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Subjective Health and Physical-Activity Engagement across Adulthood: Distinguishing between Within-Person and Between-Person Associations

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Keywords

Loss-prevention · Goal orientation · Lifespan development · Self-rated health

Abstract

Introduction: It is assumed that age-related increases in loss (e.g., health decline) motivate behavioral changes (e.g., prevention of health decline) across adulthood. This assumption has rarely been directly tested in empirical research, and the current study seeks to fill this gap. ***Methods:*** By performing random intercept cross-lagged panel model and multilevel modeling analyses on a three-wave longitudinal dataset from the Midlife in the United States survey (N = 7,108; 51.6% female; between 20 and 75 years at T1), we examined the between-person and the within-person associations between subjective health and engagement in physical activity. Chronic conditions, difficulty in performing daily activities, and demographic variables were controlled for. ***Results:*** At the between-person level, subjective (i.e., self-rated) health was positively associated with physical activity in the whole sample and the older subgroup (T1 age >55 years), but not in the younger subgroup (T1 age <35 years). At the within-person level, the association between subjective health and subsequent physical activity was negative in the whole sample and the older subgroup, but nonsignificant (between T1 and T2) or positive (between T2 and T3) in the younger subgroup. ***Discussion:*** This study revealed various associations between subjective health and engagement in physical activity across levels (the within- vs. between-person level) and across age groups (younger vs. older group). The finding contributes to a better understanding of people's health behavior in reaction to health decline at different ages. It also supports the proposition that age-related intraindividual increases in losses (e.g., health decline) motivate behaviors that counteract such losses (e.g., physical activity that protects health).

Introduction

Health is a vital component of human quality of life, and physical activity plays a key role in maintaining health. It has been extensively studied how physical activity affects health and well-being, but less is known about how health influences engagement in physical activity. As health declines and becomes more of a concern as people

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age, do older adults react more strongly to health changes, and thus show stronger associations between health and subsequent physical activity, compared with younger adults? To address the research question, we analyzed the 20-year longitudinal data from the Midlife in the United States (MIDUS) survey. Using the random intercept cross-lagged panel model (RI-CLPM) and multilevel modeling (MLM) techniques, we distinguished between the within-person and between-person associations between subjective (i.e., self-rated) health and physical activity across adulthood. The study aims to contribute to a better understanding of both individuals' health behavior and behavioral changes across adulthood. As sustained engagement in physical activity is typically goal-directed and planned, the study also provides insight into motivation/goal development across adulthood.

Personal development is a process of achieving a favorable balance between gains and losses [1–3]. However, the ratio of losses to gains disproportionately increases as we age. Coping with age-related increases in loss (e.g., a prevalent decline in health and functioning levels) becomes a major life task, especially in late adulthood [4, 5]. Several influential lifespan development theories have been proposed to explain how people cope with age-related increases in loss, such as the model of selection, optimization, and compensation [6], the lifespan theory of control [7], and the dual-process model of coping [8]. These theories have their roots in the proposition that people flexibly regulate their motivation and behavior to manage life changes and challenges such as increasing losses. A good example of such regulation is the gradual change in goal orientation and goal-directed behavior across adulthood. It has been shown that while younger adults are primarily concerned with growth and striving for gains (e.g., acquiring new skills), older adults are more concerned with maintaining resources/functioning and avoiding losses (e.g., maintaining physical fitness and avoiding health decline) [9–12]. The age-related shift in goal orientation and goal-directed behavior has been interpreted as an adaptive response that counteracts age-related increases in loss and optimizes gain-to-loss ratios [12, 13].

According to these theories, age-related increases in loss drive age-related changes in motivation and behavior. In the health domain, for instance, health decline with age motivates people to protect their health. Surprisingly, little research has directly examined the relationship between loss (e.g., health decline) and motivation (e.g., health-protective motivation) or behavior (e.g., health-protective behavior) across adulthood. While a few recent studies have examined the association [10, 14], only cross-sectional data were used, making it difficult to reveal developmental changes. To fill the gap, the current study investigated the association between loss (e.g., health decline) and behavior (e.g., physical activity) in the health domain using a longitudinal dataset from the MIDUS survey. Specifically, we examined the between-person and within-person associations between self-rated health and engagement in physical activity across adulthood. Distinguishing between these two types of associations is essential, as only within-person associations provide developmental insights, i.e., how a person's change in one construct (e.g., decline or improvement in subjective health) is associated with the person's follow-up change in another construct (e.g., increased or decreased engagement in physical activity) [15, 16].

Health is a major life domain, and age-related decline in health (a major type of loss) is prevalent and almost inevitable, particularly in late adulthood. As a result, prevention of health decline and diseases becomes more prioritized as people age [17]. Regular engagement in physical activity is widely recognized and recommended as a means to maintain fitness and prevent health problems [18]. The relationships between health change and physical activity (particularly at the within-person level) can provide insights into behavioral change during adulthood. In MIDUS, participants were asked to report their engagement in moderate-to-vigorous physical activity during the past year. Such sustained engagement in physical activity is usually goal-directed and planned [19, 20]. As such, examining the relationships between health change and physical activity can also shed light on motivation development across adulthood, even though motivation is not directly assessed. If age-related increases in loss (e.g., health decline) drive loss-prevention motivation and behavior (e.g., health-protective behavior) as asserted in the abovementioned lifespan development theories, then we should observe a disassociation between the between-person and within-person "health-physical activity" relationships. To be specific, at the between-person level, better health should be associated with greater engagement in physical activity as frequently reported in the literature [21]. However, at the within-person level, declines in health should be followed by increased engagement in physical activity, and this association should be stronger in late adulthood than in early adulthood.

The Current Study

The current study examined the association between subjective health and physical activity using longitudinal data from MIDUS. The RI-CLPM and MLM techniques are used to separate the associations at the within-person and between-person levels [22, 23]. Rather than focusing on objective health, we were more interested in subjective health because human behavior is ultimately more determined by perceptions (e.g., perceptions of the situational factors, norms, and control) [7, 24, 25].

We focused on moderate-to-vigorous physical activity but not light physical activity because the former was measured at all timepoints, while the latter was measured only at the last two timepoints in the MIDUS survey. Moreover, the literature shows that moderate-to-vigorous physical activity has robust beneficial influences on health, while light physical activity has weaker effects, if any [26–28]. Many physical activity guidelines (e.g., those developed by the World Health Organization, Australia, Canada, USA) recommend moderate-to-vigorous physical activity for maintaining and promoting health. Nevertheless, we conducted the same set of analyses for both moderate-to-vigorous physical activity (see the Result section) and light-to-vigorous physical activity (see the online supplement; for all online suppl. material, see www.karger.com/doi/10.1159/000527797), and the analyses yielded the same pattern of associations between health and physical activity.

To test our hypotheses regarding motivated health-protective behavior and physical activity, we controlled for participants' difficulty in performing daily activities when predicting physical activity engagement. This allowed us to rule out the possibility that some participants did less physical activity merely because they were objectively less capable of doing so. In this way, participants' variations in physical activity in our models were more likely to be driven by motivational changes induced by their health changes. Based on the discussion above, the following hypotheses were proposed.

H1. **(a)** At the between-person level, subjective health is positively associated with engagement in (moderate-to-vigorous) physical activity. In other words, people with better subjective health are more likely to be those with greater engagement in physical activity. **(b)** At the within-person level (the main focus of this study), subjective health is negatively associated with subsequent engagement in physical activity. In other words, intraindividual decline in health tends to be followed by enhanced engagement in physical activity.

H2. The within-person association between subjective health and subsequent engagement in physical activity is stronger in older than in younger adults.

Materials and Methods

Sample Information

Data used in the present study were from MIDUS, a nationwide longitudinal survey of health and well-being consisting of three measurement waves (the year 1995–1996, 2005–2006, and 2013–2014). A national sample of N = 7,108 US adults was recruited at timepoint 1 (T1). A majority of the participants were randomly selected from working telephone banks. Participants provided data through a telephone interview (about 30 min) and a self-administered questionnaire (around 100 pages) by mail. In this sample, 51.6% of the participants were female and 80.3% were white, and their initial ages (at T1) were between 20 and 75 years (M = 46.4, SD = 13.00; 9.7% between 20 and 29 years, 25.0% between 30 and 39 years, 25.7% between 40 and 49 years, 19.7% between 50 and 59 years, 13.9% between 60 and 69 years, and 5.1% equal to or above 70 years). Regarding the highest education levels reached by T1, 11.1% of the participants had not completed high school, 58.0% had completed high school, 20.2% had completed a bachelor's degree, and 10.4% had completed a master's degree or above. In terms of marital status, 65.6% of the participants were married, 13.5% were divorced, 5.0% were widowed, 2.8% were separated from partners, and 12.9% were single at T1. In terms of employment status, 62.5% of the participants were employed, 13.7% were self-employed, and the others were unemployed or retired at T1. As for income, 39.6% of participants had yearly household income lower than $50,000, 26.3% between $50,000 and $99,999, 15.1% between $100,000 and $199,999, and 5.1% greater than or equal to $200,000 at T1. N = 4,955 participants from the original sample were interviewed at T2, and 3,294 participants were interviewed at T3. More detailed descriptions of the sample, procedures, and data are documented on the MIDUS website (http://www.midus.wisc.edu/).

Measures

The specific items measuring the following variables are presented in the online supplement.

Subjective and Objective Health Status

Participants rated their current general health (from 0 "the worst possible health" to 10 "the best possible health"), physical health (from 1 "poor" to 5 "excellent"), and mental health (from 1 "poor" to 5 "excellent"). Each participant's scores on these items were standardized and then averaged to indicate subjective health status, with higher scores indicating better health. Cronbach's α of the three items was above 0.70 for the whole sample, the younger subgroup (T1 age <35 years), and the older subgroup (T1 age >55 years) at all three timepoints (except for α = 0.66 for the older subgroup at T3). Objective health status, as a control variable, was indicated by the number of chronic conditions over the past year.

Engagement in Physical Activity

Moderate-to-vigorous physical activity was measured at all three timepoints, while light physical activity was measured at T2 and T3 but not T1. As discussed above, we focused on moderate-to-vigorous physical activity since it is more strongly associated with health. Nonetheless, we conducted the same analyses with physical activity at all intensities (i.e., light to vigorous), and the same main findings were obtained (see the online supplement). At T1, physical activity was divided into four types: moderate/vigorous physical activity during the summer/winter (four items in total). At T2 and T3, the four types of physical activity measured at T1 (i.e., moderate/vigorous physical activity during the summer and winter) were further divided according to life domains (i.e., paid job, domestic chores, and leisure or free time), resulting in 12 items in total. Participants rated each type of activity using a six-point scale (from 1 "several times a week" to 6 "never"). Cronbach's α of the measure was above 0.79 at all three timepoints for the whole sample, the younger subgroup, and the older subgroup. For each timepoint, we computed engagement in moderate-to-vigorous activity by averaging the corresponding items. A higher score indicates a higher level of engagement in physical activity.

Difficulty in Performing Daily Activities

The measure included two items capturing the capacity to conduct basic activities of daily living (i.e., "How much does your health limit you in bathing or dressing yourself/walking one block") [29] and seven items capturing the capacity to conduct instrumental activities of daily living (e.g., "How much does your health limit you in lifting or carrying groceries) [30]. Participants rated each item using a four-point scale (from 1 "a lot" to 4 "not at all"). Cronbach's α was above 0.80 for the whole sample, the younger subgroup, and the older subgroup at all three timepoints. Scores on the items were reversed and averaged to indicate difficulty in performing daily activities, with a higher score indicating a higher difficulty level.

Analytical Strategies

Structural equation modeling, e.g., RI-CLPM, and multilevel modeling (MLM; also known as hierarchical linear modeling, HLM) are often used to analyze longitudinal data [31, 32]. There are advantages and disadvantages to both methods. For example, RI-CLPM can model multiple predictor variables and multiple outcome variables simultaneously, and handle missing values in both predictor and outcome variables flexibly, e.g., by using full information maximum likelihood estimation [33]. However, there are difficulties incorporating the moderation effects of continuous variables into RI-CLPM. A common way is to categorize a moderator variable into two or more groups and then perform a multigroup RI-CLPM to examine whether the interested path coefficients significantly differ across these groups [34]. In contrast, MLM can flexibly model moderation effects of both categorical and continuous variables but cannot handle multiple outcome variables at the same time. It can also handle missing values in the outcome variable very well but not those in the predictor variables [31, 32]. As RI-CLPM and MLM have different strengths and weaknesses, we cross-validated our results using both methods.

RI-CLPM Analysis

Using the package *lavaan* [35] in R [36], we conducted RI-CLPM analyses [22, 34] to disentangle the within-person and between-person associations between (subjective and objective) health and physical activity. As shown in Figure 1, the RI-CLPM model decomposed each observed variable at each timepoint – subjective health (Sub_1, Sub_2, and Sub_3; note that the subscript here indicates timepoint), objective health (Obj_1, Obj_2, and Obj_3), and physical activity (Act_1, Act_2, and Act_3) – into a between-person component (i.e., random intercepts Sub_{int}, Obj_{int}, and Act_{int}) and a within-person component (e.g., Sub_{w1}, in which the subscript $_w$ indicates "within-subject," and the number indicates timepoint). The random intercepts captured each participant's time-invariant trait-like levels of subjective health, objective health, and physical activity (i.e., each subject's cross-time mean scores on these variables). The relationships among the random intercepts indicated the associations between health and physical activity at the between-person level. The within-person components captured each participant's time-varying within-person changes from their mean levels of subjective health, objective health, and physical activity. The concurrent and cross-lagged relationships among these within-person components indicated the within-person associations between health and physical activity.

As we are primarily interested in subjective health, we included a control for objective health (as indicated by the number of chronic conditions) in our model. Demographics (age, sex, education, income, employment, and marital status) were controlled as covariates. To ensure participants' within-person changes in physical activity did not merely reflect changes in the difficulty of conducting physical activity (but were more related to motivational changes related to health decline), we also controlled for the person-mean centered difficulty in performing daily activities (dif_w). Full information maximum likelihood estimation was applied to deal with missing values. To test whether the associations between health and physical activity varied with age (i.e., the moderation effect of age), a multigroup RI-CLPM analysis was conducted to compare the younger (T1 age <35 years) and older subgroups (T1 age >55 years). The age cut-offs (35 and 55 years) were chosen to ensure large and comparable sample sizes in the two age groups and to ensure that no younger adults entered late adulthood during the survey period (i.e., all participants in the younger group were under 55 years old by T3).

MLM Analysis

We also conducted MLM analyses to cross-validate the associations between health and physical activity, particularly the time-lagged predictive effects of health on physical activity at the within-person level. Measurement timepoints (level-1 factor) were nested within persons (level-2 factor) in the MLM models. We decomposed the key predictor variables (subjective health and objective health) into time-invariant between-person components (i.e., cross-time person means $Subjective_{between}$ and $Objective_{between}$) and time-varying within-person components (i.e., person-mean centered scores $Subjective_{within}$ and $Objective_{within}$). As shown in Equation (1), at level 1 of the MLM model, physical activity at timepoint t (i.e., $Activity_t$) was regressed on the within-person components of health at timepoint $t-1$ (i.e., $Subjective_{within\,(t-1)}$ and $Objective_{within\,(t-1)}$). The main effects of *Timepoint* and *T1 Age* (which was used to divide the sample into different age groups in the RI-CLPM analysis described above), as well as their interactions with the within-person components of health, were also included as predictors. Demographics ($Demographics_t$), difficulty in performing daily activities ($Difficulty_t$) at timepoint t, and physical activity at timepoint $t-1$ were controlled as covariates. As shown in Equation (2), at level 2 of the MLM model, the intercept was predicted by the between-person components of health ($Subjective_{between}$ and $Objective_{between}$) and their interactions with *T1 Age* and *Timepoint*.

Table 1. Descriptive results and correlations within and across measurement timepoints

	M	*SD*	T1 1	T1 2	T1 3	T1 4	T2 1	T2 2	T2 3	T2 4	T3 1	T3 2	T3 3	T3 4
Time 1 (T1)														
1. Age	46.38	13.00	1											
2. Subjective health (*z*)	0	0.83	**−0.10**	1										
3. Chronic conditions	2.41	2.51	**0.18**	**−0.47**	1									
4. Activity	4.68	1.24	**−0.26**	**0.34**	**−0.24**	1								
Time 2 (T2)														
1. Age	55.43	12.45	1	**−0.06**	**0.16**	**−0.23**	1							
2. Subjective health (*z*)	0	0.84	**−0.13**	**0.58**	**−0.35**	**0.25**	**−0.13**	1						
3. Objective health	2.46	2.59	**0.21**	**−0.34**	**0.53**	**−0.20**	**0.21**	**−0.44**	1					
4. Activity	3.12	1.33	**−0.28**	**0.09**	**−0.09**	**0.36**	**−0.28**	**0.12**	**−0.08**	1				
Time 3 (T3)														
1. Age	63.64	11.35	1	−0.01	**0.14**	**−0.16**	1	−0.02	**0.18**	**−0.23**	1			
2. Subjective health (*z*)	0	0.85	**−0.05**	**0.51**	**−0.32**	**0.19**	**−0.06**	**0.60**	**−0.38**	**0.11**	**−0.05**	1		
3. Objective health	3.25	3.15	**0.16**	**−0.34**	**0.52**	**−0.15**	**0.16**	**−0.37**	**0.58**	**−0.09**	**0.16**	**−0.48**	1	
4. Activity	3.21	1.38	**−0.28**	**0.17**	**−0.15**	**0.38**	**−0.28**	**0.15**	**−0.17**	**0.47**	**−0.28**	**0.22**	**−0.17**	1

Significant coefficients are marked in bold ($p < 0.05$). *Z* within brackets in the first column means that the score was standardized.

MLM model Level 1:

$$\text{Activity}_t = \text{Intercept} + \text{Demographics}_t + \text{Difficulty}_t + \text{Activity}_{t-1} + \text{Timepoint} + \text{T1\_Age} + \text{Subjective}_{\text{within }(t-1)} + \text{Objective}_{\text{within }(t-1)} + \text{Timepoint} * \text{Subjective}_{\text{within }(t-1)} + \text{T1\_Age} * \text{Subjective}_{\text{within }(t-1)} + \text{Timepoint} * \text{Objective}_{\text{within }(t-1)} + \text{T1\_age} * \text{Objective}_{\text{within }(t-1)} + e \quad \text{(Equation 1)}$$

MLM model Level 2:

$$\text{Intercept} = \text{Subjective}_{\text{between}} + \text{Objective}_{\text{between}} + \text{Timepoint} * \text{Subjective}_{\text{between}} + \text{T1\_Age} * \text{Subjective}_{\text{between}} + \text{Timepoint} * \text{Objective}_{\text{between}} + \text{T1\_age} * \text{Objective}_{\text{between}} \quad \text{(Equation 2)}$$

Results

Descriptive Results

Table 1 displays the mean values, standard deviations, and intercorrelations of the key variables for the whole sample (the results for the younger and older subgroups are displayed in online suppl. Tables S1 and S2). For the whole sample, higher ages were associated with more chronic conditions (i.e., worse objective health), worse subjective health, and less engagement in physical activity at all three timepoints. Physical activity was positively associated with subjective health and objective health (i.e., fewer chronic conditions) at all three timepoints.

Note that participants' scores on the three items measuring subjective health were standardized and then averaged to indicate subjective health in Table 1. To examine whether subjective health decreased with time (and thus can be used to reflect age-related decline in the health domain), we compared the whole sample's original ratings (i.e., the ratings before standardization) on each item across the three timepoints. As expected, the results showed that participants' ratings on the overall health item (T1: $M = 7.63$, $SD = 1.43$; T2: $M = 7.56$, $SD = 1.45$; T3: $M = 7.35$, $SD = 1.58$), the physical health item (T1: $M = 3.68$, $SD = 0.91$; T2: $M = 3.67$, $SD = 0.94$; T3: $M = 3.43$, $SD = 1.038$), and the mental health item (T1: $M = 3.88$, $SD = 0.91$; T2: $M = 3.88$, $SD = 0.90$; T3: $M = 3.63$, $SD = 0.95$) all significantly decreased over time (ps < 0.001).

RI-CLPM Results

A RI-CLPM (see Fig. 1) was performed to estimate the associations between health and moderate-to-vigorous physical activity for the whole sample, $\chi^2 = 713.84$, $df = 55$, $p < 0.001$, $CFI = 0.91$, $RMSEA = 0.07$, $SRMR = 0.03$, and then a multigroup RI-CLPM was performed to estimate the associations for the younger (T1 age <35 years) and the older age groups (T1 age >55 years), $\chi^2 = 415.52$, $df = 110$, $p < 0.001$, $CFI = 0.91$, $RMSEA = 0.07$, $SRMR = 0.04$. The path coefficients of interest are listed in Table 2, and the detailed results are displayed in online supplementary Table S3 (similar RI-CLPM results for light-to-vigorous physical activity are displayed in online suppl. Table S4).

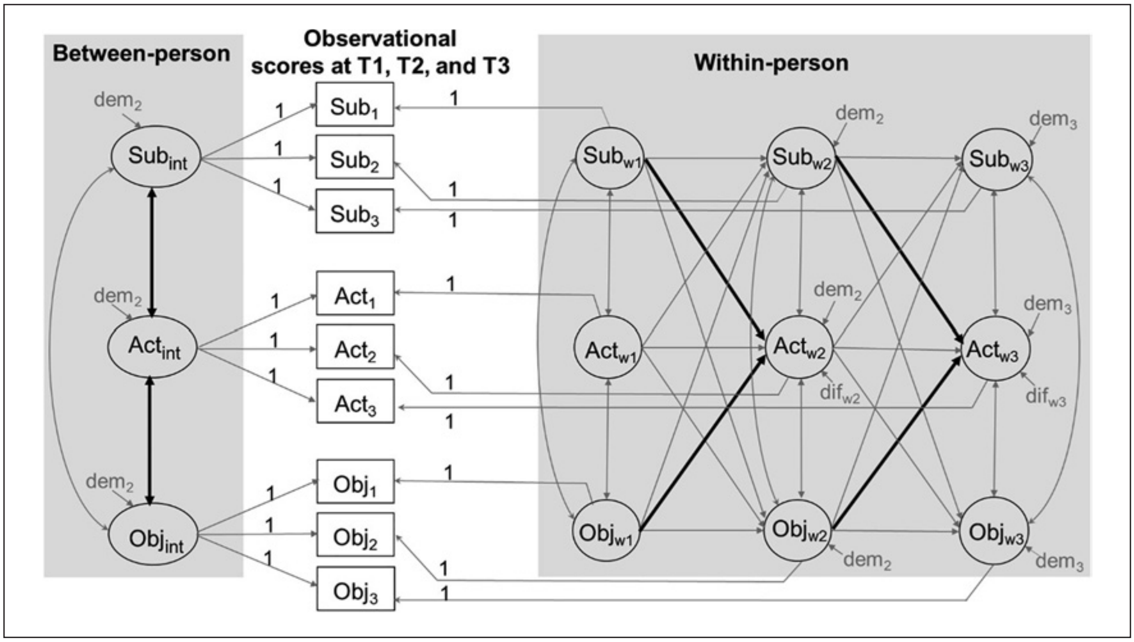

Fig. 1. The random intercept cross-lagged panel model (RI-CLPM) of the associations between health and engagement in physical activity. The left panel in grey illustrates the between-person associations (participants' demographics at T2 were used to represent their average demographic statuses across the three timepoints and were controlled for as covariates). The right panel in grey illustrates the within-person associations (demographics and difficulty in performing daily activities were controlled for as covariates). The paths of interest (i.e., associations between health and physical activity) are highlighted in bold. Sub, subjective health; Obj, objective health (indexed by the number of chronic health conditions); Act, engagement in physical activity; dif, difficulty in performing daily activities (controlled as covariates when predicting Act_{w2} and Act_{w3}); dem2 and dem3, demographics at timepoint 2 and 3 (including age, sex, education, income, employment, marital status; controlled as covariates); subscript $_{int}$, random intercept (i.e., between-person component); subscript $_{w}$, within-person component; the numbers in the subscript, timepoint.

Between-Person Correlations

At the between-person level, subjective health was positively associated with physical activity in the whole sample ($b = 0.41$, $SE = 0.05$, $z = 8.53$, $p < 0.001$) and the older subgroup ($b = 0.44$, $SE = 0.10$, $z = 4.55$, $p < 0.001$), but not the younger subgroup ($b = 0.20$, $SE = 0.19$, $z = 1.07$, $p = 0.28$). The number of chronic conditions (as an indicator of objective health) was negatively associated with physical activity in the whole sample ($b = -0.25$, $SE = 0.04$, $z = -5.69$, $p < 0.001$) and the older subgroup ($b = -0.20$, $SE = 0.08$, $z = -2.44$, $p = 0.02$), but not the younger subgroup ($b = -0.40$, $SE = 0.26$, $z = -1.54$, $p = 0.13$). The results showed that participants (especially older participants) with better subjective and objective health were more strongly engaged in physical activity, or the other way around, that participants more strongly engaged in physical activity tended to be healthier. The result was largely consistent with hypothesis **H1a**.

Within-Person Time-Lagged Associations

At the within-person level, subjective health was negatively (T1 to T2; $b = -0.29$, $SE = 0.09$, $z = -3.23$, $p = 0.001$) or nonsignificantly (T2 to T3; $b = -0.07$, $SE = 0.06$, $z = -1.16$, $p = 0.25$) associated with subsequent engagement in physical activity in the whole sample. This association was constantly negative in the older subgroup (T1 to T2: $b = -0.43$, $SE = 0.15$, $z = -2.88$, $p = 0.004$; T2 to T3: $b = -0.43$, $SE = 0.21$, $z = -2.02$, $p = 0.04$), but either nonsignificant (T1 to T2; $b = -0.17$, $SE = 0.27$, $z = -0.62$, $p = 0.54$) or positive (T2 to T3; $b = 0.29$, $SE = 0.14$, $z = 2.06$, $p = 0.01$) in the younger subgroup. Most of the other cross-lagged associations were not significant. The results indicate that, after controlling for objective health and difficulty in performing daily activities, decline in subjective health was followed by increases in physical activity at the within-person level among older (but not younger) adults. The result was largely consistent with hypotheses **H1b** and **H2**.

MLM Results

An MLM analysis was performed to cross-validate the results yielded by the RI-CLPM analysis described above, particularly the time-lagged effects of health on moderate-to-vigorous physical activity in different age groups. Table 3 displays the results of the MLM analysis (similar results for light-to-vigorous physical activity are displayed in online suppl. Table S5).

Between-Person Correlations

At the between-person level, stronger engagement in physical activity was associated with better subjective health and objective health (indicated by fewer chronic conditions). These between-person associations changed with time, as indicated by the significant interactions between health and timepoints ($Timepoint * Subjective_{between}$, $\beta = 0.18$, $SE = 0.05$, $t = 3.25$, $p = 0.001$; $Timepoint * Objective_{between}$, $\beta = -0.05$, $SE = 0.02$, $t = -3.11$, $p = 0.002$). These between-person associations did not vary with participants' initial ages, as indicated by the nonsignificant $T1\_Age * Subjective_{between}$ and $T1\_Age * Objective_{between}$ interaction effects (ps > 0.07). The results overall converge with the between-person correlations yielded by the RI-CLPM analyses, largely supporting **H1a**.

Within-Person Time-Lagged Associations

At the within-person level, there was a significant $T1\_Age * Subjective_{within\ (t-1)}$ interaction effect on $Activity_t$ ($\beta = -0.01$, $SE = 0.003$, $t = -2.36$, $p = 0.018$), indicating an age-varying effect of subjective health on subsequent engagement in physical activity. Follow-up analysis showed a significant $Subjective_{within\ (t-1)}$ effect on $Activity_t$ in the older subgroup ($\beta = -0.23$, $SE = 0.08$, $t = -2.92$, $p = 0.004$), but not in the younger subgroup ($\beta = -0.08$, $SE = 0.09$, $t = 0.85$, $p = 0.396$). The main and interaction effects of objective health at the within-person level were nonsignificant (ps > 0.10). The results overall converge with the between-person correlations yielded by the RI-CLPM analyses, largely supporting **H1b** and **H2**.

Discussion

By conducting RI-CLPM and MLM analyses on a longitudinal dataset from the MIDUS survey, we examined the between-person and within-person associations between subjective health and engagement in moderate-to-vigorous physical activity in adulthood, as well as the moderation effects of age (younger vs. older age group) on these associations. Largely consistent with our hy-

Table 2. Between- and within-person associations between health and physical activity in different age groups

	Whole sample				Older group (>55 years)				Younger group (<35 years)				Group comparison
	b/β	*SE*	*Z*	*p* value	*b*/β	*SE*	*Z*	*p* value	*b*/β	*SE*	*Z*	*p* value	
Between-person correlations													
$Sub_{int} \leftrightarrow Act_{int}$	**0.41/0.48**	**0.05**	**8.53**	**<0.001**	**0.44/0.51**	**0.10**	**4.55**	**<0.001**	0.20/0.23	0.19	1.07	0.28	*p* = 0.25
$Obj_{int} \leftrightarrow Act_{int}$	**−0.25/-0.30**	**0.04**	**−5.69**	**< 0.001**	**−0.20/-0.23**	**0.08**	**−2.44**	**0.02**	−0.40/−0.46	0.26	−1.54	0.13	*p* = 0.47
$Sub_{int} \leftrightarrow Obj_{int}$	**−0.63/-0.70**	**0.03**	**−21.95**	**<0.001**	**−0.65/-0.71**	**0.06**	**−10.86**	**<0.001**	**−0.65/-0.70**	**0.10**	**−6.81**	**<0.001**	*p* = 0.99
Within-person cross-lagged associations													
$Sub_{w1} \rightarrow Act_{w2}$	**−0.29/-0.14**	**0.09**	**−3.23**	**0.001**	**−0.43/-0.23**	**0.15**	**−2.88**	**0.004**	−0.17/−0.07	0.27	−0.62	0.54	*p* = 0.40
$Sub_{w2} \rightarrow Act_{w3}$	−0.07/−0.03	0.06	−1.16	0.25	**−0.43/-0.18**	**0.21**	**−2.02**	**0.04**	**0.29/0.14**	**0.14**	**2.06**	**0.01**	**p = 0.005**
$Obj_{w1} \rightarrow Act_{w2}$	**0.11/0.12**	**0.04**	**2.46**	**0.01**	0.07/0.08	0.10	0.64	0.52	0.16/0.17	0.12	1.39	0.17	*p* = 0.54
$Obj_{w2} \rightarrow Act_{w3}$	−0.003/−0.003	0.02	−0.12	0.91	0.05/0.06	0.07	0.76	0.45	0.10/0.11	0.06	1.85	0.06	*p* = 0.58
$Act_{w1} \rightarrow Sub_{w2}$	−0.02/−0.03	0.03	−0.64	0.52	−0.01/−0.02	0.05	−0.22	0.83	0.05/0.08	0.08	0.66	0.51	*p* = 0.50
$Act_{w2} \rightarrow Sub_{w3}$	−0.01/−0.02	0.02	−0.57	0.57	−0.10/−0.15	0.06	−1.61	0.11	0.03/0.05	0.04	0.75	0.45	*p* = 0.08
$Obj_{w1} \rightarrow Sub_{w2}$	**0.08/0.18**	**0.03**	**3.00**	**0.003**	0.09/0.22	0.07	1.40	0.16	0.02/0.01	0.07	0.21	0.83	*p* = 0.93
$Obj_{w2} \rightarrow Sub_{w3}$	**−0.03/-0.07**	**0.01**	**−2.36**	**0.02**	−0.03/−0.05	0.04	−0.76	0.16	0.01/0.01	0.04	0.17	0.86	*p* = 0.49
$Act_{w1} \rightarrow Obj_{w2}$	0.11/0.07	0.10	1.12	0.26	−0.15/−0.12	0.23	−0.66	0.51	0.49/0.33	0.32	1.54	0.12	*p* = 0.10
$Act_{w2} \rightarrow Obj_{w3}$	0.07/0.03	0.07	1.06	0.29	0.29/0.11	0.23	1.30	0.19	0.19/0.09	0.13	1.42	0.16	*p* = 0.68
$Sub_{w1} \rightarrow Obj_{w2}$	0.21/0.08	0.19	1.11	0.27	0.01/0.004	0.41	0.02	0.98	0.47/0.18	0.67	0.70	0.48	*p* = 0.56
$Sub_{w2} \rightarrow Obj_{w3}$	**−0.39/-0.09**	**0.14**	**−2.72**	**0.007**	0.31/0.06	0.45	0.70	0.48	−0.56/−0.14	0.29	−1.90	0.06	*p* = 0.10

The older group included participants with T1 age below 35 years, and the younger group included those with T1 age above 55 years. *b*, unstandardized coefficient; β, standardized coefficient; Sub, subjective health; Obj, objective health (indicated by the number of chronic conditions); Act, physical activity; the subscript $_{int}$, random intercept; $_{w}$, within-person variation.

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Table 3. Effects of health on physical activity using MLM

Predictor variables	Outcome: $Activity_t$				
	Estimate (β)	*SE*	*df*	*t*	*p* value
Intercept	**2.109**	**0.169**	**3,789**	**12.446**	**<0.001**
T1_Age	**−0.015**	**0.002**	**2,884**	**−6.319**	**<0.001**
Sex	**0.202**	**0.032**	**2,106**	**6.255**	**<0.001**
$Education_t$	**−0.016**	**0.006**	**2,498**	**−2.462**	**0.014**
$Employ_t$	**0.131**	**0.036**	**4,889**	**3.631**	**<0.001**
$Marital_t$	−0.006	0.035	3,256	−0.179	0.858
$Income_t$	**0.036**	**0.016**	**5,809**	**2.270**	**0.023**
$Difficulty_t$	**−0.180**	**0.027**	**4,825**	**−6.600**	**0.000**
$Activity_{t-1}$	**0.360**	**0.014**	**5,143**	**26.455**	**<0.001**
Timepoint	**0.798**	**0.059**	**2,874**	**13.415**	**<0.001**
$Subjective_{within\ (t-1)}$	0.244	0.157	5,029	1.554	0.120
$Objective_{within\ (t-1)}$	0.072	0.052	5,350	1.383	0.167
$Subjective_{between}$	0.015	0.114	2,934	0.130	0.897
$Objective_{between}$	**0.102**	**0.037**	**2,926**	**2.759**	**0.006**
Timepoint * $Subjective_{within\ (t-1)}$	−0.074	0.081	4,686	−0.913	0.361
Timepoint * $Objective_{within\ (t-1)}$	0.002	0.025	5,086	0.083	0.934
T1_Age * $Subjective_{within\ (t-1)}$	**−0.007**	**0.003**	**4,976**	**−2.361**	**0.018**
T1_Age * $Objective_{within\ (t-1)}$	−0.002	0.001	5,361	−1.605	0.109
Timepoint * $Subjective_{between}$	**0.178**	**0.055**	**2,248**	**3.245**	**0.001**
Timepoint * $Objective_{between}$	**−0.053**	**0.017**	**2,438**	**−3.105**	**0.002**
T1_Age * $Subjective_{between}$	0.000	0.002	2,711	−0.059	0.953
T1_Age * $Objective_{between}$	−0.001	0.001	2,797	−1.763	0.078

The subscript $_t$ refers to timepoint *t*, $_{t-1}$ refers to timepoint t-1, $_{within}$ refers to within-person component, and $_{between}$ refers to between-person component. Activity, engagement in physical activity; Subjective, subjective health; Objective, objective health; Difficulty, difficulty in performing daily activities.

potheses, there was a positive between-person association, but a negative within-person association, between subjective health and physical activity in the whole sample and the older subgroup (but not in the younger subgroup).

In terms of theoretical contribution, the current study provides empirical evidence for the role that age-related decline/loss plays in (motivational and) behavioral changes across adulthood. It is widely assumed in the literature that increasing losses motivate goal and behavioral changes as we age [4, 5]. However, the assumption has rarely been directly tested in empirical studies. Using the RI-CLPM [22, 34] and MLM techniques, we found a dissociation between the within-person and between-person association between subjective health and engagement in physical activity in late adulthood. Specifically, the association was positive at the between-person level but negative at the within-person level in the whole sample and the older subgroup (but not the younger subgroup). The positive association between subjective health and physical activity at the between-person level echoes the well-established finding in the literature that regular engagement in physical activity benefits health [21]. It is also possible that older adults with better (vs. poorer) health tend to be more engaged in physical activity. The negative within-person association between subjective health and physical activity at the within-person level indicates that older adults tend to increase their engagement in physical activity when experiencing health decline. The finding supports the core proposition that increasing losses (e.g., health decline) associated with aging promote loss-prevention motivations and behaviors in late adulthood, as asserted in the dominant lifespan development theories [6–8].

The study also contributes to a better understanding of the determinants of physical activity in different age groups. As discussed above, our results indicate that health declines in older adults tended to be followed by increased engagement in physical activity. Our findings are consistent with the literature which shows that health benefits are important determinants of older adults' engagement in physical activity [37]. Compared to the older subgroup, the association between health and physical activity was less consistent and robust in the younger subgroup. This could be because younger adults were healthier (or felt healthier) in general and had smaller variations in subjective health and physical activity levels, making it more difficult to detect the associations between these two variables. However, further inspection of the data revealed that the variations (as indicated by standard deviations) in health and physical activity were similar among the two age groups. Another possible reason for the unstable relationship between health and physical activity is that health decline might be less of a concern for younger adults and thus played a smaller role in determining physical activity engagement in the younger (vs. the older) age group [38]. Supporting this argument, subjective health was positively (but not negatively) associated with follow-up physical activity engagement (T2 to T3) at the within-between level in the younger subgroup. The result indicated that health declines in younger adults tended to be followed by decreased engagement in physical activity, or in other words, health improvements tended to be followed by increased engagement in physical activity. This may be because younger adults who experienced improvements in health (vs. those who experienced declines) had a greater sense of control over their health, resulting in greater subsequent engagement in physical activity. Another possible explanation for the positive association between health and physical activity engagement is that younger adults with better health were more likely to take on jobs and lifestyles involving more physical activity. There is also a possibility that younger adults' engagement in physical activity was more influenced by factors other than self-perceived health or motivation to counteract health decline [39]. As a result, the relationship between subjective health and physical activity differed between younger and older adults. Due to the age-differential relationships between subjective health and physical activity, it is crucial to use different strategies to motivate physical activity in different age groups with tailored interventions and training programs. Our findings suggest that emphasizing physical activity as a means to prevent health loss may be more effective in promoting physical activity engagement among older (vs. younger) adults.

In terms of methodological implications, the present study highlights the importance of disentangling within-person effects from between-person effects in longitudinal designs. Understanding intraindividual changes or developmental processes requires an examination of within-person effects [15]. By distinguishing between within- and between-person effects, the current study revealed an interesting finding: the patterns of relationship between subjective health and subsequent physical activity were opposite at the within- and between-person levels among older individuals. The effects at these two levels could cancel each other out and conceal the true nature of the relationship if they are not separated. As seen in Table 1, correlations between subjective health and subsequent physical activity are weak when within- and between-person effects are not separated. The lack of separation between within- and between-person effects may also partly explain the conflicting results in the research on the determinants of physical activity: While some studies found significant effects of health status on older adults' physical activity, the others did not (for a review, see [40]). It would be beneficial for future longitudinal studies to take into account within- and between-person effects separately in order to better reflect developmental processes and individual differences in motivation and behavior.

There were several limitations to this study. First, the time intervals between measurement points (10 years in the MIDUS survey) might be too long for detecting certain time-ordered (autoregressive and cross-lagged) associations, such as the cross-lagged prediction effect of physical activity on health. Second, we only used the decline in subjective health to assess health loss with age. In the current sample, the between-person correlation between subjective health and age was relatively weak, and the within-person decline in subjective health across timepoints was relatively small. Thus, the decline in subjective health may be seen as an aspect of gradual, slight age-related losses. Future studies could examine the roles of other types of losses (e.g., acute and large losses such as the occurrence of severe diseases, death of partner or close others) in motivational and behavioral changes across adulthood. Another limitation is that we only examined the relationships between loss (i.e., health decline) and behavior (i.e., physical activity). Human development in different life domains follows various trajectories [4], and recent studies suggested that the association between loss and goal/motivation could vary across life domains [10]. Cross-domain longitudinal studies are needed to test the generalizability of the role of loss in goal/behavioral development across adulthood identified in this study.

Despite these limitations, the current study provides robust evidence showing that health decline was associated with subsequent increases in physical activity during late adulthood. The finding provides empirical evidence

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for the proposition in the literature that age-related increases in loss motivated behavioral changes across adulthood. The study also contributes to a better understanding of the determinant effect of subjective health on health behavior in different age groups.

Statement of Ethics

The current study uses a publicly accessible dataset, and thus, an ethics approval regarding the involvement of human and/or animal subjects is not required.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

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Author Contributions

Both authors (Natalie Wong; Xianmin Gong) contributed to data analysis, manuscript writing, and manuscript revision.

Data Availability Statement

In the current study, we used a publicly accessible dataset, which is available at http://midus.wisc.edu/index.php. Further inquiries can be directed to the corresponding author.

References

1 Baltes PB. Theoretical propositions of life-span developmental psychology: on the dynamics between growth and decline. Dev Psychol. 1987;23(5):611–26.
2 Freund AM, Baltes PB. Life-management strategies of selection, optimization and compensation: measurement by self-report and construct validity. J Pers Soc Psychol. 2002;82(4):642–62.
3 Staudinger UM, Marsiske M, Baltes PB. Resilience and reserve capacity in later adulthood: potentials and limits of development across the life span. Dev Psychopathol. 1995;2:801–47.
4 Heckhausen J, Dixon RA, Baltes PB. Gains and losses in development throughout adulthood as perceived by different adult age groups. Dev Psychol. 1989;25(1):109–21.
5 Staudinger UM, Marsiske M, Baltes PB. Resilience and levels of reserve capacity in later adulthood: perspectives from life-span theory. Dev Psychopathol. 1993;5(4):541–66.
6 Baltes PB, Baltes MM. Psychological perspectives on successful aging: the model of selective optimization with compensation. In: Baltes PB, Baltes MM, editors. Successful aging: perspectives from the behavioral sciences. New York: Cambridge University Press; 1990. p. 1–34.
7 Heckhausen J, Wrosch C, Schulz R. Agency and motivation in adulthood and old age. Annu Rev Psychol. 2019;70(1):191–217.
8 Brandtstädter J, Greve W. The aging self: stabilizing and protective processes. Dev Rev. 1994;14(1):52–80.
9 Ebner NC, Freund AM, Baltes PB. Developmental changes in personal goal orientation from young to late adulthood: from striving for gains to maintenance and prevention of losses. Psychol Aging. 2006;21(4):664–78.
10 Gong X, Freund AM. It is what you have, not what you lose: effects of perceived gains and losses on goal orientation across adulthood. J Gerontol B Psychol Sci Soc Sci. 2020;75(10):2106–11.
11 Heckhausen J. Developmental regulation in adulthood: age-normative and sociostructural constraints as adaptive challenges. New York: Cambridge University Press; 1999.
12 Freund AM. Age-differential motivational consequences of optimization versus compensation focus in younger and older adults. Psychol Aging. 2006;21(2):240–52.
13 Freund AM, Hennecke M, Mustafić M. On gains and losses, means and ends: goal orientation and goal focus across adulthood. In: Ryan RM, editor. The Oxford handbook of human motivation. 2nd ed. New York: Oxford University Press; 2012. p. 284–304.
14 Saajanaho M, Viljanen A, Read S, Eronen J, Kaprio J, Jylhä M, et al. Mobility limitation and changes in personal goals among older women. J Gerontol B Psychol Sci Soc Sci. 2014;71(1):1–10.
15 Berry D, Willoughby MT. On the practical interpretability of cross-lagged panel models: rethinking a developmental workhorse. Child Dev. 2017;88(4):1186–206.
16 Zyphur MJ, Allison PD, Tay L, Voelkle MC, Preacher KJ, Zhang Z, et al. From data to causes I: building a general cross-lagged panel model (GCLM). Organ Res Methods. 2020;23(4):651–87.
17 Hsieh CM. Age and relative importance of major life domains. J Aging Stud. 2005;19(4):503–12.
18 World Health Organization. Global recommendations on physical activity for health. Geneva: World Health Organization; 2010.
19 Hamilton K, White KM. Extending the theory of planned behavior: the role of self and social influences in predicting adolescent regular moderate-to-vigorous physical activity. J Sport Exerc Psychol. 2008;30(1):56–74.
20 Godin G, Kok G. The theory of planned behavior: a review of its applications to health-related behaviors. Am J Health Promot. 1996;11(2):87–98.
21 Lear SA, Hu W, Rangarajan S, Gasevic D, Leong D, Iqbal R, et al. The effect of physical activity on mortality and cardiovascular disease in 130 000 people from 17 high-income, middle-income, and low-income countries: the PURE study. Lancet. 2017;390(10113):2643–54.
22 Hamaker EL, Kuiper RM, Grasman RP. A critique of the cross-lagged panel model. Psychol Methods. 2015;20(1):102–16.
23 Mund M, Nestler S. Beyond the cross-lagged panel model: next-generation statistical tools for analyzing interdependencies across the life course. Adv Life Course Res. 2019;41:100249.
24 Ajzen I. The theory of planned behavior. Organ Behav Hum Decis Process. 1991;50(2):179–211.
25 Lachman ME, Neupert SD, Agrigoroaei S. The relevance of control beliefs for health and aging. In: Schaie KW, Willis SL, editors. Handbook of the psychology of aging. 7th ed. Boston, MA: Academic Press; 2011. p. 175–90.
26 Lee I-M, Paffenbarger RS Jr. Associations of light, moderate, and vigorous intensity physical activity with longevity: the Harvard Alumni Health Study. Am J Epidemiol. 2000;151(3):293–9.

27 Poitras VJ, Gray CE, Borghese MM, Carson V, Chaput J-P, Janssen I, et al. Systematic review of the relationships between objectively measured physical activity and health indicators in school-aged children and youth. Appl Physiol Nutr Metab. 2016;41(6 Suppl 3):197–239.
28 Füzéki E, Engeroff T, Banzer W. Health benefits of light-intensity physical activity: a systematic review of accelerometer data of the National Health and Nutrition Examination Survey (NHANES). Sports Med. 2017;47(9):1769–93.
29 Katz S. Assessing self-maintenance: activities of daily living, mobility, and instrumental activities of daily living. J Am Geriatr Soc. 1983;31(12):721–7.
30 Lawton MP, Brody EM. Assessment of older people: self-maintaining and instrumental activities of daily living. Gerontologist. 1969;9(3 Part 1):179–86.
31 Wu W, Selig JP, Little TD. Longitudinal data analysis. In: Little TD, editor. The Oxford handbook of quantitative methods (Vol 2): statistical analysis. New York, NY: Oxford University Press; 2013. p. 387–410.
32 Schoemann AM, Rhemtulla M, Little TD. Multilevel and longitudinal modeling. In: Reis HT, Judd CM, editors. Handbook of research methods in social and personality psychology. 2nd ed. Cambridge, UK: Cambridge University Press; 2014. p. 571–88.
33 Enders CK, Bandalos DL. The relative performance of full information maximum likelihood estimation for missing data in structural equation models. Struct Equ Model A Multidiscip J. 2001;8(3):430–57.
34 Mulder JD, Hamaker EL. Three extensions of the random intercept cross-lagged panel model. Struct Equ Model A Multidiscip J. 2021;28(4):638–48.
35 Rosseel Y. Lavaan: an R package for structural equation mdeling. J Stat Softw. 2012;48:1–36.
36 R Core Team. R: a language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing; 2017.
37 Koeneman MA, Verheijden MW, Chinapaw MJ, Hopman-Rock M. Determinants of physical activity and exercise in healthy older adults: a systematic review. Int J Behav Nutr Phys Act. 2011;8(1):142–15.
38 Meyerhof H, Jones CM, Schüz B. Intra-individual trajectories of subjectively prioritizing health over other life domains. Appl Psychol Heal Well Being. 2022;14(4):1448–63.
39 Kelly S, Martin S, Kuhn I, Cowan A, Brayne C, Lafortune L. Barriers and facilitators to the uptake and maintenance of healthy behaviours by people at mid-life: a rapid systematic review. PLoS One. 2016;11(1):e0145074.
40 van Stralen MM, De Vries H, Mudde AN, Bolman C, Lechner L. Determinants of initiation and maintenance of physical activity among older adults: a literature review. Health Psychol Rev. 2009;3(2):147–207.