounder-adjusted model): Model 2 covariates, live alone, social support, sleep disturbance, pain
[e]Model 4: Model 3 covariates, BMI, number of chronic diseases, depression symptoms, anti-depressant use, physical functioning (SPPB)
*mean minutes per bout of sitting time

For sedentary behavior, negative associations between sitting time and mean sitting bout duration existed for both optimism and positive affect in Model 1, adjusting for age and race/ethnicity. After additional adjustment of Model 3 confounders, the sedentary behavior and optimism associations remain negative, but were no longer statistically significant. For positive affect, the sedentary behavior associations were attenuated in Model 3 and Model 4, and a statistically significant negative association remained for mean sitting bout duration (β=-0.1, 95% CI -0.10,-0.02, *p*-value=0.002), but not for sitting time.

Table 3 illustrates the magnitude of the relationships between psychosocial outcomes and physical behavior with Model 3 predictions for optimism and positive affect global scores at 25^{th}, 50^{th}, and 75^{th} distribution percentiles for each physical behavior. Study participants exhibited the following median physical behavior patterns: 0.8 hours/day MVPA, 4.8 hours/day LPA, 10.2 hours/day sitting time, and 11.8 minutes mean sitting bout duration with median optimism and positive affect scores of 24 (SD=3.6) and 34 (SD=6.1) respectively. Consistent with the detailed linear regression analyses, increases by quartile percentiles of MVPA predict small 0.1-0.2 score increases in optimism. Other physical behaviors show virtually no change in optimism from the 25^{th} to 75^{th} percentiles. For positive affect, each increment in quartile percentage of PA predicted a 0.1-0.2 score increase, and each increase in quartile percentage of sedentary behavior predicted a 0.1-0.2 score decrease.

Table 3. Adjusted means of optimism and positive affect at select percentiles of physical behavior metric distributions

Average:	Optimism Score Adjusted Mean (95% CI)	Positive Affect Score Adjusted Mean (95% CI)
MVPA, hours/day		
25th %ile: 0.5	24.9 (24.5, 25.2)	33.4 (32.8, 33.9)
50th %ile: 0.8	25.0 (24.7, 25.3)	33.5 (33.0, 34.0)
75th %ile: 1.2	25.2 (24.9, 25.5)	33.7 (33.2, 34.2)
LPA, hours/day		
25th %ile: 4.0	25.0 (24.7, 25.3)	33.4 (32.9, 34.0)
50th %ile: 4.8	25.0 (24.7, 25.3)	33.6 (33.1, 34.1)
75th %ile: 5.6	25.1 (24.8, 25.4)	33.8 (33.3, 34.3)
Sitting time, hours/day		
25th %ile: 9.0	25.1 (24.8, 25.4)	33.8 (33.2, 34.3)
50th %ile: 10.2	25.1 (24.8, 25.4)	33.6 (33.1, 34.2)
75th %ile: 11.3	25.1 (24.7, 25.4)	33.5 (33.0, 34.0)
MBD, minutes		
25th %ile: 9.2	25.1 (24.8, 25.4)	33.9 (33.3, 34.4)
50th %ile: 11.8	25.1 (24.8, 25.4)	33.7 (33.2, 34.2)
75th %ile: 15.0	25.0 (24.7, 25.3)	33.5 (33.0, 34.0)

Abbreviations: *MVPA* moderate-vigorous physical activity, *LPA* light physical activity, *MBD* mean sitting bout duration, *CI* confidence interval
Estimates are based on linear regression models that include adjustment for all Model 3 covariates: age, race/ethnicity, educational attainment, smoking, alcohol use, live alone, social support, sleep disturbance and pain.

Sensitivity Analysis

Women missing data on optimism or positive affect and therefore excluded from our study (n=1957) were older (80.1±6.7 vs 78.1±6.6 years) with lower total PA (5.5±1.5 vs 5.7±1.5 mean hours/day) and were more likely to be non-Hispanic Black (37.4 vs 31.5%), have three or more chronic conditions (28.4% vs 18.1%) and use antidepressants (13.5% vs 11.3%) (Appendix 1).

Optimism measure subscale analyses illustrated that neither the optimism subscale or positive affect subscale is driving the association between physical behavior and optimism (Appendix 3). Beta coefficients for the pessimism and optimism subscales separately represented approximately 50% of the full-scale optimism beta coefficient; therefore, we reported results for the full-scale optimism measure and present results for each subscale in the appendix.

Although there was not strong evidence of statistically significant interaction with the potential effect modifiers examined in this study (Appendix 4), differential effect estimates by age showed possible effect modification. Point estimates for beta coefficients showed a stronger association in older participants ≥80 years old compared to those <80 years old for all physical behaviors with optimism and positive affect. We also observed stronger point estimates in non-Hispanic White women, who were older (81±6 years) than non-Hispanic Black and Hispanic/Latina women (75±6 years). Except for MVPA, non-Hispanic Black women generally appeared to have null associations. Additionally, when stratifying by number of chronic conditions, the point estimates for beta coefficients for MVPA and optimism and positive affect appear to be stronger for those with multimobidities (≥2 chronic conditions) compared to those without (0-1 chronic conditions).

DISCUSSION

By examining accelerometer-measured physical behavior and self-reported optimism and positive affect measures in a large, well-characterized cohort of older women, our study confirmed small positive associations between MVPA with both optimism and positive affect. For positive affect, we also observed small positive associations for LPA and small negative associations for mean sitting bout duration; however, contrary to our hypothesis, null associations were observed for LPA and sedentary behaviors with optimism and sitting time with positive affect.

Models with minimal adjustment by age and race/ethnicity demonstrated hypothesized directionality: positive associations between MVPA and LPA with optimism and positive affect, and negative associations between sitting time and mean sitting bout duration. Notably, all observed associations were modest in magnitude with attenuation from the minimally adjusted models to the full confounder-adjusted models. In the full confounder-adjusted models, optimism was only associated with MVPA, and positive affect was associated with MVPA, LPA, and mean sitting bout duration, but no longer had a statistically significant association with sitting time. Further inclusion of confounders that were also potential mediators (e.g. BMI, chronic disease, depression symptoms, anti-depressant use, SPPB) partially attenuated the full confounder-adjusted model for MVPA and optimism and minimally attenuated positive affect associations, but these associations remained statistically significant. In this study, limited attenuation of these covariates suggests that mediation is not the primary cause for the observed associations.

Previous findings on the associations of physical behavior with optimism and positive affect show small or null effects with accelerometer-measured physical behavior.[26,30,31]

Consistent with the bulk of literature, our study demonstrated a mix of modest and null associations between study exposures and outcomes. It is important to note that psychological well-being is often measured differently across studies and this variation in measurement could be a source of inconsistencies that are observed in the literature. Psychological well-being measures may include one or several combined aspects of well-being (e.g. optimism, positive affect, negative affect, quality of life, life satisfaction, extraversion, self-esteem, stress, isolation) and also may define and measure the aspects differently; there is currently no standard measure for psychological well-being and researchers should understand the limitations and not assume interchangeability of the various measures.[11] As previously mentioned, two studies that used accelerometer-measured PA in older adults and different measures of well-being came to contradictory conclusions: one found a positive relationship between psychosocial well-being, measured as life satisfaction, and LPA, but no relationship with MVPA.[30] In contrast, another study demonstrated no association for accelerometer-measured LPA, weak positive associations for MVPA, and weak negative associations for sedentary time with measures that included combined aspects of well-being and some measures of positive affect.[31] Notably, the overall findings of the latter, a randomized control study of older adults, were relatively consistent with our study.

Physical behavior assessed with different types of self-report and accelerometer measurements may also be a source of inconsistency in the literature. Self-reported physical behaviors are typically operationalized by activities that are easily recalled (e.g. leisure vigorous activity, commute sitting times) and PA typically reflects intentional exercise (e.g. vigorous walking, tennis, swimming) and may not reliably capture other common forms of daily life movement (e.g. gardening, cooking, babysitting grandchildren).[25] Compared to self-reported PA, accelerometer-measured physical behavior can more accurately measure a broader suite of physical behaviors, particularly LPA and sitting time, and includes both intentional exercise and all other forms PA.[25] However, except for sleep time, accelerometer-measured physical behavior is typically not linked to situational context. As observed by LaMonte (2019), self-reported and accelerometer-measured physical behavior are related but typically capture different aspects of the human movement construct.[25]

Other studies support the likelihood that domains for physical behaviors are an important determinant in the association between physical behavior with optimism and positive affect. Pressman observed that positive affect was positively associated with the frequency in participating in enjoyable leisure activities (e.g spending quiet time alone, socializing with others, and hobbies).[56] Research also suggests that intentional exercise and non-exercise PA may convey independent well-being benefits. For example, Whitehead et al. found that for older adults, duration of purposeful exercise was beneficial for daily positive affect, and although non-exercise PA also had influence on positive affect, the impact was lower and did not depend on activity time.[57] These differences could help explain inconsistencies in research evaluating physical behaviors and positive well-being measures.

In the present study, LPA was positively associated and sedentary behaviors were negatively associated with positive affect but these physical behavior exposures were not associated with optimism. The differences in associations between physical behavior with positive affect and optimism may be attributed to the more modifiable nature of the positive affect state compared to trait optimism, particularly as personality is typically considered to be more stable in older adulthood.[58] As observed in previous studies, significant life transitions and intense interventions may modify trait optimism.[59] Perhaps more intense PA (e.g. more MVPA) or significant life changes (e.g. changes in socioeconomic status, transitions in social roles) are essential to change trait optimism, whereas less intense physical behavior changes (e.g. more LPA, less sitting time) may be sufficient to increase positive affect state.[10] Future experimental studies are needed to address these speculations.

The OPACH study included a large cohort of postmenopausal women from multiple sites, races/ethnicities, and socioeconomic backgrounds, and this diversity expands the generalizability of our findings. Another strength of our study was the comprehensive inclusion of age-relevant, validated and objective measures of physical behavior. Notably, after robust adjustment with a high number of measured confounders, associations still persisted. Our study evaluated psychosocial well-being by using specific outcome measures for optimism and positive affect instead of broad definitions of well-being that may not be easily comparable across studies. Optimism measured by LOT-R is clearly defined and evaluated as a single bipolar measure and as two separate unidimensional measures of optimism and pessimism. Positive affect measured by mDES in our study overcomes limitations of other commonly used positive affect measures (e.g. PANAS,[60] POMS,[61] CES-D[62]) by providing a balanced, wide range of positive emotions, not exclusively focusing on high arousal emotions (e.g. alert, excited, lively, energetic), and not including non-emotions items (e.g. strong, determined, active, self-esteem).

Although the cross-sectional nature of this study prevented disentangling the complicated and likely bidirectional relationship between physical behavior with optimism and positive affect, the slight temporal difference of physical behaviors being measured one to two years, on average, prior to the optimism and positive affect measures provides justification for characterizing physical behaviors as exposure variables and optimism and positive affect as outcome variables. Accordingly, overestimation due to the effects of reverse causality in the observed associations may be lessened. Evidence supporting a bidirectional relationship between physical behaviors and positive affect exists. For example, Gibbs et al. observed mid-life bidirectionality for associations between MVPA and mental component scores (MCS), which included a couple positive affect measures; baseline MCS had a stronger impact on 10-year change in MVPA than baseline MVPA's effects on 10-year change in MCS.[63]

Single time measurements can effectively and efficiently represent usual physical behaviors, trait optimism, and positive affect state. Studies demonstrate that participant optimism levels are relatively stable[59] over a few weeks to 10 years with relatively high test-retest reliability ranging from 0.58 to 0.79.[64,65] Research also supports that 24-hour ratings of positive affect are more accurate than recall of average and usual emotions[66] and state positive affect demonstrates statistical overlap with trait positive affect.[11] Finally, physical behavior measured with a single, 7-day accelerometer monitoring period has been shown to be a reliable measure of two- to three- year usual physical activity and sedentary behavior patterns in older women.[67]

Although not statistically significant, associations were directionally stronger in older women (≥80 vs <80 years old) and those with multimorbidities. Assuming the validity of these directional associations, outcome missingness of older, sicker women may have attenuated the study associations and introduced sampling bias due to differential missingness. However, even with inclusion of a high percentage of older, multimorbid women, the difference would not change overall study inferences. To address the potential limitation from selection bias due to covariate missingness, we compared associations generated with multiple imputation and complete case analysis, and minimal differences were observed. Given the relatively consistent associations, we conclude that the impact from selection bias was limited.

CONCLUSIONS

In summary, we observed modest but robust associations for the studied relationships with MVPA exposures and those with positive affect outcomes, except for sitting time. Next steps include investigating whether these findings are causal through future studies. With respect to physical behavior, interventions should consider including a mix of LPA and MVPA, as LPA is more attainable for this population and MVPA may be more impactful. Furthermore, the domains of physical activity and sedentary behavior should be measured, as the situational context of physical behaviors has an impact on psychosocial well-being. Until physical behavior measures can simultaneously and accurately capture duration, intensity, patterns, and domain, our understanding of its impacts on psychosocial well-being will be incomplete.

Although associations between physical behavior with optimism and positive affect were small over the average study period of one to two years, it is important to consider the longer-term power of the upward spiral effect of healthy behaviors on positive emotions and the reciprocal nature of positive emotions on healthy behaviors. The upward spirals of positive emotions reinforce lifestyle change with increased positive health behaviors for better health and more resilience through a range of biologically and psychological resources, which protect against negativity.[10] As explanation for the mechanism behind the upward spiral effect, behavioral neuroscience postulates that increases in positive affect can create a "liking" of the positive health behavior which unconsciously becomes desire to increase the health behavior.[10] Similar to Fredickson's broaden and build theory, Chopik et al. hypothesizes that increases in optimism may affect health and health behavior with a similar upward spiral mechanism.[44] This is critical in older women, particularly among the oldestold, because aging-related processes (e.g. declining health, fewer social connections, and the declining material resources)[44], mortality-related processes (e.g. low levels of cognitive and physical functioning)[44], and the "sobering up theory," which posits that older adults tend to lower expectations as they perceive death is approaching,[68] can lead to declines in optimism and well-being.[44] In conclusion, we recommend age-appropriate, attainable interventions that encourage older women to move more than they are currently to benefit from the upward spiral effects of physical activity and well-being and ultimately improve many other aspects of their health.

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APPENDIX 1

Table 4: Comparison of baseline characteristics between Analytic Sample (n=4168) and Sample with Missing Outcomes (n=1957), WHI Objective Physical Activity and Cardiovascular Health Study

CHARACTERISTIC	ANALYTIC SAMPLE (n=4168)	MISSING OUTCOME (n=1957)	*p*-value
Total physical activity[a] (h/d), *mean (SD)*	5.7 (1.5)	5.5 (1.5)	<0.001
Age (years), *mean (SD)*	78.1 (6.6)	80.1 (6.7)	<0.001
Race/ethnicity, *n (%)*			<0.001
Non-Hispanic White	2112 (50.7)	933 (47.7)	
Non-Hispanic Black	1315 (31.5)	732 (37.4)	
Hispanic/Latina	741 (17.8)	292 (14.9)	
Education, *n (%)*			<0.001
High school or less	783 (18.9)	454 (23.4)	
Some college	1560 (37.7)	789 (40.6)	
College graduate or more	1797 (43.4)	701 (36.1)	
Current smoker, *n (%)*	106 (2.7)	53 (3.3)	0.281
Alcohol use, *n (%)*			<0.001
Never	1373 (34.7)	716 (43.8)	
<1 per week	1411 (35.7)	501 (30.6)	
1-2 per week	424 (10.7)	161 (9.8)	
3-4 per week	277 (7)	107 (6.5)	
5-6 per week	232 (5.9)	70 (4.3)	
Everyday	237 (6)	80 (4.9)	
Live alone, *n (%)*	1735 (45.4)	749 (48.6)	0.035
Social support, *mean (SD)*	37.7 (7.6)	36.3 (8.2)	<0.001
Sleep disturbance, *mean (SD)*	7.2 (4.7)	7.3 (4.7)	0.564
Pain[b], *mean (SD)*	66.9 (25.3)	64.1 (26.6)	<0.001
BMI (kg/m2), *mean (SD)*	28.1 (5.7)	28 (5.8)	0.349
Chronic conditions[c]			<0.001
none	816 (19.6)	256 (13.2)	
one	1497 (36)	583 (30.1)	
two	1091 (26.2)	550 (28.4)	
three+	754 (18.1)	550 (28.4)	
Depression symptoms[d], *n (%)*	215 (5.6)	130 (8.5)	<0.001
Antidepressant use, *n (%)*	472 (11.3)	264 (13.5)	0.017
Physical function (SPPB), *mean (SD)*	8.5 (2.4)	7.6 (2.6)	<0.001

Abbreviations: SD, standard deviation; NA, not applicable; BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); SPPB, short physical performance battery, WHI, Women's Health Initiative.
p-value: ANOVA for continuous variables and chi-squared for categorial variables.
[a]Adjusted for accelerometer awake wear time using residuals method. Total Physical Activity is the sum of Moderate-Vigorous Physical Activity and Light Physical Activity.
[b] Higher pain score indicates a more favorable health state in regards to pain
[c]Sum of cancer, cerebrovascular disease, cognitive impairment, sensory impairment, cardiovascular disease, chronic obstructive pulmonary disease, diabetes, frequent falls, urinary incontinence, depression, and osteoarthritis.
[b]Shortened Center for Epidemiologic Studies Depression Scale (CES-D), ≥0.06 categorized as depression symptoms.

APPENDIX 2

Table 5: Association of Accelerometer-measured Physical Activity Behavior with Optimism and Positive Affect among OPACH participants, 2012-14 (n=4168)[a]

	Moderate-Vigorous PA (hrs/day)				Light PA (hrs/day)				Sitting Time (hrs/day)				Mean Sitting Bout Duration (mins)			
	β	95%CI	*p*-value	N	β	95%CI	p-value	N	B	95%CI	p-value	N	β	95%CI	*p*-value	N
OPTIMISM																
Model 1[b]	0.62	(0.42, 0.82)	<0.001	4168	0.11	(0.02, 0.20)	0.02	4168	-0.08	(-0.15, -0.02)	0.01	4041	-0.03	(-0.05, -0.01)	0.02	404
Model 2[c]	0.53	(0.32, 0.73)	<0.001	3917	0.1	(0.01, 0.19)	0.04	3917	-0.08	(-0.15, -0.01)	0.02	3807	-0.02	(-0.05, 0.00)	0.04	380
Model 3[d]	0.41	(0.21, 0.62)	<0.001	3444	0.03	(-0.06, 0.13)	0.49	3444	-0.02	(-0.09, 0.05)	0.59	3355	-0.01	(-0.04, 0.01)	0.27	335
Model 4[e]	0.32	(0.08, 0.55)	0.01	2872	0.01	(-0.09, 0.12)	0.81	2872	0.01	(-0.07, 0.09)	0.82	2798	-0.01	(-0.04, 0.02)	0.39	279
POSITIVE AFFECT																
Model 1[b]	0.74	(0.39, 1.09)	<0.001	4168	0.23	(0.07, 0.38)	0.005	4168	-0.13	(-0.25, -0.02)	0.02	4041	-0.06	(-0.10, -0.03)	0.001	404
Model 2[c]	0.76	(0.40, 1.12)	<0.001	3917	0.26	(0.10, 0.43)	0.002	3917	-0.16	(-0.28, -0.04)	0.01	3807	-0.07	(-0.11, -0.03)	<0.001	380
Model 3[d]	0.51	(0.15, 0.87)	0.01	3444	0.22	(0.06, 0.39)	0.008	3444	-0.11	(-0.22, 0.01)	0.08	3355	-0.06	(-0.10, -0.02)	0.003	335
Model 4[e]	0.44	(0.03, 0.84)	0.03	2872	0.23	(0.04, 0.41)	0.02	2872	-0.13	(-0.27, 0.01)	0.06	2798	-0.06	(-0.11, -0.01)	0.01	279

[a]Results were generated with complete case analysis.

[a]Model 1: age, race/ethnicity

[b]Model 2: Model 1 covariates, educational attainment, smoking, alcohol use

[c]Model 3: Model 2 covariates, live alone, social support, sleep disturbance, pain

[d]Model 4: Model 3 covariates, BMI, number of chronic diseases, depression symptoms, anti-depressant use, physical functioning (SPPB)

Table 6: Association of Accelerometer-measured Physical Activity Behavior with LOT-R Optimism Subscale and LOT-R Pessimism Subscale among OPACH participants, 2012-14[a] (n=4168)

	Moderate-Vigorous PA (hrs/day)			Light PA (hrs/day)			Sitting Time (hrs/day)			Mean Sitting Bout Duration*		
	β	**95%CI**	***p*-value**	**β**	**95%CI**	***p*-value**	**β**	**95%CI**	***p*-value**	**β**	**95%CI**	***p*-value**
LOT-R OPTIMISM SUBSCALE												
Model 1[b]	0.28	(0.16, 0.40)	<0.001	0.06	(0.00, 0.11)	0.04	-0.04	(-0.08, 0.00)	0.04	-0.01	(-0.03, 0.00)	0.04
Model 2[c]	0.27	(0.15, 0.39)	<0.001	0.07	(0.01, 0.12)	0.01	-0.04	(-0.08, -0.01)	0.02	-0.02	(-0.03, 0.00)	0.01
Model 3[d]	0.21	(0.09, 0.33)	<0.001	0.04	(-0.01, 0.10)	0.10	-0.02	(-0.06, 0.01)	0.24	-0.01	(-0.02, 0.00)	0.12
Model 4[e]	0.17	(0.05, 0.29)	0.005	0.04	(-0.02, 0.09)	0.21	-0.01	(-0.05, 0.03)	0.62	-0.01	(-0.02, 0.01)	0.31
LOT-R PESSIMISM SUBSCALE												
Model 1[b]	-0.34	(-0.47, -0.22)	<0.001	-0.05	(-0.11, 0.01)	0.09	0.04	(0.00, 0.09)	0.04	0.01	(0.00, 0.03)	0.04
Model 2[c]	-0.25	(-0.38, -0.13)	<0.001	-0.05	(-0.10, 0.01)	0.11	0.03	(-0.01, 0.07)	0.11	0.01	(0.00, 0.03)	0.07
Model 3[d]	-0.17	(-0.29, -0.05)	0.01	-0.02	(-0.08, 0.03)	0.41	0.01	(-0.03, 0.05)	0.63	0.01	(-0.01, 0.02)	0.45
Model 4[e]	-0.08	(-0.21, 0.04)	0.20	0.02	(-0.04, 0.08)	0.50	-0.03	(-0.07, 0.02)	0.21	-0.01	(-0.02, 0.01)	0.46

[a]Results were generated by models implemented using multiple imputation by chained equations to prevent covariate missing data bias.
[a]Model 1: age, race/ethnicity
[b]Model 2: Model 1 covariates, educational attainment, smoking, alcohol use
[c]Model 3: Model 2 covariates, live alone, social support, sleep disturbance, pain
[d]Model 4: Model 3 covariates, BMI, number of chronic diseases, depression symptoms, anti-depressant use, physical functioning (SPPB)
*mean minutes per bout of sitting time

APPENDIX 4

Table 7: Stratified Models of Accelerometer-measured Physical Activity Behaviors with Optimism and Positive Affect, OPACH (2012-14)

	Moderate-Vigorous PA (hrs/day)				Light PA (hrs/day)				Sedentary Behavior (hrs/day)				Mean Sedentary Bout Duration (mins)			
	β[a]	95% CI	N	*p*-interaction	β[a]	95%CI	N	*p*-interaction	β[a]	95%CI	N	*p*-interaction	β[a]	95%CI	N	*p*-interaction
TOTAL SAMPLE	0.41	(0.21, 0.62)	3444	-	0.03	(-0.06, 0.13)	3444	-	-0.02	(-0.09, 0.05)	3355	-	-0.01	(-0.04, 0.01)	3355	-
OPTIMISM																
Age*				0.09				0.27				0.23				0.25
<80	0.32	(0.06, 0.58)	1877		-0.01	(-0.15, 0.12)	1877		0.02	(-0.08, 0.12)	1828		0.00	(-0.03, 0.04)	1828	
≥80	0.76	(0.43, 1.09)	1567		0.11	(-0.02, 0.24)	1567		-0.08	(-0.18, 0.01)	1527		-0.03	(-0.06, 0.00)	1527	
Race/Ethnicity				0.46				0.42				0.45				0.77
White	0.42	(0.12, 0.71)	1768		0.08	(-0.05, 0.21)	1768		-0.06	(-0.15, 0.03)	1724		-0.02	(-0.05, 0.01)	1724	
Black	0.22	(-0.16, 0.60)	1073		0.01	(-0.15, 0.18)	1073		0.04	(-0.08, 0.17)	1042		0.00	(-0.04, 0.04)	1042	
Hispanic	0.77	(0.28, 1.26)	603		-0.09	(-0.34, 0.16)	603		-0.04	(-0.22, 0.14)	589		-0.02	(-0.10, 0.06)	589	
Social Support				0.49				0.15				0.89				0.58
Low	0.34	(0.04, 0.65)	1710		-0.04	(-0.18, 0.09)	1710		0.01	(-0.08, 0.11)	1661		-0.01	(-0.04, 0.02)	1661	
High	0.40	(0.10, 0.69)	1734		0.10	(-0.03, 0.24)	1734		0.01	(-0.09, 0.10)	1694		-0.02	(-0.05, 0.02)	1694	
Number of Chronic Conditions				0.37				0.37				0.26				0.54
0-1	0.27	(0.02, 0.53)	1943		0.07	(-0.05, 0.19)	1943		-0.05	(-0.13, 0.04)	1903		-0.02	(-0.05, 0.01)	1903	
2+	0.57	(0.21, 0.94)	1495		-0.04	(-0.19, 0.11)	1495		0.05	(-0.06, 0.16)	1446		0.00	(-0.03, 0.03)	1446	
POSITIVE AFFECT	0.51	0.145 , 0.873	3444	-	0.22	0.058 , 0.386	3444	-	-0.11	-0.225 , 0.012	3355	-				-
Age*				0.25				0.27				0.16				0.51
<80	0.34	(-0.12, 0.79)	1877		0.11	(-0.12, 0.33)	1877		0.00	(-0.17, 0.16)	1828		-0.04	(-0.10, 0.02)	1828	
≥80	0.92	(0.34, 1.51)	1567		0.37	(0.13, 0.60)	1567		-0.25	(-0.42, -0.08)	1527		-0.08	(-0.13, -0.03)	1527	
Race/Ethnicity				0.44				0.29				0.14				0.54
White	0.77	(0.24, 1.29)	1768		0.36	(0.13, 0.59)	1768		-0.23	(-0.40, -0.07)	1724		-0.08	(-0.13, -0.03)	1724	
Black	0.21	(-0.43, 0.85)	1073		0.04	(-0.24, 0.33)	1073		0.01	(-0.20, 0.22)	1042		-0.02	(-0.09, 0.05)	1042	
Hispanic	0.40	(-0.44, 1.25)	603		0.14	(-0.29, 0.57)	603		0.05	(-0.26, 0.36)	589		-0.05	(-0.18, 0.08)	589	
Social Support				0.62				0.97				0.82				0.70
Low	0.33	(-0.23, 0.90)	1710		0.29	(0.04, 0.54)	1710		-0.11	(-0.29, 0.06)	1661		-0.06	(-0.12, -0.01)	1661	
High	0.38	(-0.10, 0.87)	1734		0.29	(0.06, 0.51)	1734		-0.07	(-0.24, 0.09)	1694		-0.07	(-0.12, -0.01)	1694	
Number of Chronic Conditions[b]				0.19				0.63				0.35				0.67
0-1	0.24	(-0.20, 0.68)	1943		0.17	(-0.04, 0.37)	1943		-0.03	(-0.18, 0.12)	1903		-0.05	(-0.10, 0.01)	1903	
2+	0.90	(0.26, 1.53)	1495		0.30	(0.04, 0.57)	1495		-0.21	(-0.41, -0.02)	1446		-0.08	(-0.13, -0.02)	1446	

Abbreviations: PA = physical activity; CI = confidence interval

[a]Model 3: age, race/ethnicity, educational attainment, smoking, alcohol use, live alone, social support, sleep disturbance, pain

[c]Sum of cancer, cerebrovascular disease, cognitive impairment, sensory impairment, cardiovascular disease, chronic obstructive pulmonary disease, diabetes, frequent falls, urinary incontinence, depression, and osteoarthritis. To obtain p-interation, the number of Chronic diseases variable was forced into Model 3 as a main effect and interaction term.