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Cross-sectional and longitudinal associations of self-perceptions of aging with physical activity in multimorbidity: The role of depressive **symptoms**

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HIGHLIGHTS

- Perceived age-related gains were cross-sectionally, but not consistently longitudinally, associated with higher physical activity.
- Perceived age-related losses were associated with lower physical activity both cross-sectionally and longitudinally, directly and indirectly through depressive symptoms.
- Self-perceptions of aging may represent relevant and modifiable psychological correlates of physical activity in middle-aged and older adults with multimorbidity.

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ABSTRACT

Objective: This study investigated, among middle-aged and older individuals with multimorbidity, the cross-sectional and four-year associations of Awareness of Age-Related Gains and Losses (AARC-Gains, AARC-Losses) with physical activity and whether depressive symptoms mediate these associations.
Methods: The study used UK PROTECT data collected in 2019 and 2021. Measures used included the Community Healthy Activities Model Program for Seniors, the Awareness of Age-Related Change questionnaire, and the Patient Health Questionnaire. Multiple linear regressions and structural equation modeling were used.
Results: The cross-sectional and longitudinal sample comprised 4947 (mean age= 67.5, 73.3% female) and 1814 individuals, respectively. Cross-sectionally, higher AARC-Gains were associated with greater number (β= 0.13, 95% CI [0.10, 0.16]), duration (β= 0.12, 95% CI [0.09, 0.15]), and intensity (β= 0.12, 95% CI [0.09, 0.15]) of physical activity. Lower AARC-Losses were associated with higher number (β= -0.19, 95% CI [-0.22, -0.16]), duration (β= -0.20, 95% CI [-0.23, -0.16]), and intensity (β= -0.21, 95% CI [-0.24, -0.18]) of physical activity. Longitudinally, higher baseline AARC-Losses were associated with lower number (β= -0.05, 95% CI [-0.07, -0.03]), duration (β= -0.05, 95% CI [-0.08, -0.02]), and intensity (β= -0.06, 95% CI [-0.08, -0.04]) of physical activity at follow-up. Depressive symptoms partially mediated these associations. AARC-Gains showed inconsistent or non-significant associations with physical activity.
Conclusions: Perceiving many age-related losses may hinder engagement in physical activity directly and indirectly through depressive symptoms. Interventions promoting physical activity among individuals with

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multimorbidity may benefit from strategies that reframe negative self-perceptions of aging and address depressive symptoms, complementing clinical recommendations.

1. Introduction

As the population ages worldwide, the prevalence of non-communicable diseases rises dramatically. Non-communicable diseases are non-transmissible, long-term, and often slowly progressive conditions such as cardiovascular diseases, cancer, diabetes, chronic respiratory conditions, and musculoskeletal disorders. They represent the leading global cause of both disability and death (Li et al., 2025). Indeed, over half of the world's population aged 60 and older lives with two or more non-communicable diseases (hereafter referred to as multimorbidity) (Chowdhury et al., 2023). Evidence from the United States (Lee et al., 2024) and European countries (Han et al., 2025) indicates an increased prevalence of multimorbidity after the age of 50. Compared to individuals with a single disease, those with multimorbidity are at greater risk of hospitalization, functional decline, and adverse mental health (Marengoni et al., 2011). Healthcare systems are heavily impacted by multimorbidity in terms of clinical management, care coordination, and financial strains (Moffat & Mercer, 2015). The need to mitigate this burden has placed disease prevention and self-care promotion as current major priorities for public health (World Health Organization, 2022).

Managing multimorbidity is complex, requiring intricate pharmacological regimens and substantial lifestyle and social adjustments. Among these, physical activity is important to improve prognosis and increase life expectancy (Chudasama et al., 2019). Because of the benefits of physical activity, in 2020, the World Health Organization released updated Guidelines on Physical Activity and Sedentary Behavior, in which is recommended that all adults, including those with multimorbidity, engage in 150 to 300 min of moderate-intensity activity, 75 to 150 min of vigorous-intensity activity, or an equivalent combination of both per week (Bull et al., 2020). However, physical activity remains insufficiently practiced among adults, especially among those who are older (Keadle et al., 2016) and living with one or more non-communicable diseases (Barker et al., 2019; Brawner et al., 2016). Indeed, findings from multiple countries, including England (Barker et al., 2019) and the United States (Brawner et al., 2016), show that middle-aged and older individuals with non-communicable diseases perform significantly less moderate and vigorous activity per week than those without medical conditions.

Given its well-established benefits, lack or little engagement with physical activity among middle-aged and older adults with multimorbidity raises important public health concerns. Identifying the barriers that middle-aged and older adults face in engaging in physical activity is a critical first step for developing tailored and clinically meaningful exercise-promoting interventions. While pain, fatigue, and functional limitations may understandably hinder physical activity when living with non-communicable diseases (LaRowe & Williams, 2022; Murphy et al., 2013), potentially modifiable psychological factors play a critical role as well. These include fear of injury, lack of confidence, misconceptions about symptoms exacerbation during exercise, discomfort in group-based settings, and internalized ageist beliefs (Cigarroa et al., 2022; Massie & Meisner, 2019). Physical exercise programs which do not address these psychological aspects risk failing to foster engagement and long-term adherence (Hurst et al., 2023). The current study will focus on two possible modifiable psychological barriers of physical activity that may be present among people with multimorbidity: Self-Perceptions of Aging (SPA) and depressive symptoms. Indeed, due to the difficulties related to living with non-communicable diseases, individuals with multimorbidity may be susceptible to the development of more negative SPA and depressive symptoms (Bi et al., 2021; Rupprecht et al., 2022; Sabatini et al., 2023). One could hypothesize that these, in turn, hamper physical activity engagement among individuals with multimorbidity.

SPA capture how individuals experience, perceive, and interpret their own aging process (Diehl & Wahl, 2024). According to Stereotype Embodiment Theory (Levy, 2009), across the lifespan individuals internalize age-related beliefs that, during middle and older age, may increasingly shape their behaviors and health. According to this theory, individuals with negative SPA hold pessimistic and rigid views of growing older (e.g. assuming that age-related decline is inevitable) which may discourage them from engaging in health-promoting behaviors (e.g. balanced diet). However, this lack of adherence to health-enhancing behaviors may expose them to a greater and faster decline in health, thereby effectively confirming their negative beliefs. In support of this theory, studies have shown that individuals with more negative SPA are less physically active, whereas those with more positive SPA are more physically active (Massie & Meisner, 2019; Wurm et al., 2010). Moreover, those with more positive SPA maintain better mental, physical, and cognitive health whereas individuals with negative SPA are at greater risk of poor health and mortality (Westerhof et al., 2023). However, studies focusing on middle and older adults with non-communicable diseases are scarce (Lieber et al., 2025; Mezza et al., 2025), although health conditions seem to increase individuals' vulnerability to negative SPA (Bodner, 2017; Prasad et al., 2023; Sabatini et al., 2023).

In the context of multimorbidity, SPA have often been investigated through the construct of Awareness of Age-Related Change (AARC) (Diehl & Wahl, 2010), which concurrently captures the positive (AARC-Gains) and negative (AARC-Losses) age-related changes individuals perceive in different life domains (e.g., health, cognitive functioning, and interpersonal relationships), reflecting the subjective experience of aging in everyday functioning. This makes AARC particularly appropriate in multimorbidity, where individuals' daily fluctuations in symptoms and functional limitations are likely to shape their interpretation of how they are aging. Studies have shown that multimorbidity is associated not only with higher AARC-Losses, reflecting an increased perception of age-related decline, but also with higher AARC-Gains, possibly indicating adaptive coping and resilience in the face of illness (Rupprecht et al., 2022; Sabatini et al., 2023). However, those physical diseases most commonly associated with aging, such as arthritis, show stronger associations with AARC-Losses than AARC-Gains (Dunsmore & Neupert, 2022; Sabatini et al., 2023).

The experience of depressive symptoms is also highly common among people with non-communicable diseases (Bi et al., 2021; Birk et al., 2019). Moreover, the risk of experiencing depressive symptoms rises with the number of diseases (Bi et al., 2021) and the severity of depressive symptoms often worsens as the conditions progress (Birk et al., 2019). This may in part reflect the limitations and adjustments imposed by the chronic diseases, which often entail the loss of meaningful activities, reduced participation in community life and the financial strain from long-term treatment (Ni et al., 2024). Depressive symptoms can, in turn, complicate the diseases management, by reducing self-care practices and engagement with healthy behaviors (Grenard et al., 2011). In particular, depressive symptoms (e.g., lack of motivation and energy) are known barriers to physical activity among people with non-communicable diseases, predicting declining physical activity (Gudmundsson et al., 2015) and poor adherence to exercise programs (Swardfager et al., 2016). This creates a vicious cycle: reduced physical activity accelerates the physical decline and leads to further detrimental consequences for health (Durstine et al., 2013). In sum, living with multimorbidity may lead to more negative SPA and depressive symptoms. These may, in turn, hamper physical activity

engagement. Although AARC-Losses have been consistently associated with increased depressive symptoms in later life (Sabatini et al., 2020), evidence is missing for individuals with non-communicable diseases. Moreover, although Stereotype Embodiment Theory hypothesizes a direct path from SPA to behaviors such as physical activity, depressive symptoms may represent a mediating factor through which negative SPA translate into reduced physical activity (Sabatini et al., 2020).

Clarifying the long-term relationships between SPA (AARC-Gains and AARC-Losses), depressive symptoms, and physical activity in this population may inform the design of interventions aimed at increasing physical activity among middle and older adults living with multimorbidity. Using a sample of UK individuals aged 50 and over living with two or more non-communicable diseases, this study aims to: (1) investigate the cross-sectional associations of AARC-Gains and AARC-Losses with number, duration and intensity of physical activities; (2) investigate the four-year longitudinal associations of AARC-Gains and AARC-Losses with the same indicators of physical activity; (3) investigate whether depressive symptoms mediate the possible longitudinal associations of AARC-Gains and AARC-Losses with indicators of physical activity. This study has the following hypotheses: (i) higher AARC-Gains and lower AARC-Losses are independently associated at cross-sectional level with greater engagement with physical activity. (ii) higher AARC-Gains and lower AARC-Losses at baseline (2019) are associated with greater engagement with physical activity at follow-up (2023) while adjusting for baseline physical activity and age, sex, education, marital status, employment, and number of non-communicable diseases. (iii) depressive symptoms at least partially mediate the longitudinal associations of AARC-Gains and AARC-Losses with physical activity.

2. Materials and methods

2.1. Transparency and openness

This study is a secondary analysis of UK PROTECT (Platform for Research Online to investigate Genetics and Cognition in Aging) data. The study was not preregistered. Data are not publicly available due to ethical and governance restrictions of the UK PROTECT study but can be accessed upon approval by the UK PROTECT steering committee. The analysis code is available from the corresponding author upon reasonable request.

2.2. Sample and procedure

This study uses 2019 data for 4947 individuals, and four-year longitudinal data for 1814 individuals. Data was collected online through the UK PROTECT cohort. Inclusion criteria in UK PROTECT were being a UK resident, English speaker, aged $\geq$ 50 years, having internet access, and no diagnosis of dementia. Recruitment was conducted nationwide and among existing research cohorts including Exeter 10,000, Join Dementia Research, and Brains for Dementia Research. For the purpose of this study, participants from the UK PROTECT 2019 wave with multimorbidity, defined as the presence of two or more non-communicable diseases, were kept in the study sample (N= 5141). Additionally, those who did not complete the AARC and/or physical activity questionnaire in 2019 were excluded from the study sample, resulting in 4947 participants for the cross-sectional analyses. The longitudinal sample comprised a subsample of participants who completed questionnaires assessing depressive symptoms and physical activity in 2019 and 2023 (N= 1814). All participants provided online consent at enrolment in the UK PROTECT platform. UK PROTECT obtained ethical approval from the London Bridge NHS Research Ethics Committee and Health Research Authority (Ref:13/LO/1578).

2.3. Measures

Physical Activity was assessed with the Community Healthy Activities Model Program for Seniors (CHAMPS) questionnaire (Stewart et al., 2001). Participants were presented with 28 physical activities (e.g., dancing, golf, heavy gardening) and asked to report frequency (0= *never; 1= once; 2= twice or more*) and duration (1= *less than 1 hour*; 2= *1–2 ½ hours*; 3= *3–4 ½ hours*; 4= *5–6 ½ hours*; 5= *7–8 ½ hours*; 6= *9 or more hours*) during a typical week over the past four weeks. Three total indicators were derived and used as continuous variables in the analyses: (1) number of different activities; (2) total weekly duration, calculated as the sum of hours spent in all endorsed activities (range: 0–168); (3) total weekly intensity, calculated by multiplying hours per activity by its metabolic equivalent value, and then summing across activities. Supplementary Table 1 reports metabolic equivalent values for each activity. Activities not endorsed or missing receive a score of 0. Higher scores indicate greater activity variety, duration, and intensity. Because the CHAMPS is a behavioral checklist of many different physical activities, items are not expected to correlate highly. Consequently, we have not calculated Cronbach's alpha for this measure. However, construct validity and test-retest reliability of the CHAMPS has been proved adequate in past research (Stewart et al., 2001).

Awareness of Age-Related Change was measured using the 10-item version of the questionnaire (AARC-10 SF) (Kaspar et al., 2019), comprising five items assessing AARC-Gains and five items assessing AARC-Losses. Items start with the stem: *"With my increasing age, I realize that…"* and are rated on a five-point Likert scale (1= *not at all*; 2= *a little bit*; 3= *moderately*; 4= *quite a bit*; 5= *very much*). Subscale scores for AARC-Gains and AARC-Losses were calculated by summing the five respective items (range 5–25), with higher scores indicating greater AARC-Gains or AARC-Losses. The full list of items is reported in Supplementary Table 2. In this sample, Cronbach's α for the AARC-Gains subscale was 0.76 and for the AARC-Losses subscale was 0.80.

Depressive Symptoms over the previous two weeks were assessed with the nine-item Patient Health Questionnaire (Kroenke et al., 2001). Each item assesses symptom frequency: *not at all* (0); *several days* (1); *more than half the days* (2); *nearly every day* (3). The total score is the sum of the item scores (range: 0–27); higher scores indicate more depressive symptoms. Cronbach's alpha in this sample was 0.92.

Socio-Demographic Variables comprised age, sex, education, marital status, and employment status. Education comprised: secondary education; post-secondary education; vocational qualifications; undergraduate degrees; post-graduate degrees; doctorates. Marital status was grouped as: married, co-habiting, or civil partnership; widowed; separated or divorced; and single. Employment status included: employed full-time; employed part-time; self-employed; retired; and unemployed.

Number of Non-Communicable Diseases was obtained from the count of 27 conditions such as stroke and arthritis. The list of conditions, and number participants having each non-communicable disease is reported in Supplementary Table 3.

2.4. Data analyses

Summary statistics of study variables administered in 2019 were reported for the cross-sectional study sample, the longitudinal study sample, and those who did not provide longitudinal data. Chi-squared tests and analysis of variance tests (ANOVA) were used to compare study variables between those who provided longitudinal data and those who did not. Multiple linear regression models were fit to investigate the cross-sectional associations of AARC-Gains and AARC-Losses with each physical activity outcome (number of physical activities, duration of physical activity, and intensity of physical activity). To these models, age, sex, education, marital status, employment status, number of non-communicable diseases, and depressive symptoms in 2019 were added as covariates as they are often associated with SPA and physical activity (Barker et al., 2019; Dutt & Wahl, 2018; Sabatini et al., 2020). Multiple linear regression models were also fitted to investigate the longitudinal associations of AARC-Gains and AARC-Losses assessed in 2019 with indicators of physical activity assessed in 2023. These models adjusted

for age, sex, education, marital status, employment status, number of non-communicable diseases, and the given indicator of physical activity, all assessed in 2019. Models were not adjusted for depressive symptoms as these were hypothesized to be in the causal pathway. Structural equation modeling (SEM) was used to test the mediating role of follow-up depressive symptoms in the longitudinal association of baseline AARC-Losses with each of the indicators of physical activity at follow-up. Mediation models were not tested for AARC-Gains due to the longitudinal associations of AARC-Gains and indicators of physical activity being either statistically not-significant or of negligible size. Mediation models for AARC-Losses controlled for 2019 levels of depressive symptoms and physical activity. For the mediation models, the following goodness of fit statistics were estimated: Root mean squared error of approximation (RMSEA); Comparative fit index (CFI); Tucker–Lewis index (TLI); and Standardized Root Mean Squared Residual (SRMR). Criteria for acceptable model fit were RMSEA < 0.08 (90 % CI: between 0 and 0.08); CFI and TLI > 0.90, and SRMR < 0.08 indicating Good fit and < 0.05 indicating excellent fit (Byrne, 2012). Standardized (β) regression coefficients were reported as indicators of the effect size. Coefficients ≤ 0.09 were considered negligible, 0.10–0.29 as small, 0.30–0.49 as moderate, and ≥ 0.50 as large. Complete case analyses were conducted using STATA version 18.

As this study was based on secondary analyses of an existing cohort dataset, the sample size was determined by the number of eligible UK PROTECT participants meeting the inclusion criteria or having two or more health conditions and completing the relevant measures. Nonetheless, both the cross-sectional and the longitudinal samples were large enough for the types of analyses undertaken. More specifically, using G*Power we estimated that to detect a small effect using multiple regression models with one outcome and nine predictors and setting alpha at 0.05 and power at 0.80, a minimum of 791 participants were needed. For mediation models including 8 covariates we estimated that 500 participants would have been needed to detect a small indirect effect (Fairchild & McDaniel, 2017).

3. Results

3.1. Descriptive statistics

The cross-sectional study sample comprised 4947 participants with a mean age of 67.54 years (SD= 7.3 years; range: 50–95 years; Table 1, Table 2). Most participants were women (73.3 %), married or cohabiting (68.6 %), retired (72.5 %), and 52.4 % had a university degree. On average, participants had 2.63 non-communicable diseases and the mean score for depressive symptoms was 3.3. Mean scores for AARC-Gains and AARC-Losses were 18.13 and 11.05, respectively, indicating relatively high perceived gains and relatively low perceived losses (Sabatini et al., 2023). Participants reported engaging in 7.7 physical activities per week on average, with a mean weekly duration of 12.2 hours and a mean intensity score of 36.9.

The longitudinal sample comprised 1814 participants (See Supplementary Table 4). At baseline their mean age was 66.9 years; 72.7 % were women, 55.9 % had a university degree, and 72.1 % were retired. Participants had on average 2.57 non-communicable diseases each. Their mean score for depressive symptoms was 2.98. Their mean scores for AARC-Gains and AARC-Losses were 18.00 and 10.58, respectively. Participants on average reported engaging in 8 physical activities in a typical week and engaging in them for 12.19 hours. Mean intensity of physical activity was 37.50. Compared to the longitudinal sample (See Supplementary Table 4), those who did not provide longitudinal data were on average one year older ($p< .001$), less-educated ($p< .001$), had minimally more non-communicable diseases ($p= .002$), reported more depressive symptoms ($p< .001$) and more AARC-Losses ($p< .001$), and conducted fewer physical activities ($p< .001$). For the longitudinal study sample, in 2023 mean depressive symptoms were 3.10 (SD= 3.50). In 2023 participants engaged in 7.76 physical activities, and for 12.17 hours, and the mean intensity of physical activity was 36.87 (SD= 31.33).

Table 1
Descriptive statistics at baseline/2019 for the cross-sectional study sample. N=4947.

Variables	Statistics
Age; M (SD; range)	67.54 (7.33; 50–95)
Women, n (%)	3602 (73.3)
Education, n (%)	
Secondary education	741 (15.1)
Post-secondary education	555 (11.3)
Vocational qualification	1044 (21.2)
Undergraduate degree	1544 (31.4)
Post-graduate degree	849 (17.3)
Doctorate	183 (3.7)
Marital status, n (%)	
Married, co-habiting, or civil partnership	3370 (68.6)
Widowed	556 (11.3)
Separated or divorced	655 (13.3)
Single	335 (6.8)
Employment status	
Employed (full-time)	418 (8.5)
Employed (part-time)	532 (10.8)
Self-employed	308 (6.3)
Retired	3562 (72.5)
Unemployed	94 (1.9)
Number of non-communicable diseases, M (SD)	2.63 (0.89)
Two, n (%)	2861 (57.8)
Three, n (%)	1371 (27.7)
Four, n (%)	496 (10.0)
Five or more, n (%)	219 (4.5)
Depressive symptoms, M (SD)	3.28 (3.88)
Awareness of age-related gains, M (SD)	18.13 (3.86)
Awareness of age-related losses, M (SD)	11.05 (3.58)
Number of physical activities, M (SD)	7.76 (3.21)
Duration of engagement with physical activity, M (SD)	12.17 (9.40)
Intensity of physical activity, M (SD)	36.87 (31.33)

3.2. Cross-sectional linear regression models

After adjusting for covariates, higher AARC-Gains (β= 0.13; 95 % CI [0.10, 0.16]; $p< .001$) and lower AARC-Losses (β= -0.19, 95 % CI [-0.22, -0.16]; $p< .001$) were associated with engagement with a higher number of physical activities at baseline (Table 3). R^2 for the overall model was 0.10. Moreover, higher AARC-Gains (β= 0.12, 95 % CI [0.09, 0.15]; $p< .001$) and lower AARC-Losses (β= -0.20, 95 % CI [-0.23, -0.16]; $p< .001$) were associated with higher duration of physical activity. R^2 for the overall model was 0.06. Finally, higher AARC-Gains (β= 0.12, 95 % CI [0.09, 0.15]; $p< .001$) and lower AARC-Losses (β= -0.21, 95 % CI [-0.24, -0.18]; $p< .001$) were associated with greater intensity of physical activity. R^2 for the overall model was 0.07. All associations were of small size and stronger for AARC-Losses compared to AARC-Gains. Among the covariates, sex emerged as the most consistent correlate, being significantly associated with all three physical activity outcomes.

3.3. Longitudinal linear regression models

After adjusting for covariates, higher AARC-Gains in 2019 were associated with a lower number of physical activities (β = -0.04, 95 % CI [-0.07, -0.02], $p< .001$) and higher duration of physical activity (β = 0.04, 95 % CI [0.01, 0.06], p=.010) assessed in 2023, whereas no significant association was found with intensity of physical activity (β = -0.01, 95 % CI [-0.03, 0.01], $p= .293$) in 2023 (Table 4). After adjusting for covariates, higher baseline AARC-Losses were associated with a lower number of physical activities (β= -0.05, 95 % CI [-0.07, -0.03]; $p< .001$; R^2 overall model= 0.09; Table 4), lower duration of physical activity (β= -0.05, 95 % CI [-0.08, -0.02]; p< .001; R^2 overall model= 0.35), and less intense physical activity (β= -0.06, 95 % CI [-0.08, -0.04]; p< .001; R^2 overall model= 0.09) in 2023. Among the covariates,

Table 2
Bivariate correlations among study variables at baseline.

	Number of PA	Duration of PA	Intensity of PA	AARC-Gains	AARC-Losses	Age	Sex	Education	Employment	Number of diseases
Duration of PA	0.55; 0.001	_								
Intensity of PA	0.56; 0.001	0.98; 0.001	_							
AARC-Gains	0.15; 0.001	0.11; 0.001	0.10; 0.001	_						
AARC-Losses	-0.23; 0.001	-0.18; 0.001	-0.19; 0.001	0.002; 0.890	_					
Age	-0.002; 0.893	-0.01; 0.384	-0.03; 0.03	-0.05; 0.002	0.17; 0.001	_				
Sex	-0.01; 0.344	-0.04; 0.002	-0.07; 0.001	0.16; 0.001	-0.08; 0.001	-0.17; 0.001	_			
Education	0.08; 0.001	0.01; 0.612	0.02; 0.107	-0.04; 0.006	-0.07; 0.001	-0.03; 0.021	-0.05; 0.001	_		
Employment status	-0.07; 0.001	-0.06; 0.001	-0.05; 0.002	-0.06; 0.001	-0.06; 0.001	-0.37; 0.001	-0.01; 0.709	0.03; 0.023	_	
Number of diseases	-0.12; 0.001	-0.05; 0.001	-0.07; 0.001	-0.01; 0.809	0.22; 0.001	0.15; 0.001	-0.01; 0.370	-0.02; 0.083	-0.08; 0.001	_
Depressive symptoms	-0.18; 0.001	-0.08; 0.001	-0.08; 0.001	-0.14; 0.001	0.45; 0.001	-0.13; 0.001	0.05; 0.001	-0.06; 0.001	0.06; 0.001	0.15; 0.001

Notes. Pearson's correlations coefficients are reported for continuous variables. Spearman's correlation coefficients are reported for categorical variables. PA= Physical activity.

baseline physical activity emerged as the most consistent correlate across all three outcomes, while age also showed significant associations with number and intensity of physical activity at follow-up.

3.4. Mediation models

After adjusting for covariates, depressive symptoms partially mediated the associations of AARC-Losses with number, duration, and intensity of physical activities (see Fig. 1). Specifically, the effect of AARC-Losses on depressive symptoms was positive and significant (β = 0.21, 95 % CI [0.17, 0.25]). Depressive symptoms had a negative and significant effect on the number of physical activities (β = -0.06, 95 % CI [-0.11, -0.01]), duration (β = -0.08, 95 % CI [-0.13, -0.03]), and intensity (β = -0.06, 95 % CI [-0.11, -0.01]) of physical activities. AARC-Losses also had a negative effect on the number of physical activities (β = -0.005, 95 % CI [-0.10, -0.01]), duration (β = -0.05, 95 % CI [-0.09; -0.002]), and intensity (β = -0.06, 95 % CI [-0.11; -0.02]) of physical activities. For all sets of outcomes, the fit statistics indicate that the models fit the data well. Specifically, in the model with the number of physical activities as the outcome, RMSEA was 0.007 (90 % CI [0.00; 0.06]); CFI was 1.000; and TLI was 0.999. In the model with duration of physical activity as the outcome, RMSEA was 0.06 (90 % CI [0.03, 0.11]); CFI was 0.996; and TLI was 0.935. In the model with intensity of physical activity as the outcome, RMSEA was 0.044 (90 % CI [0.010, 0.088]); CFI was 0.998; and TLI was 0.965.

4. Discussion

This study found that higher AARC-Gains and lower AARC-Losses were cross-sectionally associated with greater physical activity engagement across multiple dimensions: number, duration and intensity. In contrast, whereas lower baseline AARC-Losses predicted greater physical activity engagement at follow-up, AARC-Gains did not show this longitudinal association. Finally, depressive symptoms partially mediated the longitudinal association of AARC-Losses with engagement with physical activity. These findings expand limited prior evidence on SPA, that showed that positive SPA can promote active aging among healthy middle-aged and older individuals (Beyer et al., 2019; Stephan et al., 2020), by highlighting their relevance for physical activity levels even among individuals facing multimorbidity.

A recent cross-sectional study found that SPA are associated with vigorous physical activity among individuals with one or more non-communicable diseases (Mezza et al., 2025). Consistent with these findings, the current study results support the idea that, despite multimorbidity, individuals who perceive their own aging as a period of growth and maintenance are more engaged in physical activity, whereas those who view own aging as dominated by losses and decline are less engaged in physical activity. Moreover, the longitudinal design of this study made it possible to observe that more perceived age-related losses were associated with less physical activity at follow-up. This suggests that in individuals with multimorbidity, negative SPA may contribute to shaping behavioral choices in ways that restrict opportunities for movement. According to Stereotype Embodiment Theory (Levy, 2009), the perception of being "in loss" with advancing age may be enacted in time, leading individuals to gradually disengage from activities they might come to feel "too old" for (Meisner et al., 2013). Among people facing multimorbidity, this influence is understandable for vigorous activities, where the perceived sense of decline and loss, combined with fear of pain, falling or worsening existing medical conditions, may discourage exercise participation (Zhaoyang et al., 2020). Yet, the use of the CHAMPS questionnaire indicates that negative SPA may also undermine confidence and motivation for lighter activities that may require energy and mobility (e.g. social engagement, volunteering) (Robertson & Kenny, 2016). Conversely, AARC-Gains at baseline showed inconsistent associations with physical activity at follow-up across the three indicators, suggesting that their motivational predictive value may be less stable over time, particularly in the context of multimorbidity. It may be that AARC-Gains are more closely related to current engagement in physical activity, possibly reflecting positive outcomes of being active. Indeed, although most research describes SPA as antecedents of physical activity, some show that increased physical activity can lead to more positive SPA, suggesting a bidirectional or even inverted causation model (Klusmann et al., 2012).

Another novel contribution of this study is the identification of depressive symptoms as a partial mediator of the longitudinal association between higher AARC-Losses and lower physical activity. In other words, perceived age-related losses seem to affect engagement in physical activity not only directly but also indirectly, by increasing vulnerability to depressive symptoms such as low mood, pessimistic attitudes and lack of motivation. This pathway might better clarify how negative SPA can translate into reduced engagement in health-related behaviors, adding nuance to theoretical models such as Stereotype Embodiment Theory (Levy, 2009). While Stereotype Embodiment Theory proposes that internalized age beliefs directly shape health behaviors, our findings indicate that mood-related factors may intervene in this process, pointing to a more complex pathway than originally proposed and to possible interconnections between the behavioral and psychological pathway (Dutt & Wahl, 2018; Sabatini et al., 2020).

Table 3
Cross-sectional associations of awareness of age-related gains and losses with number, duration, and intensity of physical activity.

Independent variables	Number of physical activities β (95 % CI); *p*	Duration of physical activity β (95 % CI); p	Intensity of physical activity β (95 % CI); *p*
Awareness of age-related gains	0.13 (0.10; 0.16); 0.001	0.12 (0.09; 0.15); 0.001	0.12 (0.09; 0.15); 0.001
Awareness of age-related losses	-0.19 (-0.22; -0.16); 0.001	-0.20 (-0.23; -0.16); 0.001	-0.21 (-0.24; -0.18); 0.001
Age	-0.02 (-0.06; 0.01); 0.179	-0.02 (-0.06; 0.02); 0.324	-0.03 (-0.07; 0.003); 0.069
Sex	-0.05 (-0.08; -0.02); 0.001	-0.08 (-0.11; -0.05); 0.001	-0.11 (-0.14; -0.08); 0.001
Education			
Secondary education	-0.06 (-0.10; -0.03); 0.001	-0.01 (-0.04; 0.03); 0.699	-0.01 (-0.04; 0.02); 0.479
Post-secondary education	-0.03 (-0.06; 0.002); 0.065	0.02 (-0.01; 0.05); 0.288	0.01 (-0.02; 0.04); 0.644
Vocational qualification	-0.02 (-0.05; 0.01); 0.201	-0.02 (-0.05; 0.02); 0.317	-0.02 (-0.05; 0.01); 0.196
Undergraduate degree	Reference category	Reference category	Reference category
Post-graduate degree	0.02 (-0.01; 0.05); 0.188	-0.002 (-0.03; 0.03); 0.901	0.004 (-0.03; 0.04); 0.814
Doctorate	0.02 (-0.01; 0.05); 0.193	0.01 (-0.02; 0.04); 0.550	0.01 (-0.02; 0.04); 0.471
Marital status			
Married, co-habiting, or civil partnership	Reference category	Reference category	Reference category
Widowed	0.01 (-0.03; 0.03); 0.763	-0.01 (-0.04; 0.02); 0.372	-0.01 (-0.04; 0.02); 0.384
Separated or divorced	0.001 (-0.03; 0.03); 0.948	-0.003 (-0.03; 0.03); 0.863	-0.01 (-0.04; 0.02); 0.655
Single	-0.05 (-0.08; -0.02); 0.001	-0.04 (-0.06; -0.01); 0.016	-0.04 (-0.07; -0.01); 0.005
Employment status			
Employed (full-time)	-0.09 (-0.12; -0.06); 0.001	-0.08 (-0.11; -0.04); 0.001	-0.07 (-0.10; -0.03); 0.001
Employed (part-time)	-0.05 (-0.08; -0.02); 0.001	-0.06 (-0.09; -0.02); 0.001	-0.05 (-0.08; -0.01); 0.003
Self-employed	-0.02 (-0.05; 0.01); 0.126	-0.01 (-0.03; 0.02); 0.709	0.001 (-0.03; 0.03); 0.956
Retired	Reference category	Reference category	Reference category
Unemployed	-0.05 (-0.08; -0.02); 0.001	0.002 (-0.03; 0.03); 0.915	0.003 (-0.03; 0.03); 0.837
Number of non-communicable diseases	-0.07 (-0.10; -0.04); 0.001	-0.02 (-0.05; 0.01); 0.186	-0.03 (-0.06; 0.001); 0.059
Depressive symptoms	-0.04 (-0.07; -0.01); 0.013	0.04 (0.01; 0.07); 0.017	0.04 (0.01; 0.08); 0.009

N=4947. β= Standardized regression coefficient.

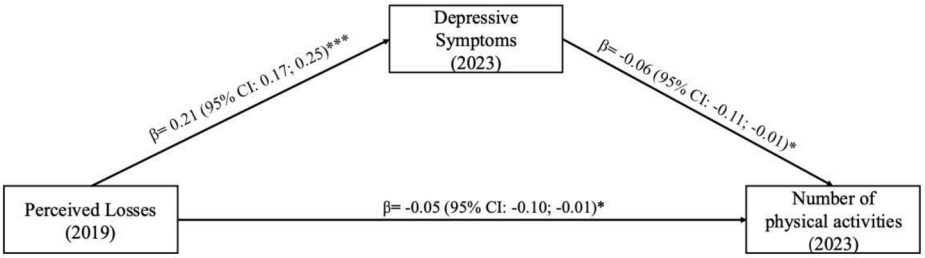
Overall, these findings offer insights for clinical practices and interventions aimed at increasing physical activity among individuals with multimorbidity. In this population, addressing maladaptive illness-related misconceptions that may lead to avoidance of physical activity (e.g., the belief that activity may exacerbate symptoms or worsen pain) (Demmelmaier et al., 2018; Zhaoyang et al., 2020) through psycho-educational and clinical interventions can be particularly challenging. People with multimorbidity often experience their medical condition as unique, intertwined burden, rather than as distinct diseases (Holland et al., 2024). This perspective may complicate the disentanglement of objective physical limitations from inaccurate perceptions, calling for caution in intervention approaches. The presence of depressive symptoms may further worsens the perception of multimorbidity, as they are associated with beliefs of uncontrollability, incurability, and intensified emotional burden (Jaltuszewska et al., 2024).

In this context, although existing evidence is scarce, SPA may represent a modifiable target for interventions aimed at promoting physical activity. For example, a psychoeducational component

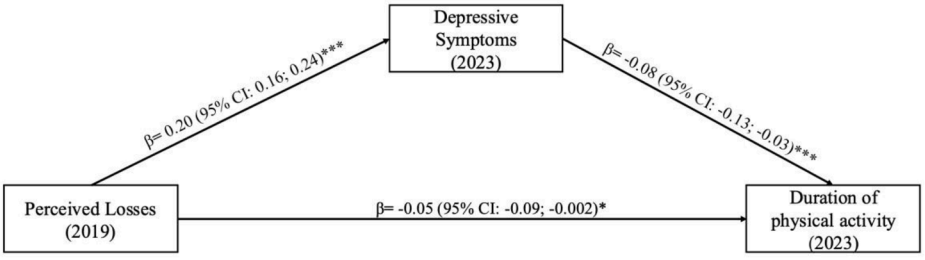
Table 4
Longitudinal associations of awareness of age-related gains and losses in 2019 with number, duration, and intensity of physical activity in 2023.

Independent variables	Number of physical activities β (95 % CI); p-value	Duration of physical activity β (95 % CI); p-value	Intensity of physical activity β (95 % CI); p-value
Awareness of age-related gains	-0.04 (-0.07; -0.02); 0.001	0.04 (0.01; 0.06); 0.010	-0.01 (-0.03; 0.01); 0.293
Awareness of age-related losses	-0.05 (-0.07; -0.03); 0.001	-0.05 (-0.08; -0.02); 0.001	-0.06 (-0.08; -0.04); 0.001
Age	-0.09 (-0.12; -0.06); 0.001	0.003 (-0.03; 0.04); 0.865	-0.07 (-0.09; -0.04); 0.001
Sex	0.01 (-0.01; 0.03); 0.394	-0.03 (-0.06; 0.00003); 0.050	-0.02 (-0.04; 0.001); 0.063
Education			
Secondary education	-0.05 (-0.07; -0.02); 0.001	-0.01 (-0.04; 0.02); 0.678	-0.03 (-0.05; -0.01); 0.011
Post-secondary education	-0.05 (-0.07; -0.02); 0.001	-0.03 (-0.06; -0.002); 0.037	-0.04 (-0.06; -0.01); 0.001
Vocational qualification	-0.04 (-0.06; -0.01); 0.004	-0.01 (-0.04; 0.02); 0.562	-0.02 (-0.04; 0.01); 0.166
Undergraduate degree	Reference category	Reference category	Reference category
Post-graduate degree	0.01 (-0.01; 0.04); 0.267	0.004 (-0.03; 0.03); 0.801	0.02 (-0.003; 0.04); 0.090
Doctorate	0.02 (0.001; 0.04); 0.042	-0.03 (-0.06; 0.001); 0.057	0.01 (-0.01; 0.03); 0.353
Marital status			
Married, co-habiting, or civil partnership	Reference category	Reference category	Reference category
Widowed	-0.02 (-0.04; 0.003); 0.092	-0.02 (-0.04; 0.01); 0.247	-0.02 (-0.04; 0.01); 0.149
Separated or divorced	-0.01 (-0.03; 0.01); 0.234	0.01 (-0.01; 0.04); 0.317	-0.01 (-0.03; 0.01); 0.395
Single	-0.01 (-0.04; 0.01); 0.195	-0.02 (-0.04; 0.01); 0.242	-0.01 (-0.04; 0.01); 0.207
Employment status			
Employed (full-time)	-0.04 (-0.06, -0.01); 0.002	0.01 (-0.02; 0.04); 0.522	-0.03 (-0.06; -0.01); 0.005
Employed (part-time)	-0.03 (-0.05; -0.01); 0.008	0.01 (-0.03; 0.03); 0.761	-0.03 (-0.05; -0.01): 0.008
Self-employed	-0.02 (-0.04; 0.003); 0.086	0.03 (0.002; 0.06); 0.033	-0.004 (-0.03; 0.02); 0.745
Retired	Reference category	Reference category	Reference category
Unemployed	-0.02 (-0.05; -0.002); 0.031	-0.004 (-0.03; 0.02); 0.788	-0.02 (-0.04; 0.0004); 0.054
Number of non-communicable diseases	-0.03 (-0.05; -0.01); 0.016	-0.03 (-0.06; -0.01); 0.016	-0.02 (-0.04; 0.002); 0.079
Physical activity in 2019	0.21 (0.19; 0.23); 0.001	0.58 (0.56; 0.60); 0.001	0.24 (0.21; 0.26); 0.001

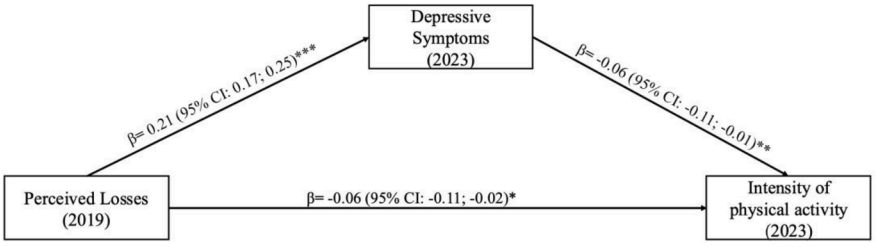
N= 1814. β= Standardized regression coefficient. Models are adjusted for age, sex, education, marital status, employment status, number of non-communicable diseases and the given indicator of physical activity, all assessed in 2019.



Chi² baseline vs saturated model; p-value= 1794.657; .001
Root Mean Squared Error of Approximation RMSEA= 0.007 (0.00; 0.06)
Comparative Fit Index (CFI)= 1.000
Tucker–Lewis index (TLI)= 0.999
Standardized Root Mean Squared Residual (SRMR)= 0.003



Chi² baseline vs saturated model; p-value= 1792.511; .001
Root Mean Squared Error of Approximation RMSEA= 0.06 (0.03; 0.11)
Comparative Fit Index (CFI)= 0.996
Tucker–Lewis index (TLI)= 0.935
Standardized Root Mean Squared Residual (SRMR)= 0.008



Chi² baseline vs saturated model; p-value= 1783.306; .001
Root Mean Squared Error of Approximation RMSEA= 0.044 (0.010; 0.088)
Comparative Fit Index (CFI)= 0.998
Tucker–Lewis index (TLI)= 0.965
Standardized Root Mean Squared Residual (SRMR)= 0.006

Fig. 1. Figure.

addressing age-stereotypes and SPA could be coupled with a behavioral component tailored to individuals' health conditions and functional abilities (e.g., Beyer et al., 2019). Supporting individuals in differentiating domains of functioning that are compromised by age-related decline from those that remain preserved or only partially affected (e.g., social relationships) may help foster a more balanced and nuanced view of one's condition and more positive self-perceptions. These may, in turn, promote better adaptation to the challenges of multimorbidity and enhance physical engagement. Psychoeducational interventions aimed to reframe negative SPA may work well if combined with individualized psychological support, especially when depressive symptoms are present. Approaches rooted in self-compassion may be particularly relevant, as they encourage acceptance of age and illness-related changes while reducing rumination on perceived losses (Zhang et al., 2023).

In sum, multidimensional approaches may be needed to foster physical activities among individuals with multimorbidity who may experience negative SPA and some depressive symptoms. Only a careful assessment of psychological factors, together with the evaluation of individuals' clinical conditions and functional abilities, may help healthcare professionals to provide more realistic and personalized recommendations on the type, intensity, and duration of physical activity. Such a comprehensive approach, which can be implemented in physical or virtual clinical contexts as an individual or group-based

program, is consistent with the person-centered perspective emphasized in the World Health Organization's self-care framework (World Health Organization, 2022). By grounding physical activity programs in realistic and meaningful prescriptions aligned with individuals' values, needs, and capabilities, this approach may enhance both adherence and long-term maintenance among people living with multimorbidity.

4.1. Strengths and limitations

This study has several strengths. First, the large sample size enhances the robustness of the findings. Second, the longitudinal design made it possible to investigate the effects of AARC-Gains and AARC-Losses on physical activity over four years. Third, the use of the CHAMPS questionnaire made it possible to comprehensively assess physical activity including light and more intense activities (Mezza et al., 2025). Fourth, the focus on a sample of individuals with multimorbidity is a strength of this study as so far research has mostly investigated the effects of SPA on the behaviors and health of the general population, overlooking their potential value for those living with non-communicable diseases.

Nonetheless, this study has limitations. First, it is based on secondary data analyses of the UK PROTECT dataset, which comprises almost all individuals of White ethnicity and with above-average education Moreover, the study sample showed a predominance of women. This limits generalizability of results to the general UK population and future research would benefit from examining these associations in more heterogeneous samples. Second, the UK PROTECT study collects data online, excluding from its sample individuals without internet access and/or with limited digital literacy. Third, no objective assessment of physical activity (e.g., accelerometers) was undertaken. Fourth, information on income or broader socioeconomic status was not available in the dataset, limiting the ability to account for the potential role of socioeconomic disadvantage across the associations examined. Fifth, longitudinal data was only available for a subsample. Compared to those who provided longitudinal data, those who did not were on average one year older, less-educated, had more health conditions, reported more depressive symptoms and more AARC-Losses, and conducted slightly fewer physical activities. It may be that longitudinal effects would have been stronger if this subsample experiencing more depressive symptoms and AARC-Losses would have provided data at follow-up. Sixth, information on general views on aging was not collected, although these may also be related to depressive symptoms and physical activity (Meisner et al., 2013). Last, measures of disease severity were not employed in the present analyses, although they could have strengthened the interpretation of the associations.

5. Conclusions

This study contributes to the growing body of evidence positioning SPA as critical psychological factors directly and indirectly associated with physical activity in the context of multimorbidity. The findings suggest that, among individuals aged 50+ years with multimorbidity, those reporting more perceived age-related losses are less engaged in physical activity over time and this may be partially due to them experiencing more depressive symptoms. These findings provide important insights into the psychological pathways influencing physical activity in this population. Interventions aimed at increasing physical activity levels among individuals with multimorbidity could benefit from the inclusion of psychological strategies/components that target both SPA and depressive symptoms.

Changes in affiliation

There were no changes in author affiliations after completion of the study.

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Institutional review board statement / ethical approval

UK PROTECT obtained ethical approval from the London Bridge NHS Research Ethics Committee and Health Research Authority (Ref:13/LO/1578). Ethical approval was not required for this specific study in accordance with local or national guidelines.

Informed consent

Written informed consent to participate in follow-up assessments was not directly obtained but inferred by the enrolment to the study at UK PROTECT platform.

Data availability statement

The data that support the findings of this study are not publicly available due to UK PROTECT data being available only after having received approval from the UK PROTECT steering committee and having paid a data access fee. To request access to UK PROTECT data please email protect.data @exeter.ac.uk.

CRediT authorship contribution statement

Fabrizio Mezza: Writing – review & editing, Writing – original draft, Methodology, Conceptualization. **Eugene Tang:** Writing – review & editing, Project administration, Funding acquisition. **Daniela Lemmo:** Writing – review & editing, Conceptualization. **Maria Francesca Freda:** Writing – review & editing, Conceptualization. **Maria Mataró:** Writing – review & editing. **Blossom C.M. Stephan:** Writing – review & editing. **Anne Corbett:** Writing – review & editing. **Clive Ballard:** Writing – review & editing. **Byron Creese:** Writing – review & editing. **Dag Aarsland:** Writing – review & editing. **Adam Hampshire:** Writing – review & editing. **Abbie Palmer:** Writing – review & editing. **Serena Sabatini:** Writing – review & editing, Writing – original draft, Project administration, Methodology, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.archger.2026.106273.

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