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REGULAR ARTICLE

Well-being and Long-term Physical Activity Participation in Midlife Adults: A Latent Class Analysis

Jerrald L. Rector, PhD • Sharon L. Christ, PhD • Elliot M. Friedman, PhD

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Abstract

Background Despite the benefits of physical activity, a large majority of adults fail to get the recommended amount of regular exercise, and interventions to increase physical activity typically achieve only temporary improvements. The potential contribution of positive psychological functioning to the maintenance of physical activity has not been widely examined.

Purpose To test the hypothesis that psychological well-being would increase the likelihood of sustained physical activity in adults using a person-centered approach with longitudinal data.

Methods Participants (N = 2,214) were from the longitudinal Survey of Midlife Development in the United States (MIDUS). Continuous latent variables representing physical activity at three waves of MIDUS were used to partition respondents into distinct (categorical) classes based on longitudinal activity profiles.

Results Latent class analyses identified three distinct physical activity profiles: sustained, consistently low, and declining activity (the normative class). Multinomial logistic regression analyses showed that the odds of membership in the sustained activity class were significantly higher for those with higher eudaimonic well-being (OR = 1.08 [1.03–1.13], p = .001), after adjustment for diverse covariates. Supplemental analyses revealed similar associations for specific subdomains of eudaimonic well-being.

Conclusion This study provides evidence that greater well-being may help sustain physical activity in the long term. These results suggest that improving well-being may be a useful addition to interventions aimed at increasing long-term physical activity participation.

Keywords Eudaimonic • Hedonic • Latent class • Physical activity • Well-being

Jerrald L. Rector
jlrector@purdue.edu

Department of Human Development and Family Studies, Purdue University, Fowler Memorial House, 1200 W. State St., West Lafayette, IN 47907-2055, USA

Introduction

Despite the well-known health benefits, an estimated 35% of adults fail to meet the recommended 150 min of moderate-intensity physical activity per week based on self-report [1]; this number rises to 95% for objectively measured physical activity bouts [2]. As the fourth leading cause of death worldwide, physical inactivity represents an important public health concern [3], and any increase above current physical activity levels is accompanied by decreases in disease and mortality risk in a dose-dependent manner [4, 5]. Thus, physical activity represents an important modifiable behavior for disease prevention. Nonetheless, targeted interventions aimed at increasing physical activity often instill improvements that are only transient [6], suggesting that current interventions lack a key component for sustained improvement [7]. Building upon the foundation of accumulating evidence described below, this study tests the hypothesis that positive psychological functioning may be one such component. Specifically, we examine the associations between discrete domains of psychological well-being and long-term physical activity participation in a national population sample of community-dwelling adults.

An important aim of the current study was to first characterize long-term physical activity patterns across

a wide range of middle and later life. Two issues motivate this aim. First, secular declines in physical activity in midlife are widely assumed, but compared with earlier periods of the life course, little research has investigated longitudinal patterns of physical activity among middle-aged and older adults [8]. In addition, most studies assessing the relationship between age and physical activity have been cross-sectional [9, 10], although a recent study using data from the English Longitudinal Study of Aging showed age-related declines in median levels of physical activity over an 11-year follow-up period [11]. Second, interindividual differences in many aspects of health and functional ability increase with age, as some individuals start to experience declines whereas others retain high levels of function [12]. Most studies focus on average levels of physical activity and change in activity over time and thereby run the risk of missing diverse patterns of physical activity participation within the population. In this study, we take advantage of the large and age-diverse MIDUS sample and use a person-centered approach—latent class analysis—to identify trajectories of physical activity over an 18- to 20-year period of middle and later life. We do not have any a priori hypotheses about the nature of these unique trajectories but anticipate that there will be more than one, and at least one will represent a normative decline in activity over time.

For the primary aim of this study—relating psychological well-being to long-term physical activity participation—Broaden-and-Build Theory [13, 14] provides a useful contextual framework. The theory holds that experiencing positive emotions fosters the expansion of an individual's social and cognitive resources for coping with the challenges of daily life [15]. For example, repeated experiences of positive emotions are linked to greater personal resilience, stronger social connections, greater creativity and mindfulness, and improved regulation of emotion, as indexed by increased vagal tone [16]. Specifically, a relevant extension of the Broaden-and-Build Theory, the positive upward spiral theory of lifestyle change, holds that adherence to new health behaviors increases to the extent that positive emotions are experienced while engaging in such behaviors [16]. Here, we extend this framework to investigate the reciprocal and reinforcing relationship between well-being and the maintenance of physical activity over time. Physical activity has been previously shown to increase later well-being, partially via increased positive emotions [17]. The reverse theoretical orientation (i.e., well-being predicting long-term physical activity) has not been tested. The possibility that psychological well-being might promote physical activity is consistent with the theory's focus on positive functioning as a catalyst for the accumulation of diverse resources.

We focus on two domains of psychological well-being: hedonic and eudaimonic [18, 19]. Hedonic well-being is associated with pleasure, contentment, and the avoidance of physical and mental discomfort. It is typically assessed using ratings of positive and negative mood and life satisfaction [18, 20]. Eudaimonic well-being reflects the Aristotelian ideal of the pursuit of personal excellence [18, 19], which has been operationalized with Ryff's Psychological Well-Being (PWB) Scales [21, 22] among others. This domain is typically assessed using measures of purpose in life, social relationships, and personal growth. Conceptually and empirically, hedonic and eudaimonic aspects of well-being are considered to be related but distinct [18, 19, 23].

There is limited evidence that well-being affects subsequent physical activity participation. A recent prospective study of English adults aged 50 years or older assessed diverse aspects of well-being—control, autonomy, self-realization, and pleasure—and found that greater well-being predicted higher median levels of physical activity, as well as higher odds of increasing activity in those inactive and slower declines in activity among those previously active [11]. Eudaimonic aspects of well-being—purpose in life and personal growth—were linked to higher self-reported physical activity levels among women aged 35–45 years [24]. The purpose in life was also associated with self-reported and accelerometer-measured physical activity in a sample of 104 community-dwelling adults aged 18–80 years [25]. However, both of these studies were cross-sectional, leaving open the question of whether well-being can promote physical activity participation. Lewis, et al. [7] reported exploratory results from an 8 week eudaimonic-enhancement intervention suggesting that the greatest gains in eudaimonic well-being were associated with significant increases in pedometer-measured physical activity. Similarly, a recent study of older adults who completed a group-based program aimed at improving eudaimonic well-being reported anecdotal increases in physical activity [26]. However, as previously noted, short-term improvements in physical activity participation are seldom sustained in the long term, and studies with longer follow-up periods are needed.

Studies examining the impact of hedonic well-being on long-term physical activity participation are largely absent from the current literature. One randomized clinical trial showed that percutaneous coronary patients receiving a positive affect-boosting intervention had nearly twice the improvements in caloric expenditure compared with controls over the subsequent 12 months [27]. Ratings of positive affect have also been shown to predict increased physical activity on a time scale ranging from the next 30 min to the next day, with mixed results for negative affect [28, 29]. The current study extends the existing literature by adding new information on the association of hedonic and eudaimonic well-being and long-term profiles of physical activity in a large sample

of community-dwelling middle-aged and older adults. We anticipate that hedonic and eudaimonic well-being will increase the odds of having a physical activity profile indicative of long-term participation. As the PWB Scale comprises six subscales assessing diverse conceptual facets of well-being [21], we additionally examined whether individual subscales were particularly predictive of long-term participation in supplemental analyses.

Because the few studies on long-term activity in middle-aged and older adults to date rely upon cross-sectional data or use one aggregate trajectory, it is unknown whether multiple longitudinal activity profiles exist within the population. Furthermore, although there is a clear association between psychological well-being and physical activity, it is also not known whether psychological well-being is predictive of sustained physical activity long term. The two aims of the present study will fill these gaps by (a) identifying any unique long-term profiles of physical activity and (b) using well-being to predict membership in each profile. If higher well-being results in a profile indicative of activity maintenance, well-being may be a key component in improving intervention outcomes among community-dwelling adults looking to reap the health benefits of long-term physical activity participation.

Methods

Participants

Participants for this study (N = 2,214, 54.4% female) were from all three waves of the longitudinal Survey of Midlife Development in the United States (MIDUS). MIDUS comprises a national probability sample of noninstitutionalized English-speaking adults living in the coterminus USA. The first wave of data (MIDUS 1) was collected from 1995 to 1996. In addition to a random digit dialing sample, data were also included from siblings of participants in the random digit dialing sample, oversamples from five metropolitan areas in the USA, and a national sample of twin pairs; the original N = 7,108 respondents were aged 25–75 years (mean = 47). The second wave (MIDUS 2) was collected from 2004 to 2006 and consisted of N = 4,963 (mean age = 56, range = 30–84) respondents from MIDUS 1 who were successfully recontacted and completed the phone survey 9 to 10 years later, corresponding to a 75% mortality-adjusted retention rate [30]. The third wave of data (MIDUS 3) was collected from 2012 to 2014 among N = 3,294 (mean age = 63, range = 39–93) respondents who completed the MIDUS 2 phone survey, a 77% response rate when adjusted for deaths or ineligibility. Of the participants surveyed by phone at MIDUS 3, N = 2,525 completed a self-administered questionnaire containing the physical activity items used in the present study. Participants were excluded if they had missing data on the physical activity items at any wave (N = 161), leaving N = 2,364 participants with full information on physical activity. Participants were further excluded if they were missing information on any of the well-being items and/or covariates at MIDUS 1 (N = 150), leaving N = 2,214 with full information for analysis. Compared with participants excluded due to missing data (N = 311), those included in the final analytic sample (N = 2,214) were younger and more likely to be male.

Physical Activity

At all three waves, participants were asked to rate the frequency of moderate ("bowling or using a vacuum cleaner") and vigorous ("running or lifting heavy objects long enough to work up a sweat") physical activity during the summer and winter (1 = *never*; 6 = *several times a week or more*). Responses to these four items (two intensities × two seasons) were used as indicators for a latent physical activity variable for each wave. These continuous latent variables were then used to estimate latent classes or characteristic profiles of physical activity from MIDUS 1 to MIDUS 3 using a latent categorical variable (see below). The reliability for these four physical activity items were α = .80, α = .91, and α = .91 for MIDUS 1, 2, and 3, respectively. When compared with population estimates from the Center for Disease Control and Prevention (CDC), the proportions of individuals within activity classifications (inactive, not regularly active, and regularly active) derived from the MIDUS measures were found to be similar but may overestimate physical inactivity due to reports being from summer and winter only [31].

Psychological Assessments

Hedonic well-being

Hedonic well-being was operationalized using variables for positive affect, negative affect, and life satisfaction. At MIDUS 1, positive and negative affect was measured separately using two sets of six items [32]. Participants were asked how much of the time in the past 30 days they felt "cheerful," "in good spirits," and "full of life" (positive affect) and "nervous," "restless or fidgety," and "that everything was an effort" (negative affect). Participant responses ranged from 1 = *all of the time* to 5 = *none of the time*. Responses were reverse coded and averaged to create a total score for positive affect (α = .91) and negative affect (α = .87). Higher scores indicated higher levels of positive and negative affect. Life satisfaction was measured by five items asking participants to rate their satisfaction with life overall, work, health, relationship

with their spouse/partner, and relationship with their children using an 11-point scale ranging from 0 = *worst possible* to 10 = *best possible* (α = .67) [33]. The internal consistency for the life satisfaction measure is expectedly low due to the diverse areas of life considered. In the current analyses, the patterns of association with life satisfaction were similar whether using the five-item scale or using the five individual items as independent variables. For simplicity, the rating represented in the five-item scale was included in all analyses.

Eudaimonic well-being

Eudaimonic well-being was assessed using the Ryff Scales of PWB [21, 22]. The PWB measure consists of six subscales assessing positive relationships with others, self-acceptance, personal growth, environmental mastery, autonomy, and purpose in life. The three-item version of the PWB subscales was used at MIDUS 1, and participants responded using a 7-point Likert scale (1 = *strongly agree* to 7 = *strongly disagree*). Responses to these items were reverse coded as appropriate and summed to create a total score for each subscale with higher scores indicating higher levels of well-being. Given relatively low internal consistency estimates at MIDUS 1 (range from α = .36 for purpose in life to α = .59 for self-acceptance), a composite average well-being score was calculated (α = .76).

The six subscales of the PWB measure are both theoretically and empirically distinct in the ways they relate to outcomes of interest [21, 22, 34]. The relatively low consistency of these subscales at MIDUS 1 meant that it was challenging to assess the association of physical activity profiles and each of these subscales. However, the 7-item versions of the PWB scales were available at MIDUS 2 with internal consistency ranging from α = .70 for purpose in life to α = .85 for self-acceptance in the current sample. These 7-item versions were used in the supplemental analysis described below (see Statistical Analyses).

Depression and generalized anxiety disorder

Depression and generalized anxiety disorder (GAD) were determined using the short form of the Composite International Diagnostic Interview (CIDI-SF) [35]. Depression was measured by two 7-item scales assessing depressed affect (α = .95) and anhedonia (α = .88). For depressed affect, participants were asked, "During two weeks in past 12 months, when you felt sad, blue, or depressed, did you…" (e.g., "lose interest in most things?"; "feel down on yourself, no good, or worthless?"). For anhedonia, participants were asked, "During two weeks in past 12 months, when you lost interest in most things, did you…" (e.g., "feel more tired out or low on energy than is usual"; "have a lot more trouble concentrating than usual"). The total number of "Yes" responses for the depressed affect and anhedonia scales were averaged to create a continuous variable ranging from 0 to 7 with higher scores indicating higher depression. For anxiety, participants responded to 10 items assessing how often in the past 12 months they experienced psychophysiological reactions (e.g., irritability, restlessness, low energy, memory, and sleep problems) because of worrying (1 = *most days*; 4 = *never*). The number of "most days" responses was summed to create a continuous anxiety score (range 0–10) with higher scores indicating greater anxiety (α = .87).

Health Covariates

As poor health can impair well-being and reduce physical activity participation, we accounted for chronic conditions, self-rated health, and physical activity limitations. The number of chronic medical conditions was obtained from participant self-report of presence or absence of heart problems, cancer, hypertension, high cholesterol, obesity, asthma, arthritis, HIV or AIDS, diabetes, tuberculosis, neurological disorders, stroke, and/or ulcers (score range: 0–13). Self-rated physical health was measured using a single item asking "In general, would you say your physical health is..." (1 = *poor*; 5 = *excellent*). Finally, as perceptions of health limitations to physical activity may confound the relationship between well-being and self-reported activity, participants were asked in two separate questions how much their health limited their ability to engage in moderate or vigorous physical activity (1 = *not at all*; 4 = *a lot*).

Sociodemographic and Lifestyle Factors

As physical activity participation may differ by age, sex, and education [8, 9], a continuous variable for participant age and a dichotomous variable for sex (1 = female) were included in all models. Educational attainment was determined from a telephone interview question, and a categorical variable (1 = *high school diploma or equivalent*; 2 = *some college*; 3 = *4 year college degree or more*) was included in all models. As financial concerns could influence physical activity participation and well-being, a categorical variable assessing how difficult it is for participants to pay their monthly bills (4 = *not at all difficult*; 3 = *not very difficult*; 2 = *somewhat difficult*; 1 = *very difficult*) was used in all models. Given the small number of non-White respondents in the overall sample (~6%), a dichotomous variable for race (1 = *non-White*) was used. Finally, as health behaviors, such as cigarette smoking, may represent pathways by which well-being may impact physical activity participation, a categorical variable

for smoking behavior (1 = *nonsmoker*; 2 = *ex-smoker*; 3 = *current smoker*) was included in the models.

Latent Class Analyses

Latent classes representing distinct profiles of moderate and vigorous physical activity across MIDUS 1, MIDUS 2, and MIDUS 3 were fitted using Mplus statistical software (version 7) [36]. A four-item latent physical activity variable was calculated for each wave using self-reported frequencies of physical activity at two intensities (vigorous and moderate) during two times of the year (in the summer and in the winter). The latent physical activity variable from each wave was then used in latent class analysis to allocate participants into latent profiles based on their activity levels at each wave [37, 38]. Models with 1 to 4 classes were estimated for the total sample of N = 2,364 participants with valid physical activity measures at all three waves of MIDUS. The best-fitting model was selected using the following criteria: (a) log likelihood, (b) Akaike information criterion, (c) sample size adjusted Bayesian information criterion values, (d) average posterior probabilities within classes, (e) entropy values, (f) class sizes, (g) theoretical meaningfulness, and (h) interpretability of results. To take advantage of the higher internal consistency of the individual PWB subscales at MIDUS 2, using the same approach described above, new latent classes were estimated from self-reported physical activity at MIDUS 2 and MIDUS 3 in the supplemental analyses.

Statistical Analyses

For the main analyses, hedonic and eudaimonic well-being measures at MIDUS 1 were entered in separate models as independent variables predicting class membership in multinomial logistic regression analyses using SPSS Statistics software version 24 (IBM SPSS, Chicago, IL, USA). These analyses were adjusted for potential confounders of the relationship between well-being and physical activity participation, including age, sex, education, race, difficulty paying bills, body mass index, smoking status, chronic medical conditions, self-rated physical health, health limitations to vigorous and moderate physical activity, depression, and GAD.

In the supplemental analyses, latent physical activity classes were estimated for participants from MIDUS 2 to MIDUS 3 only. Using identical methods as in the main analyses, each of the 7-item versions of the eudaimonic well-being domains and their composite were entered in separate models as independent variables predicting the odds of class membership with multinomial logistic regression. These analyses were adjusted for the same covariates used in the main analyses but with MIDUS 2 as the baseline.

Due to the multiple comparisons of the individual domains of well-being with physical activity class membership, the main and the supplemental analyses were adjusted using the Holm–Bonferroni method, which helps limit type II error inflation associated with the original Bonferroni method [39]. All generated p-values within each set of multinomial logistic regression analyses were considered a single comparison, yielding corrections for 42 tests in main analysis and 48 tests in the supplemental analyses. This corresponded to critical values of $\alpha = .00143$ and $\alpha = .00122$ for the main and the supplemental analyses, respectively.

Results

The longitudinal analytic sample (N = 2,214) included participants with full information on physical activity at all three waves (follow-up range: 18–20 years) and MIDUS 1 well-being and covariates.

Latent Class Analysis Results

Of the models tested, the four-class solution had the best statistical fit but raised concerns about replicability and theoretical meaningfulness. The three-class solution met both statistical and theoretical criteria and was thus selected as the best fit. For this solution, the entropy was 0.90, and the probabilities of single class assignment for class 1, 2, and 3 were 95.2%, 96.5%, and 95.5%, respectively. For a table of model fit statistics and comparisons between solutions, see Supplementary Material File 1. As shown in Fig. 1, the resulting three classes partitioned participants into those who consistently engaged in physical activity about once a week (sustained activity; N = 1,102; 46.6%), consistently engaged in activity less than once a month (low activity; N = 80; 3.4%), or who steadily declined in activity over time (declining activity; N = 1,182; 50.0%). As mentioned above, 150 of the 2,364 (6.3%) participants with full information on physical activity were further excluded due to missing information on well-being variables and/or covariates. For the analytic sample (N = 2,214), the proportions of participants in each class remained largely the same—N = 1,041 (47.0%), N = 74 (3.3%), and N = 1,099 (49.6%) for sustained activity, low activity, and declining activity, respectively.

Main Analyses

Table 1 shows the characteristics of the sample stratified by physical activity class. Post hoc pairwise comparisons among continuous variables revealed that each class differed significantly from the others on body mass index, limitations to activity, and self-rated physical health (all $p \leq .05$), with body mass index and limitations to

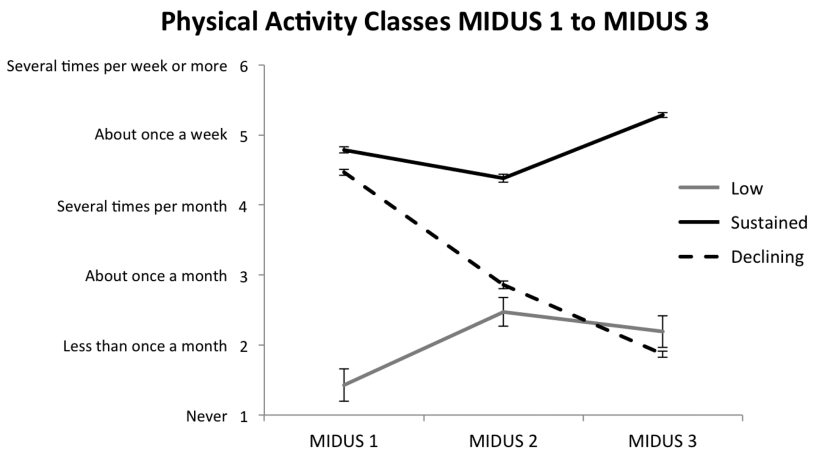

Fig. 1. Longitudinal physical activity profiles identified by latent class analyses (N = 2,364). Profiles show those with consistently low activity (low; N = 80), sustained activity (sustained; N = 1,102), and those who declined (declining; N = 1,182) in activity over time. Error bars are SEM. *MIDUS* Survey of Midlife Development in the United States.

vigorous and moderate activity progressively decreasing and self-rated health progressively increasing when moving from the low activity class to the sustained activity class. The sustained activity class was also significantly younger and had fewer chronic conditions compared with the low and declining classes (both $p \leq .01$), but age, chronic conditions, depression, and GAD scores did not differ between the low and declining activity classes (all $p > .40$).

With the exception of negative affect, the three classes differed significantly in well-being scores (Table 1). Post hoc comparisons revealed that scores for life satisfaction (all $p \leq .01$) and eudaimonic composite (all $p \leq .05$) in each class were significantly different from the other two classes. Additionally, the sustained activity class had significantly higher positive affect than the declining and low activity classes (both $p < .05$).

Table 2 shows the odds ratios for membership in the low or sustained activity classes—the normative declining activity class was the reference group. The covariates were first adjusted for all other covariates (Model 1), and then each well-being predictor was entered in turn as a separate independent variable (Models 2–5). Compared with the declining activity class, odds of being in the sustained activity class decreased with age, greater difficulty paying bills, and higher limitations to vigorous activity and increased with higher self-rated health. Odds of membership in the low activity class increased with higher limitations to moderate activity. No other associations were statistically significant after adjustment for multiple comparisons (Table 2).

After adjustment for potential confounders, the odds of being in the sustained activity class were significantly increased by higher scores on the eudaimonic well-being composite. Additionally, higher life satisfaction decreased the odds of membership in the low activity class (Table 2). No other well-being measures discriminated between the low and declining activity classes after adjustment for multiple comparisons.

Supplemental Analyses

The supplemental analyses took advantage of the higher internal consistency of the individual PWB subscales at MIDUS 2 and examined associations between each subscale and longitudinal profiles of physical activity participation between the second and third waves of MIDUS.

The supplementary analyses sample consisted of 2,422 participants with valid physical activity measures at MIDUS 2 and MIDUS 3. Based on the same model selection criteria as the main analyses, a three-class solution was chosen representing three activity patterns: increasing activity (n = 886, 36.6%), decreasing activity (n = 967, 39.9%), and stable activity (n = 569, 23.5%). Model fit statistics and comparisons between solutions for the supplemental analyses are available in Supplementary Material File 2. The figure in Supplementary Material File 3 shows the mean physical activity level at each wave for each class in the three-class solution. Of the 2,422 participants, 211 were excluded due to missing information on well-being items and/or covariates at MIDUS 2, leaving N = 2,211 with full information for the supplemental analyses. Cross-tabulation of class membership in the supplementary and main analyses showed that 96.4% of those in the new increasing activity class were previously represented by the sustained activity class and 93.9% of those in the decreasing activity class were previously in the declining activity class—suggesting consistency in the process of generating the classes. Approximately, 96.6% of those in the stable activity class came from the sustained and declining activity classes (47.9% and 48.7%, respectively). The mixture of participants reclassified into the latter class likely reflects the older baseline age at MIDUS 2

Table 1 Participant characteristics by physical activity class membership (MIDUS 1–MIDUS 3)

		Class				
	Total (N = 2,214)	Low (N = 74)	Declining (N = 1,099)	Sustained (N = 1,041)	F/χ^2	p-value
Age (at baseline; years)	46.06 (11.10)	48.58 (10.07)	48.28 (11.14)	43.53 (10.58)	53.21[a]	<.001
Sex (%female)	54.4	48.6	58.5	50.5	14.75[b]	.001
Education (%)					53.75[c]	<.001
High school/GED	29.2	44.6	34.0	23.1		
Some college/2-year degree	28.6	28.4	29.5	27.7		
Degree from 4-year college	42.2	27.0	36.5	49.3		
Race (%White)	94.5	89.2	94.7	94.7	4.23[b]	.120
Difficult to pay bills					27.59[d]	<.001
Very difficult	4.3	8.1	5.3	3.0		
Somewhat difficult	25.7	36.5	28.0	22.6		
Not very difficult	39.0	31.1	38.4	40.2		
Not at all difficult	30.9	24.3	28.3	34.2		
Body mass index (kg/m^2)	26.57 (5.16)	28.99 (7.21)	26.93 (5.21)	26.02 (4.86)	17.06[a]	<.001
Smoking status (%)					22.05[c]	<.001
Current smoker	16.1	27.0	18.4	13.0		
Ex-smoker	30.3	31.1	30.8	29.6		
Never smoker	53.6	41.9	50.8	57.4		
Chronic conditions	0.91 (1.11)	1.14 (1.14)	1.06 (1.18)	0.74 (0.99)	24.12[a]	<.001
Self-rated physical health (1–5)	3.73 (0.90)	3.26 (0.97)	3.60 (0.89)	3.91 (0.86)	44.26[a]	<.001
Limitations to vigorous activity	1.97 (1.05)	2.46 (1.16)	2.16 (1.08)	1.74 (0.95)	55.42[a]	<.001
Limitations to moderate activity	1.29 (0.67)	1.77 (1.17)	1.36 (0.72)	1.18 (0.52)	40.16[a]	<.001
Depression (CIDI)	0.66 (1.77)	0.61 (1.63)	0.70 (1.82)	0.62 (1.73)	0.47[a]	.625
Generalized anxiety disorder (CIDI)	0.14 (0.86)	0.27 (1.06)	0.12 (0.78)	0.15 (0.92)	1.17[a]	.310
Positive affect	3.43 (0.69)	3.28 (0.75)	3.38 (0.71)	3.50 (0.67)	9.83[a]	<.001
Negative affect	1.49 (0.56)	1.54 (0.64)	1.51 (0.57)	1.47 (0.55)	1.49[a]	.226
Life satisfaction	7.83 (1.15)	7.14 (1.50)	7.79 (1.16)	7.93 (1.09)	18.81[a]	<.001
Eudaimonic composite	16.92 (2.28)	15.93 (2.35)	16.7 (2.29)	17.23 (2.22)	21.76[a]	<.001

Values are mean (*SD*) or percent. *MIDUS* Survey of Midlife Development in the United States; *GED* General Equivalency Diploma; *CIDI* composite international diagnostic interview.

[a]Degrees of freedom = 2, 2211.

[b]Degrees of freedom = 2.

[c]Degrees of freedom = 4.

[d]Degrees of freedom = 6.

and the correspondingly flatter activity profile from MIDUS 2 to MIDUS 3. For a full cross-tabulation table, see Supplementary Material File 4.

The participant characteristics and multinomial logistic regression results of these additional analyses are available in Supplementary Material Files 5 and 6, respectively. Briefly, the multinomial logistic regression results showed that in fully adjusted models (N = 2,211), higher scores on the PWB composite, personal growth, purpose in life, and self-acceptance predicted greater odds of being in the increasing activity class compared with the decreasing activity class (the normative reference group). Specifically, the subdomains of purpose in life and personal growth showed the strongest odds increase at 4% (both $p < .001$) after adjustment for multiple comparisons (Supplementary Material File 6).

Given the comparatively small number of participants in the low activity class in the main analyses, we conducted additional regression diagnostics that identified a few participants as potentially influential cases. With one exception—a significant odds ratio for the PWB composite, OR (95% CI) = 0.88 (0.78–0.98), p = .02—excluding these cases did not affect any of the observed odds ratios. Thus, the impact of eudaimonic well-being on reducing the odds of membership in the low activity class compared with the normative decline may be underestimated

Table 2 Odds ratios, 95% confidence intervals, and *p*-values for physical activity class membership from multinomial logistic regression analyses

Model		Low (N = 74)	*p*-value	Sustained (N = 1,041)	*p*-value
1	Age (at baseline; years)	1.00 (0.98–1.03)	.775	0.96 (0.95–0.97)	**<.001**
	Sex				
	Male	1.73 (1.03–2.89)	.038	1.28 (1.06–1.55)	.010
	Female	(Reference)		(Reference)	
	Education				
	High school/GED	1.36 (0.73–2.50)	.331	0.71 (0.57–0.89)	.004
	Some college/2 year degree	1.16 (0.60–2.22)	.661	0.81 (0.65–1.01)	.058
	Degree from 4 year college	(Reference)		(Reference)	
	Race				
	Non-white	2.12 (0.92–4.86)	.077	1.07 (0.72–1.60)	.735
	White	(Reference)		(Reference)	
	Difficulty paying bills				
	Very difficult	1.23 (0.42–3.58)	.711	0.42 (0.25–0.69)	**.001**
	Somewhat difficult	1.17 (0.60–2.27)	.647	0.65 (0.50–0.83)	**.001**
	Not very difficult	0.78 (0.40–1.51)	.462	0.81 (0.65–1.01)	.063
	Not at all difficult	(Reference)		(Reference)	
	Smoking status				
	Never smoker	1.60 (0.85–3.02)	.149	0.69 (0.53–0.91)	.007
	Ex-smoker	1.12 (0.62–2.02)	.702	1.06 (0.86–1.31)	.578
	Current smoker	(Reference)		(Reference)	
	Body mass index (kg/m^2)	1.07 (1.02–1.12)	.004	0.99 (0.97–1.02)	.545
	Chronic conditions	0.73 (0.56–0.96)	.022	1.01 (0.91–1.12)	.890
	Self-rated physical health	0.76 (0.56–1.03)	.074	1.27 (1.12–1.42)	**<.001**
	Limitations to vigorous activity	0.92 (0.68–1.24)	.566	0.82 (0.73–0.92)	**.001**
	Limitations to moderate activity	1.79 (1.26–2.55)	**.001**	1.01 (0.84–1.22)	.915
	Depression	0.91 (0.78–1.07)	.253	1.00 (0.94–1.05)	.921
	Generalized anxiety disorder	1.10 (0.88–1.38)	.399	1.13 (1.01–1.26)	.041
	Well-being predictors[a]				
2	Positive affect	0.93 (0.64–1.35)	.703	1.23 (1.06–1.42)	.007
3	Negative affect	0.91 (0.56–1.48)	.691	1.01 (0.83–1.23)	.898
4	Life satisfaction	0.71 (0.57–0.87)	**.001**	1.07 (0.98–1.18)	.147
5	Eudaimonic composite	0.91 (0.81–1.01)	.081	1.08 (1.03–1.13)	**.001**

Membership in "low" and "sustained" activity classes are both compared with membership in the "declining" class (N = 1,099).

Model 1: Covariates only; Model 2: Model 1 + Positive affect; Model 3: Model 1 + Negative affect; Model 4: Model 1 + Life satisfaction; Model 5: Model 1 + Eudaimonic well-being composite.

Bold-faced values are significant after Holm–Bonferroni adjustment for n = 42 comparisons (α = .00143).

[a]Models 2–5 represent separate models.

in Table 2. No other regressions showed indications of highly influential cases. For additional discussion of regression model fit, assumptions, and diagnostics, see Supplementary Material File 7.

Discussion

The current study examined the links between psychological well-being and longitudinal profiles of physical activity participation in a large sample of community-dwelling adults in midlife. Three distinct profiles of activity across the 20-year period emerged representing a normative group with declining activity over time and two additional profiles that had sustained or consistently low levels of activity. Higher scores on composite eudaimonic well-being were associated with increased odds of having a physical activity profile indicative of long-term participation, compared with that of the normative decline. Supplemental analyses showed that the individual subdomains of purpose in life, personal growth, and

self-acceptance were also significant predictors of having a sustained activity profile. These associations were robust to adjustment for a wide range of potential confounders, including sociodemographic factors, chronic medical conditions, self-rated health, depression, anxiety, and health limitations to moderate and vigorous physical activity participation. These results suggest that presence of psychological well-being is linked to greater likelihood of sustained physical activity participation in middle-aged and older adults.

A nuanced picture of physical activity participation through adulthood emerged from these analyses. Most prior studies have concluded that there is a normative decline in physical activity through midlife [9, 10, 40, 41] resulting in the extremely low levels of physical activity in older adults. However, as pointed out by Hamer et al. [8], there are few longitudinal data on patterns of physical activity through adulthood, particularly from midlife into older age, and fewer that allow for diverse patterns of physical activity. The present study used latent class analysis to identify discrete longitudinal trajectories of physical activity participation over an 18- to 20-year span of middle and later life. Consistent with earlier research, the largest proportion of participants (N = 1,099) in the current sample showed a steady decline in activity over time. However, a similarly large class of participants (N = 1,041) showed relatively sustained physical activity participation over time. These analyses also identified a smaller group of participants (N = 74) who were consistently inactive over time. Although replication in other samples is warranted, this smaller class may represent a high-risk population as they were characterized by higher body mass index, more limitations to physical activity and lower life satisfaction, eudaimonic well-being, and self-rated physical health at baseline compared with the normative group.

Membership in each of these classes was influenced by a different array of factors. For example, compared with the normative declining activity class, older age made membership in the sustained activity class less likely but did not influence likelihood of membership in the low activity class. Greater limitations to moderate activity predicted greater likelihood of being in the low activity class compared with the declining activity class but were unrelated to the odds of being in the sustained activity class. These results show that aging does not inevitably result in declines in physical activity. Moreover, the diverse factors that predict sustained levels of physical activity through midlife are different from those that predict consistently low levels of activity, an observation that could inform interventions designed to improve physical activity participation in this population.

The principal aim of this study was to assess the extent to which positive psychological functioning was uniquely linked to sustained physical activity participation through middle and later life. We found that positive dimensions of eudaimonic well-being predicted greater likelihood of membership in the sustained activity class compared with the normative declining activity class, whereas depression and negative affect did not. Importantly, these associations were robust to adjustments for a range of demographic, socioeconomic, and health-related factors.

The links between physical activity and eudaimonic well-being have not been well studied, but the present results are consistent with prior research showing that an 8-week eudaimonic-enhancement intervention produced significant increases in physical activity [7]. The associations between hedonic well-being and physical activity are better established. An earlier review showed that in the six available studies investigating the relationship between affective states and subsequent activity, positive affective states were associated with subsequent activity [28]. Recent studies have shown that momentary positive affect induces transitory increases in subsequent activity [29, 42]. The lack of association in the current study suggests that although positive affect may bolster short-term activity, it may not support activity maintenance in the long term. The lack of an association between negative affect and physical activity profile, however, is consistent with cross-sectional [43] and short-term longitudinal research [28]. Finally, to our knowledge, no other studies have investigated the impact of life satisfaction on long-term physical activity participation, but the current association is consistent with cross-sectional findings showing significantly higher odds of physical inactivity at progressively lower levels of life satisfaction [44]. Collectively, the present results suggest that positive psychological functioning in a large sample predicts sustained physical activity through middle and later life.

Supplemental analyses probed the relationship between eudaimonic composite scores and physical activity participation profile by using the more reliable PWB subscales at MIDUS 2. These analyses showed that higher levels of purpose in life, personal growth, and self-acceptance were each associated with increased odds of having an activity profile indicative of long-term participation. It is notable that purpose in life and personal growth showed the strongest links with class membership, an observation that may speak to why these particular domains have been the focus of most cross-sectional studies [24, 25]. Purpose in life is associated with a sense of directedness and intentionality, and personal growth, which is especially representative of the concept of eudaimonia, involves continual developing and becoming [21]. The strong sense of striving and commitment embodied in these domains may be particularly conducive to physical activity. These results suggest that interventions to promote these two specific domains of eudaimonic well-being, if incorporated into

physical activity interventions, may have a particularly robust impact on outcomes.

The results presented here may have practical or clinical significance. Across the 18–20 years of follow-up, those participants in the normative declining activity class engaged in moderate-to-vigorous physical activity, on average, about once a month, whereas the sustained activity class averaged about once per week. Over time, moving from a normative decline to more sustained activity levels can have a tangible impact on morbidity and mortality [4, 5]. If higher levels of well-being contribute to higher odds of membership in the sustained activity class, then the resulting health benefits and survival advantage accompanying even small shifts toward sustained activity could be substantial. Group-based interventions have already been used to foster significant increases in well-being among middle-aged and older adults [7, 26], exemplifying the plausibility of improving both well-being and physical activity participation. From an integrated behavioral health standpoint, health care professionals could incorporate a well-being enhancement intervention into physical activity interventions to improve outcomes.

Within the Broaden-and-Build Framework, the increased physical activity resulting from enhanced well-being may help fuel the upward spiral of lifestyle change in a way that increasing physical activity alone may not accomplish. Thus, the current study supports the possibility that interventions integrating both well-being and activity could have a larger impact long term on mental and physical health outcomes than either alone.

It is also worth mention that since the last wave of MIDUS was collected, there has been marked technological advancement in physical activity promotion, particularly with respect to commercially available activity monitors and smartphone applications. Although these devices are promising, recent evidence from randomized-controlled trials investigating their impact on physical activity seems equivocal, and very little is known about their impact on long-term participation [45–48]. Receiving increasingly granular information about one's daily activity and health practices does not appear, at least on its own, to promote sustained change in long-term health behavior. Thus, without some sort of complementary behavior change program, it is unrealistic to expect these devices to produce prolonged results [49].

There are a few features of this study that limit the conclusions that can be drawn about well-being and long-term physical activity participation. Primarily, physical activity participation was determined by self-report. Although individuals tend to overestimate the amount of physical activity in which they engage, making self-report data less reliable for assessments of absolute levels of activity, self-reports of physical activity do accurately capture relative differences in physical activity participation (e.g., by gender and age)— activity is higher in males than in females and lower with increasing age [2]. Moreover, if subjective assessments of physical activity varied with well-being, estimates of longitudinal associations could have been biased. The use of latent variables to measure physical activity buffered the random measurement error, yielding more reliable estimates of activity [37]. It is also of note that the physical activity measures in MIDUS may be conservative and therefore may overestimate physical inactivity [31]. The next step for research in this area is to confirm the prospective relationship between well-being and physical activity using objective activity measures. Such studies will be able to further address concerns about potential inaccuracies in self-report data.

Although it is also a major strength of this study, physical activity classes were created using participants across a wide age range. As the relationship between age and change in physical activity across adulthood may be complex [9, 10], the activity profiles may have differed if baseline age was included in their estimation. However, the variability in age was inherently parsed out between the classes and was reflected in the significant age differences. As a significant predictor of class membership in its own right, age was also controlled for in the well-being analyses. Future studies with class membership relative to continuous age, or separate classes stratified by early, middle, and late adulthood, may further distinguish factors relevant to long-term activity in these specific life stages.

Lastly, there were a disproportionate number of White participants in the sample, making the generalization of these findings to other races difficult. Further studies are needed to confirm whether these findings generalize to other races.

In sum, this study provides evidence that higher levels of eudaimonic well-being may promote sustained long-term physical activity participation in a large, age-diverse sample of adults after accounting for a wide range of known determinants of physical activity. Overall, this study suggests that improving well-being in middle-aged and older adults may move an individual from the normative profile of declining physical activity across adulthood to one in which activity is maintained at higher levels over time. These findings provide support to the possibility that increasing well-being in parallel with activity levels could represent an effective, novel approach for interventions aimed at sustained increases in both mental and physical health in adults.

Supplementary Material

Supplementary material is available at *Annals of Behavioral Medicine* online.

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Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Authors' Contributions J. L. Rector and E. M. Friedman drafted and critically revised the article. S. L. Christ also provided critical revisions of the articles and made substantial contributions to the analysis and interpretation of the data.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This article does not contain any studies with animals performed by any of the authors.

Informed Consent Informed consent was obtained from all individual participants included in the study.

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