European Journal of Ageing (2020) 17:469–476
https://doi.org/10.1007/s10433-019-00537-7

ORIGINAL INVESTIGATION

Physical activity and subjective age across adulthood in four samples

Yannick Stephan[1] · Angelina R. Sutin[2] · Antonio Terracciano[2]

Published online: 15 October 2019

Abstract
The present study examined the prospective association between physical activity and subjective age across adulthood and factors that mediate this association. Participants were adults aged from 20 to 90 years ($N > 10{,}000$) drawn from the Wisconsin Longitudinal Study graduates and siblings samples, the Health and Retirement Study and the Midlife in the United States Survey. In the four samples, physical activity was assessed at baseline and subjective age was measured 8 to 20 years later. Personality, self-rated health, disease burden, depressive symptoms, and cognition were assessed as potential mediators. In the four samples, higher physical activity at baseline was associated with a younger subjective age at follow-up. Logistic regression revealed that physical activity was related to a 30–50% higher likelihood of feeling younger 8 to 20 years later. Significant indirect effects were found through openness to experience and self-rated health in the four samples. This study provides new evidence on the link between a health-related behavior and subjective age. Physically active individuals may sustain health and an open psychological disposition that is associated with feeling younger.

Keywords Subjective age · Physical activity · Personality · Health

Introduction

Subjective age, or how old or young individuals feel relative to their chronological age, has attracted much interest in the last decade. A younger subjective age is associated with a range of positive outcomes across adulthood, including better mental and physical health (Choi and DiNitto 2014; Demakakos et al. 2007), biological functioning (Stephan et al. 2019), and higher cognition (Stephan et al. 2016). Furthermore, feeling younger is consistently related to longevity in European samples such as the English Longitudinal Study of Ageing (Rippon and Steptoe 2015), US samples, such as the Midlife in the United States (MIDUS), the Health and Retirement Study (HRS), and the National Health and Aging Trends Study (NHATS) (Stephan et al. 2018). Given these outcomes, there is a need for a better understanding for the factors that shape subjective age. According to existing conceptualizations, subjective age is a biopsychosocial marker of aging (Kotter-Grühn et al. 2015; Stephan et al. 2015). In this approach, the age individuals feel is thought to reflect health, well-being, and overall functioning (Kotter-Grühn et al. 2015; Stephan et al. 2015). Although subjective age has been related to a range of factors, from biological to environmental, surprisingly little is known about the extent to which health-related behaviors may shape the perception of age. The present study examines the association between physical activity and subjective age across adulthood.

A physically active lifestyle is likely to contribute to subjective age because it has a range of health, cognitive and psychological benefits across adulthood that have been found to relate to subjective aging. Specifically, physical activity reduces the risk of disease (Lear et al. 2017) and promotes self-rated health (Trachte et al. 2016), better cognition (Colcombe and Kramer 2003), and higher extraversion, openness, agreeableness, and conscientiousness (Allen et al. 2015; Stephan et al. 2014a, b). In turn, studies conducted in large longitudinal surveys, including the MIDUS, the HRS, and the Wisconsin Longitudinal Study (WLS), found that individuals without chronic conditions, with fewer depressive symptoms, more favorable evaluations of their

Responsible editor: Matthias Kliegel.

Guest editors: Anna E. Kornadt and Verena Klusmann.

✉ Yannick Stephan
yannick.stephan@umontpellier.fr

[1] Euromov, University of Montpellier, UFRSTAPS, 700, Avenue du Pic St Loup, 34090 Montpellier, France

[2] Florida State University College of Medicine, Tallahassee, USA

health, better cognitive functioning, and who have higher extraversion and openness are more likely to feel younger (Bergland et al. 2014; Hubley and Hultsch 1994; Hubley and Russell 2009; Hughes and Lachman 2018; Stephan et al. 2012, 2015). This indirect evidence suggests a hypothetical model in which a physically active lifestyle fosters a favorable health, cognitive, and psychological profile that in turn leads to a younger subjective age. However, past research has mostly focused on the extent to which subjective age predicts physical activity. For example, in the HRS, feeling younger than one's age has been related to a physically active lifestyle over time (Stephan et al. 2016). This association has been supported by other research (Caudroit et al. 2012; Stephan et al. 2016; Wienert et al. 2017). Only one cross-sectional study conducted in the MIDUS has examined whether physical activity predicts subjective age and revealed that frequent leisure time physical activity is related to a younger subjective age (Chen et al. 2018). However, the relation between a physically active life and subjective age remains relatively unaddressed and little is known about the factors that may mediate this association.

The present study tested the prospective association between physical activity and subjective age using four large longitudinal samples. The use of several samples in a coordinated analysis allows to test for the replicability and reproducibility of results (Hofer and Piccinin 2009). In such coordinated analysis, the comparability of studies is improved by testing similar models with similar covariates. Therefore, four samples were identified that were comparable in overall design, with physical activity assessed at baseline and subjective age assessed years later. Based upon the coordinated analysis approach, the association between physical activity and subjective age was estimated separately within each sample and then summarized using meta-analytic techniques. The purpose of this study was to examine the link between physical activity and subjective age that is the extent to which this behavior is related to feeling younger or older than one's age. Building upon the previous cross-sectional report (Chen et al. 2018), the current study utilized a prospective design to examine whether the associations are evident even when physical activity and subjective age are assessed years apart. We further tested multiple potential mediators of such association to advance knowledge on potential pathways. The present study could be considered as a prerequisite for further research on the effect of physical activity intervention on subjective age. Of note, however, this study did not examine the association between physical activity and change in subjective age because subjective age was not assessed at baseline in two of the four samples.

Building upon evidence for the range of implications of a physically active lifestyle, it was hypothesized that greater physical activity will be prospectively related to a younger subjective age. Furthermore, the study tested the hypothesis that lower disease burden, lower depressive symptoms, and higher self-rated health, extraversion, openness to experience, and cognition mediate the association between physical activity and subjective age (see Fig. 1). The study further

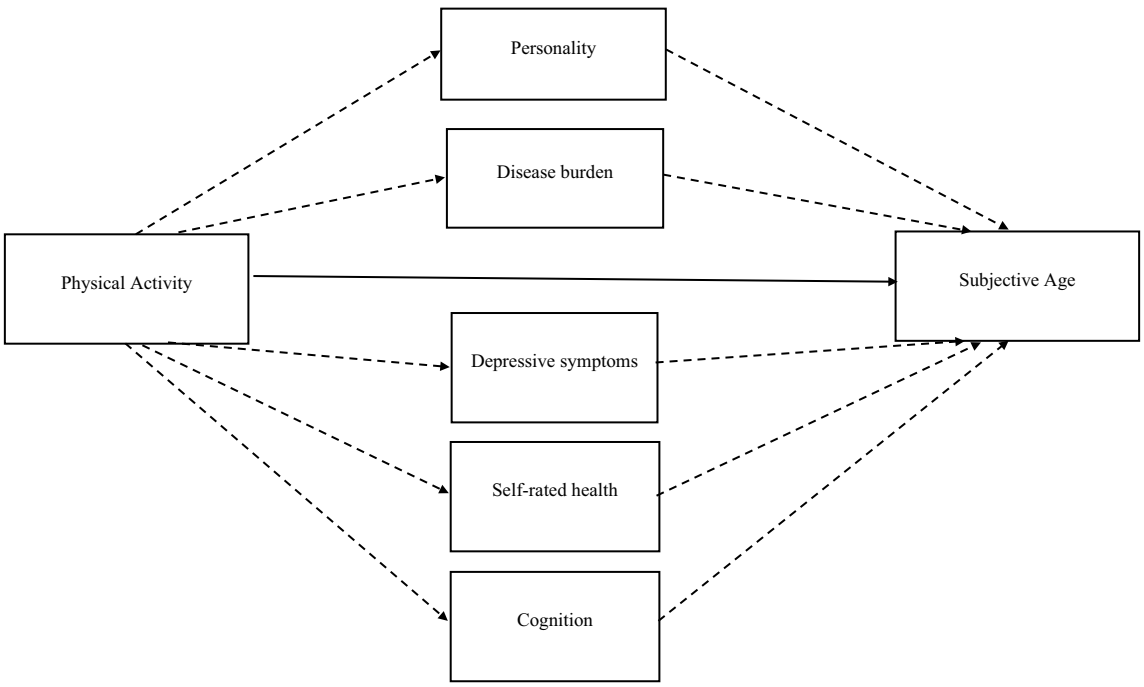

Fig. 1 Hypothesized mediational model of the relationship between physical activity and subjective age

tested whether the associations were moderated by age to identify potential age-differential effects.

Methods

Participants

Data from the Wisconsin Longitudinal Study Graduate (WLSG) and Siblings (WLSS) samples, the Health and Retirement Study (HRS), and the Midlife in the United States Survey (MIDUS) were used in the present study. In the four samples, physical activity was available at baseline and subjective age at follow-up, and the mediating variables were available from an intermediate wave. Characteristics of the four samples are presented in Table 1.

The Wisconsin Longitudinal Study is a long-term study of a random sample of 10,317 men and women born between 1937 and 1940 who graduated from Wisconsin high schools in 1957. In addition to this main sample, the WLS also collected data on a selected sibling of some of the graduates. The WLS sample is broadly representative of older, white, non-Hispanic Americans who completed at least a high school education. Physical activity was assessed in 1992–1993 for the WLSG and in 1993–1994 for the WLSS, and subjective age was assessed in 2011 for both samples. The mediating variables were assessed in 2004 for the WLSG and in 2005 for the WLSS. Complete demographic and physical activity data at baseline were obtained from 6797 participants in the WLSG and from 3462 participants in the WLSS. Of these participants and with outliers removed on subjective age, 3916 individuals aged from 50 to 56 years and 1739 participants aged from 30 to 75 years provided subjective age data at follow-up in 2011 in the WLSG and the WLSS, respectively. Within these samples, 3341 and 1430 individuals, respectively, in the WLSG and the WLSS also provided complete data on mediators. Attrition analysis revealed that individuals with subjective age data in 2011 had higher baseline physical activity level in the WLSG ($d = .14$) and the WLSS ($d = .12$). They were also younger ($d_{WLSG} = .16$ and $d_{WLSS} = .27$), more educated ($d_{WLSG} = .22$ and $d_{WLSS} = .30$), and more likely to be female in the WLSG than those without follow-up data.

The HRS is a nationally representative longitudinal study of Americans aged 50 years and older. The present study uses the 2008, 2012 and 2016 waves. In 2008, a total of 16,443 participants provided complete data on physical activity and demographics. Among these participants, 3185 individuals provided complete subjective age measures in 2016. With outliers on subjective age removed at follow-up, the final analyzed sample was composed of 3182 participants aged from 50 to 90 years at baseline with an 8-year follow-up. Within this sample, complete data on the mediators were obtained from 2361 participants in 2012. Attrition analysis revealed that individuals with complete data at follow-up were younger ($d = .46$), more educated ($d = .23$), more physically active ($d = .33$), more likely to be white and female than those with incomplete data at follow-up.

Table 1 Descriptive statistics for the four samples

Variables	WLSG		WLSS		HRS		MIDUS	
	M/%	SD	*M*/%	SD	*M*/%	SD	*M*/%	SD
Age (years)	53.17	0.61	52.65	6.71	66.27	8.03	46.57	11.23
Sex (% women)	55%	–	55%	–	61%	–	55%	–
Race (% white)	100%	–	100%	–	83%	–	95%	–
Education	13.90	2.39	14.12	2.56	13.01	3.00	7.36	2.45
Subjective age	0.17	0.13	0.17	0.13	0.15	0.15	0.17	0.14
Physical activity	2.62	0.84	2.71	0.81	2.57	1.07	4.84	1.11
Cognition[a]	6.93	2.28	6.91	2.23	15.48	4.00	0.31	1.55
Neuroticism[a]	2.97	0.91	3.04	0.86	1.96	0.59	2.04	0.62
Extraversion[a]	3.83	0.89	3.74	0.85	3.19	0.55	3.11	0.57
Openness[a]	3.61	0.76	3.60	0.73	2.92	0.55	2.92	0.52
Agreeableness[a]	4.81	0.70	4.75	0.67	3.54	0.47	3.44	0.50
Conscientiousness[a]	4.82	0.68	4.76	0.67	3.40	0.46	3.43	0.44
Disease burden[a]	1.86	1.77	1.88	1.67	2.15	1.28	2.23	2.27
Self-rated health[a]	4.10	0.63	4.07	0.62	3.29	0.99	7.58	1.43
Depressive symptoms[a]	8.06	7.36	8.88	7.76	1.16	1.79	0.56	1.66

WLSG: $N = 3916$; WLSS: $N = 1739$; HRS: $N = 3182$; MIDUS = 2528; See "Methods" section for differences in the assessment and coding of the variables in each sample

[a]Variables measured in 2003–2005 for the WLSG ($N = 3341$), 2004–2007 ($N = 1430$) for the WLSS, 2012 ($N = 2361$) for the HRS, 2004–2006 ($N = 2244$) for the MIDUS

The present study also used data from the three waves of the MIDUS. In 1995–1996 (MIDUS I), 6108 participants provided complete data on baseline physical activity and demographic factors. Of this sample, subjective age data were obtained from 2559 individuals at follow-up in 2013–2014 (MIDUS III). A total of 2528 participants (age range 20–74 years) with a follow-up of almost 20 years were included in the analysis after having removed outliers on subjective age. Of these participants, complete data on mediators were obtained from 2244 individuals in 2004–2006. Individuals with complete data at follow-up were more educated ($d = .35$), more physically active ($d = .22$), more likely to be white and female than those with incomplete data at follow-up.

Measures

Physical activity

In both the WLSG and the WLSS, physical activity was assessed using two items that asked how often they participated in light physical activity and how often they participate in vigorous physical exercise or sports. A scale ranging from 1 (less than once per month) to 4 (three or more times per week) was used. Answers to the two items were averaged, with higher scores indicating higher frequency of physical activity. In the HRS, participants answered two items that asked how often they take part in vigorous and moderate sports or activities using a scale ranging from 1 (more than once a week) to 4 (hardly ever or never). The mean of answers to the two items was computed. Participants in the MIDUS sample reported how often they engaged in vigorous and moderate leisure physical activity during their leisure or free time both in the summer and the winter using a scale ranging from 1 (never) to 6 (several times a week). Summer and winter ratings were averaged. In both the HRS and the MIDUS, participants with at least one answer to one physical activity question were included.

Subjective age

In the four samples, participants were asked to report the age they felt most of the time. Felt age was obtained in years and was subtracted from chronological age and then divided by chronological age, resulting in a proportional discrepancy score (e.g., Stephan et al. 2016). Positive values indicated a younger subjective age, and negative values indicated an older subjective age. Values three standard deviations above or below the mean were considered outliers, leading to the exclusion of 59 participants in the WLSG, 30 in the WLSS, three in the HRS, and 31 in the MIDUS.

Personality

In the WLS samples, participants completed a 29-item version of the Big Five Inventory (John et al. 1991) which assessed neuroticism, extraversion, openness to experience, agreeableness, and conscientiousness. Each item was rated on a scale that ranged from 1 (*disagree strongly*) to 6 (*agree strongly*). Answers were averaged for each trait. In both the HRS and the MIDUS, the Midlife Development Inventory (MIDI; Zimprich et al. 2012) was used to assess personality traits. Participants were asked how much 26 adjectives that assessed neuroticism, conscientiousness, extraversion, openness, and agreeableness described them on a scale ranging from 1 (*not at all*) to 4 (*a lot*). Cronbach's alphas ranged from .64 to .80.

Disease burden

In the four samples, the sum of diagnosed conditions was used as a measure of disease burden. Participants were asked to report whether a medical professional ever told them that they had diabetes, heart conditions, hypertension, and other illnesses. Disease burden was obtained by summing the number of diagnosed conditions in each sample.

Self-rated health

In the four samples, participants were asked a single item about their health. Response options ranged from 1 (very poor) to 5 (excellent) in both WLS samples, from 1 (poor) to 5 (excellent) in the HRS, and from 0 (worse) to 10 (best) in the MIDUS.

Depressive symptoms

The 20-item version Center for Epidemiologic Studies Depression Scale (CES-D; Radloff 1977) was used to measure depressive symptoms in both WLS samples. Participants were asked to indicate on how many days during the past week did they experience symptoms of depression. Answers were summed across items using a scale from 0 to 3, with higher scores representing higher depressive symptoms. A shorter eight-item version of the CES-D was used in the HRS (Wallace et al. 2000). Participants indicated whether they experienced eight symptoms during the past week using a yes/no format. The Composite International Diagnostic Interview Short Form (CIDI-SF; Kessler et al. 1998) was used in the MIDUS. Participants reported their experience of depressed mood and anhedonia that lasted for 2 weeks of the last 12 months using a yes/no format. In both the HRS and the MIDUS, a composite score was computed on the basis of answers to the CES-D and the CIDI-SF, with higher values representing higher depressive symptoms.

Cognition

In both WLS samples, respondents were asked six similarities items drawn from the Wechsler Adult Intelligence Scale (WAIS). An example item is: "In what way are an orange and a banana alike?" Each item was scored between 0 and 2, where 2 is the highest score. Items were summed, with higher values reflecting better cognition. Cognitive functioning was assessed using the modified Telephone Interview for Cognitive Status (TICSm) in the HRS (Crimmins et al. 2011). A composite score ranging from 0 to 27 was computed from a test of immediate and delayed recall to assess short-term memory, a serial 7 subtraction test to assess working memory, and a backward counting test to assess mental processing speed. The Brief Test of Adult Cognition by Telephone (BTACT; Lachman et al. 2014) was used in the MIDUS. Episodic memory and executive functioning scores were computed from seven cognitive dimensions by averaging these dimensions and standardizing to *z* scores. A global cognition score was computed by adding episodic memory and executive functioning.

Covariates

Chronological age was included as a covariate to account for potential age-related confounding of the predictor variables. Sex and education were also included as covariates. The equivalent years of regular education based on highest degree obtained was used as a measure of educational level. In the MIDUS, education was assessed on a scale from 1 (*no grade school*) to 12 (*doctoral level degree)*. Race was controlled in the HRS and the MIDUS.

Data analysis

In the four samples, linear regression analyses were conducted to predict follow-up subjective age from baseline physical activity, controlling for age, sex and education, and race where available. Using logistic regression, we tested whether physical activity predicted the likelihood of feeling younger (coded as 1) versus feeling older than one's chronological age (coded as 0). The dichotomy of feeling younger versus older than the chronological age provides an alternative and more intuitive reporting of the association. Additional analyses were conducted to test whether age moderated the association between physical activity and subjective age. Finally, personality, disease burden, self-rated health, cognition, and depressive symptoms were tested as mediators using the PROCESS macro with 5000 bootstrapped samples (Hayes 2013). These mediators were included simultaneously in the analysis.

Results

As hypothesized, the linear regression revealed that higher physical activity at baseline was related to younger subjective age at follow-up (Table 2). This association was found in the WLSG, the WLSS, and the HRS, but not in the MIDUS. The size of the association between physical activity and subjective age was comparable or stronger than the size of the demographic factors, such as age, sex, and education. Logistic regression further indicated that one SD higher physical activity was related to 30% to 50% higher likelihood of feeling younger than one's age at follow-up in the four samples (Table 2). The meta-analysis supported this association (Table 2). Age did not moderate the relation between physical activity and subjective age in the WLSG ($\beta = .03$, $p = .08$), the WLSS ($\beta = -.04$, $p = .12$), the MIDUS ($\beta = .01$, $p = .50$), and the HRS ($\beta = -.03$, $p = .09$).

Bootstrap analysis indicated that self-rated health and the personality trait openness mediated the association between baseline physical activity and follow-up subjective age in the WLSG, the WLSS, and the HRS (Table 3): More frequent physical activity was associated with higher openness and better subjective health, which in turn related to a younger subjective age. These two variables also mediated the association between physical activity and subjective age in the MIDUS, even though the direct effect was not significant. There were also sample-specific mediators. In the WLSS, the association between physical activity and follow-up subjective age was mediated by depressive symptoms (Table 3), such that higher physical activity was associated with a younger subjective age in part because of its association with lower depressive symptoms. In the HRS, more frequent physical activity was related to feeling younger through higher extraversion and lower neuroticism. Finally, there was an indirect effect of physical activity on subjective age through cognition and disease burden in the MIDUS, such that greater physical activity was related to better cognition and lower disease burden, which in turn was associated with a younger subjective age.

Discussion

Based upon four large longitudinal samples of middle-aged and older adults, the present study found that frequent physical activity was prospectively related to a younger subjective age. This association was observed across different samples and time spans that ranged from 8 to 20 years. This study adds to existing knowledge by providing replicable prospective evidence that physical activity is associated with age felt.

Table 2 Summary of linear and logistic regression analysis predicting subjective age from physical activity in the four samples

Variables	WLSG		WLSS		HRS		MIDUS		Meta-analysis	
	β^a	Odds ratio (95% CI)[b]	β^a	Odds ratio (95% CI)[c]	β^a	Odds ratio (95% CI)[d]	β^a	Odds ratio (95% CI)[e]	β^a	Odds ratio (95% CI)
Age	−0.01	0.87 (0.68–1.11)	−0.04	1.05 (1.01–1.08)**	−0.02	1.03 (1.02–1.05)*	0.00	1.04 (1.02–1.05)***		
Sex	−0.08***	0.68 (0.49–0.93)*	−0.05*	0.77 (0.49–1.20)	−0.03	0.89 (0.68–1.18)	−0.04	0.78 (0.57–1.08)		
Race	–	–	–	–	−0.05**	0.73 (0.50–1.06)	−0.02	1.21 (0.64–2.29)		
Education	0.08***	1.09 (1.01–1.18)*	0.06*	1.14 (1.03–1.26)*	0.03	1.06 (1.01–1.10)*	0.05*	1.16 (1.08–1.24)***		
Physical activity	0.08***	1.42 (1.21–1.67)***	0.08***	1.42 (1.08–1.88)*	0.11***	1.56 (1.36–1.80)***	0.03	1.27 (1.09–1.48)**		
Random effect									0.08 (0.04–0.11)***	1.42 (1.29–1.56)***
Heterogeneity (I^2)									67.34	20.56

*$p < .05$; **$p < .01$; ***$p < .001$

[a]Standardized regression coefficients

[b]Logistic regression predicting the likelihood of feeling younger versus older than one's chronological age in the WLSG. Younger subjective age: $N = 3463$; older subjective age: $N = 164$

[c]Logistic regression predicting the likelihood of feeling younger versus older than one's chronological age in the WLSS. Younger subjective age: $N = 1523$; older subjective age: $N = 84$

[d]Logistic regression predicting the likelihood of feeling younger versus older than one's chronological age in the HRS. Younger subjective age: $N = 2454$; older subjective age: $N = 252$

[e]Logistic regression predicting the likelihood of feeling younger versus older than one's chronological age in the MIDUS. Younger subjective age: $N = 2128$; older subjective age: $N = 178$

The present study further identified factors that may explain the association between frequent physical activity and a younger subjective age. In particular, the results suggest that physically active individuals are more likely to feel younger years later because they are more exploratory and curious (i.e., higher openness) and because they perceive their health more favorably. This pattern was robust as it was observed in four samples, using different measures, and over different follow-up periods. These findings confirm that higher openness and positive health ratings are among the most consistent predictors of a younger subjective age (Canada et al. 2013; Hubley and Russell 2009; Stephan et al. 2012). Open individuals are more likely to have multiple interests and engage in a variety of activities as they age (Stephan et al. 2014a, b). Higher physical activity may help open-minded individuals maintain such tendencies, which in turn may sustain a younger subjective age. Open individuals are more likely to distance themselves from their age-group and the typical older individual, and as a result, feel younger than their age (Canada et al. 2013). In addition, better self-rated health indicates not only the absence of chronic conditions, but also a higher level of energy, vitality, functionality, and positive bodily feelings and sensations, which may translate into a feeling of being younger than one's age (Hubley and Russell 2009; Stephan et al. 2015). This pattern suggests that a physically active lifestyle is likely to promote personality- and health-related resources that are beneficial for a younger subjective age.

Additional factors may also explain the association between physical activity and subjective age. For example, regular physical activity may contribute to more positive views about aging that also translate into a younger subjective age (Hess et al. 2017; Kornadt et al. 2018). In addition, biological and functional pathways may explain a part of this association. Physically activity, for example, is associated with better muscular and pulmonary functions (Dodds et al. 2013; O'Donovan and Hamer 2018) and lower risk of obesity (Bell et al. 2014), which are related to feeling younger than one's age (Stephan et al. 2015).

The present study extends existing conceptualization of subjective age (Stephan et al. 2015). The age individuals feel is considered a biopsychosocial marker of aging that is sensitive to a range of factors, from biological functioning to environmental influences (Kotter-Grühn et al. 2015; Stephan et al. 2015). This study further reveals that subjective age is a marker of the adoption and benefits of health-related behaviors such as physical activity. The present research thus provides an additional explanation for the consistent association between subjective age and a range of outcomes, including dementia (Stephan et al. 2017) and mortality (Stephan et al. 2018). A younger subjective age may be related to a lower risk of incident dementia and mortality because it reflects the adoption of a physically active lifestyle beneficial for cognition and survival. There are practical implications of

Table 3 Summary of bootstrap analysis in the four samples

Variables	WLSG	WLSS	HRS	MIDUS
Cognition	.0001 (−.0001; .0004)	−.0002 (−.0007; .0002)	.000 (−.0003; .0004)	.0005 (.0001; .0011)
Neuroticism	.0002 (−.0004; .0008)	.0001 (−.0009; .0010)	.0008 (.0001; .0016)	.000 (−.0002; .0003)
Extraversion	.0005 (−.0001; .0012)	.0006 (−.0001; .0015)	.0021 (.0006; .0037)	.0006 (−.0003; .0016)
Openness	.003 (.0019; .0040)	.002 (.0007; .0033)	.0027 (.0015; .0041)	.0021 (.0011; .0032)
Agreeableness	.0002 (−.0002; .0006)	.0001 (−.0005; .0007)	−.0003 (−.0009; .0002)	−.0001 (−.0005; .0002)
Conscientiousness	.0006 (.0000; .0012)	.0000 (−.0009; .0009)	−.0001 (−.001; .001)	−.0001 (−.0008; .0006)
Disease Burden	.0001 (−.0001; .0004)	−.0004 (−.0015; .0006)	.0009 (−.0003; .0021)	.0008 (.0001; .0016)
Self-rated Health	.004 (.0032; .0059)	.005 (.0026; .0072)	.0045 (.0027; .0064)	.0027 (.0015; .0040)
Depressive symptoms	.0002 (−.0004; .0008)	.002 (.0004; .0038)	.0007 (−.0003; .0018)	−.0001 (−.0006; .0003)

Bootstrap estimates and 95% bias-corrected confidence interval for indirect effects of physical activity on subjective age through cognition, neuroticism, extraversion, openness, agreeableness, conscientiousness, disease burden, self-rated health, and depressive symptoms controlling for age, sex, education, and race when available

the present study. The findings suggest that physical activity programs may prove useful to promote a younger subjective age. In turn, feeling younger may ultimately lead to a range of health and cognitive benefits. The present study also suggests that assessment of felt age could help to identify individuals with a sedentary lifestyle who feel older. These individuals may benefit from interventions directed toward increasing physical activity participation and other behavioral changes.

The present study has several strengths including the examination of the associations between physical activity and subjective age in four large samples with different follow-up periods and the identification of mediating variables of this association. However, there are also several limitations. The interpretation of causal associations is limited by the observational design of this study. Furthermore, the present study only focused on the association between baseline physical activity and subsequent subjective age. Randomized controlled studies and experimental research are needed to test whether physical activity programs result in change in subjective age. In addition, such research may examine whether feeling younger over time leads to health-related and cognitive benefits. Indeed, existing studies on the outcomes of subjective age are observational and focus on static level of this construct. Therefore, the test of the effect of physical activity on changes in subjective age and whether these changes manifest into changes in health or cognition, could provide a test of the causal roles of both physical activity and changes in subjective age. Subjective age has also been found to predict changes in physical activity (Stephan et al. 2016; Wienert et al. 2017), which suggests a bidirectional relation between physical activity and subjective age. In addition, physical activity was measured using self-reported measures. Future research may include an objective assessment of physical activity. Furthermore, the samples in the present study have a positive selection bias that limits the generalizability of the findings. All samples are from the USA. Future research should examine whether similar patterns are found in other cultures, especially non-Western countries. Finally, involvement in physical activity may be broadly indicative of a healthy lifestyle, including lower health-risk behaviors such as smoking and alcohol consumption. Therefore, future research may examine the simultaneous contribution of physical activity, smoking, alcohol, and diet on subjective age.

In sum, the present study provides new evidence for the association between physical activity and subjective age across adulthood: A physically active lifestyle contributes to feeling younger, in part because of the personality and health benefits of such a life style.

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