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Recreational Physical Activity in Postmenopausal Women is Stable Over 8-Years of Follow-Up

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Abstract

Background—The Women's Health Initiative (WHI) provides a unique opportunity to study a large, diverse, and well-characterized cohort of post-menopausal women. The goals of this study were to examine (1) longitudinal trajectories of energy expenditure from recreational physical activity (PA) in MET hr/wk (2) whether women who belong to different recreational PA trajectories engage in different types of PA, and (3) whether baseline socio-demographic, health, psychosocial, and lifestyle characteristics predict membership in these PA trajectories.

Methods—Women from the WHI Observational Study with baseline PA data (n=92,629) were included in the analyses. Physical activity, measured via self-report six times over eight years, was converted to MET hr/wk for analysis; other baseline variables were also obtained via self-report. Latent growth curve mixture models and latent profile models were used to analyze 8-year longitudinal PA trajectories and cross-sectional PA composition, respectively, across three age strata, 50-59, 60-69, and 70+.

Results—Women fell into three distinct, stable PA trajectories (highly, moderately, and minimally active) over 8-years of follow-up with nearly 75% of the women classified as minimally active. The majority of women who were at least moderately active engaged in a fairly balanced combination of walking, moderate, and vigorous PA. Socio-demographic characteristics, e.g. income, education, and lifestyle behaviors such as past vigorous PA, smoking, fruit and vegetable intake, were predictive of longitudinal PA class membership, as were some aspects of health status, e.g. body mass index, but not health related quality of life.

Conclusions—Self-reported recreational PA is largely stable across nearly a decade of follow-up and thus, reliance on one cross-sectional assessment of PA level at baseline is likely sufficient in epidemiological studies.

Keywords

Physical activity; older adults; cross-sectional; longitudinal

Introduction

Physical activity (PA) has been defined as any bodily movement produced by skeletal muscles that result in energy expenditure. Exercise is a subset of PA that is planned, structured, and repetitive and has as a final or an intermediate objective the improvement or maintenance of physical fitness.¹ Despite the significance of regular PA in the preservation of health and functioning,²⁻⁴ only 5% of adults 65 years and older in the United States actually meet current PA recommendations of participating in 150 minutes of moderate intensity exercise per week.⁵ Furthermore, experimental studies of behavioral interventions for PA typically report that approximately 50% of individuals who successfully initiate an exercise program are unable to persist in the long term.⁶⁻⁸ Lifestyle behaviors such as PA have been thought to change and evolve across time and over the life course. However, either by design or due to statistical limitations, PA has not been treated or modeled as a dynamic behavioral process in previous studies; a majority of studies have defined PA patterns based on only one or two time points.⁹⁻¹² The Women's Health Initiative (WHI) provides a unique opportunity to study longitudinal PA trajectories in a large, well-characterized, diverse cohort of women that is not available anywhere else.¹³ Furthermore, the availability of socio-demographic, health status and other lifestyle behavioral variables in this large data set allows for comparison of previously reported predictors of PA from other smaller studies. The study of PA trajectories and their determinants can lead to a greater understanding of the relationships between behavioral patterns and key health outcomes and thus may inform the development of more personalized and effective PA guidelines and interventions in the long term.

In this study we examined: 1) longitudinal 8-year trajectories for total energy expenditure from recreational PA in MET hr/wk among post-menopausal women; 2) baseline cross-sectional exercise composition in MET hr/wk expended through mild, moderate, walking, or vigorous exercise by women belonging to different PA trajectories; and 3) baseline socio-demographic characteristics, lifestyle behaviors, health and psychosocial status as possible predictors of longitudinal PA trajectory membership.

Methods

The WHI is a prospective, multi-center clinical trial and observational study designed to address the risk factors for morbidity and mortality of cancer, cardiovascular disease, and osteoporotic fractures among postmenopausal women aged 50–79 years.¹³ Women who gave written, informed consent were enrolled in the WHI from 1993-1998 at 40 primary clinical centers and nine satellite centers in the United States. Women were either specifically recruited for the observational cohort study or entered it because they were ineligible or unwilling to be randomized into the clinical trials. The women included in this analysis are from the observational study (OS) cohort. OS participants (n=93,676) were evaluated in a baseline screening clinic visit and completed annual health update questionnaires. They were again evaluated during a clinic visit in year 3, followed by additional OS questionnaires from year 3 through the end of the main WHI study in 2005.

Study Sample

We included all women with baseline PA data (n=92,629). One percent of the OS sample had missing PA data at baseline (n=1,047). Physical activity data were available for 89% of the sample in Y3-Y5, 86% in Y6, 77% in Y7, and 54% in Y8. The low percentage of participants with Y8 data reflects not only women who died or were otherwise lost to follow-up, but is also due to the fact that women enrolled in the OS in 1998 were unable to complete their full 8 years in WHI before the study ended in 2005.

Measurement of Physical Activity

Physical activity was assessed with a detailed questionnaire on the frequency and duration of walking and of other types of recreational PA activity (vigorous, moderate, and mild) at baseline and years 3-8. Walking was assessed by a series of questions about the frequency of walks outside the home for more than 10 minutes without stopping, the average duration of each walk, and the usual walking pace. Vigorous exercise was defined as “you work up a sweat and your heart beats fast,” and examples included aerobics, aerobic dancing, jogging, tennis, and swimming laps. Moderate exercise was defined as that which was “not exhausting,” and examples included biking outdoors, using an exercise machine (such as a stationary bicycle or a treadmill), calisthenics, easy swimming, and popular or folk dancing. Examples for mild exercise were slow dancing, bowling, and golf.

Using a standardized classification of energy expenditure associated with PA,¹⁴ weekly energy expenditure scores in metabolic equivalents (MET score) were calculated. METs capture the total volume of PA including intensity, duration and frequency. One MET represents the metabolic rate equivalent to consuming 3.5 milliliters of oxygen per kilogram

of body weight per minute and is equivalent to resting metabolic rate.¹⁵ Energy expenditure in units of MET hr/wk is an expression of the amount of energy expenditure that is *independent* of body weight. The composite measure of total recreational PA energy expenditure used in this study was derived from the sum of energy expenditures from vigorous, moderate, and mild exercise and walking. A subset of the participants in the WHI-OS (n=1092) was recruited into a reliability study to assess the reproducibility of selected questionnaires, including the PA assessment. The average time between baseline and repeated assessment was three months. The test retest reliability for PA, using weighted kappa, ranged from 0.67 to 0.71.¹⁶

Measurement of Baseline Predictors

Socio-demographic characteristics included age, ethnicity, marital status, education, income, employment status, living situation, caregiving responsibilities, and current residence (defined according to the US Census classification of clinic site as Northeast, South, Midwest and West). Health behaviors including smoking, dietary patterns (number of servings of fruits & vegetables per day and percent of daily energy from fat), alcohol intake, hormone use (ever), and previous participation in vigorous exercise were collected by questionnaires. Past vigorous activity at age 18, 35, and 50 were assessed with this question, “For each of the ages below, did you usually do strenuous or very hard exercises at least 3 times a week? This would include exercise that was long enough to work up a sweat and make your heart beat fast.”

Health status—Height and weight were measured during the clinic visit, and body mass index (BMI), was calculated as weight (kg)/height(m)². The Medical Outcomes Study Short-Form 36 (MOS SF-36) measures eight domains of health related quality of life, HRQL (physical functioning, vitality/energy, pain, social functioning, general health perception, role limitations-emotions, physical role limitations, and emotional well-being).¹⁷ Other health status indicators included history of falls, hip fractures after age 55, hospitalizations, and chronic medical illnesses (cardiovascular disease, congestive heart failure, hypertension, cancer, emphysema, asthma, and arthritis).

Psychosocial—Depressive symptoms in the past week and history of depression were assessed with a scale that used six items from the Center for Epidemiological Studies Depression Scale (CES-D)¹⁸ and two items from the Diagnostic Interview Schedule (DIS), respectively.¹⁹ Perception of social support was measured with an abbreviated 9-item version of the MOS Social Support Scale.²⁰

Statistical Analysis

Both longitudinal and cross-sectional analyses of patterns of energy expenditure from recreational PA were performed separately for each age strata (50-59, 60-69, and 70+) due to a possible interaction between age cohorts and recreational PA classes.

In the longitudinal analysis, latent growth curve mixture analysis (LGCA) was used to define trajectories in recreational PA over the course of 8 years that characterize a group of women with similar PA patterns versus other classes of like individuals. These models are

based on change in PA as a function of time with growth or decline in PA represented by latent factors capturing the intercept (i.e. estimated baseline score), slope (i.e. estimated change over time), and a parameter representing a latent (unobserved) categorical variable that identifies homogenous classes varying in level and/or rate of change in PA. For the growth models we compared linear, cubic and quadratic models and found that the cubic and quadratic models fit the data no better than a linear model; thus, only results from the linear models are presented. We used an expectation maximization (EM) algorithm²¹ which assumes missing data is ignorable and uses all available data to estimate the underlying trajectories. Given that the trajectories fit were based on linear growth, this required at least two time points per participant to contribute to the estimation of the parameters.

For the cross-sectional analysis we investigated recreational PA composition at baseline (mild, moderate, walking and vigorous activity) for each of the empirically derived longitudinal trajectories using latent profile analysis models (LPA). Similar to LGCA, these models characterize individuals who engage in similar patterns of recreational PA. We used list-wise deletion for missing data since missing any of the four PA categories was assumed to be random.

For both longitudinal and cross-sectional analyses (LGCA and LPA), women were assigned a probability of being in each of the identified classes with the goal of a model leading to a unique assignment of a given woman to a given class (e.g. $\text{Pr}(\text{ClassA})=1.0$; $\text{Pr}(\text{ClassB})=0.0$), or minimally providing a distinctively high probability to a given class versus all others (e.g. .95 versus .05). Model fit was evaluated as recommended by Muthen²², using information criteria fit indices (Bayesian Information Criterion, BIC²³ and Akaike's Information Criterion, AIC²⁴); low values indicate model parsimony. Since these indices are influenced by sample size and we had high power to discern distinct classes, we also used other criteria to help identify a meaningful fit of model and data. These included class interpretability (the extent to which additional classes provided unique information), class prevalence (preferring classes with at least 2% of the sample for improved replicability), and entropy (a measure of classification based on posterior probability values, with higher values representing better classification). We used MPlus (version 5.0, Los Angeles, CA) for the LGCA and LPA analyses.

Baseline predictors of longitudinal PA—Given the ordinal nature of the observed longitudinal PA trajectory classes (minimally, moderately, and highly active), generalized ordinal logistic regression models were used. The model provides one coefficient, the adjusted odds of membership in the next higher activity category, unless for a given predictor variable the parallel assumption is not met. In this case, two coefficients are provided (since there are 3 classes); one coefficient gives the odds of being in either of the two higher activity classes relative to the lowest and the second estimates the odds of being in the highest relative to the two lower groups. All baseline variables were entered simultaneously in the models. In keeping with the age stratified analyses of the longitudinal PA trajectories, these multivariate models were also constructed by three age strata since predictors of PA trajectories may differ by age groups. We used STATA (version 10; Stata Corporation, College Station, TX) for these analyses.

Results

Sample Characteristics

Baseline socio-demographic, lifestyle behavior, health and psychosocial characteristics are summarized in Table I.

Longitudinal Recreational PA Trajectories

We tested a 2-, 3-, 4-, 5-, and 6-class model structure on total PA in MET hr/wk by age strata and found that a 3-class solution best represented the longitudinal data (Figure I, see Appendix for additional details). The figure depicts three distinct stable linear PA trajectories across the three age strata: 1) minimally active (70.8 to 73.6% of each age group); 2) moderately active (22.5% to 25.1%), and 3) highly active (4.6% to 3.9%). The equations defining each trajectory in the three age strata are shown at the bottom of Figure I. For example, in the 50-59 age group, the minimally active group's equation was $7.7 + .01(\text{Time})$; the slope or growth parameter was not significantly different from zero. For both the moderately and highly active classes, there was significant growth in recreational PA over time ($p < .001$ for moderately, $p = .008$ for highly active women) but the actual impact of the growth was minimal (about 0.3 METs per year * 8 years = total gain of 2.4 MET hr/wk or approximately 30 minutes of brisk walking). Similarly, there was substantively little change in the average trajectory for each class in the 60-69 age group. The minimally active class had a significant decline ($p < .001$) while the highly active class had a significant increase in energy expenditure ($p < .001$). The moderately active group had no significant change from their baseline PA. For the oldest age group (70+), each growth parameter indicated a slight decrease over 8 years. The minimally and moderately active groups had significant but modest declines of about 3 MET hrs/wk (both, $p < .001$). The decline in PA in the highly active group was not significantly different from zero. Overall the three PA classes within each age group showed remarkably stable levels of energy expenditure over the 8 years of follow-up.

Baseline PA Composition of Longitudinal Trajectories

We identified three to five distinct cross-sectional classes of PA for each age strata within each of the three longitudinal trajectories, minimally, moderately and highly active (Figure II). Among minimally active women, a majority (85-88%) reported very small amounts of moderate PA and walking, but no vigorous PA (Class 1, all three age strata); however in each age group there was at least one class among the minimally active women with unusually high amount of vigorous PA (Classes 2 & 4). The majority of moderately active women expended comparable amounts of energy in walking, moderate, and vigorous PA (Class 1, 72-83%), whereas for a minority of moderately active women nearly half of their recreational PA came from mild activities (Classes 3 & 4). Nearly two-thirds of the highly active women engaged in only moderate, walking, and vigorous PA (Class 1), but a third of these women also performed some mild PA (Classes 2-5).

Baseline Predictors of Membership in PA Trajectories

The results by age strata are summarized in Table II. For the most part, baseline socio-demographics, lifestyle behavior, and health status variables predictive of recreational PA class membership were similar across age groups, with a few exceptions.

Socio-Demographics—The odds of engaging in higher levels of recreational PA were lower for African-American women aged 60 and older (Odds Ratio, OR: 0.78 & 0.70; both $P < .01$) but higher for Hispanic women aged 70+ (OR: 1.43; $P < .05$) and for American-Indian women younger than 60 (OR: 1.79; $P < .05$) compared to Caucasian women. The odds of engaging in higher levels of recreational PA increased with family income (OR for women with >75,000/yr compared to women with family incomes <20,000/yr: 1.20-1.33; $P < .05$), and with a college education (OR of being at least moderately active for women with a college degree compared to women without high school diploma: 1.27-1.44; $P < .01$). Having never been married reduced the odds of engaging in high levels of recreational PA for women aged 60 and older (OR: 0.77 & 0.73; $P < .01$), whereas living alone was associated with a higher likelihood of being more active (OR for ages 50 to 69 1.19 & 1.2; $P < .01$; for the oldest group, living alone only distinguished being in the highest PA class versus the moderately or minimally active classes OR: 1.49; $P < .01$). Caregiving responsibilities did not appear to affect class membership with the exception of women in their 60's where caregiving slightly reduced their odds of being very highly active (OR: 0.88; $P < .05$). Current employment was associated with lower odds of engaging in higher levels of recreational PA (OR: 0.72-0.86; $P < .05$). Women living in the western US were slightly more likely to engage in higher levels of recreational PA than women in the Northeast (OR: 1.15-1.22; $P < .01$).

Lifestyle Behaviors—Participation in vigorous PA at 35 and 50 years of age was associated with significantly greater odds of participating in higher levels of recreational PA later in life. The odds of being in the highly compared to moderately or minimally active classes were consistently greater (OR: 2.74-5.42) than the odds of being in moderately or highly versus minimally active class (OR: 1.92-3.0) for women who engaged in vigorous PA at 35 and 50 years of age. Current smoking decreased the likelihood of engaging in higher levels of PA for women under 70 (OR: 0.67 & 0.70; $P < .01$). Greater alcohol intake was associated with increased likelihood of being at least moderately active (OR: 1.19-1.23, $P < .01$). Higher intake of fruits and vegetables and lower fat intake were associated with slightly greater odds of being more physically active ($P < .01$). Hormone use predicted membership out of the minimally active class only for women 60 and older (OR: 1.08-1.09, $P < .05$), but did not distinguish being in the highest PA group.

Health Status—The associations between various dimensions of baseline HRQL recreational PA class membership were either non-existent or only marginally meaningful (OR: 1.01-1.03, $P < .01$). Neither history of falling nor having a hip fracture after age 55 predicted recreational PA. Women 70 and older who had three or more chronic diseases were less likely to participate in recreational PA (OR: 0.72, $P < .01$). Hospitalization within the previous 2 years was associated with decreased odds of being in a higher activity class only for younger women (OR: 0.90, $P < .05$). Women who were overweight or obese had

significantly lower odds of participating in PA (OR compared to women of normal weight: 0.48-0.76; $P<.01$).

Psychosocial Status—Women younger than 60 with current or recent depressive symptoms were more likely to be in a higher PA class compared to women who did not have depressive symptoms (OR: 1.12; $P<.05$); this effect was not significant in older women. Neither history of depression nor current levels of perceived social support predicted PA participation.

Discussion

The goal of this study was to examine recreational physical activity in a large cohort of ethnically-diverse post-menopausal women through a combination of longitudinal and cross-sectional analyses. The longitudinal analyses were performed to answer the questions (a) how does recreational PA change over time and (b) which variables, assessed at baseline, predict the subsequent PA over 8 years of follow-up? The cross-sectional analyses were performed to answer the question, what type of exercises (walking, mild, moderate, or vigorous) women in different overall categories of recreational activity preferentially choose to engage in.

Longitudinal Recreational PA Trajectories

A notable finding is the stability of total energy expenditure from recreational PA in MET hr/wk –also referred to as tracking – across 8 years of follow-up. Tracking is defined as the ability to predict subsequent behaviors from earlier behaviors or one's tendency to maintain a certain relative rank compared to others.²⁵ One of the most consistent predictors of current behavior is past proximal behavior.^{26,27} In this study, participation in vigorous exercise at age 35 and 50 was the strongest predictor of recreational PA, in particular membership in the most active PA class. Determining the extent of tracking is important both for predicting outcomes and considering causal factors associated with PA. Physical activity patterns could be explained by sustained effects of the environment, genetics, and/or a combination of factors. Only one other published study has used latent growth curve modeling to define classes of leisure time PA. Four distinct PA classes were identified in a cohort of Canadians aged 18-60 based on three assessments of PA over a 20-year period: consistently inactive (56%), consistently active (11.7%), increasing (25.2%), and decreasing (7.1%) trajectories.²⁸ Our findings are similar to this study to the extent that the inactive group was a dominant class. However, the presence of two classes showing changes in PA over time is in contrast to our findings. Even in our models with higher numbers of classes, we did not observe classes of strikingly different declines or increases. These differences could be due to the longer follow-up period, the wider age range, inclusion of men, or the small number of older participants in the Canadian sample. Interestingly, women classified as minimally active expend on average, approximately the equivalent amount of total PA as recommended by current national guidelines (at least 150 minutes/wk of moderate-intensity aerobic PA ~7.5 MET hrs/wk)¹ and moderately active women expend as much energy to prevent weight gain (at least 420 minutes/wk of moderate-intensity aerobic PA ~21.5 MET hrs/wk).^{29,30}

Baseline PA Composition of Longitudinal Trajectories

Since the three longitudinal trajectories of recreational PA (minimally, moderately, or highly active) were mostly defined by levels of exercise participation at baseline, we conducted cross-sectional analyses to understand whether, within each of the three trajectories, we could distinguish different classes of women who preferentially chose to engage in one type of exercise versus another. Such differences in exercise choice may be associated with differences in disease and injury risk. For example, recent evidence suggests that having more breaks in sedentary time was associated with improved metabolic risk factors despite similar levels of total PA.³¹ The majority of the moderately and highly active women engaged in a combination of moderate, walking and vigorous recreational PA. A smaller percentage also engaged in a fair amount of mild PA (e.g. slow dancing, bowling, or golfing). For older women, a balanced distribution of PA intensity may actually be beneficial in reducing risk of musculoskeletal injury.³²³³ For the minimally active women, the class that emerged with a relatively high level of vigorous activity likely captures a small minority of women who have periodic spikes in their exercise behavior but whose longitudinal pattern reflect a consistently minimal level of total energy expenditure from recreational PA.

Predictors of PA Trajectory Membership

Socio-demographic characteristics previously associated with recreational PA in cross-sectional studies³⁴⁻³⁶ were similarly predictive of exercise behavior maintained over time, i.e. longitudinal recreational PA trajectory membership investigated in this paper. Consistent with previous studies,²⁸³⁷⁻⁴⁰ low family income and less education were associated with lower levels of PA. Earlier studies have found PA to decrease with retirement from physically demanding jobs and to increase with retirement from a sedentary job.⁴¹ Lack of time likely explains decreased PA with employment in our subjects. A surprising finding from this study was the contrasting relationship between race/ethnicity and PA class membership. While older Hispanics had greater odds of being in a higher PA group compared to Caucasians, African-American women actually had lower odds of being in the active classes. Caregiving responsibilities surprisingly did not predict PA class membership. Individuals who are prevention focused are more likely to engage in health promoting behaviors such as not smoking,²⁶ drinking moderate amounts of alcohol, eating more fruits and vegetables, consuming less fat and engaging in regular PA.⁴²⁴³⁴⁴ The results of this longitudinal analysis are in agreement with previous cross-sectional observations in that those who engage in other healthy behaviors are likely to be more physically active. Previous studies reported an inverse relationship between PA levels with increasing co-morbidities, lower physical functioning, depression and perceived health status. Older adults with greater disability and limited functioning tend to have lower self-efficacy for PA.⁴⁵ They also attribute lower PA levels to the presence of greater numbers of chronic conditions⁴⁶⁴⁷ and past injuries.⁴⁸⁴⁹ Studies of older women report that perceptions of poor health status and fear of injury are associated with decreased PA.³⁸⁴⁷⁵⁰ We made a similar observation that increased chronic disease burden was predictive of PA trajectory. However, none of the HRQL dimensions or previous history of injury from falling were associated with PA. While multiple longitudinal studies of relatively healthy adult and older adult community samples showed an association between depressive symptoms and PA levels,⁵¹⁻⁵⁹ we did not observe a consistent relationship across the age strata. Interestingly,

higher depressed mood was associated with greater odds of being moderately or highly active in the younger cohort. It is possible that PA is seen as a useful strategy to manage depressed mood.⁶⁰ Perceived social support also did not predict PA class membership; however, exercise-specific support has been found to be more closely related to PA.⁶¹

Limitations

There are several limitations to this study. The generalizability of the findings is limited mainly to healthy, ambulatory and well-educated women; the extent to which the results can be generalized to men is not known. Recreational physical activity was measured using self-report which can be subject to recall and social-desirability bias.⁶² Recent data suggests that predictors of self-reported PA differ from predictors of objectively quantified free-living PA.⁶³ For other behaviors such as dietary intake, a recent report of WHI women found that younger age, higher BMI, and being Hispanic or Black were associated with underreporting of energy intake compared to objective assessments using doubly labeled water.⁶⁴ Future studies of PA patterns will need to develop models to correct for measurement error associated with self-report or use objective assessments, e.g. accelerometers. In addition, the cycling/fluctuating pattern associated with PA and other lifestyle behaviors may be discounted when behaviors are infrequently assessed.

This paper was designed to examine baseline predictors of PA trajectories, thus we did not account for time varying covariates such as new disease onset, therapeutic treatments and other relevant behavioral and psychosocial variables over time that could impact the PA trajectory. Our future analyses will examine these relationships. Although we applied a state-of-the-art analytical technique to characterize ordered trajectories of PA, there are some limitations including clearly identifying how many classes are sufficient and defining how individuals are assigned to their specific class. The fact that we were able to replicate these trajectories across the three age strata suggests that the classes are reasonably stable and sufficiently represent the data. Finally, we assumed that missing assessments were missing at random which may not fully hold.

Strengths

Strengths of this study include the large number and racial diversity of the cohort, the prospective design and repeated detailed assessments of PA behavior which made modeling of growth trajectories possible, the relatively high rate of follow-up through year 7, the use of advanced statistical techniques to account for missingness, and the ability to examine numerous socio-demographic, behavioral, health status, and psychosocial variables. Many studies have characterized PA patterns using cross-sectional data and even fewer have examined changes in PA between two time points. To our knowledge, this is the first study to report the pattern of PA over almost a decade in a large sample of ethnically diverse women.

Conclusions

In conclusion, we have shown, in the largest multi-ethnic volunteer cohort of post-menopausal women to date, that self-reported PA is for the most part stable across nearly a decade of follow-up and thus, reliance on one cross-sectional assessment of PA levels is

likely sufficient in epidemiological studies, that there are generally three distinct PA classes (highly active, moderately active, and minimally active), and that previously identified socio-demographic characteristics and lifestyle behaviors are similarly predictive of longitudinal PA class membership.

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Appendix

To illustrate the procedures for selecting the three-class model, we present a detailed look at age group 1 (50-59) as an example. Table 1A shows the BIC fit measure for the 3, 4, 5, and 6-class models; each entropy value; the smallest class size (% of sample); and the improvement in fit over the previous model. Clearly there was an improvement in fit with each additional 3 degrees of freedom used per additional class fit; in part this is due to the power of having 20,000+ cases in each age group. Judging fit based on entropy, the 3-class model had the highest value (.88) and entropy for the 5-class model was .83 with two diagonal elements having less than .85. In the 3-class model, no class size was less than 4.6% of the sample and in the 4 and 5-class models, each had an identified class with less than 2% of the sample; the 4-class model had a high PA group (baseline mean 60.8 MET

hrs/wk) that included 1.7% of sample and 5-class model also had a high PA group that included 0.9% of the sample (baseline mean 67.7 MET hrs/wk). While strict statistical criteria suggests a more complex model like the 5+ class model was best, using entropy and smallest class size points to the 3-class model. Figure 1A shows the mean trajectory for each of the classes in the 3-class model using a random sample of 10 cases whose most probably membership is the given class. This serves to illustrate fluctuation about each class and the general classification procedure where individuals are assigned based on how well they fit the class and that the average trajectory represents a latent ideal type with variability about the specific trajectory.

Table 1A

Longitudinal Recreational PA Trajectories Model Fit Characteristics

	3-Class Model	4-Class Model	5-Class Model	6-Class Model
BIC (df)	1341064 (21 df)	1334686 (24 df)	1332063 (27 df)	NA *
BIC	15901	6378	2623	
Entropy	.88	.86	.83	
Size of smallest class (% sample)	4.6%	1.7%	0.9%	

BIC=Bayesian Information Criteria (↓ values indicate better model fit); Entropy (↑ values indicate better model fit)

* Forcing the model to have 6 classes showed no cases in the 6th class hence the 6-class model was not considered an improvement over the 5-class model

Figure 1A.
Recreational PA Trajectories for n=10 women in each class of the 3-class model (ages 50-59)

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Figure I.

3-Class Model of Total Recreational Physical Activity Energy Expenditure (MET-hr/wk)

Growth Trajectories over 8 Years by Age

Note: Total recreational PA: Mild + Moderate + Walking + Vigorous PA; Dashed lines at 7.5 and 21.5 MET-hr/wk represent national PA recommendations for 150 to 420 minutes of moderate intensity activity per week to obtain “substantial health benefit”¹ or prevent weight gain,³⁰ respectively.

Figure II.

Composition of Physical Activity Energy Expenditure (MET-hr/wk) at Baseline for Each Age Strata by Longitudinal Trajectories

Note: Cross-sectional baseline classes of recreational PA were estimated from three longitudinal PA trajectories (minimally, moderately, or highly active). For example, three unique classes were observed for 50-59 y/o women who were classified as minimally active over the 8 years of follow-up. The largest class (#1) included women (88.4%) who engaged in a small amount of mild and moderate PA; class #2 included 7.5% of women who engaged in a sizable amount of vigorous PA; and class #3 included 4.1% of women who engaged in mostly mild PA.

Table I

Descriptive characteristics for women with baseline physical activity data (n=92,629)^a

	Mean ± SD/n (%)
<i>Socio-Demographics</i>	
Age	63.6 ± 7.4
50-59	29,379 (32%)
60-69	40,736 (44%)
70+	22,514 (24%)
Race/Ethnicity	
White	77,212 (83%)
African-American	7,562 (8%)
Hispanic	3,475 (4%)
American-Indian	416 (0.4%)
Asian/Pacific Islander	2,653 (3%)
Other	1,048 (1%)
Family income, \$	
<\$20,000	16,500 (18%)
20,000-34,999	19,979 (22%)
35,000-49,999	17,282 (20%)
50,000-74,999	17,312 (20%)
75,000	17,535 (20%)
Education	
High school/general equivalency degree	19,663 (21%)
Schooling after high school	33,567 (36%)
College degree	38,647 (42%)
Marital status	
Never married	4,341 (5%)
Married or partnered	57,199 (62%)
Widowed	16,111 (17%)
Divorced/separated	14,540 (16%)
Living alone	24,364 (26%)
Caregiving to ill family member or friend on a regular basis (>2x/wk)	13,851 (15%)
Employment status	
Currently employed part/full	32,330 (35%)
Not employed	60,299 (65%)
US Region	
Northeast	21,132 (23%)
South	24,137 (26%)
Midwest	20,448 (22%)
West	26,912 (29%)
<i>Lifestyle Behaviors</i>	
Vigorous PA participation, 18y	40,011 (43%)

	Mean $\pm$ SD/n (%)
Vigorous PA participation, 35y	40,077 (43%)
Vigorous PA participation, 50y	35,778 (39%)
Smoking	
Never smoked	46,835 (51%)
Past smoker	39,204 (42%)
Current smoker	5,727 (6%)
Alcohol intake, drinks/wk	
0/past drinker	27,750 (30%)
<1	10,634 (11%)
1-6	42,163 (46%)
7	11,585 (13%)
Fruits & vegetables, medium servings/day	4.4 $\pm$ 2.2
Daily energy from fat (%)	30.2 $\pm$ 8.5
Hormone use, ever	55,086 (59%)
<i>Health Status</i>	
Medical Outcomes Study-SF 36	
Health Related Quality of Life ^b	
General health perception	73.8 $\pm$ 18.4
Physical functioning	81.1 $\pm$ 20.4
Physical role limitations	72.7 $\pm$ 36.4
Pain	74.2 $\pm$ 23.7
Vitality-energy	63.6 $\pm$ 19.4
Emotional role limitations	83.6 $\pm$ 30.2
Social functioning	89.3 $\pm$ 18.5
Number of falls in previous year	
0	62,458 (67%)
1	29,655 (32%)
Hx of hip fracture at age 55	527 (0.6%)
Total number of chronic diseases	
0	24,346 (26%)
1-2	53,439 (58%)
3	11,737 (13%)
Hospitalized last 2 years	14,906 (16%)
Body mass index, kg/m ²	
Underweight (<18.5)	1095 (1%)
Normal (18.5-24.9)	36,316 (39%)
Overweight (25.0-29.9)	31,126 (34%)
Obese ($\geq$ 30)	23,009 (25%)
<i>Psychosocial Status</i>	
Current depressed mood (CESD)	2.4 $\pm$ 2.6
<5	77,149 (83%)
5	14,666 (17%)

	Mean $\pm$ SD/n (%)
History of depression (DIS)	11,406 (12%)
Perceived social support	36.3 $\pm$ 7.6

^aMissing data ranged from 0% to 4% (e.g. family income)

^bHigher scores indicate better health

Table II

Baseline predictors of membership in three longitudinal total physical activity energy expenditure (MET-hr/wk) trajectories (minimal, moderate, and high) by age strata

	Age: 50-59 (n=29,379)	Age: 60-69 (n=40,736)	Age: 70+ (n=22,514)
Adjusted Odds Ratios (95% CI)			
Demographics			
Race/Ethnicity			
White ^a	-	-	-
African-American (Min vs. Mod&High) ^b	0.92 (0.81-1.06)	0.78 (0.68-0.90) **	0.70 (0.55-0.88) **
(Min&Mod vs. High) ^b		1.17 (0.89-1.53)	
Hispanic	0.90 (0.77-1.07)	0.93 (0.77-1.12)	1.43 (1.05-1.94) *
American-Indian	1.79 (1.14-2.81) *	1.04 (0.60-1.81)	1.15 (0.53-2.48)
Asian/Pacific Islander	0.94 (0.79-1.13)	1.12 (0.96-1.31)	0.99 (0.78-1.25)
Other	0.83 (0.61-1.15)	0.72 (0.54-0.98)	0.86 (0.57-1.28)
Family income, \$			
<\$20,000	-	-	-
20,000-34,999	0.87 (0.77-0.99) *	0.88 (0.81-0.97) **	0.99 (0.89-1.11)
35,000-49,999	0.91 (0.81-1.03)	1.02 (0.93-1.12)	1.09 (0.96-1.24)
50,000-74,999	1.04 (0.93-1.17)	1.04 (0.95-1.15)	1.33 (1.16-1.53) **
75,000	1.33 (1.18-1.49) *	1.20 (1.09-1.33) **	1.26 (1.08-1.46) **
Education			
High school/GED	-		
Some college	1.08 (0.97-1.20)	1.14 (1.05-1.23) **	1.17 (1.04-1.32) **
(Min&Mod vs. High) ^b			0.91 (0.70-1.18)
College degree	1.27 (1.14-1.42) **	1.35 (1.24-1.47) **	1.44 (1.28-1.62) **
(Min&Mod vs. High) ^b	1.10 (0.94-1.28)		1.06 (0.82-1.37)
Marital status			
Never married	0.84 (0.71-1.0)	0.77 (0.66-0.91) **	0.73 (0.58-0.91) **
Married or partnered	-	-	-
Widowed	0.95 (0.80-1.12)	0.97 (0.87-1.09)	0.90 (0.78-1.04)
(Min&Mod vs. High) ^b			0.69 (0.53-0.89) **
Divorced/separated	0.89 (0.79-1.0)	0.85 (0.76-0.96)	0.99 (0.83-1.18)
Living alone (yes/no)	1.19 (1.06-1.34) **	1.2 (1.08-1.34) **	1.12 (0.97-1.29)
(Min&Mod vs. High) ^b			1.49 (1.16-1.90) **
Caregiving to ill family member or friend on a regular basis (yes/no)	0.97 (0.91-1.03)	1.0 (0.94-1.06)	1.03 (0.95-1.12)
(Min&Mod vs. High) ^b		0.88 (0.79-0.99) *	
Currently employed part/full-time	0.72 (0.68-0.77) **	0.80 (0.75-0.85) **	0.86 (0.75-0.93) *

		Age: 50-59 (n=29,379)	Age: 60-69 (n=40,736)	Age: 70+ (n=22,514)
Adjusted Odds Ratios (95% CI)				
Residence/US Region				
	<i>Northeast</i>	-	-	-
	South	0.91 (0.84-0.99) *	0.95 (0.88-1.04)	1.11 (0.98-1.25)
	Midwest	1.10 (1.0-1.2) *	1.04 (0.96-1.12)	1.10 (0.98-1.24)
	West	1.18 (1.08-1.29) **	1.15 (1.07-1.24) **	1.22 (1.09-1.36) **
Lifestyle Behaviors				
Vigorous PA participation (yes/no)				
	@ 18 years/old	0.99 (0.93-1.06)	0.92 (0.86-0.98) *	0.87 (0.78-0.96) **
	(Min&Mod vs. High) ^b		1.06 (0.95-1.20)	
	@ 35 years/old	1.92 (1.80-2.05) **	1.11 (1.03-1.19) **	0.94 (0.84-1.05)
	(Min&Mod vs. High) ^b	2.74 (2.39-3.15) **		1.20 (0.98-1.46)
	@ 50 years/old	-	3.0 (2.82-3.20) **	2.66 (2.41-2.92) **
	(Min&Mod vs. High) ^b		5.42 (4.68-6.29) **	4.22 (3.41-5.23) **
Smoking				
	<i>Never smoked</i>	-	-	-
	Past smoker	1.12 (1.05-1.19)	1.04 (0.98-1.10)	1.04 (0.96-1.14)
	Current smoker	0.67 (0.58-0.77) **	0.70 (0.61-0.81) **	0.81 (0.64-1.02)
Alcohol intake, drinks/wk				
	<i>0/past drinker</i>	-	-	-
	<1	1.0 (0.89-1.12)	0.95 (0.85-1.05)	1.05 (0.90-1.21)
	1-6	1.19 (1.10-1.29) **	1.15 (1.07-1.23) **	1.15 (1.04-1.27) **
	(Min&Mod vs. High) ^b		0.99 (0.86-1.13)	0.92 (0.76-1.11)
	7	1.23 (1.10-1.37) **	1.19 (1.08-1.31) **	1.09 (0.95-1.24)
	(Min&Mod vs. High) ^b		1.0 (0.84-1.19)	
	Fruits & vegetables, medium servings/day	1.13 (1.11-1.15) **	1.12 (1.11-1.14) **	1.11 (1.10-1.13) **
	Daily energy from fat (%)	0.97 (0.96-0.97) **	0.97 (0.97-0.97) **	0.98 (0.97-0.98) **
	(Min&Mod vs. High) ^b		0.98 (0.97-0.99) **	
	Hormone use, ever	0.96 (0.90-1.03)	1.08 (1.02-1.15) *	1.09 (1.01-1.19) *
	(Min&Mod vs. High) ^b		0.95 (0.84-1.07)	0.87 (0.73-1.04)
Health Status				
Medical Outcomes Study SF-36, [†]				
	General health perceptions	1.01 (1.0-1.01) **	1.01 (1.0-1.01) **	1.03 (1.0-1.0)
	(Min&Mod vs. High) ^b	1.01 (1.01-1.02) **	1.01 (1.01-1.02) **	
	Physical functioning	1.02 (1.02-1.03) **	1.02 (1.02-1.03) **	1.03 (1.02-1.03) **
	(Min&Mod vs. High) ^b		1.03 (1.03-1.04) **	1.03 (1.03-1.04) **
	Physical role limitations	1.0 (1.0-1.0)	1.0 (1.0-1.0)	1.0 (1.0-1.0)

	Age: 50-59 (n=29,379)	Age: 60-69 (n=40,736)	Age: 70+ (n=22,514)
	Adjusted Odds Ratios (95% CI)		
	(Min&Mod vs. High) ^b		
Pain	1.0 (0.99-1.0)	0.99 (0.99-0.99) ^{**}	0.99 (0.99-0.99) ^{**}
Vitality/Energy	1.02 (1.02-1.02) ^{**}	1.02 (1.01-1.02) ^{**}	1.02 (1.01-1.02) ^{**}
	(Min&Mod vs. High) ^b		
Emotional role limitations	1.0 (1.0-1.0)	1.0 (1.0-1.0)	1.0 (1.0-1.0)
Social Functioning	0.99 (0.99-0.99) ^{**}	0.99 (0.99-0.99) ^{**}	0.99 (0.99-0.99) ^{**}
Falls in previous 12 mos (yes/no)	1.06 (0.99-1.13)	1.04 (0.98-1.11)	1.04 (0.96-1.14)
Hx of hip fracture at age 55	-	0.71 (0.47-1.09)	1.21 (0.88-1.66)
Total number of chronic diseases			
0	-	-	-
1-2	0.97 (0.91-1.03)	0.93 (0.87-0.99) [*]	0.93 (0.84-1.03)
3	0.93 (0.80-1.09)	0.87 (0.78-0.97) [*]	0.72 (0.62-0.84) ^{**}
Hospitalized last 2 years (yes/no)	0.90 (0.82-0.99) [*]	0.96 (0.89-1.04)	0.99 (0.89-1.10)
Body mass index, kg/m ²			
Underweight (<18.5)	1.26 (0.97-1.63)	1.04 (0.81-1.34)	0.86 (0.63-1.18)
Normal (18.5-24.9)	-	-	-
Overweight (25.0-29.9)	0.74 (0.69-0.80) ^{**}	0.74 (0.69-0.79) ^{**}	0.76 (0.70-0.83) ^{**}
Obese (≥ 30)	0.48 (0.44-0.53) ^{**}	0.61 (0.56-0.66) ^{**}	0.65 (0.57-0.74) ^{**}
	(Min&Mod vs. High) ^b		
Psychosocial Status			
Current depressed mood (CESD, ≥ 5)	1.12 (1.01-1.25) [*]	1.09 (0.99-1.21)	1.07 (0.93-1.24)
	(Min&Mod vs. High) ^b		
History of depression (DIS) (yes/no)	0.92 (0.83-1.02)	0.94 (0.84-1.05)	0.88 (0.74-1.05)
	(Min&Mod vs. High) ^b		
Perceived social support	1.0 (1.0-1.0)	1.0 (1.0-1.0)	1.0 (1.0-1.0)

^aItalicized variables are reference categories

^bFirst row compares minimally active vs. moderately + highly active PA classes; second row compares minimally + moderately active PA vs. the highly active PA class

* P<.05,

** P<.01