Intensity of Leisure-Time Physical Activity and Dimensions of Mental Well-Being: A Reciprocal Approach Using Parallel Latent Growth Curve Modeling

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Background: The examination of the longitudinal effect of leisure-time physical activity (LTPA) on mental well-being is important, but previous studies have typically been limited by their use of a cross-sectional approach. This study empirically examined how LTPA intensity was associated with changes in distinct functions of mental well-being (eg, emotional, psychological, social) over time, and vice versa. **Methods:** Parallel latent growth curve modeling in combination with propensity score matching analysis was conducted. Data were derived from a sample of adults from the Midlife in the United States (MIDUS) study. **Results:** The results showed that the initial level of moderate LTPA at the baseline was associated with growth in psychological and social functioning over time, and vice versa. However, vigorous LTPA at the baseline was related only to growth in emotional functioning over time. **Conclusion:** The longitudinal association between LTPA and mental well-being had different matching mechanisms for LTPA intensities and their relation to distinct functioning for mental well-being. The findings contribute to an enhanced understanding of LTPA's longitudinal effect on mental well-being.

Keywords: mental health, wellness, longitudinal study

Well-being, an important barometer of mental health, has been extensively examined over the past few decades.[1,2] The World Health Organization has conceptualized mental health as "a state of well-being in which the individual realizes his or her own abilities, can cope with the normal stress of life, can work productively and fruitfully, and is able to make a contribution to his or her community."[3] Therefore, mental well-being could be regarded as a state of experience that integrates positive emotional, psychological, and social functioning.[4] According to the activity theory of aging, individuals are likely to age successfully when they stay active in physical and social health during middle age and beyond.[5] Thus, engaging in physical and social activities enables adults to improve or sustain their mental well-being over time.[6] Physical activity (PA) is typically referred to as an efficient means to develop mental health, as well as to socialize with others.[6] In this context, the type and quality of PA could play a pivotal role in successful aging with well-being.[5] Given the benefits of PA, growing research has addressed the association between PA and mental well-being.[2,7,8] Although the contribution of PA to physical health and function has been well documented, accumulating evidence also suggests that it exhibits positive effects on mental well-being.[5] Previous studies have found that PA not only is associated with reduced mental illness (such as depression and anxiety), but also has a positive effect on mental vigor and meaning in life.[7,8] In the association between PA and mental well-being, leisure-time physical activity (LTPA) has a strong and consistent association with mental well-being, compared with other domains of PA (eg, household or work-related

activity).[8] Conceptually, LTPA is a collective behavior in freely disposable time that includes sports and planned exercise.[9] Individuals who engage in LTPA could gain psychological and social benefits for their mental well-being (eg, self-development or social connection).[10] In this context, the intensity of LTPA could predict different signs of mental well-being, especially when individuals independently select exercise of a strenuous nature instead of activities imposed by others.[2] Hence, intensity levels (eg, moderate or vigorous) should be considered as critical factors of PA's mental health correlates.[11] There is growing evidence from a cross-sectional examination in support of the association of LTPA with mental well-being.[12–14] However, the findings failed not only to capture the associations across time, but also to provide strong evidence of causal effects.[15] The directionality in the relationship between LTPA and mental well-being also tends to be biased, with a focus on mental well-being (ie, LTPA → mental well-being).[16] Regarding the time sequence, individuals who engage in LTPA at the baseline are likely to show positive psychological function during the follow-up, which likely results in more engagement in LTPA over time.[17] Essentially, a reciprocal relationship may exist in the longitudinal association. In this context, several studies have examined the longitudinal relationship between LTPA and mental well-being.[10,16] Despite these efforts, to the best of our knowledge, the question remains whether LTPA intensities at baseline could be associated with a change in the dimensions of mental well-being over an extended period, along with changes in reciprocal relationships. To address the research gap, we aim to elucidate the longitudinal association of LTPA with mental well-being. Specifically, the authors attempt to investigate (1) the association of the initial level of LTPA intensity (moderate and vigorous) with changes in the dimensions of mental well-being for an extended duration and (2) reciprocal relationships in the association. Accordingly, latent growth curve modeling (LGCM) in combination with propensity score matching (PSM) was employed among nationally representative data from the Midlife in the United States (MIDUS) study.

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Methods

Sample

The MIDUS study has been used to investigate behavioral, psychological, and social factors in the health disciplines.[18] The study employed a random-digit dialing telephone survey and subsequent mail-back questionnaires.[19] The data were collected in 3 waves over a 20-year period. A total of 7108 individuals participated in the initial interview for wave 1 of MIDUS (1995–1996; age ranged from 24 to 75 y; mean = 46.40; SD = 13.00; education level: 13.21 y; males: 48.3%, females: 51.7%).[20] Approximately a decade later, the collection was conducted for wave 2 of MIDUS (2004–2006). After adjusting for mortality, it retested 75% of the participants at wave 1 (N = 4955) between 2004 and 2006 (age ranged from 35 to 86 y; mean = 55.40; SD = 12.45; education level: 14.24 y; male: 46.2%, female: 53.8%).[21] The third measurement, MIDUS wave 3 (2013–2014), occurred about 9 years later; the data were again collected for 67% of the MIDUS wave 2 (N = 3294). This was adjusted for mortality in 2013–2014 (age ranged from 42 to 92 y; mean = 64.30; SD = 11.20; education level: 14.68 y; male: 44.8%, female: 55.2%).[21] Table 1 shows the descriptive statistics of our sample.

Measures

Mental Functioning. Three major constructs for mental well-being were utilized: emotional functioning, psychological functioning, and social functioning (see Figure 1).[22]

1. Emotional functioning was measured using a 9-item version of the Positive and Negative Affect Schedule.[23] The participants were asked to report on a 5-point scale (1 = none of the time to 5 = all the time), the extent to which they felt positive symptoms (eg, satisfied or full of life: $\alpha_{wave\ 1} = .85$, $\alpha_{wave\ 2} = .87$, $\alpha_{wave\ 3} = .91$) and negative symptoms (eg, nervous or upset: $\alpha_{wave\ 1} = .71$, $\alpha_{wave\ 2} = .80$, $\alpha_{wave\ 3} = .81$).

2. Psychological functioning was measured using Ryff's 18-item Psychological Well-Being Scale,[24] which is composed of 6 dimensions, including autonomy ($\alpha_{wave\ 1} = .71$, $\alpha_{wave\ 2} = .69$, $\alpha_{wave\ 3} = .70$), environmental mastery ($\alpha_{wave\ 1} = .71$, $\alpha_{wave\ 2} = .69$, $\alpha_{wave\ 3} = .70$), personal growth ($\alpha_{wave\ 1} = .70$, $\alpha_{wave\ 2} = .74$, $\alpha_{wave\ 3} = .75$), positive relations with others ($\alpha_{wave\ 1} = .71$, $\alpha_{wave\ 2} = .77$, $\alpha_{wave\ 3} = .78$), purpose in life ($\alpha_{wave\ 1} = .68$, $\alpha_{wave\ 2} = .70$, $\alpha_{wave\ 3} = .72$), and self-acceptance ($\alpha_{wave\ 1} = .85$, $\alpha_{wave\ 2} = .82$, $\alpha_{wave\ 3} = .87$). Each dimension consisted of 3 items and was rated on a 7-point scale (1 = strongly agree to 7 = strongly disagree).

3. Social functioning was measured with Key's 15-item Social Well-Being Scale[25] with 5 dimensions, including meaningfulness of society ($\alpha_{wave\ 1} = .65$, $\alpha_{wave\ 2} = .67$, $\alpha_{wave\ 3} = .71$), social integration ($\alpha_{wave\ 1} = .73$, $\alpha_{wave\ 2} = .71$, $\alpha_{wave\ 3} = .72$), acceptance of others ($\alpha_{wave\ 1} = .65$, $\alpha_{wave\ 2} = .67$, $\alpha_{wave\ 3} = .70$), social contribution ($\alpha_{wave\ 1} = .71$, $\alpha_{wave\ 2} = .72$, $\alpha_{wave\ 3} = .77$), and social actualization ($\alpha_{wave\ 1} = .67$, $\alpha_{wave\ 2} = .65$, $\alpha_{wave\ 3} = .71$). Each dimension was composed of 3 items on a 7-point scale (1 = strongly agree to 7 = strongly disagree).

Table 1 Descriptive Statistics of Variables Used in the Analysis

| Variables	Wave I (1995–1996)		Wave II (2004–2006)		Wave III (2013–2014)	
	Mean (SD)	Range	Mean (SD)	Range	Mean (SD)	Range
Age	45.7 (11.0)	24–75	55.4 (12.45)	35–86	64.3 (11.2)	42–92
Sex, %						
Female	51.7		53.8		55.2	
Male	48.3		46.2		44.8	
Education, %						
Some college or more	62.9		65.5		69.3	
High school or less	37.1		34.5		30.7	
Marital status, %						
Married	67.7		68.6		67.4	
Not married	32.3		31.4		32.6	
Household income (in $1000)	68.87 (60.17)	0–300	73.87 (61.25)	0–300	82.71 (67.10)	0–300
Subjective social status	5.78 (1.71)	1–10	6.51 (1.75)	1–10	6.60 (1.72)	1–10
Health status						
Physical health (self-rated)	3.73 (0.92)	1–5	3.50 (1.03)	1–5	3.41 (1.00)	1–5
Mental health (self-rated)	3.94 (0.88)	1–5	3.70 (0.92)	1–5	3.57 (1.15)	1–5
Body mass index	26.51 (5.01)	9–61	27.74 (5.43)	15–56	28.19 (6.07)	16–79
Number of chronic diseases	2.16 (2.19)	0–30	2.24 (2.31)	0–30	3.21 (3.15)	0–20
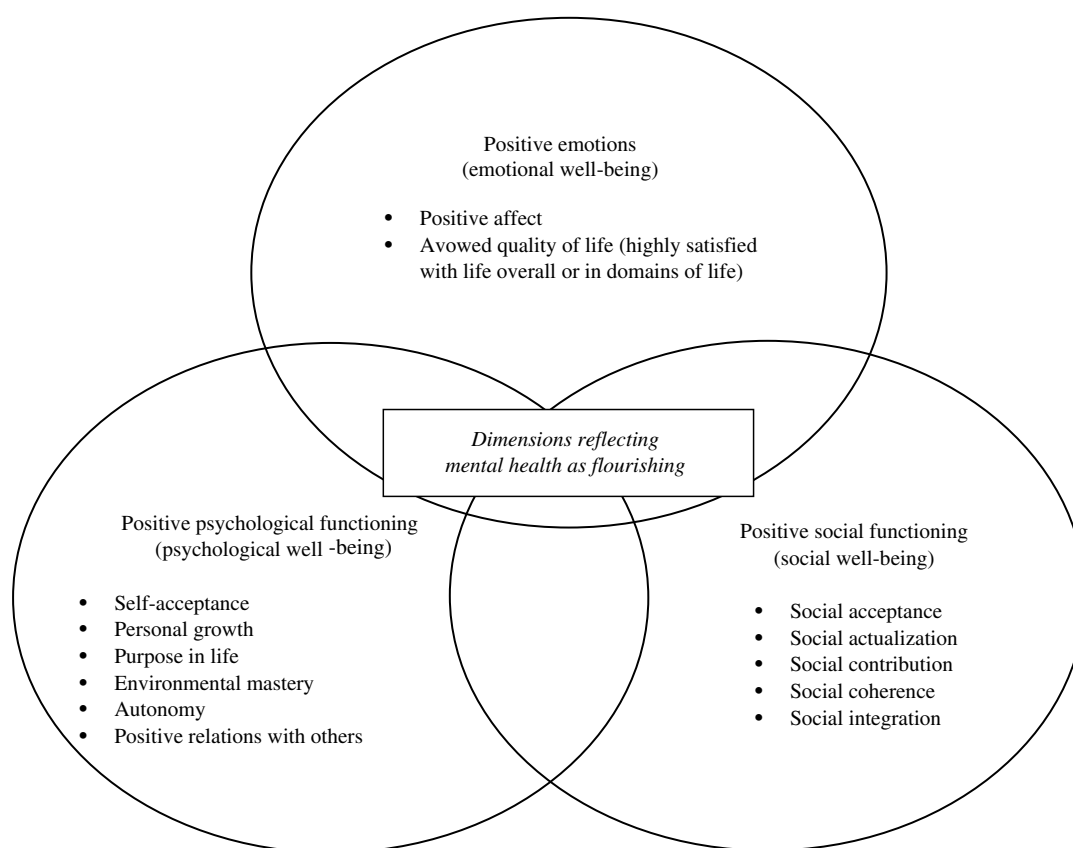
Figure 1 — The dimension of mental well-being.

Leisure-Time Physical Activity.   The LTPA was measured with particular questions. The question asked for assessing moderate LTPA was: "How often do you engage in moderate physical activity that is not physically exhausting but causes your heart rate to increase slightly and makes you work up a sweat during leisure or free time?" The question asked for assessing vigorous LTPA was: "How often do you engage in vigorous physical activity that causes your heart to beat so rapidly that you can feel it in your chest, and then you perform the activity long enough to work up a good sweat and are breathing heavily during leisure or free time?" The respondents were asked to report their level of engagement in moderate and vigorous LTPAs separately for the summer and the winter on a 6-point scale (1 = several times per week or more to 6 = never). The items were reverse-coded to indicate higher standing in the scale. An average score for each LTPA for the summer and winter seasons was created at each wave.

Confounding Factors.   Key variables previously reported as correlates of LTPA and well-being were included to assess unique variance accounted for by predictors.[2,6,26] Confonding variables were age (in years), sex (male = 0, female = 1), educational attainment (less than high school = 1 to college graduate or more = 4), income (household total income), marital status (not married = 0, married = 1), physical health (eg, self-reported health [1 = poor to 5 = excellent]), the number of chronic conditions (self-reported), body mass index (calculated by participant height and weight), and neighborhood environment (eg, neighborhood quality, cleanliness, trust in the community).

Statistical Analysis

Multiple Imputations.   Multiple imputations are useful for handling missing data, which is a common problem in longitudinal studies.[27] In this study, about 15.2% of the sample was classified as missing data. We used multivariate imputations by chained equations with the data sets to include large numbers of incomplete variables (the imputation process can also handle categorical and continuous variables).[27] All variables were included in the imputation process, and 25 imputed data sets were created with 10 iterations via R 4.0.3 package (open-source software package) with multivariate imputations by chained equations. The 25 imputed estimates were merged into a single composite estimate.

Propensity Score Matching.   Within the imputed data, PSM was conducted to reduce selection bias and to avoid issues of endogeneity.[28] The PSM enables explanatory covariates to match similar groups by assigning treatments based on observed covariates to reduce selection bias.[29] The treatment in this study was participation in LTPA. A propensity score was calculated for nonparticipation and participation in groups. The estimated propensity scores were used to adjust for all covariates in the estimation. Specifically, nonparticipation was matched on a 1-to-1 basis to participation based on similar propensity scores (see Table 2). The distribution of the standardized differences across potential covariates is illustrated in Figure 2.

Latent Growth Curve Modeling.   We used the LGCM statistical technique to assess the longitudinal association between the intensity of LTPA and the distinct dimensions of mental functions concerning well-being. The key advantage of LGCM is that indicators in one construct can predict the subsequent growth change of variables in

Table 2　Descriptive Statistics for Covariates After Matching by PSM in Moderate and Vigorous LTPAs

Variables	Nonparticipation in moderate LTPA (n = 714)		Participation in moderate LTPA (n = 714)		Prematch standardized difference[a]	Postmatch standardized difference[a]
	Mean	SD	Mean	SD		
Age	45.45	11.06	45.17	10.71	0.07	−0.002
Gender	1.46	0.49	1.47	0.50	0.31	0.02
Marriage	1.79	1.39	1.72	1.33	−0.04	−0.05
Income	3.34	4.48	3.23	4.12	0.02	−0.02
Education	7.48	1.79	7.45	2.23	−0.09	−0.01
Physical health	3.95	0.83	3.74	0.88	−0.39	−0.25
Chronic condition	1.90	1.92	2.00	2.04	0.19	0.05
BMI	25.84	4.05	25.7	4.34	0.22	−0.03
NEV	3.53	0.44	3.53	0.44	−0.15	0.01

Variables	Nonparticipation in vigorous LTPA (n = 615)		Participation in vigorous LTPA (n = 615)		Prematch standardized difference[a]	Postmatch standardized difference[a]
	Mean	SD	Mean	SD		
Age	45.21	11.00	45.72	10.74	0.08	0.05
Gender	1.45	0.49	1.45	0.49	0.31	0.00
Marriage	1.77	1.36	1.72	1.36	−0.03	−0.03
Income	3.08	3.81	3.20	4.19	0.09	0.03
Education	7.57	2.37	7.58	2.18	−0.05	0.01
Physical health	3.99	0.86	3.70	0.90	−0.43	−0.32
Chronic condition	1.90	1.92	2.06	2.12	0.18	0.07
BMI	25.72	4.12	25.68	4.05	0.23	−0.01
NEV	3.52	0.05	3.54	0.42	−0.11	0.05

Abbreviations: BMI, body mass index; LTPA, leisure-time physical activity; NEV, neighborhood environment.
[a]Standardized difference indicates the difference in mean of potential covariates between treated (LTPA participation) and untreated (LTPA nonparticipation) groups.

another construct.[30] A parallel LGCM permits the examination of 2 trajectories in a single model and the determination of whether the initial level of one construct predicts the growth rate of the other. A step-by-step approach was used for the analysis.[30] First, univariate LGCM was tested to determine the variability and growth trajectory of each primary variable individually. Before the model fit, the factor loadings for the intercept of the linear model were at 1, with slopes equal to 0, 1, and 2. The nonlinear model was also assessed with factor loadings (0 and 1) for the first and the last slopes, while the second loading was permitted to be free. Since the nonlinear model had a better fit, it was subsequently used. Next, parallel LGCM was used to determine whether a growth trajectory in one domain could predict change in a different domain. Predisposing factors as covariates (eg, demographic variables, personality, neighborhood environment) were included in the models (see Figure 3).

Results

Measurement Models for LTPA and Functioning

Univariate LGCM was examined with AMOS (version 25.0; IBM Corp., Armonk, NY) before modeling parallel LGCM. Specifically, moderate and vigorous LTPAs, as well as emotional, psychological, and social functioning, were assessed separately to explore their initial levels and growth rates. The fit for all models was acceptable. Table 3

presents the model fit indices, the means of the intercept, and the slope for all variables.

Relationships Among the Intercept and Slope of LTPA and Functioning

Parallel LGCM was conducted to examine how the initial level of LTPA predicts growth in functioning, and vice versa. A total of 3 models were created and analyzed: (1) moderate–vigorous LTPA and emotional functioning, (2) moderate–vigorous LTPA and psychological functioning, and (3) moderate–vigorous LTPA and social functioning. The model for LTPA and emotional functioning indicated a good fit to the data (χ^2 [53] = 4.37, $P < .001$, comparative-fit index [CFI] = .97, root mean square error of approximation [RMSEA] = .05 with 90% CI = .049–.064, standardized root mean square residual [SRMR] = .03). The growth in emotional functioning was associated with a high initial level of vigorous LTPA at the baseline ($\beta = 0.21$, $P < .05$), suggesting a person engaging in vigorous LTPA at baseline would experience a 0.21-unit increase in emotional functioning over time. However, the intercept of moderate LTPA was not related to the growth in emotional functioning. In addition, the intercept of emotional functioning was not associated with the slopes for both moderate and vigorous LTPAs.
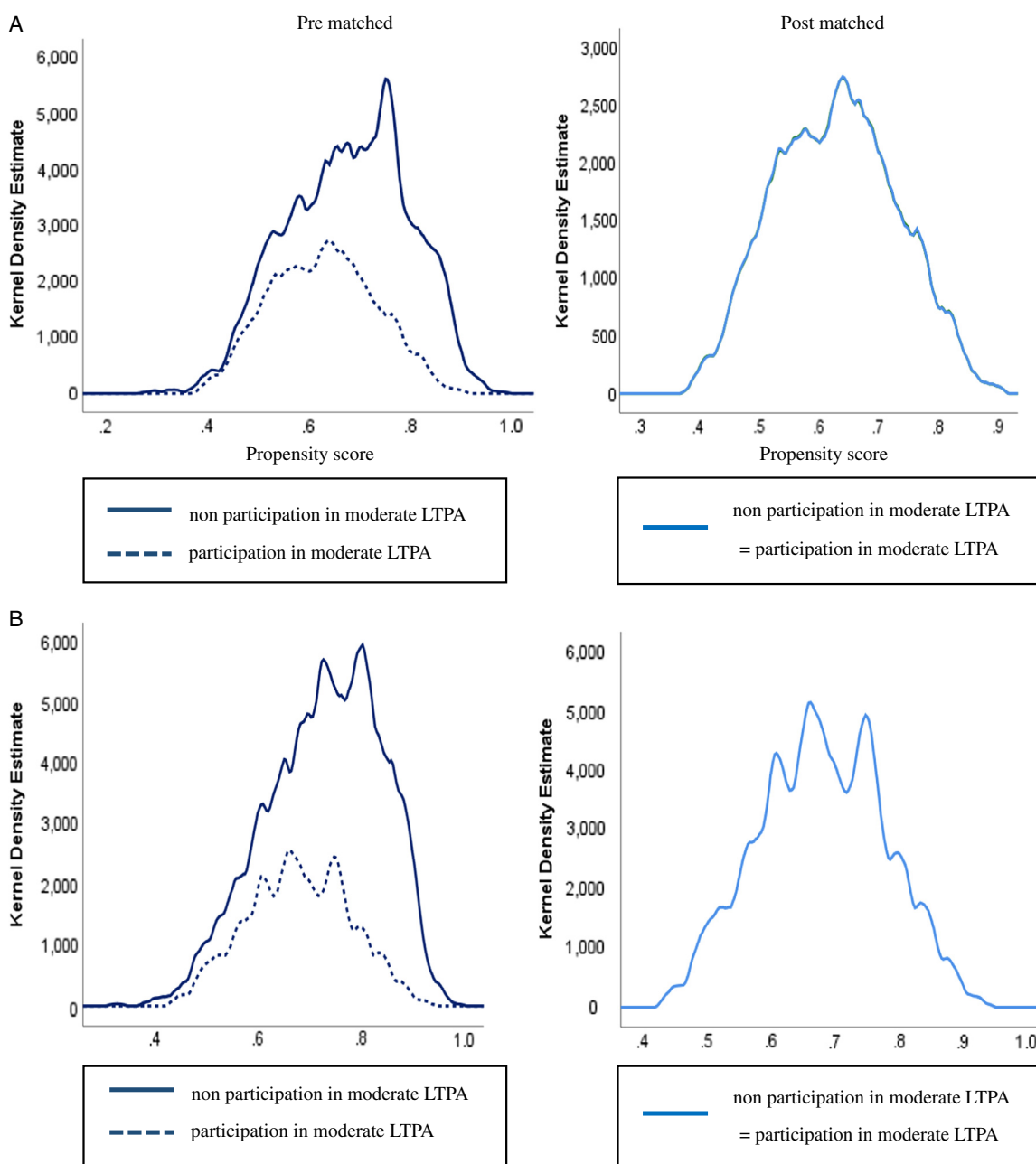
Figure 2 — Prematching and postmatching density of PSM scores. (A) Moderate LTPA and (B) vigorous LTPA. Kernel density plots between treated and untreated groups represent balanced data on the propensity score. LTPA indicates leisure-time physical activity; PSM, propensity score matching.

The model for LTPA (moderate and vigorous) and psychological functioning showed a good fit (χ^2 [53] = 4.55, $P < .001$, CFI = .96, RMSEA = .04 with 90% CI = .040–.054, SRMR = .04). The initial level of moderate LTPA positively predicted the growth in psychological functioning ($\beta = 0.41$, $P < .001$), whereas the initial level of vigorous LTPA was not related to the growth in psychological functioning. The results noted that a higher level of moderate LTPA at the baseline led to an increase in positive psychological functioning over time. Relatively, the initial level of psychological functioning was associated with the growth in both moderate ($\beta = 0.07$, $P < .01$) and vigorous ($\beta = 0.14$, $P < .001$) LTPAs. Thus, the relationship between moderate LTPA and psychological functioning illustrated that a reciprocal relationship in the longitudinal association exists.

The model fit for LTPA and social functioning had an acceptable fit for the data (χ^2 [5] = 6.63, $P < .001$, CFI = .93, RMSEA = .07 with 90% CI = .040–.054, SRMR = .03). The initial level of moderate LTPA at the baseline was associated with growth in social functioning ($\beta = 0.73$, $P < .05$), and the intercept of social functioning predicted the slope of moderate LTPA ($\beta = 0.11$, $P < .001$). Such results suggest the longitudinal association between moderate LTPA and social functioning could be reciprocal. Although the initial level of vigorous LTPA was not related to the growth in social functioning, the initial level of social functioning was associated with the growth in vigorous LTPA ($\beta = 0.12$, $P < .001$). Substantively, the results show that the initial level of social functioning predicts the growth in both moderate
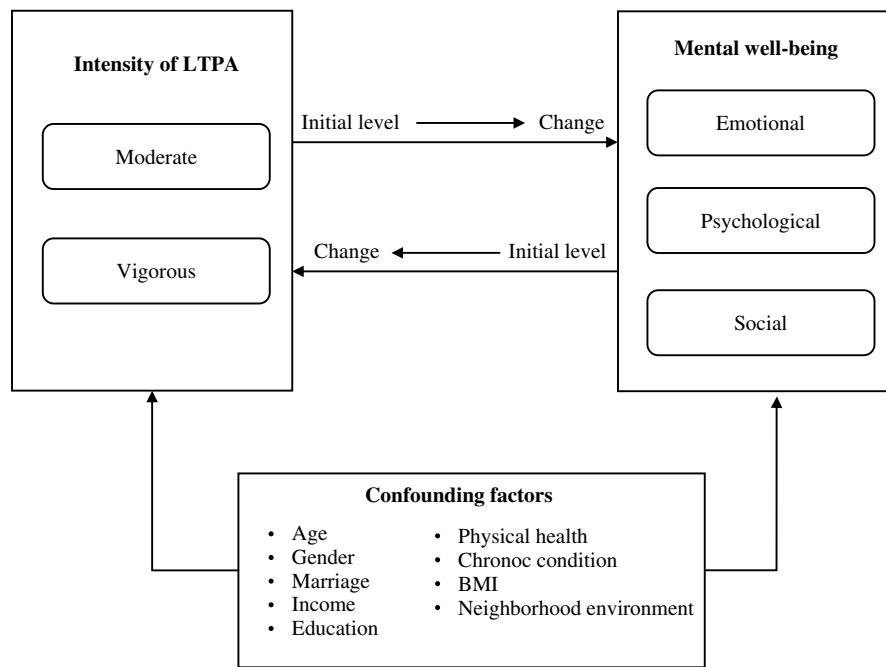
Figure 3 — Research model. BMI indicates body mass index; LTPA, leisure-time physical activity.

Table 3 Model Fit and Parameter Estimates for Univariate LGCM

	Model fit				Intercept		Slope	
Univariate LGCM model	χ^2/df	CFI	RMSEA (90% CI)	SRMR	Mean (SE)	σ^2 (SE)	Mean (SE)	σ^2 (SE)
Moderate LPTA	2.27 (2)	.999	.012 (.00–.02)	.001	5.61** (0.23)	−1.19** (0.08)	−1.05** (0.04)	−0.95** (0.13)
Vigorous LPTA	2.91 (2)	.999	.017 (.00–.05)	.002	4.80** (0.03)	0.14 (0.10)	−1.17** (0.05)	0.01 (0.93)
EMF	10.78 (2)	.989	.060 (.03–.10)	.009	8.02** (0.03)	0.67** (0.05)	−0.20** (0.03)	0.52** (0.07)
PSF	16.92 (2)	.987	.067 (.05–.12)	.014	5.75** (0.02)	0.31** (0.02)	−0.12** (0.02)	0.70* (0.02)
SOF	79.23 (2)	.999	.017 (.00–.04)	.004	4.68** (0.01)	0.46** (0.03)	−0.03 (0.02)	0.01 (0.00)

Abbreviations: CI, confidence interval; CFI, comparative-fit index; EMF, emotional functioning; LGCM, latent growth curve modeling; LTPA, leisure-time physical activity; PSF, psychological functioning; RMSEA, root mean square error of approximation; SOF, social functioning; SRMR, standardized root mean square residual. *$P < .01$. **$P < .001$.

and vigorous LTPAs over time. Table 4 presents standardized parameter estimates for all measurement models.

Discussion

Using a nationally representative data set, this study examined whether the intensity of LTPA at baseline is associated with the growth of emotional, psychological, and social functioning, and vice versa. In terms of activity theory,[5] different intensities of LTPA at baseline may be associated with changes in distinct functioning for mental health, as well as reciprocal relationships based on the intensity–functioning association over time.[31,32] This indicates that the LTPA intensities can play a role in the longitudinal association with mental well-being. More detailed discussions are presented as follows.

Moderate LTPA, Vigorous LTPA, and Emotional Functioning

The findings from the parallel LGCM showed that the association between moderate LTPA at baseline and a change in emotional

functioning was neither significant nor reciprocal. This was inconsistent with previous research,[33,34] suggesting a positive effect of moderate PA on emotional functioning. This could be due to the use of different methodologies, such as samples, measures, and research design. Previous studies primarily have used cross-sectional data and have tested the effect of PA intensity without consideration of specific domains (eg, leisure, transport, occupational, household). However, the current study focused particularly on the longitudinal association of LTPA intensities with functioning for mental health among US adults. Furthermore, given the characteristics of activity (eg, easy skill, low challenge), moderate LTPA might be less associated with emotional functioning in the long term than vigorous LTPA. Meanwhile, the results indicated that the initial level of vigorous LTPA was significantly related to changes in emotional functioning, and not vice versa. In a comparison of the nature of vigorous LTPA with moderate LTPA, the key difference was related to the degree of physical energy consumption (eg, oxygen consumption).[35] Thus, vigorous LTPA demands more energy consumption, and physical efforts with high-level skills and challenges are required. Given the activity characteristic, individuals who engaged in vigorous LTPA were likely to experience a feeling of high

Table 4 Standardized Parameter Estimates for Parallel LGCM

| | Model 1 (moderate and vigorous LTPAs−EMF) | | | | | |
| | Moderate LTPA | | Vigorous LTPA | | EMF | |
Predictors	Intercept	Slope	Intercept	Slope	Intercept	Slope
Moderate LTPA ITC						−0.06
Vigorous LTPA ITC						0.21*
EMF ITC		−0.03		0.04		
R^2	.29	.07	.10	.13	.43	.10
Age	−0.22	−0.08**	−0.06	−0.22***	0.23***	0.07
Gender	0.42***	−0.02	0.06	−0.08**	0.16***	−0.07
Marriage	0.03	−0.01	0.02	−0.01	−0.20***	0.00
Income	0.18	−0.09**	0.02	−0.10**	0.07	−0.19***
Education	0.13	0.09***	−0.01	0.11***	−0.01	0.23***
Physical health	−0.02	0.10***	−0.03	0.10***	0.32***	0.05
Chronic condition	0.15	−0.02	−0.02	0.00	−0.15***	0.09
BMI	0.06	−0.03	0.05	−0.05	−0.05	0.00
NEV	0.19	−0.05	0.02	−0.01	0.32***	0.04

| | Model 2 (moderate and vigorous LTPA−PSF) | | | | | |
| | Moderate LTPA | | Vigorous LTPA | | PSF | |
Predictors	Intercept	Slope	Intercept	Slope	Intercept	Slope
Moderate LTPA ITC						0.41***
Vigorous LTPA ITC						−0.06
PSF ITC		0.07**		0.14***		
R^2	.30	.11	.10	.14	.10	.14
Age	−0.09**	−0.09**	−0.06**	−0.19***	0.30**	0.04
Gender	0.11**	−0.02	0.03	−0.08**	0.07**	−0.13
Marriage	−0.01	0.00	0.00	−0.01	−0.13**	−0.08
Income	0.06	−0.09	0.02	−0.08	−0.01	−0.16
Education	0.02	0.08**	−0.02	0.09**	0.16**	0.24**
Physical health	−0.40	0.07	−0.49	0.12	0.77***	0.10**
Chronic condition	0.04	−0.01	−0.02	0.01	−0.26***	0.15
BMI	−0.03	−0.04	0.01	−0.04	−0.03	−0.09
NEV	0.02	−0.07**	0.00	−0.06	0.45***	−0.08

| | Model 3 (moderate and vigorous LTPA−SOF) | | | | | |
| | Moderate LTPA | | Vigorous LTPA | | SOF | |
Predictors	Intercept	Slope	Intercept	Slope	Intercept	Slope
Moderate LTPA ITC						0.73***
Vigorous LTPA ITC						0.05
SOF ITC		0.11***		0.12***		
R^2	.12	.06	.10	.15	.40	.21
Age	−0.10*	−0.10*	−0.06	−0.20***	0.35***	−0.08
Gender	0.13**	−0.02	0.04	−0.04	0.04	−0.05
Marriage	−0.01	−0.00	0.01	−0.00	−0.12**	−0.01
Income	0.07	−0.09*	0.02	−0.08**	−0.09*	−0.12***
Education	0.03	0.08**	−0.01	0.09***	−0.12***	0.08
Physical health	−0.03	0.08**	−0.04	0.15***	0.26***	−0.02
Chronic condition	0.05	−0.00	−0.02	0.01	−0.11**	−0.00
BMI	−0.02	−0.03	0.02	0.01	0.03	−0.04
NEV	0.03	−0.09*	0.00	−0.02	0.49***	−0.24***

Abbreviation: BMI, body mass index; EMF, emotional functioning; ITC, intercept; LGCM, latent growth curve modeling; LTPA, leisure-time physical activity; NEV, neighborhood environment; PSF, psychological functioning; SOF, social functioning.
*$P < .05$. **$P < .10$. ***$P < .001$.

physical self-efficacy by increasing their physical conditioning and fitness. Such benefits from vigorous LTPA could be associated with satisfaction in life domains (eg, personal, daily life, healthy living) that are linked to emotional functioning.

Moderate LTPA, Vigorous LTPA, and Psychological Functioning

Consistent with previous studies' findings,[12,13,15] this study supported the prospective effect of PA on psychological functioning during the follow-up period. Essentially, the findings showed that the initial level of moderate LTPA predicted a change in psychological functioning over an extended duration of time, and vice versa. This might be due to positive experiences, such as self-development and the satisfaction of psychological needs through sustainable engagement in moderate LTPA over time.[36] Furthermore, the initial level of psychological functioning predicted the change in moderate LTPA. That is, the longitudinal relationship between moderate LTPA and psychological functioning could be reciprocal.[37] Unlike moderate LTPA, vigorous LTPA at the baseline was not associated with a change in psychological functioning. However, the initial level of psychological functioning predicted a change in vigorous LTPA over time. This finding indicates that individuals with high-level psychological functioning tend to show increased engagement with vigorous LTPA in the long term. For this reason, psychological functioning could be a resource to increase engagement in vigorous LTPA.

Moderate LTPA, Vigorous LTPA, and Social Functioning

Similar to psychological functioning, social functioning at baseline predicted changes in moderate and vigorous LTPAs over time. However, only moderate LTPA at baseline is associated with a change in social functioning. The finding that moderate LTPA at baseline led to a change in social functioning could have a valid relation to the finding that the initial level of social functioning predicted a change in LTPA. Essentially, a dynamic reciprocal association may exist across time.[15] Relatively, social functioning at the baseline predicted a change in vigorous LTPA. Individuals with high social functioning could be more engaged in vigorous LTPA over time to fuel or refuel their sociopsychological needs. In this context, vigorous LTPA requiring high-performance skills and physical ability could be beneficial not only to sustain social functioning but also to improve social confidence and interaction. Thus, vigorous LTPA could be an efficient tool to satisfy their sociopsychological needs.

Sociodemographic Variables in the Longitudinal Association of LTPA Intensities With Mental Well-Being

Although the effect of sociodemographic variables on mental functioning was not the main focus of this study, it is noteworthy that key sociodemographic variables have effects on both the initial level and changes in LTPA intensities and dimensions of mental well-being.[6] As shown in Table 4, several sociodemographic factors could be correlates of LTPA intensities and mental well-being dimensions. For example, income and education have positive or negative effects on changes in LTPA intensities and mental functioning. Specifically, income and education in the association of moderate and vigorous LTPAs with emotional functioning were correlated to the change in LTPA intensities and emotional

functioning (model 1). Furthermore, education had an effect on the growth in both intensities and psychological functioning (model 2). Income was also associated with the changes in all intensities with social functioning (model 3). Thus, the findings imply that key sociodemographic factors could moderate the association of LTPA intensities with dimensions of mental well-being.

Limitations and Future Study

The limitations of this study should be acknowledged. First, a self-reported measure of the intensity of LTPA was used. Self-reported data may be biased and may influence the assessment of the LTPA intensity level.[38] Thus, future studies could extend this research and improve the findings' stability if objective LTPA intensity based on physiological measures was employed in the longitudinal model. Second, according to self-determination theory, intrinsic and extrinsic motivations could influence the self-regulation of LTPA intensity differently.[39] Thus, future studies could include the effect of motivation on the longitudinal association to link LTPA with mental health functioning. Finally, confounding variables (eg, injury, economic instability) could be used to examine both LTPA and well-being to provide more specific information in the longitudinal association.

Conclusion and Implications

The LTPA intensity plays an important role in the longitudinal association with mental health function. As suggested by activity theory, the findings imply that the characteristics of activity are related to development in distinct domains of mental well-being.[40] Given the differences between the characteristics of LTPA intensities (eg, skills and efforts), individuals could achieve or sustain their mental well-being differently in the long term, depending on the selected LTPA intensity. The findings indicate that different LTPA intensities predict different growth patterns in areas of mental health function. In addition, there is a reciprocal relationship that indicates the importance of matching the intensity of LTPA with improved functioning for better mental health.

From the longitudinal development of mental health perspectives, health promotion strategies should consider how the intervention effects of LTPA intensity are related to changes in mental health function and how long the association could persist. Furthermore, the intervention of moderate LTPA may be more efficient in health promotion strategies that aim to increase psychological and social functioning in the long term. Likewise, vigorous LTPA could be beneficial in interventions that target improvement in emotional functioning over time. Hence, health promotion strategies for mental health through LTPA should consider the longitudinal associations based on matching intensity with functioning.

Acknowledgments

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