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When and How Perceived Control Buffers Against Cognitive Declines: A Moderated Mediation Analysis

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Although perceived control is a well-established predictor of cognitive aging, less is known about how and under what developmental circumstances these beliefs about personal influence may protect against cognitive declines. Our study examined light physical activity (LPA) as an unexplored mechanism that may link changes in two facets of perceived control (personal mastery, perceived constraints) to longitudinal trajectories of cognitive functioning. We also examined whether mediated pathways were moderated by age (i.e., differed across the adult lifespan). We analyzed two-wave, 9-year data from the national Midlife in the United States Study (n = 2,456; M_{age} = 56 years, range = 30–84; 56% female) using autoregressive mediation and moderated mediation models. Mediation models showed that changes in personal mastery and perceived constraints predicted episodic memory and executive functioning via self-reported change in LPA. Only the mediated effects of constraints remained significant in a model that included both mastery and constraints as predictors. Moderated mediation models showed that, for episodic memory, the mediated pathways were strongest in old age and emerged only for constraints: For older but not younger adults, declines in constraints were associated with less decline in episodic memory, as mediated by increases in LPA. Results were consistent in sensitivity analyses that controlled for levels and change in moderate-to-vigorous physical activity. Findings inform lifespan theories of control and provide initial evidence that change in a largely overlooked health behavior (LPA) may underlie the link between perceived constraints and cognitive functioning, with this pathway becoming more pronounced in late life.

Public Significance Statement

People differ in the rate at which their cognitive functioning worsens with age. Although people with higher perceived control generally have slower rates of cognitive decline, little was known about how and at what stage in the lifespan this modifiable psychological resource is linked to preserved cognitive functioning. Using two waves of data collected 9 years apart in a national U.S. sample, we found that light physical activity was an overlooked but important health behavior that linked declines in perceived constraints (a facet of control) to slower cognitive declines, especially in old age. Our findings inform theories of lifespan development and point to the value of developing interventions that target changes in core psychological and behavioral factors to help slow cognitive declines.

Keywords: perceived control, perceived constraints, personal mastery, cognitive aging, light physical activity

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Data and study materials for Midlife in the United States Study (MIDUS) are publicly available from the Inter-University Consortium for Political and Social Research after registration (https://www.icpsr.umich.edu/icpsrweb/ICPSR/series/203). A bibliography of publications using MIDUS data are available at https://midus.wisc.edu/findings/index.php. Code for our statistical analyses have been made publicly available in the online Supplemental Materials. The research presented in this article has not been previously disseminated.

Participants in the present study were drawn from the MIDUS. To our knowledge, only one other study using MIDUS data has examined longitudinal light physical activity (LPA) as a predictor of cognitive aging (Hamm et al., 2024). However, Hamm et al. (2024) focused only on LPA as a health behavior predictor of cognitive functioning and did not consider the role of psychological variables. Although the present study is also based on MIDUS data, these studies are distinct in their research questions and methodologies. In contrast to Hamm et al. (2024), the present study focuses on the central role of psychological variables (personal mastery, perceived constraints) as predictors of cognitive aging. Specifically, the present study sought to identify how the relationship between two underexamined facets of

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The beliefs that people hold about their ability to influence life circumstances (perceived control) are a critical psychological resource linked to reduced risk of age-related chronic disease, functional impairment, and cognitive decline (Caplan & Schooler, 2003; Hong et al., 2021; Infurna et al., 2011; Menec & Chipperfield, 1997). For example, national studies from the United States and Australia have shown that middle-aged and older adults with higher levels of perceived control experience attenuated declines in their episodic memory and executive functioning over time periods of 4–20 years (Infurna & Gerstorf, 2013; Robinson & Lachman, 2018; Windsor & Anstey, 2008). Although the link between perceived control and cognitive aging is well-established, less is known about the behavioral mechanisms that underlie this association and whether these mechanistic pathways differ across the adult lifespan.

Change in light physical activity (LPA) may reflect one such important pathway linking perceived control to healthy cognitive aging. However, LPA remains an understudied mechanism despite the fact that it remains feasible, ingrained in everyday activities, and modifiable in late life, which may make it an ideal behavioral mechanism amenable to intervention (Chipperfield, 2008; Chipperfield et al., 2008; Erlenbach et al., 2021; Trinh et al., 2022). Research has also yet to examine how such an LPA-mediated pathway may become prominent as individuals age and encounter increasing developmental constraints that reduce the feasibility of more intense forms of physical activity. There is an urgent need to fill these knowledge gaps by identifying modifiable health behavior pathways such as LPA through which perceived control may support cognitive functioning and to establish how these pathways differ across the adult lifespan. This is because rates of dementia are expected to triple by 2060 in the absence of major advances in scientific understanding of modifiable factors that remain amenable to change in midlife and old age and that can be targeted using evidence-based interventions to buffer against cognitive declines (Matthews et al., 2019).

We used two-wave data from the national Midlife in the United States (MIDUS) Study to examine the mediated and moderated pathways linking changes in two core facets of perceived control (personal mastery, perceived constraints) to 9-year trajectories of cognitive functioning. We distinguished mastery from constraints, in contrast to previous mechanistic research that has typically focused on composite indicators of control that combine these two facets (Infurna & Gerstorf, 2013; Robinson & Lachman, 2018; Windsor & Anstey, 2008). Our rationale for this approach was based on core distinctions in the approach-oriented nature of mastery versus the avoidance- or maintenance-oriented nature of constraints that may become increasingly relevant in later life (Freund et al., 2012, 2021; Heckhausen et al., 2013). The present study thus sought to contribute to a more nuanced theoretical understanding of their unique roles in buffering against key developmental losses in midlife and old age.

We first examined whether change in self-reported LPA mediated the association between shifts in mastery and constraints and changes in cognitive functioning. We subsequently tested whether these mediated pathways differed across the adult lifespan based on the premise that associations between mastery and especially constraints, LPA, and cognitive aging may become pronounced in later life. This is because old age reflects a period of the lifespan when maintaining LPA may become more challenging and yet increasingly implicated in the preservation of cognitive functioning. We also evaluated the extent to which the proposed pathways were robust when adjusting for levels and change in moderate-to-vigorous physical activity (MVPA).

Mechanisms That Link Perceived Control to Cognitive Aging

Lachman's process model of control provided a theoretical basis for our examination of LPA as an understudied mechanism that may underlie the association between perceived control and healthy cognitive aging (Lachman, 2006; Robinson & Lachman, 2016; Soederberg Miller & Lachman, 1999). Derived from cognitive–behavioral theory (Bandura, 1986, 1997), Lachman's model specifies the motivation (e.g., effort), affective (e.g., depression), and health behavior (e.g., physical activity) pathways via which perceived control should buffer against declines in health and cognition. The processes in this model are posited to be reciprocal in nature. This means that, while perceived control is expected to influence cognitive aging trajectories via the proposed mechanisms, changes in cognitive functioning are also assumed to influence perceptions of control.

Consistent with the process model, there is growing evidence that MVPA reflects a positive health behavior that mediates the protective influence of perceived control on cognitive functioning (Infurna & Gerstorf, 2013; Robinson & Lachman, 2018, 2020). For example, Robinson and Lachman (2018) found that higher levels of perceived control predicted slower rates of longitudinal decline in episodic memory and executive functioning via increases in MVPA. Although this MVPA-mediated pathway is well-supported, little is known about the extent to which less strenuous and more feasible

perceived control (mastery, constraints) and cognitive functioning may be mediated by previously unexplored changes in LPA. The present study also extended previous work by identifying the age-related developmental circumstances under which these mediated pathways may become pronounced (moderated mediation).

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forms of light activity may underlie the association between perceived control and cognitive aging.

LPAs have metabolic equivalent of task values of 1.6–2.9 and include light walking, light sweeping, folding laundry, and washing dishes (Ainsworth et al., 1993; Mansoubi et al., 2015). There is growing evidence that maintaining LPA in midlife and old age has benefits for cognitive aging. Early research by Laurin et al. (2001) found that higher baseline levels of LPA predicted reduced risk of 5-year cognitive impairment in a national sample of older Canadians. Similar results were observed in subsequent studies that found older adults with higher LPA were at lower risk of cognitive impairment over 2- to 8-year follow-up periods (S. Lee et al., 2013; Lytle et al., 2004; Stubbs et al., 2017; Yaffe et al., 2001). Recent research by Hamm et al. (2024) extended this earlier work by showing that the protective influence of LPA extended to more sensitive (subclinical) indicators of cognitive aging. Their results indicated that increases in LPA buffered against longitudinal declines in episodic memory and executive functioning in middle-aged and older adults when adjusting for MVPA. These findings point to LPA as a potentially critical behavioral mechanism that supports healthy cognitive aging. Research is needed to examine whether such light activities, which remain ingrained in everyday life, reflect a core mechanism underlying the link between perceived control and cognitive functioning in midlife and old age.

Perceived control consists of two facets involving personal mastery and perceived constraints (Lachman, 2006; Lachman & Weaver, 1998). Personal mastery refers to beliefs about one's ability to perform specific actions to achieve goals. Perceived constraints refer to beliefs about external obstacles or deterrents that undermine the efficacy of personal actions to achieve goals. As discussed by Lachman and Weaver (1998) and Infurna and Mayer (2015), this two-facet conceptualization is in line with Skinner's (1996) perspective of perceived control as consisting of perceptions of competence (cf. mastery) and contingency (cf. constraints). Previous research has typically combined mastery and constraints into a composite (overarching) measure of control, but such an approach obscures important conceptual and empirical distinctions that separate these facets.

Conceptually, definitions and operationalizations of mastery focus on beliefs about personal competence, influence, tenacity, and responsibility (emphasis on "I can"; Infurna & Mayer, 2015; Lachman & Weaver, 1998). This implies that mastery may motivate the selection and pursuit of approach-oriented goals that are new, ambitious, and challenging such as increasing MVPA (Freund et al., 2012; Guo et al., 2023). Definitions and operationalizations of constraints focus on beliefs about a lack of contingency, external barriers, powerful others, and helplessness (emphasis on "I cannot"; Infurna & Mayer, 2015; Lachman & Weaver, 1998). Within the context of adult development and aging, constraints may be implicated in the selection and pursuit of avoidance-oriented goals that focus on not losing one's ability to engage in more basic and everyday tasks such as LPA and cognitively stimulating activities (Freund et al., 2012, 2021; Heckhausen et al., 2013).

Empirically, past work suggests that mastery and constraints are only moderately correlated, with less than half of their variance being shared (*r*s = −.40 to −.65; Hamm, Shane, et al., 2023; Infurna & Mayer, 2015; Lachman & Weaver, 1998). There is also emerging evidence to suggest that the consequences of mastery and constraints for health-related developmental outcomes may differ in midlife and old age. Studies by Lachman and Weaver (1998) and Infurna and Mayer (2015) found that constraints (vs. mastery) exhibited stronger associations with self-rated health across four national samples of U.S. adults. A similar pattern has been observed for cognitive functioning such that constraints (vs. mastery) was a stronger correlate of subjective memory complaints, executive functioning, episodic memory, and cognitive impairment in midlife and old age (Hong et al., 2021; Infurna et al., 2018; Khoo & Yang, 2020; P.-L. Lee, 2016; Wong & Yang, 2023). Conceptual and empirical considerations thus suggest that mastery and constraints may differ in their implications for core developmental outcomes such as maintaining cognitive functioning into later life, but research has yet to systematically examine the behavioral mechanisms that underlie these associations.

Open questions also remain regarding whether longitudinal changes over time in mastery and constraints may have consequences for age-related declines in episodic memory and executive functioning. Research has yet to address this issue because past studies have largely focused on the role of mastery and constraints assessed at a single time point (Infurna et al., 2018; Khoo & Yang, 2020; Sutin et al., 2018; Wong & Yang, 2023). This approach fails to capture ecological realities and critical long-term trends wherein these facets of control can decline, remain stable, or increase as people age and encounter shifting developmental opportunities (e.g., increased time) and constraints (e.g., functional limitations; Hamm, Shane, et al., 2023; Heckhausen et al., 2019). These shifting ecological realities also exist for long-term changes in health behaviors such as LPA that may reflect a key mediating mechanism (Hamm et al., 2024). Research is thus needed to examine whether longitudinal *changes* in mastery and constraints predict corresponding shifts in cognitive functioning, as mediated by change in LPA.

The Moderating Role of Age

Little is known about whether the mediated pathways that link mastery and constraints to cognitive functioning depend on age. Lifespan developmental theory suggests that constraints in particular may become increasingly influential in later life when people encounter a growing number of developmental losses (e.g., functional limitations, chronic disease; Baltes & Baltes, 1990; Heckhausen et al., 2019). How older adults appraise or perceive these constraints may be central to sustaining their motivation to maintain adaptive health behaviors such as LPA that have been shown to support healthy cognition into late life.

Although research has yet to examine whether such mediated associations differ across the adult lifespan, studies based on overarching measures of control provide some mixed evidence that age may play a moderating role. For example, several studies have observed stronger associations between perceived control and healthy cognitive functioning among older, rather than younger, adults (Oumohand et al., 2020; Raldiris et al., 2021; Windsor & Anstey, 2008). However other cognitive aging studies have not observed such an age-moderated association (Agrigoroaei & Lachman, 2011; Infurna & Gerstorf, 2013).

Similarly mixed findings have been observed in studies examining whether age moderates (a) the link between perceived control and physical activity or (b) the physical activity mediated pathways that link perceived control to cognitive functioning. Renner et al. (2007) found that perceived control (self-efficacy) was a stronger correlate of MVPA in midlife and early old age, whereas Cotter and Lachman (2010) did not observe such an age-moderated association. Studies by Infurna and Gerstorf (2013) and Robinson and Lachman (2020) did not yield age differences in the MVPA-mediated pathways that linked perceived control to cognitive functioning. Such inconsistent findings may be due to the fact that these studies were largely based on cross-sectional designs or relatively brief follow-up periods, did not consider LPA (vs. MVPA) as a mediator, and employed measures of perceived control that did not take into account the distinction between mastery and constraints. Longitudinal investigations are needed to examine the extent to which the links between mastery, constraints, and cognitive functioning are mediated by LPA and whether these mediated pathways become prominent as individuals age and encounter developmental losses that make vigorous forms of activity less feasible.

The Present Study

We used two-wave, 9-year data from the national MIDUS study to address our research objectives. The first objective was to examine the extent to which change in self-reported LPA reflects an important, understudied, and feasible health behavior pathway linking shifts in personal mastery and perceived constraints to healthy cognitive aging. We focused on longitudinal (autoregressive) changes in central indicators of cognitive functioning shown to be sensitive to early age-related declines: episodic memory and executive functioning (Hughes et al., 2018). We expected increases in mastery and declines in constraints to predict less decline in cognitive functioning and that this association would be mediated by increases in LPA.

The second objective was to examine whether these mediated pathways differed across the adult lifespan (i.e., were moderated by age). We expected the indirect effects of mastery and constraints to become more pronounced in old age. Specifically, we expected that changes in mastery and especially constraints would more strongly predict corresponding shifts in LPA in later life when individuals commonly encounter developmental losses that can undermine more vigorous forms of activity. In turn, we expected that increases in LPA would be more strongly linked with preserved cognition in old age, a period of the lifespan when maintaining LPA may become more challenging and yet increasingly tied to the maintenance of cognitive functioning. The present study was thus designed to directly extend our recent work based on national MIDUS data that showed longitudinal increases in LPA buffered against cognitive declines (Hamm et al., 2024; see Data Transparency Statement in author note for further details).

Method

Transparency and Openness

Participants in the present study were drawn from MIDUS. Data and study materials for MIDUS are publicly available from the Inter-University Consortium for Political and Social Research after registration (https://www.icpsr.umich.edu/icpsrweb/ICPSR/series/203). Code for our statistical analyses have been made publicly available in the online Supplemental Materials. The design, hypotheses, and analytic plan were not preregistered. As described below, we report how sample size was determined, any data exclusions, all data preparations, and all measures used for our analyses.

Participants and Procedure

We examined our research questions using data from the MIDUS National Longitudinal Study of Health and Well-being. A detailed summary of MIDUS can be found elsewhere (Brim et al., 2004; Ryff et al., 2017). Briefly, MIDUS is an ongoing national study of U.S. adults who were 25–75 years old at baseline assessment (1995–2013). Baseline data were assessed in 1995 (Wave 1; $n = 7{,}108$), and all willing participants were reassessed in 2004 (Wave 2; $n = 4{,}963$) and 2013 (Wave 3; $n = 3{,}294$). The present study focused on participants from Waves 2–3 because LPA and cognitive functioning were not assessed at Wave 1. At both Waves 2 and 3, survey data on our predictor (mastery, constraints) and mediator (LPA) variables were assessed approximately 1 month prior to data on our cognitive outcome measures (episodic memory, executive functioning).

Inclusion criteria for the present study were that participants provided data at Waves 2 and 3 on our focal predictors (mastery, constraints) and at least one of our mediators (LPA) or outcome measures (episodic memory, executive functioning). These criteria allowed us to examine how longitudinal changes in facets of perceived control predicted corresponding trajectories of cognitive functioning, as mediated by LPA and moderated by age. At Wave 2, the analyzed sample ($n = 2{,}456$) had a mean age of 56 ± 11 years (range = 30–84), was 56% female and 94% White, had an average household income of $75,503, and 71% had some postsecondary education. MIDUS data collection was reviewed and approved by the Education and Social/Behavioral Sciences and the Health Sciences Institutional Review Boards at the University of Wisconsin–Madison.

As is typical in longitudinal studies (Lindenberger et al., 2001; Radler & Ryff, 2010), participants in the analyzed sample (who provided longitudinal data at Waves 2 and 3) were more likely to be younger, female, have higher education and income, have fewer functional limitations, to report fewer perceived constraints, to be more physically active, and to have higher episodic memory and executive functioning ($ps = .001–.039$). The magnitudes of these differences were small ($ds = 0.07–0.39$; Cohen, 1988). A detailed summary of attrition in MIDUS can be found elsewhere (Hughes et al., 2018; Radler & Ryff, 2010).

Study Measures

Personal Mastery and Perceived Constraints

Mastery and constraints were assessed at Waves 2 and 3 using the 12-item MIDUS Sense of Control Scale (Lachman & Weaver, 1998). The scale is comprised of two subscales that capture personal mastery (e.g., I can do just about anything I set my mind to) and perceived constraints (e.g., What happens in my life is often beyond my control). Participants indicated their agreement with the four mastery and eight constraint items using a 7-point scale (1 = *strongly agree*, 7 = *strongly disagree*). Missing item-level data for each scale were minimal in the analyzed sample (<1%). Mastery and constraint scores were derived by calculating mean scores of the reverse-coded items for each subscale, such that higher scores reflected higher levels of mastery (αs = .74–.75) and constraints (αs = .85–.87).

As recommended by Cohen et al. (2013) when using two-wave longitudinal data, we subsequently generated our primary predictor measures of regressed (residualized) change in mastery and constraints by regressing Wave 3 scores on the corresponding baseline (Wave 2) levels of each measure. Residuals from these analyses reflected regressed change that statistically partialed out (adjusted for) variance due to baseline levels in each facet of perceived control (Maxwell et al., 2017; Tennant et al., 2022). We saved these residuals and used them as indicators of regressed, longitudinal change in each measure of control (Cohen et al., 2013). Scores of 0 on our regressed change measures roughly reflect average (expected) sample rates of 9-year decline in mastery (raw decline $M = -0.17$) and increases in constraints (raw increase $M = 0.15$). Positive regressed change values indicate less decline than expected in this sample, whereas negative values indicate steeper (more) decline than expected in this sample. See Table 1 and Supplemental Table S1 for a summary of the sample characteristics and interitem correlations between the study variables.

LPA

Frequency of light (LPA), moderate (MPA), and vigorous physical activity (VPA) were assessed with 18 items at Waves 2 and 3 using a 6-point scale (1 = *several times a week or more*, 6 = *never*). We reverse coded all items so that higher scores reflected more frequent physical activity. Missing item-level data for each scale were minimal in the analyzed sample (≤5%). Participants were asked to report how often they engaged in LPA that requires little physical effort. Examples of LPA provided to participants included: light housekeeping like dusting or laundry, bowling, archery, easy walking, golfing with a power cart, or fishing. They reported how often they engaged in LPA during summer and winter and in home, work, and leisure settings. Thus, items captured LPA across multiple domains and seasons.

We created a continuous measure of our LPA mediator at Waves 2 and 3 following the approach developed by Cotter and Lachman (Cotter & Lachman, 2010; Robinson & Lachman, 2018). Participants' highest LPA score from either the home, work, or leisure domain in summer was averaged with their highest LPA score from either the home, work, or leisure domain in winter. In this way, participants who engaged in regular light activity during leisure time but not at work or home (or vice versa) were still scored as being frequently engaged in LPA. As with personal mastery and perceived constraints, we generated our primary measures of regressed (residualized) change in LPA by regressing Wave 3 scores on corresponding baseline levels of LPA (Wave 2; Cohen et al., 2013; Maxwell et al., 2017; Tennant et al., 2022). Residuals from these analyses were saved and used as indicators of regressed, longitudinal change in LPA (Cohen et al., 2013). Scores of 0 on our regressed change measure roughly reflect average (expected) sample rates of 9-year decline in LPA (raw decline $M = -0.10$). Positive regressed change values indicate less decline than expected in this sample, whereas negative values indicate steeper (more) decline than expected in this sample.

A similar approach was employed to create MVPA scores at Waves 2 and 3, which were used as covariates in our sensitivity analyses (Cotter & Lachman, 2010). MPA (e.g., brisk walking, low-impact aerobics) and VPA (e.g., running, lifting heavy objects) were also assessed during summer and winter and in home, work, and leisure settings. MPA and VPA scores were first created using the same method described for LPA. As recommended by Cotter and Lachman (2010), MVPA scores at each wave were then generated based on whichever score was highest (MPA or VPA). We created measures of regressed (residualized) change in MVPA by regressing Wave 3 scores on the corresponding baseline levels of MVPA (Wave 2).

Table 1
Sample Characteristics and Interitem Correlations

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Age[a]	—														
2. Sex (female)[b]	−.01	—													
3. Race (minority)[b]	−.02	.04	—												
4. SES[a]	−.09	−.19	−.02	—											
5. ADL limitations[a]	.27	.17	.01	−.26	—										
6. Mastery	−.02	−.06	.00	.19	−.18	—									
7. Constraints	−.05	.11	.03	−.31	.27	−.50	—								
8. LPA[a]	−.10	.07	−.10	.17	−.15	.07	−.12	—							
9. EM[a]	−.27	.23	−.04	.14	−.11	.03	−.08	.16	—						
10. EF[a]	−.38	−.13	−.12	.36	−.24	.04	−.13	.17	.37	—					
11. ΔMastery[ac]	−.10	−.01	−.02	.10	−.10	.00	−.14	.07	.05	.08	—				
12. ΔConstraints[ac]	.14	.00	.00	−.17	.14	−.08	−.01	−.10	−.11	−.12	−.28	—			
13. ΔLPA[ac]	−.19	.04	−.05	.12	−.16	.03	−.07	.01	.10	.14	.09	−.12	—		
14. ΔEM[ac]	−.29	.14	−.04	.11	−.13	.02	−.04	.09	.01	.20	.05	−.11	.12	—	
15. ΔEF[ac]	−.29	−.02	−.03	.06	−.13	−.02	.00	.05	.05	.00	.06	−.10	.17	.22	—
M	55.57	1.56	0.06	0.08	1.69	5.76	2.46	5.22	0.10	0.13	0.00	−0.01	0.00	0.00	0.00
SD	11.22	0.50	0.23	0.70	0.81	1.03	1.11	1.32	0.91	0.64	0.89	0.96	1.35	0.83	0.47

Note. All correlations ≥.|05| are significant at $p < .05$.; n range = 1,977–2,456. SES = socioeconomic status; ADL = activities of daily living (limitations); LPA = light physical activity; EM = episodic memory; EF = executive functioning; Δ = regressed change; Mastery = personal mastery; Constraints = perceived constraints.
[a] Wave 2. [b] Wave 1. [c] Wave 3.

Cognitive Function

The Brief Test of Adult Cognition by Telephone (BTACT) was used to assess episodic memory and executive functioning at Waves 2 and 3 (Lachman & Tun, 2008; Tun & Lachman, 2006). Previous research with middle-aged and older adults has shown the BTACT to be a reliable and valid measure of central dimensions of cognition involving episodic memory and executive functioning (Hamm et al., 2020; Lachman et al., 2014; Tun & Lachman, 2006). A detailed summary of the BTACT can be found elsewhere (Hughes et al., 2018; Lachman et al., 2010, 2014).

Briefly, the BTACT battery includes two cognitive tests to assess episodic memory and five tests to evaluate executive functioning (Lachman et al., 2014). Episodic memory was assessed using immediate and delayed recall tasks (free recall of 15 words). Executive functioning was assessed using measures of inductive reasoning (completing patterns in a number series), category verbal fluency (number of animal names produced in 1 min), working memory span (backward digit span), processing speed (number of digits produced counting backward from 100 in 30 s), and attention switching and inhibitory control (Stop and Go Switch Task). The Stop and Go Switch Task comprised a reaction time test involving normal (respond GO to stimulus GREEN and STOP to stimulus RED) and reverse conditions (respond STOP to stimulus GREEN and GO to stimulus RED; Tun & Lachman, 2008). For the executive functioning measure, we used a recommended filter that retained data only for participants with valid scores on the Stop and Go Switch Task (Lachman et al., 2014; Tun & Lachman, 2008). Valid scores were those in which there were no technical malfunctions, the participant understood the task, and the participant was not distracted by external events.

Measures of episodic memory and executive functioning factors were calculated by averaging the standardized values of their respective subtests at each wave (Hughes et al., 2018). We removed one extreme outlier with a Wave 3 executive functioning score that was more than 12 *SD*s above the mean. We generated our primary outcome measures of regressed (residualized) change in episodic memory and executive function by regressing Wave 3 scores on the corresponding baseline (Wave 2) levels of each measure (Cohen et al., 2013; Maxwell et al., 2017; Tennant et al., 2022). Residuals from these analyses were saved and used as indicators of regressed, longitudinal change in episodic memory and executive functioning (Cohen et al., 2013). Scores of 0 on our regressed change measures roughly reflect average (expected) sample rates of 9-year decline in episodic memory (raw decline $M = -0.13$) and executive functioning (raw decline $M = -0.26$). Positive values indicate less decline than expected in this sample, and negative values indicate steeper (more) decline than expected.

A similar approach was employed to create composite cognitive functioning scores at Waves 2 and 3, which were used as an alternative indicator of cognition in our sensitivity analyses. We z-scored and then averaged each of the seven cognitive tests to create a composite indicator of cognitive functioning at Wave 2 and Wave 3. Consistent with previous research, we used the raw Wave 2 means and standard deviations to generate the z scores for each test at Wave 3. We created measures of regressed (residualized) change in composite cognitive functioning by regressing Wave 3 scores on the corresponding baseline levels at Wave 2.

Demographic Covariates

Age, sex, race, socioeconomic status (SES), and functional limitations in activities of daily living (ADLs) are well-established correlates of physical activity and cognitive functioning and were thus included as covariates in the main analyses (Dixon & Lachman, 2019; Hughes et al., 2018; Lachman et al., 2014; Robinson & Lachman, 2018; Tran et al., 2014). Age in years was assessed at Wave 2. Sex (1 = *male*, 2 = *female*) and race (0 = *White*, 1 = *non-White*) were assessed at Wave 1. Three self-report measures of SES were assessed at Wave 2: level of formal education completed (1 = *no school or grade school*, 12 = *doctoral degree*), total household income in U.S. dollars, and perceived SES using the reverse-coded MacArthur Scale of Subjective Social Status (1 = *top rung*, 10 = *bottom rung*). Because the three SES indicators were positively correlated (*r*s = .13–.35), we computed a composite SES score by first z-standardizing and then averaging the z-scored measures ($M = 0.09$, $SD = 0.69$; Hamm et al., 2021; Wrosch et al., 2018). ADL limitations were assessed at Wave 2. Participants reported the extent to which health limited their ability to perform seven ADLs using a 4-point scale (1 = *a lot*, 4 = *not at all*): lifting or carrying groceries; climbing several flights of stairs; bending, kneeling, or stooping; walking more than a mile; walking several blocks; vigorous activities (e.g., running); and moderate activities (e.g., vacuuming). Scores were reverse coded so that higher scores reflected greater functional limitations.

Rationale for Analyses

We conducted autoregressive models to assess the mediated and moderated pathways linking changes in each facet of perceived control (personal mastery, perceived constraints) to two-wave, longitudinal changes in cognitive functioning (Hayes, 2017). Step 1 models assessed the extent to which regressed changes in mastery and constraints predicted regressed changes in cognitive functioning, as mediated by regressed change in LPA (mediation models; see Supplemental Figure S1). Step 2 models incorporated interaction terms with age (Age × ΔMastery, Age × ΔConstraints, Age × ΔLPA) to assess whether the link between regressed changes in the predictors and the mediators differed across the adult lifespan (moderated mediation models; see Supplemental Figure S1). All models controlled for age, sex, race, SES, functional limitations, and baseline levels of each predictor, mediator, and outcome measure (i.e., autoregressive effects). We controlled for baseline levels of each outcome variable to account for their associations with the other predictor variables in the model. The predictor, mediator, and outcome variables in our models reflected regressed change in facets of perceived control, physical activity, and cognitive functioning rather than raw change or gain scores, which can produce misleading results (Cohen et al., 2013; Maxwell et al., 2017; Tennant et al., 2022). We also conducted sensitivity analyses to test whether all pathways were robust when controlling for levels of, and change in, MVPA. Sensitivity analyses were also conducted using a composite indicator of cognitive functioning as the outcome variable based on the z-scored average of the seven cognitive tests (instead of treating episodic memory and executive functioning as separate indicators of cognitive functioning).

All models were conducted in Mplus 8 using maximum likelihood estimation, with missing data handled using full information maximum likelihood. We tested indirect (mediation) and conditional indirect effects (moderated mediation) for significance using a bootstrap approach that employed 95% confidence intervals (CIs; Hayes, 2017; Preacher & Hayes, 2008). Mediation was confirmed if zero fell outside the 95% CI based on 5,000 samples of the unstandardized beta weights. Standardized and unstandardized regression coefficients are presented for all models.

Results

Step 1: Mediation Models Predicting Longitudinal Changes in Cognitive Functioning

Preliminary Analyses

Initial Step 1 autoregressive models tested whether changes in personal mastery and perceived constraints predicted corresponding trajectories of episodic memory and executive functioning in the absence of the proposed mediator (LPA). Models controlled for age, sex, race, SES, functional limitations, and baseline levels of the predictors and outcomes. Results of separate models showed that only declines in constraints ($\beta = -.06$, $b = -.06$, $SE = .018$, $p = .002$) predicted less decline in episodic memory. Increases in mastery did not predict changes in episodic memory ($p = .484$). The same pattern was observed for executive functioning such that declines in constraints ($\beta = -.06$, $b = -.03$, $SE = .011$, $p = .002$) but not increases in mastery ($p = .296$) predicted less decline in executive functioning.

Main Analyses

Step 1 autoregressive mediation models tested whether (a) regressed changes in perceived mastery and constraints predicted corresponding change in LPA (mediator) and (b) regressed changes in the predictors and mediator predicted longitudinal changes in episodic memory and executive functioning (outcomes). Mastery and constraints (predictors) were first run in separate models and then in simultaneous entry models to evaluate their unique influence. See Tables 2–3 for a summary of all Step 1 analyses.

Episodic Memory Models. Results of separate mediation models showed that increases in mastery and declines in constraints both predicted corresponding increases in LPA (see Table 2). Changes in constraints, but not mastery, predicted less decline in episodic memory. Increases in LPA predicted less decline in episodic memory. We subsequently used a bootstrap approach to test whether changes in mastery and constraints had indirect effects on changes in episodic memory via increases in LPA. Results indicated that increases in mastery ($\beta = .0032$, $b = .0031$, 95% CI [.0004, .0072] percent mediated = 31%) and declines in constraints ($\beta = -.0041$, $b = -.0036$, 95% CI [−.0081, −.0006], percent mediated = 7%) were associated with less decline in episodic memory, as mediated by increases in LPA (see Figure 1). Results of subsequent mediation models that simultaneously entered mastery and constraints showed that only the indirect effects of constraints remained significant ($\beta = -.0037$, $b = -.0033$, 95% CI [−.0075, −.0004], percent mediated = 6%).

We conducted several sets of sensitivity analyses to evaluate the robustness of our findings. Results were consistent when controlling for baseline levels and regressed change in MVPA, with the only exception being that the mediated mastery pathway was reduced to nonsignificance (see Supplemental Table S2). Similarly, results were also consistent when controlling for regressed change in ADL limitations, with the only exception being that the mediated mastery pathway was reduced to nonsignificance. Finally, results remained consistent in sensitivity analyses that employed a composite indicator of cognitive functioning as the outcome variable based on the *z*-scored average of the seven cognitive tests (see Supplemental Tables S6–S7).

Executive Functioning Models. We note that the only distinction between the episodic memory and executive functioning models was that they predicted different outcomes (i.e., the same autoregressive mediation models were employed to predict executive

Table 2

Step 1 Mediation Analyses Predicting Longitudinal Changes in Light Physical Activity (LPA) and Episodic Memory

	Mastery model				Constraints model				Mastery and Constraints model			
	ΔLPA		ΔEpisodic memory		ΔLPA		ΔEpisodic memory		ΔLPA		ΔEpisodic memory	
Predictor	β	*b* (*SE*)	β	*b* (*SE*)	β	*b* (*SE*)	β	*b* (*SE*)	β	*b* (*SE*)	β	*b* (*SE*)
Baseline	−.05	−.05 (.021)*	−.15	−.14 (.020)*	−.06	−.06 (.021)*	−.15	−.14 (.020)*	−.06	−.06 (.021)*	−.16	−.15 (.020)*
Age	−.15	−.02 (.002)*	−.28	−.02 (.002)*	−.15	−.02 (.003)*	−.28	−.02 (.002)*	−.16	−.02 (.003)*	−.28	−.02 (.002)*
Sex (female)	.16	.21 (.055)*	.40	.34 (.035)*	.16	.21 (.055)*	.40	.34 (.035)*	.16	.21 (.055)*	.40	.34 (.035)*
Race (minority)	−.25	−.34 (.117)*	−.20	−.17 (.076)*	−.25	−.33 (.116)*	−.19	−.17 (.076)*	−.25	−.34 (.116)*	−.21	−.18 (.076)*
SES	.09	.19 (.041)*	.12	.14 (.026)*	.09	.15 (.042)*	.11	.13 (.026)*	.08	.15 (.042)*	.10	.13 (.026)*
ADL limitations	−.11	−.19 (.036)*	−.05	−.06 (.023)*	−.10	−.17 (.037)*	−.05	−.04 (.023)*	−.10	−.17 (.037)*	−.04	−.05 (.023)*
Baseline mastery	−.01	−.01 (.027)	−.00	−.002 (.017)					−.04	−.05 (.030)	−.03	−.02 (.019)
ΔMastery	**.06**	**.09 (.030)***	**.01**	**.007 (.019)**					**.03**	**.05 (.032)**	**−.01**	**−.01 (.020)**
Baseline Constraints					−.05	−.06 (.026)*	−.03	−.03 (.016)	−.06	−.08 (.030)*	−.05	−.04 (.019)*
ΔConstraints					**−.08**	**−.11 (.029)***	**−.05**	**−.05 (.018)***	**−.07**	**−.10 (.030)***	**−.06**	**−.05 (.019)***
Baseline LPA			.04	.02 (.013)			.03	.02 (.013)			.03	.02 (.013)
ΔLPA			**.06**	**.04 (.013)***			**.05**	**.03 (.013)***			**.05**	**.03 (.013)***

Note. Parameter estimates for the main predictors (ΔMastery, ΔConstraints) and mediators (ΔLPA) in our mediation models are shown in bold font. Δ = regressed change; *SE* = standard error; SES = socioeconomic status; ADL = activities of daily living (limitations); Mastery = personal mastery; Constraints = perceived constraints.

* $p < .05$.

Table 3
Step 1 Mediation Analyses Predicting Longitudinal Changes in Light Physical Activity (LPA) and Executive Functioning

	Mastery model				Constraints model				Mastery and Constraints model			
	ΔLPA		ΔExecutive function		ΔLPA		ΔExecutive function		ΔLPA		ΔExecutive function	
Predictor	β	*b* (*SE*)	β	*b* (*SE*)	β	*b* (*SE*)	β	*b* (*SE*)	β	*b* (*SE*)	β	*b* (*SE*)
Baseline	−.05	−.05 (.021)*	−.19	−.14 (.018)*	−.06	−.06 (.021)*	−.18	−.14 (.018)*	−.06	−.06 (.021)*	−.19	−.14 (.018)*
Age	−.15	−.02 (.002)*	−.31	−.01 (.001)*	−.16	−.02 (.003)*	−.31	−.01 (.001)*	−.16	−.02 (.003)*	−.31	−.01 (.001)*
Sex (female)	.16	.21 (.055)	−.07	−.03 (.020)	.16	.21 (.055)*	−.07	−.03 (.020)	.16	.21 (.055)*	−.07	−.03 (.020)
Race (minority)	−.25	−.34 (.117)*	−.21	−.10 (.046)*	−.25	−.33 (.116)*	−.22	−.11 (.046)*	−.25	−.34 (.116)*	−.21	−.10 (.046)*
SES	.10	.19 (.041)*	.06	.04 (.016)*	.08	.15 (.042)*	.05	.03 (.016)*	.08	.15 (.042)*	.05	.04 (.016)*
ADL limitations	−.11	−.19 (.036)*	−.04	−.02 (.013)	−.10	−.17 (.037)*	−.03	−.02 (.014)	−.10	−.17 (.037)*	−.03	−.02 (.014)
Baseline Mastery	−.01	−.01 (.027)	−.03	−.02 (.010)					−.04	−.05 (.030)	−.05	−.03 (.011)*
ΔMastery	**.06**	**.09 (.030)***	**.01**	**.01 (.011)**					**.03**	**.05 (.032)**	**−.01**	**−.01 (.012)**
Baseline Constraints					−.05	−.06 (.026)*	−.01	−.00 (.010)	−.06	−.08 (.030)*	−.04	−.02 (.011)
ΔConstraints					**−.08**	**−.11 (.029)***	**−.05**	**−.03 (.011)***	**−.07**	**−.10 (.030)***	**−.06**	**−.03 (.011)***
Baseline LPA			.03	.01 (.008)			.03	.01 (.008)			.03	.01 (.008)
ΔLPA			**.13**	**.05 (.008)***			**.13**	**.05 (.008)***			**.12**	**.04 (.008)***

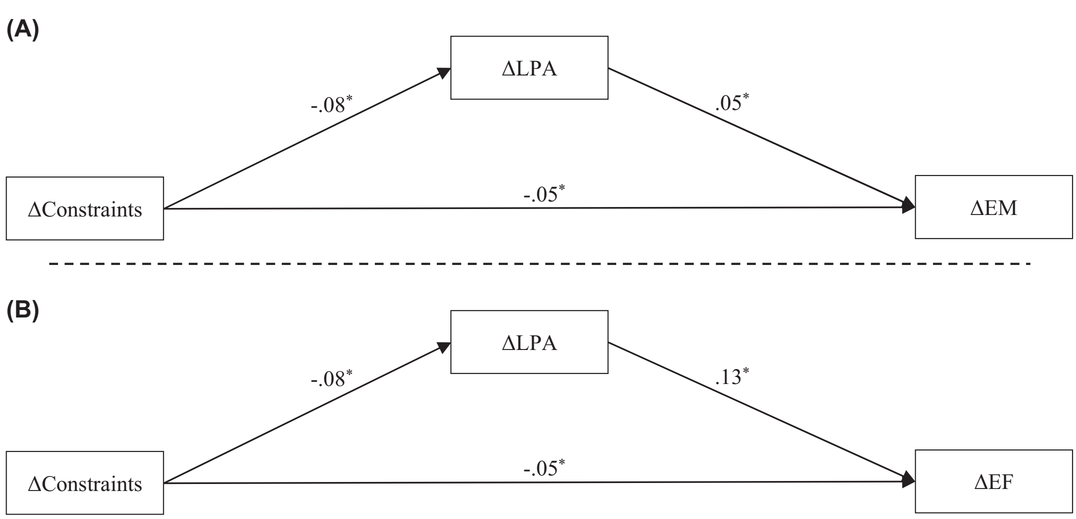
Note. Parameter estimates for the main predictors (ΔMastery, ΔConstraints) and mediators (ΔLPA) in our mediation models are shown in bold font. Δ = regressed change; *SE* = standard error; SES = socioeconomic status; ADL = activities of daily living (limitations); Mastery = personal mastery; Constraints = perceived constraints.
* $p < .05$.

functioning). As a result, the pattern of associations linking mastery and constraints (predictors) to change in LPA (mediator) were consistent with those reported above (see Table 3).

Results of separate mediation models showed that changes in constraints, but not mastery, predicted less decline in executive functioning. Increases in LPA predicted less decline in executive functioning. Results of bootstrapped tests indicated that increases in mastery (β = .0073, *b* = .0040, 95% CI [.0010, .0079], percent mediated = 40%) and declines in constraints (β = −.0098, *b* = −.0050, 95% CI [−.0089, −.0018], percent mediated = 16%) were associated with less decline in executive functioning, as mediated by increases in LPA (see Figure 1). Results of subsequent mediation models that simultaneously entered mastery and constraints showed that only the indirect effects of constraints remained significant (β = −.0090, *b* = −.0045, 95% CI [−.0087, −.0014], percent mediated = 13%).

We conducted several sets of sensitivity analyses to evaluate the robustness of our findings. Results were consistent when controlling

Figure 1
Step 1 Mediation Models



Note. Step 1 mediation models predicting two wave, 9-year ΔEM (Panel A) and ΔEF (Panel B) via changes in light physical activity (ΔLPA). Standardized regression weights are reported. Results for only the perceived constraints (ΔConstraints) models are presented for brevity. Results were consistent for personal mastery when mastery and constraints were entered in separate models, but mastery paths were attenuated to nonsignificance in models that simultaneously entered mastery and constraints as predictors (see Tables 2–3). Δ = regressed change; EM = episodic memory; EF = executive functioning; LPA = light physical activity.
* $p < .05$.

for baseline levels and regressed change in MVPA (see Supplemental Table S3). Similarly, results were also consistent when controlling for regressed change in ADL limitations, with the only exception being that the mediated mastery pathway was reduced to nonsignificance. Finally, our results remained consistent in sensitivity analyses that employed a composite indicator of cognitive functioning as the outcome variable based on the *z*-scored average of the seven cognitive tests (see Supplemental Tables S6–S7).

Step 2: Moderated Mediation Models Predicting Longitudinal Changes in Cognitive Functioning

Preliminary Analyses

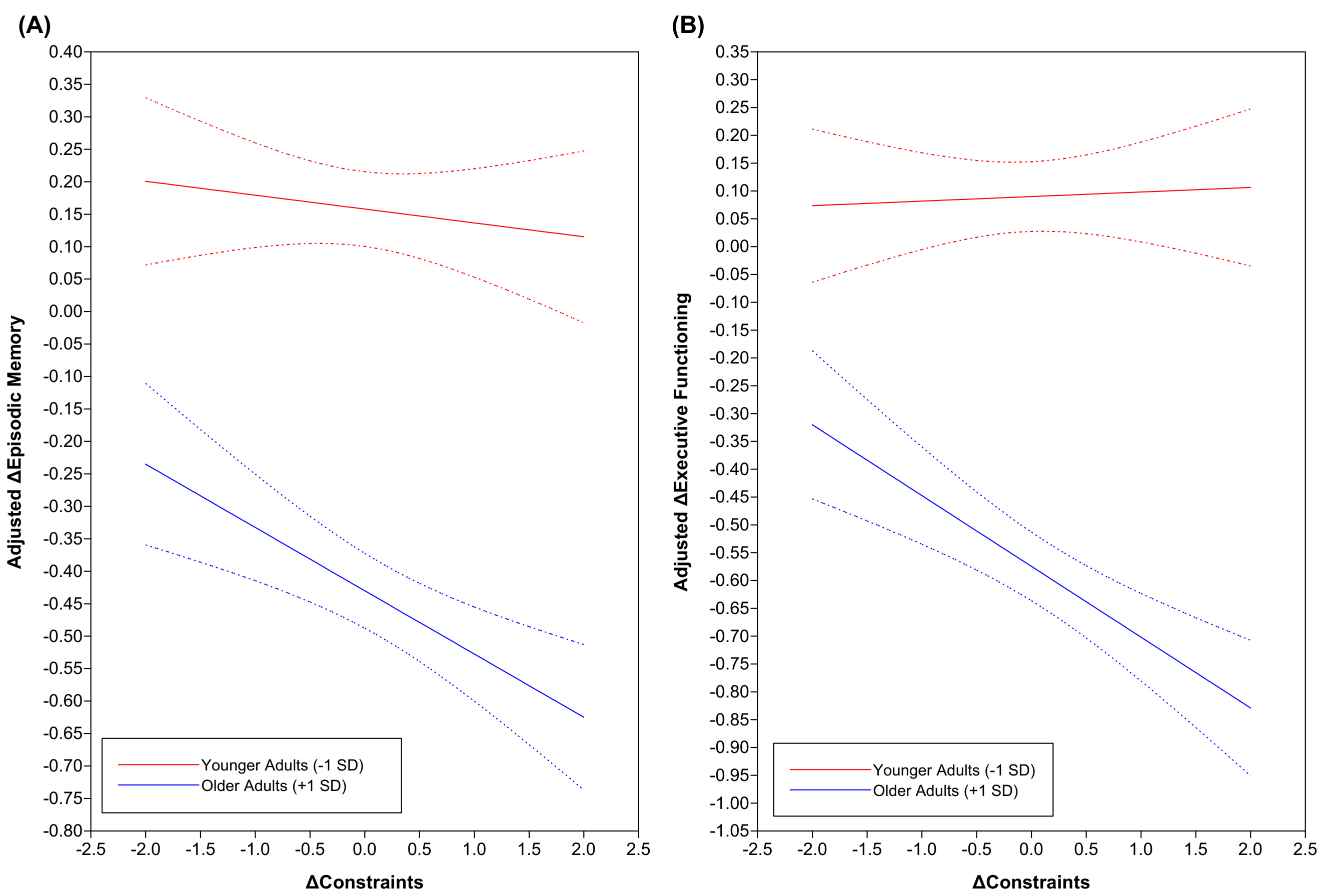
Initial Step 2 autoregressive models tested for age-moderated associations between changes in each facet of perceived control and corresponding trajectories of episodic memory and executive functioning in the absence of the mediator (LPA). Models controlled for age, sex, race, SES, functional limitations, and baseline levels of the predictors and outcomes. Results of separate models predicting changes in episodic memory showed that age-moderated associations were only observed for changes in perceived constraints ($\beta = -.04$, $b = -.003$, $SE = .001$, $p = .047$). Simple slope analyses showed that declines in constraints were associated with less decline in episodic memory for older (+1 *SD* = aged 67 years; $\beta = -.10$, $b = -.08$, $SE = .023$, $p < .001$) but not younger adults (−1 *SD* = aged 44 years; $\beta = -.02$, $b = -.02$, $SE = .025$, $p = .451$).

A similar pattern was observed for executive functioning. Results of separate models revealed age-moderated associations for changes in constraints ($\beta = -.07$, $b = -.003$, $SE = .001$, $p = .001$), but not mastery ($p = .912$). Simple slope analyses showed that declines in constraints were associated with less decline in executive functioning for older (+1 *SD* = aged 67 years; $\beta = -.13$, $b = -.06$, $SE = .014$, $p < .001$) but not younger adults (−1 *SD* = aged 44 years; $\beta = .01$, $b = .004$, $SE = .015$, $p = .807$).

Predicted values (PVs) that adjusted for average (raw) sample declines of −.13 units in episodic memory and −.26 in executive functioning serve to contextualize the practical significance of these effect sizes (see Figure 2). Small but meaningful differences emerged between older adults who perceived declines in their

Figure 2

Age × ΔConstraints Interactions on Longitudinal Cognitive Functioning



Note. Age × ΔConstraints interactions predicting two-wave, 9-year ΔEM (Panel A) and ΔEF (Panel B). Standardized simple slopes of ΔConstraints with 95% confidence intervals are presented at younger (−1 *SD* in red) and older ages (+1 *SD* in blue). Predicted values were adjusted for average (raw) sample declines of −.13 units in episodic memory and −.26 units in executive functioning. Δ = regressed change; EM = episodic memory; EF = executive functioning; Constraints = perceived constraints. See the online article for the color version of this figure.

constraints: PV estimates suggested that rates of 9-year decline in episodic memory (PVs = −.33 vs. −.43) and executive functioning (PVs = −.45 vs. −.57) were reduced by approximately 22%–23% for older adults whose constraints declined by a standard deviation relative to those who remained stable.

Main Analyses. Step 2 autoregressive models incorporated interaction terms with age to assess whether the mediated mastery/constraints → LPA → cognitive functioning pathways were moderated by age (i.e., differed across the adult lifespan). We thus simultaneously tested the extent to which age moderated the mastery/constraints–LPA relationships, the mastery/constraints–cognitive functioning relationships, and the LPA–cognitive functioning relationships. Variables involved in the interaction terms were mean-centered to facilitate interpretation. See Tables 4–5 for a summary of all Step 2 analyses.

Episodic Memory Models. Results of separate models showed that age moderated the association between changes in constraints, but not mastery, and longitudinal change in LPA (see Table 4). Simple slope analyses showed that declines in constraints were associated with increases in LPA for older (+1 *SD*; β = −.11, *b* = −.16, *SE* = .037, $p < .001$) but not younger adults (−1 *SD*; β = −.04, *b* = −.05, *SE* = .041, *p* = .205).

Age moderated the associations between change in LPA and change in episodic memory. Simple slope analyses showed that increases in LPA were associated with less decline in episodic memory for older (+1 *SD*; β = .08, *b* = .05, *SE* = .015, *p* = .001) but not younger adults (−1 *SD*; β = −.02, *b* = −.01, *SE* = .021, *p* = .581). Because age moderated both the constraints–LPA and LPA–episodic memory associations, we subsequently used a bootstrap approach to test whether changes in constraints had conditional indirect effects on changes in episodic memory via change in LPA. This allowed us to examine whether the mediated effects we observed in Step 1 were pronounced for older adults. Results indicated that, for older but not younger adults, declines in constraints (β = −.0094, *b* = −.0081, 95% CI [−.0162, −.0022], percent mediated = 10%) were associated with less decline in episodic memory, as mediated by increases in LPA (see Figure 3). Results of subsequent models that simultaneously entered mastery and constraints showed that the conditional indirect effects of constraints, but not mastery, remained significant (β = −.0089, *b* = −.0077, 95% CI [−.0158, −.0019], percent mediated = 9%).

We conducted several sets of sensitivity analyses to evaluate the robustness of our findings. Results were consistent when controlling for baseline levels and regressed change in MVPA (see Supplemental Table S4). Similarly, results were also consistent when controlling for regressed change in ADL limitations. Finally, results were also largely consistent in sensitivity analyses that employed a composite indicator of cognitive functioning as the outcome variable based on the *z*-scored average of the seven cognitive tests (see Supplemental Tables S8–S9). The only exception was that the Age × ΔLPA interaction predicting the composite indicator of cognitive functioning was reduced to nonsignificance, suggesting that the doubly moderated mediation findings for episodic memory in our main analyses should be interpreted with some caution. However, there was still consistent support across all analyses for a simplified moderated mediation model that omitted the Age × ΔLPA interaction as a predictor of cognitive functioning. Findings from this more conservative and robust model indicated that there was an increasingly strong association between changes in constraints and changes in cognitive functioning with advancing age, and this conditional association was mediated by changes in LPA. However, the link between changes in LPA and changes in composite cognitive functioning did not depend on age.

Executive Functioning Models. We note that the only distinction between the episodic memory and executive functioning models was that they predicted different outcomes (i.e., the same moderated mediation model was employed to predict executive functioning). As a result, the pattern of age-moderated associations

Table 4

Step 2 Moderated Mediation Analyses Predicting Longitudinal Changes in Light Physical Activity (LPA) and Episodic Memory

	Mastery model				Constraints model				Mastery and Constraints model			
	ΔLPA		ΔEpisodic memory		ΔLPA		ΔEpisodic memory		ΔLPA		ΔEpisodic memory	
Predictor	β	*b* (*SE*)	β	*b* (*SE*)	β	*b* (*SE*)	β	*b* (*SE*)	β	*b* (*SE*)	β	*b* (*SE*)
Baseline	−.05	−.05 (.021)*	−.16	−.15 (.020)*	−.06	−.06 (.021)*	−.16	−.15 (.020)*	−.06	−.06 (.021)*	−.16	−.15 (.020)*
Age	−.15	−.02 (.002)*	−.28	−.02 (.002)*	−.15	−.02 (.003)*	−.28	−.02 (.002)*	−.15	−.02 (.003)*	−.27	−.02 (.002)*
Sex (female)	.16	.21 (.055)*	.42	.34 (.036)*	.16	.21 (.055)*	.42	.35 (.036)*	.16	.21 (.055)*	.41	.35 (.036)*
Race (minority)	−.25	−.34 (.117)*	−.21	−.18 (.078)*	−.25	−.33 (.116)*	−.21	−.17 (.076)*	−.25	−.34 (.116)*	−.21	−.18 (.076)*
SES	.10	.19 (.041)*	.12	.14 (.026)*	.08	.15 (.042)*	.10	.12 (.026)*	.08	.15 (.042)*	.10	.12 (.026)*
ADL limitations	−.11	−.19 (.036)*	−.06	−.06 (.023)*	−.10	−.17 (.037)*	−.04	−.05 (.023)	−.10	−.17 (.037)*	−.04	−.05 (.023)*
Baseline Mastery	−.01	−.01 (.027)	−.01	.00 (.017)					−.04	−.05 (.030)	−.03	−.02 (.019)
ΔMastery	.06	.08 (.030)*	.01	.01 (.019)					.03	−.01 (.020)	−.01	−.01 (.020)
Age × ΔMastery	**.01**	**.00 (.003)**	**−.01**	**.00 (.002)**					**.01**	**−00 (.003)**	**−.01**	**−.00 (.002)**
Baseline Constraints					−.05	−.06 (.026)*	−.03	−.03 (.016)	−.06	−.07 (.030)*	−.05	−.04 (.019)*
ΔConstraints					−.07	−.11 (.029)*	−.05	−.04 (.018)*	−.07	−.10 (.030)	−.05	−.05 (.019)*
Age × ΔConstraints					**−.04**	**−.01 (.002)***	**−.03**	**−.00 (.013)**	**−.04**	**−.01 (.002)**	**−.03**	**−.00 (.002)**
Baseline LPA			.03	.02 (.013)			.03	.02 (.013)			.03	.02 (.013)
ΔLPA			.04	.02 (.014)			.03	.02 (.014)			.03	.02 (.014)
Age × ΔLPA			**.06**	**.003 (.001)***			**.05**	**.003 (.001)***			**.06**	**.003 (.001)***

Note. Parameter estimates for the main predictors (Age × ΔMastery, Age × ΔConstraints) and mediators (Age × ΔLPA) in our moderated mediation models are shown in bold font. Δ = regressed change; *SE* = standard error; SES = socioeconomic status; ADL = activities of daily living (limitations); Mastery = personal mastery; Constraints = perceived constraints.
* $p < .05$.

Table 5
Step 2 Moderated Mediation Analyses Predicting Longitudinal Changes in Light Physical Activity (LPA) and Executive Functioning

	Mastery model				Constraints model				Mastery and Constraints model			
	ΔLPA		ΔExecutive function		ΔLPA		ΔExecutive function		ΔLPA		ΔExecutive function	
Predictor	β	*b* (*SE*)	β	*b* (*SE*)	β	*b* (*SE*)	β	*b* (*SE*)	β	*b* (*SE*)	β	*b* (*SE*)
Baseline	−.05	−.05 (.021)*	−.19	−.14 (.018)*	−.06	−.06 (.021)*	−.19	−.14 (.018)*	−.06	−.06 (.021)*	−.19	−.15 (.018)*
Age	−.15	−.02 (.002)*	−.32	−.01 (.001)*	−.15	−.02 (.003)*	−.32	−.01 (.001)*	−.15	−.02 (.003)*	−.31	−.01 (.001)*
Sex (female)	.16	.21 (.055)	−.07	−.04 (.021)	.16	.21 (.055)*	−.07	−.03 (.020)	.15	.21 (.055)*	−.07	−.04 (.020)
Race (minority)	−.25	−.34 (.117)*	−.22	−.10 (.046)*	−.25	−.33 (.116)*	−.23	−.11 (.046)*	−.25	−.34 (.116)*	−.22	−.11 (.046)
SES	.10	.19 (.041)*	.06	.04 (.016)*	.08	.15 (.042)*	.05	.03 (.016)*	.08	.15 (.042)*	.05	.04 (.016)*
ADL limitations	−.11	−.19 (.036)*	−.04	−.02 (.014)	−.10	−.17 (.037)*	−.03	−.02 (.014)	−.10	−.17 (.037)*	−.03	−.02 (.014)
Baseline Mastery	−.01	−.01 (.027)	−.04	−.02 (.010)					−.04	−.05 (.030)	−.06	−.03 (.011)*
ΔMastery	.06	.08 (.030)*	.01	.01 (.012)					.03	.05 (.032)	.00	.00 (.012)
Age × ΔMastery	**.01**	**.00 (.003)**	**.00**	**.00 (.001)**					**.01**	**.00 (.003)**	**−.01**	**−.00 (.001)**
Baseline Constraints					−.05	−.06 (.026)*	−.01	−.00 (.010)	−.06	−.07 (.030)*	−.04	−.02 (.011)
ΔConstraints					−.07	−.11 (.029)*	−.05	−.02 (.011)*	−.07	−.10 (.030)*	−.05	−.03 (.011)*
Age × ΔConstraints					**.04**	**−.01 (.002)***	**−.06**	**−.00 (.001)***	**−.04**	**−.01 (.002)**	**−.07**	**−.00 (.001)***
Baseline LPA			.03	.01 (.008)			.03	.01 (.008)			.03	.01 (.008)
ΔLPA			.13	.04 (.008)*			.12	.04 (.008)*			.12	.04 (.008)*
Age × ΔLPA			**.02**	**.00 (.001)**			**.01**	**.00 (.001)**			**.01**	**.00 (.001)**

Note. Parameter estimates for the main predictors (Age × ΔMastery, Age × ΔConstraints) and mediators (Age × ΔLPA) in our moderated mediation models are shown in bold font. Δ = regressed change; *SE* = standard error; SES = socioeconomic status; ADL = activities of daily living (limitations); Mastery = personal mastery; Constraints = perceived constraints.
* $p < .05$.

linking each facet of perceived control (predictors) to change in LPA (mediators) were consistent with those reported above (see Table 5). Age-moderated associations were only observed for changes in constraints when predicting changes in executive functioning. No age-moderated associations were observed for change in LPA (mediator) when predicting changes in executive functioning (outcome). Consequently, tests of conditional indirect effects (moderated mediation) were not conducted because the mediator–outcome paths were not moderated by age.

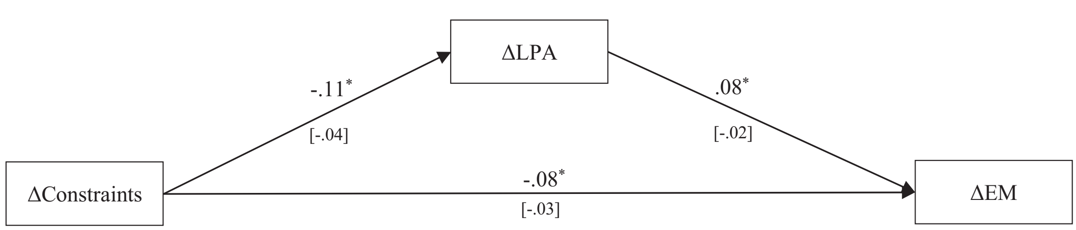
Discussion

Our study sought to shed light on when and how perceived control buffers against cognitive declines. Findings inform lifespan theories of control in disentangling the mediated and moderated pathways for two distinct facets of control involving personal mastery and perceived constraints. Results advance the literature by identifying LPA as a largely overlooked health behavior that mediates the relationship between changes in constraints and trajectories of cognitive functioning. Findings also provide initial evidence that this pathway may become pronounced in later life when opportunities for MVPA are often diminished.

LPA Mediates the Association Between Perceived Constraints and Cognitive Functioning

Informed by Lachman's (2006) process model of control, our study is among the first to document how change in LPA mediates the association between changes in facets of perceived control and longitudinal trajectories of cognitive functioning. Previous research

Figure 3
Step 2 Moderated Mediation Model



Note. Step 2 moderated mediation model predicting two-wave, 9-year ΔEM via change in LPA. Standardized regression weights are reported. Results for only the perceived constraints (ΔConstraints) model are presented for brevity (moderated mediation was not observed for personal mastery). Paths are presented separately for younger (−1 *SD*) and older adults (+1 *SD*): Paths for older adults are reported above the arrow, and paths for younger adults are reported below the arrow (in brackets). Δ = regressed change; EM = episodic memory; LPA = light physical activity.
* $p < .05$.

has focused on the cognitive consequences of baseline levels of overarching perceptions of control, as mediated by forms of physical activity (i.e., MVPA) that become less common and viable in old age (Caplan & Schooler, 2003; Infurna & Gerstorf, 2013; Robinson & Lachman, 2018; Seeman et al., 1996). Our findings highlight the unique influence of changes in individual facets of control involving mastery and constraints and emphasize the importance of capturing the ecological reality that these perceptions can, and do, shift over time. In particular, results suggest longitudinal shifts in constraints (vs. mastery) are a stronger predictor of longitudinal episodic memory and executive functioning, as mediated by an understudied health behavior (LPA) that remains feasible across the adult lifespan. Effect sizes were small but meaningful in showing that LPA mediated 6%−40% of the association between facets of control and cognitive functioning. Sensitivity analyses also demonstrated that these LPA-mediated associations were not simply due to levels or changes in MVPA.

These findings are consistent with theoretical and empirical considerations that suggest constraints—which emphasizes a lack of contingency, external barriers, and personal helplessness—may play a more prominent role with respect to loss–avoidance developmental goals, such as maintaining capacity to engage in LPA and cognitively stimulating tasks (Freund et al., 2012; Infurna & Mayer, 2015; Lachman & Weaver, 1998). Supporting this logic, changes in constraints, but not mastery, had robust indirect effects on longitudinal cognitive functioning that were due in part to its influence on LPA. While constraints (vs. mastery) were the stronger predictor in the present study, this may not be the case for other health-related outcomes that involve more approach- or gain-oriented goals such as increasing MVPA (Freund et al., 2012; Guo et al., 2023; Hong et al., 2021). Mastery may take on a more prominent role with respect to such gain-oriented objectives due to the nature of this construct, which emphasizes personal competence, influence, and tenacity.

Our results can also be leveraged to inform best practice recommendations for future research on perceived control. Findings point to the value of distinguishing mastery and constraints in conceptual models predicting developmental outcomes that exhibit age-related shifts in the extent to which they rely on approach- versus avoidance-oriented goals. In early adulthood and midlife when gain-oriented goals are more prominent, mastery may be a more robust predictor. However, this may shift toward constraints being the stronger predictor in old age when loss- or maintenance-oriented goals become more salient (Baltes & Baltes, 1990; Freund et al., 2012; Heckhausen et al., 2013).

The present study focused on a previously overlooked health behavior (LPA) that may reflect an important mediating mechanism linking facets of control to healthy cognitive aging. However, Lachman's process model specifies additional affective (e.g., positive affect), physiological (e.g., cortisol), and behavioral (e.g., strategies) pathways via which mastery and constraints should buffer against declines in health and cognition. These pathways are supported by indirect evidence showing that perceived control predicts each of these proposed mediators and that each mediator predicts cognition (Bollini et al., 2004; Comijs et al., 2010; Hamm, Barlow, et al., 2023; Hamm et al., 2020; Hamm, Shane, et al., 2023; Hittner et al., 2020). However, future research in this area is needed to directly test whether these factors mediate the link between control and healthy cognitive aging.

LPA Becomes a More Prominent Mediating Mechanism as Individuals Age

The present findings also advance the literature in documenting how the pathways linking different facets of perceived control to longitudinal cognitive functioning may shift across the adult lifespan (Maggio et al., 2019). Previous research that did not consider the distinction between mastery and constraints had yielded mixed evidence for whether the influence of (overarching) perceived control on cognition was moderated by age (Infurna & Gerstorf, 2013; Oumohand et al., 2020; Raldiris et al., 2021; Robinson & Lachman, 2020; Windsor & Anstey, 2008). Our preliminary analyses extend this work by providing new evidence that the association between changes in constraints, but not mastery, and corresponding shifts in cognitive functioning became stronger in old age. Contextualized effect sizes were small but meaningful and suggest that rates of 9-year decline in episodic memory and executive functioning were reduced by nearly 25% for participants whose perceived constraints declined by a standard deviation relative to those who remained stable (see Figure 2).

Our subsequent main analyses showed that the moderated association between constraints and episodic memory was mediated by LPA: The indirect pathway linking changes in constraints to changes in episodic memory was pronounced in old age. These results extend previous empirical work that had yet to examine how the mediated pathways that link mastery and constraints to cognitive aging may depend on developmental circumstances (Hong et al., 2021; Infurna et al., 2018; P.-L. Lee, 2016; Robinson & Lachman, 2018; Wong & Yang, 2023). They are also consistent with lifespan theories of motivation which posit that, as individuals age and encounter increasing developmental constraints, they shift toward loss–avoidance goals that commonly focus on maintaining existing levels of functioning across domains that include everyday physical activity and cognition (Baltes & Baltes, 1990; Freund et al., 2012, 2021; Heckhausen et al., 2013). This implies that how older adults perceive these constraints may be central to sustaining their motivation to maintain adaptive health behaviors such as LPA that have been shown to support healthy cognition into late life. In line with this logic, our results suggest that, for older adults, appraising constraints as less inhibiting as they aged was instrumental in sustaining their everyday LPA. In turn, maintaining this feasible health behavior into late life was protective against declines in episodic memory. Sensitivity analyses also demonstrated that these associations that were mediated by LPA and moderated by age were not due to levels or changes in MVPA.

Although further research is needed to replicate and extend our findings, the present results could potentially inform the development of interventions that target personal mastery or perceived constraints. Both factors exhibited change over time, are modifiable, and may represent viable target mechanisms for intervention. However, the present findings point to perceived constraints as an intervention target that may be especially relevant and consequential in old age. This is because later life is commonly accompanied by developmental constraints and losses that can threaten beliefs about one's capacity to influence core developmental outcomes, including remaining physically active and maintaining one's cognitive functioning (Baltes & Baltes, 1990; Heckhausen et al., 2019). Further work is needed to examine whether well-timed interventions designed to buffer against increased perceptions of constraints can improve developmental outcomes when administered prior to or shortly after the onset of age-related losses (cf. Parker et al., 2022).

Limitations and Conclusion

Although our study is supported by the use of two-wave, 9-year data on facets of perceived control, LPA, and cognitive functioning in a large national sample, it is not without limitations. First, MIDUS measures of physical activity were based on self-reports, as is common in population-based studies where large-scale behavioral assessments are typically not feasible (Yemiscigil & Vlaev, 2021). Individuals tend to overestimate their levels of physical activity, which can result in some bias when estimating absolute levels (P. H. Lee et al., 2011). However, because our primary measures of physical activity were based on *changes* over time, this issue was partially mitigated to the extent that participants who overestimate their activity at one wave may be more likely to do so again at subsequent waves. Future research is nevertheless needed using behaviorally assessed physical activity. Second, changes in our predictor, mediator, and outcome variables occurred during a largely overlapping time interval given that they were assessed at the same waves (Waves 2 and 3). However, the present study does feature a modest time lag given that our predictor and mediator variables (mastery, constraints, LPA) were measured approximately 1 month before our outcome variables at both waves (episodic memory, executive functioning). Nevertheless, reciprocal relations between these perceptions, health behaviors, and cognitive functions are possible and even likely, as suggested by Lachman's (2006) process model of control. Further research with more frequent assessments is needed to tease apart the issue of directionality or bidirectionality. Third, the MIDUS sample was largely White and upper middle class. Further research is needed to replicate these findings in racially and socioeconomically diverse samples.

In sum, the present findings provide evidence that change in LPA reflects a previously overlooked health behavior that links change in perceived constraints to longitudinal trajectories of cognitive functioning. Results also suggest that the mediated link between constraints and episodic memory via LPA becomes pronounced in late life when individuals commonly encounter more barriers to MVPA. These findings inform lifespan theories of control by documenting the mechanistic processes and developmental circumstances that underlie the association between constraints and cognitive aging. Findings also have practical implications for the development of evidence-based interventions and point to the potential value of targeting changes in core psychological (perceived constraints) and behavioral (LPA) factors to buffer against cognitive declines.

References

Agrigoroaei, S., & Lachman, M. E. (2011). Cognitive functioning in midlife and old age: Combined effects of psychosocial and behavioral factors. *The Journals of Gerontology: Series B*, *66B*(Suppl. 1), i130–i140. https://doi.org/10.1093/geronb/gbr017

Ainsworth, B. E., Haskell, W. L., Leon, A. S., Jacobs, D. R., Jr., Montoye, H. J., Sallis, J. F., & Paffenbarger, R. S., Jr. (1993). Compendium of physical activities: Classification of energy costs of human physical activities. *Medicine and Science in Sports and Exercise*, *25*(1), 71–80. https://doi.org/10.1249/00005768-199301000-00011

Baltes, P. B., & Baltes, M. M. (1990). Psychological perspectives on successful aging: The model of selective optimization with compensation. In P. B. Baltes & M. M. Baltes (Eds.), *Successful aging: Perspectives from the behavioral sciences* (pp. 1–34). Cambridge University Press. https://doi.org/10.1017/CBO9780511665684.003

Bandura, A. (1986). The explanatory and predictive scope of self-efficacy theory. *Journal of Social and Clinical Psychology*, *4*(3), 359–373. https://doi.org/10.1521/jscp.1986.4.3.359

Bandura, A. (1997). *Self-self efficacy: The exercise of control*. Freeman.

Bollini, A. M., Walker, E. F., Hamann, S., & Kestler, L. (2004). The influence of perceived control and locus of control on the cortisol and subjective responses to stress. *Biological Psychology*, *67*(3), 245–260. https://doi.org/10.1016/j.biopsycho.2003.11.002

Brim, O. G., Ryff, C. D., & Kessler, R. C. (2004). *How healthy are we? A national study of well-being at midlife*. University of Chicago Press.

Caplan, L. J., & Schooler, C. (2003). The roles of fatalism, self-confidence, and intellectual resources in the disablement process in older adults. *Psychology and Aging*, *18*(3), 551–561. https://doi.org/10.1037/0882-7974.18.3.551

Chipperfield, J. G. (2008). Everyday physical activity as a predictor of late-life mortality. *The Gerontologist*, *48*(3), 349–357. https://doi.org/10.1093/geront/48.3.349

Chipperfield, J. G., Newall, N. E., Chuchmach, L. P., Swift, A. U., & Haynes, T. L. (2008). Differential determinants of men's and women's everyday physical activity in later life. *The Journals of Gerontology. Series B, Psychological Sciences and Social Sciences*, *63*(4), S211–S218. https://doi.org/10.1093/geronb/63.4.S211

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. Lawrence Erlbaum.

Cohen, J., Cohen, P., West, S. G., & Aiken, L. S. (2013). *Applied multiple regression/correlation analysis for the behavioral sciences*. Routledge. https://doi.org/10.4324/9780203774441

Comijs, H. C., Gerritsen, L., Penninx, B. W. J. H., Bremmer, M. A., Deeg, D. J. H., & Geerlings, M. I. (2010). The association between serum cortisol and cognitive decline in older persons. *The American Journal of Geriatric Psychiatry*, *18*(1), 42–50. https://doi.org/10.1097/JGP.0b013e3181b970ae

Cotter, K. A., & Lachman, M. E. (2010). No strain, no gain: Psychosocial predictors of physical activity across the adult lifespan. *Journal of Physical Activity & Health*, *7*(5), 584–594. https://doi.org/10.1123/jpah.7.5.584

Dixon, R. A., & Lachman, M. E. (2019). Risk and protective factors in cognitive aging: Advances in assessment, prevention, and promotion of alternative pathways. In G. Samanez-Larkin (Ed.), *The aging brain: Functional adaptation across adulthood* (pp. 217–263). American Psychological Association. https://doi.org/10.1037/0000143-009

Erlenbach, E., McAuley, E., & Gothe, N. P. (2021). The association between light physical activity and cognition among adults: A scoping review. *The Journals of Gerontology: Series A*, *76*(4), 716–724. https://doi.org/10.1093/gerona/glab013

Freund, A. M., Hennecke, M., Brandstätter, V., Martin, M., Boker, S. M., Charles, S. T., Fishbach, A., Hess, T. M., Heckhausen, J., Gow, A. J., Isaacowitz, D. M., Klusmann, V., Lachman, M. E., Mayr, U., Oettingen, G., Robert, P., Röcke, C., Rothermund, K., Scholz, U., … Zadeh, R. S. (2021). Motivation and healthy aging: A heuristic model. *The Journals of Gerontology: Series B*, *76*(Suppl. 2), S97–S104. https://doi.org/10.1093/geronb/gbab128

Freund, A. M., Hennecke, M., & Mustafic, M. (2012). On gains and losses, means and ends: Goal orientation and goal focus across adulthood. In R. M. Ryan (Ed.), *The Oxford handbook of human motivation* (pp. 280–300). Oxford Academic. https://doi.org/10.1093/oxfordhb/9780195399820.013.0016

Guo, J., Hu, X., Elliot, A. J., Marsh, H. W., Murayama, K., Basarkod, G., Parker, P. D., & Dicke, T. (2023). Mastery-approach goals: A large-scale cross-cultural analysis of antecedents and consequences. *Journal of Personality and Social Psychology*, *125*(2), 397–420. https://doi.org/10.1037/pspp0000436

Hamm, J. M., Barlow, M. A., Garcia, O. G., & Duggan, K. A. (2023). Context-dependent shifts in self-regulatory personality processes during COVID-19: Changes in control predict dynamic shifts in goal reengagement capacity. *Social and Personality Psychology Compass*, *17*(8), Article e12771. https://doi.org/10.1111/spc3.12771

Hamm, J. M., Heckhausen, J., Shane, J., & Lachman, M. E. (2020). Risk of cognitive declines with retirement: Who declines and why? *Psychology and Aging*, *35*(3), 449–457. https://doi.org/10.1037/pag0000453

Hamm, J. M., Parker, K., Lachman, M. E., Mogle, J. A., Duggan, K. A., & McGrath, R. (2024). Increased frequency of light physical activity during midlife and old age buffers against cognitive declines. *Journal of Behavioral Medicine*. Advance online publication. https://doi.org/10.1007/s10865-024-00478-2

Hamm, J. M., Shane, J., Pierce, M. J., & Duggan, K. A. (2023). Individual differences in patterns of developmental opportunity and constraint during COVID-19: Implications for longitudinal well-being. *Social and Personality Psychology Compass*, *17*(8), Article e12788. https://doi.org/10.1111/spc3.12788

Hamm, J. M., Wrosch, C., Barlow, M. A., & Kunzmann, U. (2021). A tale of two emotions: The diverging salience and health consequences of calmness and excitement in old age. *Psychology and Aging*, *36*(5), 626–641. https://doi.org/10.1037/pag0000512

Hayes, A. F. (2017). *Introduction to mediation, moderation, and conditional process analysis, second edition: A regression-based approach*. Guilford Press.

Heckhausen, J., Wrosch, C., & Schulz, R. (2013). A lines-of-defense model for managing health threats: A review. *Gerontology*, *59*(5), 438–447. https://doi.org/10.1159/000351269

Heckhausen, J., Wrosch, C., & Schulz, R. (2019). Agency and motivation in adulthood and old age. *Annual Review of Psychology*, *70*(1), 191–217. https://doi.org/10.1146/annurev-psych-010418-103043

Hittner, E. F., Stephens, J. E., Turiano, N. A., Gerstorf, D., Lachman, M. E., & Haase, C. M. (2020). Positive affect is associated with less memory decline: Evidence from a 9-year longitudinal study. *Psychological Science*, *31*(11), 1386–1395. https://doi.org/10.1177/0956797620953883

Hong, J. H., Lachman, M. E., Charles, S. T., Chen, Y., Wilson, C. L., Nakamura, J. S., VanderWeele, T. J., & Kim, E. S. (2021). The positive influence of sense of control on physical, behavioral, and psychosocial health in older adults: An outcome-wide approach. *Preventive Medicine*, *149*, Article 106612. https://doi.org/10.1016/j.ypmed.2021.106612

Hughes, M. L., Agrigoroaei, S., Jeon, M., Bruzzese, M., & Lachman, M. E. (2018). Change in cognitive performance from midlife into old age: Findings from the midlife in the United States (MIDUS) study. *Journal of the International Neuropsychological Society*, *24*(8), 805–820. https://doi.org/10.1017/S1355617718000425

Infurna, F. J., & Gerstorf, D. (2013). Linking perceived control, physical activity, and biological health to memory change. *Psychology and Aging*, *28*(4), 1147–1163. https://doi.org/10.1037/a0033327

Infurna, F. J., Gerstorf, D., Ram, N., Schupp, J., & Wagner, G. G. (2011). Long-term antecedents and outcomes of perceived control. *Psychology and Aging*, *26*(3), 559–575. https://doi.org/10.1037/a0022890

Infurna, F. J., Kappes, C., & Fraire, N. (2018). Long-term antecedents of constraints and mastery: Findings from the Health and Retirement Study. *Psychology and Aging*, *33*(6), 965–974. https://doi.org/10.1037/pag0000281

Infurna, F. J., & Mayer, A. (2015). The effects of constraints and mastery on mental and physical health: Conceptual and methodological considerations. *Psychology and Aging*, *30*(2), 432–448. https://doi.org/10.1037/a0039050

Khoo, S. S., & Yang, H. (2020). Social media use improves executive functions in middle-aged and older adults: A structural equation modeling analysis. *Computers in Human Behavior*, *111*, Article 106388. https://doi.org/10.1016/j.chb.2020.106388

Lachman, M. E. (2006). Perceived control over aging-related declines: Adaptive beliefs and behaviors. *Current Directions in Psychological Science*, *15*(6), 282–286. https://doi.org/10.1111/j.1467-8721.2006.00453.x

Lachman, M. E., Agrigoroaei, S., Murphy, C., & Tun, P. A. (2010). Frequent cognitive activity compensates for education differences in episodic memory. *The American Journal of Geriatric Psychiatry*, *18*(1), 4–10. https://doi.org/10.1097/JGP.0b013e3181ab8b62

Lachman, M. E., Agrigoroaei, S., Tun, P. A., & Weaver, S. L. (2014). Monitoring cognitive functioning: Psychometric properties of the brief test of adult cognition by telephone. *Assessment*, *21*(4), 404–417. https://doi.org/10.1177/1073191113508807

Lachman, M. E., & Tun, P. A. (2008). Cognitive testing in large-scale surveys: Assessment by telephone. In S. M. Hofer & D. F. Alwin (Eds.), *Handbook of cognitive aging: Interdisciplinary perspectives* (pp. 506–523). Sage Publications. https://doi.org/10.4135/9781412976589.n30

Lachman, M. E., & Weaver, S. L. (1998). The sense of control as a moderator of social class differences in health and well-being. *Journal of Personality and Social Psychology*, *74*(3), 763–773. https://doi.org/10.1037/0022-3514.74.3.763

Laurin, D., Verreault, R., Lindsay, J., MacPherson, K., & Rockwood, K. (2001). Physical activity and risk of cognitive impairment and dementia in elderly persons. *Archives of Neurology*, *58*(3), 498–504. https://doi.org/10.1001/archneur.58.3.498

Lee, P. H., Macfarlane, D. J., Lam, T. H., & Stewart, S. M. (2011). Validity of the international physical activity questionnaire short form (IPAQ-SF): A systematic review. *The International Journal of Behavioral Nutrition and Physical Activity*, *8*(1), Article 115. https://doi.org/10.1186/1479-5868-8-115

Lee, P.-L. (2016). Control beliefs level and change as predictors of subjective memory complaints. *Aging & Mental Health*, *20*(3), 329–335. https://doi.org/10.1080/13607863.2015.1008991

Lee, S., Yuki, A., Nishita, Y., Tange, C., Kim, H., Kozakai, R., Ando, F., & Shimokata, H. (2013). Research relationship between light-intensity physical activity and cognitive function in a community-dwelling elderly population-an 8-year longitudinal study. *Journal of the American Geriatrics Society*, *61*(3), 452–453. https://doi.org/10.1111/jgs.12119

Lindenberger, U., Gilberg, R., Little, T. D., Nuthmann, R., Pötter, U., & Baltes, P. B. (2001). Sample selectivity and generalizabilityof the results of the Berlin Aging Study. In P. B. Baltes & K. U. Mayer (Eds.), *The Berlin aging study: Aging from 70 to 100* (pp. 56–82). Cambridge University Press.

Lytle, M. E., Vander Bilt, J., Pandav, R. S., Dodge, H. H., & Ganguli, M. (2004). Exercise level and cognitive decline: The MoVIES project. *Alzheimer Disease and Associated Disorders*, *18*(2), 57–64. https://doi.org/10.1097/01.wad.0000126614.87955.79

Maggio, C., Soubelet, A., Faure, S., & Fort, I. (2019). The relationships between perceived control and episodic memory in adulthood: A review. *Aging, Neuropsychology, and Cognition*, *26*(2), 222–243. https://doi.org/10.1080/13825585.2017.1423022

Mansoubi, M., Pearson, N., Clemes, S. A., Biddle, S. J., Bodicoat, D. H., Tolfrey, K., Edwardson, C. L., & Yates, T. (2015). Energy expenditure during common sitting and standing tasks: Examining the 1.5 MET definition of sedentary behaviour. *BMC Public Health*, *15*(1), Article 516. https://doi.org/10.1186/s12889-015-1851-x

Matthews, K. A., Xu, W., Gaglioti, A. H., Holt, J. B., Croft, J. B., Mack, D., & McGuire, L. C. (2019). Racial and ethnic estimates of Alzheimer's disease and related dementias in the United States (2015–2060) in adults aged ≥65 years. *Alzheimer's & Dementia: The Journal of the Alzheimer's Association*, *15*(1), 17–24. https://doi.org/10.1016/j.jalz.2018.06.3063

Maxwell, S. E., Delaney, H. D., & Kelley, K. (2017). *Designing experiments and analyzing data: A model comparison perspective*. Routledge. https://doi.org/10.4324/9781315642956

Menec, V. H., & Chipperfield, J. G. (1997). The interactive effect of perceived control and functional status on health and mortality among young-old and old–old adults. *The Journals of Gerontology. Series B, Psychological Sciences and Social Sciences*, *52B*(3), P118–P126. https://doi.org/10.1093/geronb/52B.3.P118

Oumohand, S. E., Ward, D. D., Boenniger, M. M., Merten, N., Kirschbaum, C., & Breteler, M. M. B. (2020). Perceived stress but not hair cortisol concentration is related to adult cognitive performance. *Psychoneuroendocrinology*, *121*, Article 104810. https://doi.org/10.1016/j.psyneuen.2020.104810

Parker, P. C., Chipperfield, J. G., Hamm, J. M., Perry, R. P., Krylova, M. V., Chuchmach, L. M., & Hladkyj, S. (2022). Attributional retraining: Promoting psychological wellbeing in older adults with compromised health. *Frontiers in Sports and Active Living*, *4*, Article 949501. https://doi.org/10.3389/fspor.2022.949501

Preacher, K. J., & Hayes, A. F. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behavior Research Methods*, *40*(3), 879–891. https://doi.org/10.3758/BRM.40.3.879

Radler, B. T., & Ryff, C. D. (2010). Who participates? Accounting for longitudinal retention in the MIDUS national study of health and well-being. *Journal of Aging and Health*, *22*(3), 307–331. https://doi.org/10.1177/0898264309358617

Raldiris, T. L., Perez, E., Donovan, E. K., & Dzierzewski, J. M. (2021). Cognitive control beliefs and cognitive functioning in mid- to late-life. *British Journal of Developmental Psychology*, *39*(2), 269–281. https://doi.org/10.1111/bjdp.12357

Renner, B., Spivak, Y., Kwon, S., & Schwarzer, R. (2007). Does age make a difference? Predicting physical activity of South Koreans. *Psychology and Aging*, *22*(3), 482–493. https://doi.org/10.1037/0882-7974.22.3.482

Robinson, S. A., & Lachman, M. E. (2016). Perceived control and behavior change: A personalized approach. In J. W. Reich & F. J. Infurna (Eds.), *Perceived control* (pp. 201–228). Oxford University Press. https://doi.org/10.1093/acprof:oso/9780190257040.003.0009

Robinson, S. A., & Lachman, M. E. (2018). Perceived control and cognition in adulthood: The mediating role of physical activity. *Psychology and Aging*, *33*(5), 769–781. https://doi.org/10.1037/pag0000273

Robinson, S. A., & Lachman, M. E. (2020). Daily control beliefs and cognition: The mediating role of physical activity. *The Journals of Gerontology: Series B*, *75*(4), 772–782. https://doi.org/10.1093/geronb/gby081

Ryff, C., Almeida, D., Ayanian, J., Binkley, N., Carr, D. S., Coe, C., Davidson, R., Grzywacz, J., Karlamangla, A., Krueger, R., Lachman, M., Love, G., Mailick, M., Mroczek, D., Radler, B., Seeman, T., Sloan, R., Thomas, D., Weinstein, M., & Williams, D. (2017). *Midlife in the United States (MIDUS 3), 2013–2014* (Version v6) [Data set]. Inter-University Consortium for Political and Social Research. https://doi.org/10.3886/ICPSR36346.V6

Seeman, T., McAvay, G., Merrill, S., Albert, M., & Rodin, J. (1996). Self-efficacy beliefs and change in cognitive performance: MacArthur Studies of Successful Aging. *Psychology and Aging*, *11*(3), 538–551. https://doi.org/10.1037/0882-7974.11.3.538

Skinner, E. A. (1996). A guide to constructs of control. *Journal of Personality and Social Psychology*, *71*(3), 549–570. https://doi.org/10.1037/0022-3514.71.3.549

Soederberg Miller, L. M., & Lachman, M. E. (1999). The sense of control and cognitive aging: Toward a model of mediational processes. In T. M. Hess & F. Blanchard-Fields (Eds.), *Social cognition and aging* (pp. 17–41). Academic Press. https://doi.org/10.1016/B978-012345260-3/50003-3

Stubbs, B., Chen, L.-J., Chang, C.-Y., Sun, W.-J., & Ku, P.-W. (2017). Accelerometer-assessed light physical activity is protective of future cognitive ability: A longitudinal study among community dwelling older adults. *Experimental Gerontology*, *91*, 104–109. https://doi.org/10.1016/j.exger.2017.03.003

Sutin, A. R., Stephan, Y., & Terracciano, A. (2018). Psychological distress, self-beliefs, and risk of cognitive impairment and dementia. *Journal of Alzheimer's Disease*, *65*(3), 1041–1050. https://doi.org/10.3233/JAD-180119

Tennant, P. W. G., Arnold, K. F., Ellison, G. T. H., & Gilthorpe, M. S. (2022). Analyses of 'change scores' do not estimate causal effects in observational data. *International Journal of Epidemiology*, *51*(5), 1604–1615. https://doi.org/10.1093/ije/dyab050

Tran, D., Baxter, J., Hamman, R. F., & Grigsby, J. (2014). Impairment of executive cognitive control in type 2 diabetes, and its effects on health-related behavior and use of health services. *Journal of Behavioral Medicine*, *37*(3), 414–422. https://doi.org/10.1007/s10865-013-9499-4

Trinh, L., Alibhai, S. M. H., Culos-Reed, N., Sabiston, C. M., Jones, J. M., Rosenberg, D. E., Whitehorn, A., Bastas, D., & Faulkner, G. E. (2022). Associations of light physical activity, moderate-to-vigorous physical activity and sedentary behavior with quality of life in men on androgen deprivation therapy for prostate cancer: A quantile regression analysis. *Journal of Behavioral Medicine*, *45*(4), 533–543. https://doi.org/10.1007/s10865-022-00285-7

Tun, P. A., & Lachman, M. E. (2006). Telephone assessment of cognitive function in adulthood: The Brief Test of Adult Cognition by Telephone. *Age and Ageing*, *35*(6), 629–632. https://doi.org/10.1093/ageing/afl095

Tun, P. A., & Lachman, M. E. (2008). Age differences in reaction time and attention in a national telephone sample of adults: Education, sex, and task complexity matter. *Developmental Psychology*, *44*(5), 1421–1429. https://doi.org/10.1037/a0012845

Windsor, T. D., & Anstey, K. J. (2008). A longitudinal investigation of perceived control and cognitive performance in young, midlife and older adults. *Aging, Neuropsychology, and Cognition*, *15*(6), 744–763. https://doi.org/10.1080/13825580802348570

Wong, Y. P., & Yang, H. (2023). The influence of subjective socioeconomic status on executive functions in middle-aged and older adults. *Aging, Neuropsychology, and Cognition*, *30*(4), 505–522. https://doi.org/10.1080/13825585.2022.2055738

Wrosch, C., Barlow, M. A., & Kunzmann, U. (2018). Age-related changes in older adults' anger and sadness: The role of perceived control. *Psychology and Aging*, *33*(2), 350–360. https://doi.org/10.1037/pag0000229

Yaffe, K., Barnes, D., Nevitt, M., Lui, L.-Y., & Covinsky, K. (2001). A prospective study of physical activity and cognitive decline in elderly women: Women who walk. *Archives of Internal Medicine*, *161*(14), 1703–1708. https://doi.org/10.1001/archinte.161.14.1703

Yemiscigil, A., & Vlaev, I. (2021). The bidirectional relationship between sense of purpose in life and physical activity: A longitudinal study. *Journal of Behavioral Medicine*, *44*(5), 715–725. https://doi.org/10.1007/s10865-021-00220-2

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