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Personality and change in physical activity across 3–10 years

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ABSTRACT

Objective: To examine the association between personality traits, defined by the Five-Factor Model, and the initiation and termination of physical activity across adulthood.

Design: Longitudinal analysis of participants from nine samples (N > 28,000).

Main Outcome Measures: Physical activity status at follow-up.

Results: A random-effect meta-analysis revealed that higher conscientiousness, extraversion, and openness were related to a higher likelihood of initiation of physical activity over time among individuals who were physically inactive at baseline and to a lower risk of termination of physical activity among those who were physically active at baseline. In contrast, higher neuroticism was associated with a lower probability of initiation of physical activity and a higher likelihood of termination over time. Although not hypothesised, agreeableness was also associated with better physical activity outcomes over time.

Conclusion: This study provides the largest and the longest evidence of a replicable association between personality and change in physical activity status. Personality may motivate both the initiation and termination of physical activity.

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KEYWORDS

physical activity change; personality; five-factor model; meta-analysis; longitudinal study

1. Introduction

The adoption and long-term maintenance of a physically active lifestyle is a critical public health issue. Indeed, regular participation in physical activity (PA) promotes, better mental health (Pereira et al., 2014) and cognitive functioning (Kramer et al., 2006; Scarmeas et al., 2009), reduces the risk of developing non-communicable chronic diseases (Lee et al., 2012) and it is associated with lower risk of all-cause mortality (Ekelund et al., 2016; Samitz et al., 2011).

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More than a quarter of adults aged 18 years and older, however, are not sufficiently active (Guthold et al., 2018). It is never too late to become physically active, and physical activity in mid and late life can generate health gains (Dohrn et al., 2018; Mok et al., 2019; Saint-Maurice et al., 2019). For example, a prospective study showed that middle-aged and older adults, including those with cardiovascular disease and cancer, can derive substantial longevity benefits from becoming active, regardless of their prior PA level (Mok et al., 2019). Conversely, the non-persistence in PA over time has consequences for health. Substantial decreases in PA, for example, is associated with higher coronary heart disease mortality (Schnohr et al., 2017).

Given the importance of regular PA practice throughout life, it is necessary understand factors that motivate initiation or cessation of PA over time. Such research can help identify potential targets of intervention to promote the adoption and long-term maintenance of an active lifestyle. The present study focuses specifically on how characteristic ways of thinking, feeling and behaving (i.e. personality traits) is related to change in PA status over time.

Personality traits defined by the Five-Factor Model (FFM) (McCrae & John, 1992) are associated with PA across adulthood. Meta-analyses of cross-sectional studies find that high neuroticism, which refers to the tendency to experience distress and to be emotionally unstable, is related to less PA (Artese et al., 2017; Rhodes & Smith, 2006; Sutin et al., 2016; Wilson & Dishman, 2015). Conversely, high conscientiousness, the propensity to be self-disciplined and achievement oriented, and high extraversion, defined as the tendency to experience positive emotions and to be sociable, are both associated with more PA (Rhodes & Smith, 2006; Sutin et al., 2016; Wilson & Dishman, 2015). These associations between PA and personality traits have been found consistently across diverse populations. In addition, openness, which refers to the tendency to be creative and curious is related to higher PA. Finally, there is mixed evidence for the associations between agreeableness, which refers to the tendency to be cooperative and trusting, and PA (Artese et al., 2017; Sutin et al., 2016; Wilson & Dishman, 2015). For example, the meta-analysis conducted by Wilson and Dishman (2015) did not find an association between this trait and PA participation while Sutin et al. (2016) highlighted that higher agreeableness was associated with a lower likelihood of being physically inactive.

These findings, however, are derived mostly from cross-sectional studies and there is limited evidence for the relation between personality and change in PA over time. To our knowledge, only one longitudinal study examined this association (Allen et al., 2017). Specifically, high conscientiousness and openness predicted an increase in PA over four years, whereas high agreeableness predicted subsequent decreases in PA (Allen et al., 2017). No significant associations were found for either neuroticism and extraversion and change in PA. Personality, however, may be related to change in PA status, such as the initiation of PA among physically inactive individuals and with termination of PA among physically active people, in addition to general changes over time. There are reasons to expect such associations. The basic tendencies related to the traits may drive initiation or termination of PA. For example, physically inactive extraverted and open individuals may be more likely to engage in PA because it satisfies their need for sensation and stimulation and their need for variety and curiosity, respectively. In the same vein, conscientious individuals may be more inclined

to initiate and maintain PA because of their self-discipline, adherence to recommendations, and for the health benefits. In contrast, individuals high in neuroticism may be less likely to initiate and maintain PA over time because they may be anxious towards the harms of being physically active and may interpret PA-related sensations as feelings of pain. In addition, personality traits such as extraversion, openness, and conscientiousness are related to motivational processes that may facilitate the initiation and maintenance of PA. Studies that used the self-determination theory (Ryan & Deci, 2000), for example, found that extraverted, open, and conscientious individuals are more likely to hold self-determined forms of motivation (Ingledeew et al., 2004; Ingledeew & Markland, 2008) that are beneficial to the adoption and maintenance of a physically active lifestyle (Teixeira et al., 2012). In contrast, neuroticism is associated with less self-determined forms of motivation (Ingledeew et al., 2004) that interfere with the initiation and the maintenance of PA.

Using data from nine longitudinal studies, we examined the association between personality and longitudinal change in PA status. It was hypothesised that lower neuroticism and higher extraversion, conscientiousness, and openness would be associated with the initiation of PA among individuals who were inactive at baseline. Among physically active individuals at baseline, higher neuroticism and lower extraversion, openness and conscientiousness were expected to be related to higher risk of terminating PA by follow-up. Given the inconsistent associations between agreeableness and PA, we do not have a hypothesis for this trait but include it for the sake of completeness.

2. Methods

2.1. Participants

To test associations between personality traits and changes in PA, we selected cohorts with had a validated measure of the five personality traits defined by the FFM and two assessments of PA at different time points. In total, participants were from nine large longitudinal surveys: the Health and Retirement Study (HRS), the Midlife in the United States survey (MIDUS), the Midlife in Japan study (MIDJA), the Wisconsin Longitudinal Study Graduate sample (WLSG) and Sibling sample (WLSS), the National Health, Aging, and Trends Study (NHATS), the English Longitudinal Study of Ageing (ELSA), the Longitudinal Internet Studies for the Social Sciences (LISS), and the National Social Life, Health, and Aging Project (NSHAP). Within each cohort, participants were included if they had complete demographic, personality and PA data at baseline and complete PA data at follow-up. Descriptive statistics for the nine samples are presented in Table 1.

The HRS is a nationally representative longitudinal study of adults aged 50 years and older. HRS participants are interviewed every two years in a face-to-face interview during which they are given a psychosocial questionnaire that they complete and mail back to the University of Michigan. Data for personality, PA and demographic factors were obtained in 2006 for half of the sample and in 2008 for the other half. Data from both waves were pooled, resulting in a total of 12,305 participants. Of the total baseline sample, 8146 participants had complete PA data at follow up (in 2014

Table 1. Characteristics of the samples.

Variables	WLSG		WLSJ		MIDUS		HRS		MIDJA		ELSA		LISS		NHATS		NSHAP	
	M/%	SD	M/%	SD	M/%	SD	M/%	SD	M/%	SD	M/%	SD	M/%	SD	M/%	SD	M/%	SD
Age (Years)	64.28	0.66	63.34	6.63	55.47	11.19	66.34	8.77	54.55	13.41	65.12	8.01	47.88	14.11	78.30	7.04	71.03	6.34
Sex (% women)	53%	-	53%	-	56%	-	61%	-	53%	-	56%	-	52%	-	59%	-	55%	-
Race (% White)	-	-	-	-	84%	-	84%	-	-	-	98%	-	-	-	73%	-	86%	-
Education	14.00	2.44	14.36	2.57	7.56	2.50	13.04	2.90	4.58	2.04	4.35	2.19	3.64	1.59	5.36	2.29	3.12	1.02
Neuroticism	2.98	0.91	3.02	0.87	2.04	0.62	2.04	0.60	2.09	0.57	2.09	0.59	2.56	0.67	2.19	0.84	1.41	0.59
Extraversion	3.83	0.88	3.75	0.86	3.11	0.57	3.22	0.55	2.44	0.66	3.17	0.55	3.27	0.64	3.18	0.74	2.23	0.54
Openness	3.63	0.77	3.62	0.73	2.92	0.53	2.98	0.54	2.20	0.60	2.90	0.54	3.52	0.50	2.87	0.83	1.94	0.63
Agreeableness	4.80	0.71	4.73	0.68	3.45	0.50	3.55	0.46	2.67	0.62	3.51	0.48	3.92	0.48	3.58	0.54	2.47	0.5
Conscientiousness	4.81	0.68	4.73	0.68	3.43	0.44	3.40	0.46	2.71	0.53	3.32	0.48	3.78	0.51	3.25	0.71	2.39	0.52
Baseline physically active %	50%	-	50%	-	89%	-	80%	-	42%	-	89%	-	83%	-	70%	-	76%	-
Follow up physically active %	48%	-	48%	-	87%	-	82%	-	45%	-	81%	-	78%	-	65%	-	83%	-
% became active at follow up	27%	-	26%	-	63%	-	44%	-	26%	-	41%	-	56%	-	32%	-	58%	-
% became inactive at follow up	31%	-	30%	-	10%	-	23%	-	28%	-	14%	-	18%	-	22%	-	10%	-

Note. M: mean; SD: Standard Deviation.

WLSG: Wisconsin Longitudinal Study Graduate (United States; 2003/2005–2011, n = 3847), **WLSJ:** Wisconsin Longitudinal Study Sibling (United States; 2004/2007–2011, n = 1969), **MIDUS:** Midlife in the United States Survey (United States; 2004/2005–2013/2014, n = 2433), **HRS:** Health and Retirement Study (United States; 2006/2008–2014/2016, n = 8146), **MIDJA:** Midlife in Japan Survey (Japan; 2008–2012, n = 618), **ELSA:** English Longitudinal Study of Ageing (England; 2010–2016, n = 5901), **LISS:** Longitudinal Internet Study for the Social Sciences (Netherlands; 2008–2017, n = 2181), **NHATS:** National Social Life, Health, and Trends Study (United States; 2013/2014–2016/2017, n = 1899), **NSHAP:** National Social Life, Health, and Aging Project (United States; 2010/2011–2015/2016, n = 1518).

N total have complete data at baseline and at follow-up = 28,512.

for the 2006 subsample and in 2016 for the 2008 subsample) (61% female, Mean age: 66.34, SD: 8.77). The duration of follow-up for this sample was 8 years. More information about the HRS and how to access the data can be found at <http://hrsonline.isr.umich.edu/index.php>.

The MIDUS is a longitudinal study of non-institutionalized English-speaking adults in the United States. The present study used data from the second (2004–2005, MIDUS II) and third waves (2013–2014, MIDUS III). Baseline personality data, PA, and demographic factors were obtained using a phone interview and self-administered questionnaires from a sample of 3768 individuals. Of the total baseline sample, 2433 participants had complete PA data at follow-up (56% female, Mean age: 55.47, SD: 11.19). The duration of follow-up for this sample was 9 years. More information about MIDUS and how to access the data can be found here: <http://www.midus.wisc.edu/>.

The MIDJA is a longitudinal study of Japanese adults from the Tokyo metropolitan area designed to parallel the Midlife in the United States (MIDUS) study to compare how culture contributes to age differences in health and well-being. These data were collected during a telephone interview and by means of a self-administered questionnaire sent and returned by mail. In the present study, personality, PA and demographic factors were first assessed in 2008 in a sample of 988 participants. Of these respondents, 618 also had PA data in 2012 (53% female; Mean age: 54.55, SD: 13.41). The duration of follow-up for this sample was 4 years. More information about MIDJA and how to access the data can be found here: <http://www.midus.wisc.edu/>.

The WLS is a long-term study of a random sample of 10,317 participants who were born between 1937 and 1940 and who graduated from Wisconsin high schools in 1957 (WLSG). The WLS sample is broadly representative of older, white, non-Hispanic Americans who completed at least a high school education. In addition to the main sample, the WLS also collected data on a selected sibling of some of the graduates (WLSS). Personality and PA data were assessed using a self-administered questionnaire, which was returned by mail to WLS. Baseline personality data, PA, and demographic factors were obtained in 2003–2005 from a sample of 5824 graduates and in 2004–2007 from 3115 siblings. Follow-up PA data were collected in 2011. The duration of follow-up for these samples ranged from 4 to 8 years. A total of 3847 individuals in the WLSG (53% female; Mean age: 64.28, SD: 0.66) and 1969 participants in the WLSS (53% female, Mean age: 63.34, SD: 6.63) had complete data at baseline and follow-up. Information about how to access the WLS data can be found here: <http://www.ssc.wisc.edu/wlsresearch/>.

The NHATS is a nationally representative prospective cohort study of Medicare enrollees aged 65 years and older. Data were collected during an individual interview. Personality was assessed in 2013 for one-third of the sample and in 2014 for a second third. Data from both waves were combined, resulting in a sample of 2767 participants with complete baseline data on personality, PA and demographic factors. From this sample, 1899 individuals also provided PA data at follow-up (59% female; Mean age: 78.30, SD: 7.04). PA was obtained in 2016 for the 2013 subsample and in 2017 for the 2014 subsample. The duration of follow-up for this sample was 3 years. Information about how to access the WLS data can be found here: <http://www.nhats.org>.

The ELSA is a representative panel *study* of English men and women who are aged 50 years old and over. Data were collected through computer-assisted face-to-face interviews combined with self-reported paper questionnaires. Baseline personality traits, PA and demographic factors were assessed at Wave 5 (2010) and were obtained from a sample of 8117 participants. Follow-up PA was obtained at wave 8 (2016) from 5901 participants (56% female; Mean Age: 65.12, SD: 8.01). The duration of follow-up for this sample was 6 years. More information about ELSA and how to access the data can be found here: <http://www.elsa-project.ac.uk/>

The LISS is a longitudinal sample of households in the Netherlands. Participants complete online surveys every month. A sample of 5790 individuals provided complete personality data, PA, and demographic data at the 2008 baseline (Wave 1). Of this sample, 2181 participants (52% female; Mean age: 47.88, SD: 14.11) had complete PA data in 2017 (wave 10). The duration of follow-up for this sample was 9 years. More information about LISS and how to access the data can be found here: <http://www.lissdata.nl/lissdata/Home>

The NSHAP is a population-based study of health and social factors that aims to understand the well-being of older, community-dwelling Americans. Personality, demographic and PA data were obtained at Wave 2 (2010–2011) from a total of 2062 individuals. These data were collected through home interviews during which self-reported questionnaires were administered. Of this sample, a total of 1518 participants (55% female; Mean age: 71.03, SD: 6.34) provided PA data at follow-up, at wave 3 (2015–2016). The duration of follow-up for this sample was 5 years. Information about how to access the WLS data can be found here: <https://www.norc.org/Research/Projects/Pages/national-social-life-health-and-aging-project.aspx>.

A summary of the nationality, the starting and ending years of the follow-up and the duration of the follow-up for each sample is presented in the [supplementary material](#) in Table S1.

2.2. Measures

2.2.1. Personality traits

Personality traits were assessed using validated self-report questionnaires across cohorts. The Midlife Development Inventory (MIDI) (Zimprich et al., 2012) was used to assess personality traits in the MIDUS, the MIDJA, the HRS and the ELSA. Participants were asked how much each of 26 adjective that assessed Neuroticism, Extraversion, Openness, Agreeableness, and Conscientiousness described them on a scale ranging from 1 (*not at all*) to 4 (*a lot*). A 21-item version of the MIDI was used in the NSHAP and a shortened 10-item version was used in NHATS. A 29-item version of the Big Five Inventory (BFI) (John et al., 1991) was used in the WLSG and the WLSS. Participants were asked whether they agreed or disagreed with 29 descriptive statements using a 6-point rating scale, ranging from 1 (*disagree strongly*) to 6 (*agree strongly*). The 50-item International Personality Item Pool (IPIP) scale (Goldberg et al., 2006) was used in the LISS. Participants were asked to rate the extent to which 50 phrases described them using a scale ranging from 1 (*Very inaccurate*) to 5 (*Very accurate*).

2.2.2. Physical activity

Participants reported their PA participation using different scales across cohorts. Despite heterogeneity across measures, all items were anchored on a lower end (e.g. 'Never' or '0 hours' or 'No physical activity') of no PA. Following the categorisation proposed by Sutin et al. (2016), we coded, at baseline and follow-up, two PA statuses common to each sample, namely 'physical activity vs. physical inactivity'. Physical inactivity was defined as never engaging in PA, while physical activity was defined as engaging in at least some physical activity. In the MIDUS, participants were asked about their vigorous (e.g. running or lifting heavy objects) and moderate leisure PA (e.g. slow or light swimming, brisk walking) during both the summer months and the winter months on a scale from 1 (*several times a week or more*) to 6 (*never*). The average of the items was computed with higher scores indicating more frequent PA. Responses were recoded such that a mean of 1 was coded as inactivity and all other means were coded as PA. In the MIDJA, participants reported how often they used exercise or movement therapy in the last 12 months on a scale ranging from 1 (*never*) to 5 (*a lot*). Never was coded as inactivity, and all other answer were coded as PA. In both HRS and ELSA, participants were asked to indicate how often they participated in vigorous PA and in moderate PA on a scale from 1 (*hardly ever or never*) to 4 (*more than once a week*). The mean of the two items was computed. Responses were recoded such that a mean of 1 was coded as inactivity and all other means coded as PA. In both the WLSG and WLSS, participants were asked to report the number of hours per month they did vigorous PA alone and with others. The number of hours reported for each activity was added. A total of zero hours was coded as inactivity whereas reports of at least one hour was coded as PA. In the NHATS, participants indicated whether in the last month, they ever go walking for exercise and whether they ever spend time on vigorous PA on a yes (1)/no (0) scale. A sum of zero was coded as inactivity and all other values were coded as PA. In the NSHAP, a single item asked participants to report how often they participated in vigorous PA or exercise in the last 12 months on a scale ranging from 0 (*never*) to 5 (*five or more times per week*). Never was coded as inactivity and all other answers were coded as PA. Finally, in the LISS, two items asked on how many days during the last 7 days individuals performed strenuous PA and moderately intensive PA. For each item, participants entered the number of days per week they engaged in the activity (with 0 for none). The two items were averaged. A mean of 0 was coded as inactivity and means above 0 were coded as PA. Initiation of PA was defined as being inactive at baseline and engaging in any PA at follow-up. Termination of PA was defined as engaging in any physical activity at baseline and reporting no PA at follow-up. A summary of the measures used in each sample to assess PA is presented in the [supplementary material](#) in [Table S1](#). Descriptive statistics for PA at baseline and follow-up in the nine samples are presented in the [Table S2](#) of the [supplementary material](#).

2.2.3. Covariates

Previous studies have shown that PA changes over time can vary according to socio-demographic characteristics, including age, gender, education and race (Barnett et al.,

2008; Droomers et al., 2001; Lounassalo et al., 2019; Gabriel et al., 2018). Information on age (years), gender (coded 1 for males and 0 for females), and education level was available in all nine samples and thus these variables were included as covariates in the analyses. Education was measured on a scale ranging from 1 (no grade school) to 12 (doctoral-level degree) in the MIDUS and in the HRS, from 1 (8th-grade high school) to 8 (graduate school) in the MIDJA, from 1 (No schooling completed) to 9 (Master's, professional or doctoral degree) in the NHATS, from 1 (No qualification) to 7 (NVQ4/NVQ5/Degree or equivalent) in the ELSA, from 1 (< high school) to 4 (College) in NSHAP and from 0 (not yet completed any education) to 7 (other) in the LISS. In WLSS and WLSG, years of education were assessed on a continuous scale ranging from 0 (Less than one year of school) to 17 (Five or more years of college). Race (coded 1 for white and 0 for other) was controlled for in the MIDUS, the HRS, the NHATS, the NSHAP, and the ELSA.

2.3. Data analysis

Logistic regression analyses were conducted in each of the nine samples to test whether personality traits were associated with becoming active or inactive, independent of sociodemographic factors (age, sex, educational, race where applicable). A first set of analyses was conducted in each sample to test whether personality predicted the likelihood of initiating PA among physically inactive individuals at baseline. Physically active participants at baseline were excluded from the analysis. Physical inactivity at both baseline and follow-up was coded as 0 and moving from physical inactivity at baseline to physical activity at follow-up was coded as 1. The initiation of PA was predicted from baseline personality traits, controlling for the sociodemographic factors. A second set of analysis was conducted in each sample to test whether personality predicted the likelihood of termination PA by follow-up among participants who were physically active at baseline. Participants who were physically inactive at baseline were excluded from the analysis. Being physically active at both baseline and follow-up was recoded as 0 and being physically active at baseline and physically inactive at follow-up was recoded as 1. Terminating PA was predicted from personality traits, controlling for the sociodemographic factors. Personality scores were standardised in each sample and examined separately. For all outcomes, the analysis was run separately for each trait. These analyses were performed using the `glm()` function of 'stats' package (Core Team, 2020) in R studio software (Version 1.2.1578). R code template used for the logistic regression analyses is attached at the end of the [supplementary material](#) (S4). Random-effects meta-analyses were used to combine the associations between PA initiation, PA cessation, and each of the five personality traits. These random-effects meta-analyses were conducted on the basis of odds ratios, confidence intervals, and sample sizes for each cohort for PA initiation and cessation. Heterogeneity of effects was examined using I^2 estimates that describe the percentage of variance between effects that is not sampling error. By convention, I^2 values near 0%, 25%, 50%, or 75% indicate no, low, moderate, and high heterogeneity, respectively (Higgins et al., 2003). The random-effects meta-analysis was performed using the Comprehensive meta-analysis software.

3. Results

For information about the cross-sectional association between personality traits and baseline PA in the MIDUS, HRS, WLSG, WLSS, NHATS, ELSA, LISS, MIDJA see Sutin et al. (2016). In particular, this meta-analysis revealed that higher conscientiousness, extraversion, openness and agreeableness were associated with more physical activity and a lower likelihood of being inactive, whereas higher neuroticism was related to less physical activity and increased the risk of being inactive.

3.1. Physical activity initiation

On average, across the nine samples, 37% of participants became active (range 26%–62%). Sample characteristics on PA change are presented in the [Table S3](#) of the [supplementary material](#). As expected, extraversion, openness, conscientiousness, and neuroticism were related to the initiation of PA. Specifically, every SD higher in extraversion, openness and conscientiousness was related to an approximately 21–66%, 19–34%, and 18–51% higher likelihood of initiating PA between baseline and follow-up. In contrast, every one SD higher in neuroticism was associated with a 11–24% lower likelihood of initiating PA over this time. Of the five traits, the evidence was most consistent for extraversion and openness. Beyond the hypotheses formulated a priori, these analyses also found agreeableness was associated with PA initiation: every SD higher agreeableness is related to an approximately 12% higher likelihood of initiating PA between baseline and follow-up. The meta-analysis supported the overall pattern of relations observed across the individual studies with heterogeneity in the effects between samples ranging from low to high. More specifically, the I^2 values indicate a low heterogeneity in the effect sizes across sample for Neuroticism ($I^2=8.34$) and Agreeableness ($I^2=3.85$). There was moderate heterogeneity in the effect sizes across cohorts for Openness ($I^2=56.15$) and Conscientiousness ($I^2=60.55$). Finally, large heterogeneity is observed for Extraversion ($I^2=75.53$). The results of logistic regression analyses performed to test the associations between personality traits and physical activity initiation are presented in [Table 2](#). A forest plot summarising the associations between each personality traits and the likelihood of initiating PA is presented in [Figure 1](#).

3.2. Physical activity cessation

On average, across the nine samples, 19% of participants became inactive over the follow-up (range 10%–31%) ([Table S3](#)). As expected, extraversion, openness, conscientiousness and neuroticism were related to the likelihood of terminating PA across the follow-up among participants who were active at baseline. For every SD higher extraversion, openness and conscientiousness, the likelihood of terminating PA was reduced by around 12 to 27%, 9 to 30% and 14 to 26%, respectively. In contrast, every SD higher neuroticism was related to a 13–35% higher risk of terminating PA. Moreover, beyond the hypotheses formulated a priori, these analyses found that agreeableness was associated with PA cessation: every SD higher agreeableness is related to 6–12% lower likelihood to become inactive between baseline and follow-up.

Table 2. Summary of logistic regression analyses predicting initiation of physical activity from baseline personality traits among initially physically inactive participants.

	WLSG ^a	WLS ^a	MIDUS ^b	HRS ^b	MIDJA ^a	ELSA ^b	LISS ^a	NHATS ^b	NSHAP ^b	Point Estimate	I ²
Neuroticism	0.89* (0.80–0.99)	0.98 (0.85–1.14)	0.95 (0.75–1.24)	0.83*** (0.76–0.93)	0.76* (0.59–0.99)	1.01 (0.86–1.19)	0.93 (0.76–1.14)	0.94 (0.79–1.12)	0.85 (0.69–1.04)	0.90*** (0.85–0.95)	8.34
Extraversion	1.22*** (1.10–1.36)	1.21** (1.05–1.40)	1.15 (0.87–1.53)	1.21*** (1.10–1.33)	1.09 (0.85–1.39)	1.52*** (1.30–1.79)	0.83 (0.67–1.01)	1.04 (0.88–1.23)	1.66*** (1.34–2.08)	1.20** (1.07–1.34)	75.53
Openness	1.23*** (1.10–1.38)	1.30** (1.11–1.52)	1.17 (0.90–1.51)	1.19*** (1.08–1.31)	1.00 (0.78–1.28)	1.30** (1.11–1.53)	0.83 (0.69–1.03)	1.10 (0.92–1.31)	1.34** (1.10–1.65)	1.17*** (1.07–1.27)	56.15
Agreeableness	1.04 (0.94–1.15)	1.13 (0.98–1.32)	1.06 (0.80–1.41)	1.12* (1.01–1.23)	1.09 (0.86–1.39)	1.14 (0.98–1.33)	0.86 (0.69–1.07)	1.00 (0.85–1.18)	1.24 (0.99–1.55)	1.08** (1.02–1.14)	3.85
Conscientiousness	1.09 (0.98–1.21)	1.18* (1.02–1.37)	1.03 (0.81–1.32)	1.27*** (1.15–1.39)	1.10 (0.85–1.41)	1.42*** (1.23–1.64)	1.07 (0.87–1.31)	1.04 (0.87–1.23)	1.51*** (1.23–1.87)	1.19*** (1.09–1.29)	60.55

Note. **WLSG:** Wisconsin Longitudinal Study Graduate (United States; 2003/2005–2011, **n = 1932**), **WLS:** Wisconsin Longitudinal Study Sibling (United States; 2004/2007–2011, **n = 934**), **MIDUS:** Midlife in the United States Survey (United States; 2004/2005–2013/2014, **n = 264**), **HRS:** Health and Retirement Study (United States; 2006/2008–2014/2016, **n = 1612**), **MIDJA:** Midlife in Japan Survey (Japan; 2008–2012, **n = 358**), **ELSA:** English Longitudinal Study of Ageing (England; 2010–2016, **n = 666**), **LISS:** Longitudinal Internet Study for the Social Sciences (Netherlands; 2008–2017, **n = 360**), **NHATS:** National Social Life, Health, and Trends Study (United States; 2013/2014–2016/2017, **n = 563**), **NSHAP:** National Social Life, Health, and Aging Project (United States; 2010/2011–2015/2016, **n = 361**).

Coefficients are Odds Ratios standardised (95% Confidence intervals in parentheses).

Point Estimate summary Odds Ratios calculated from random-effects meta-analyses.

The I² statistic represents the percentage of heterogeneity between samples.

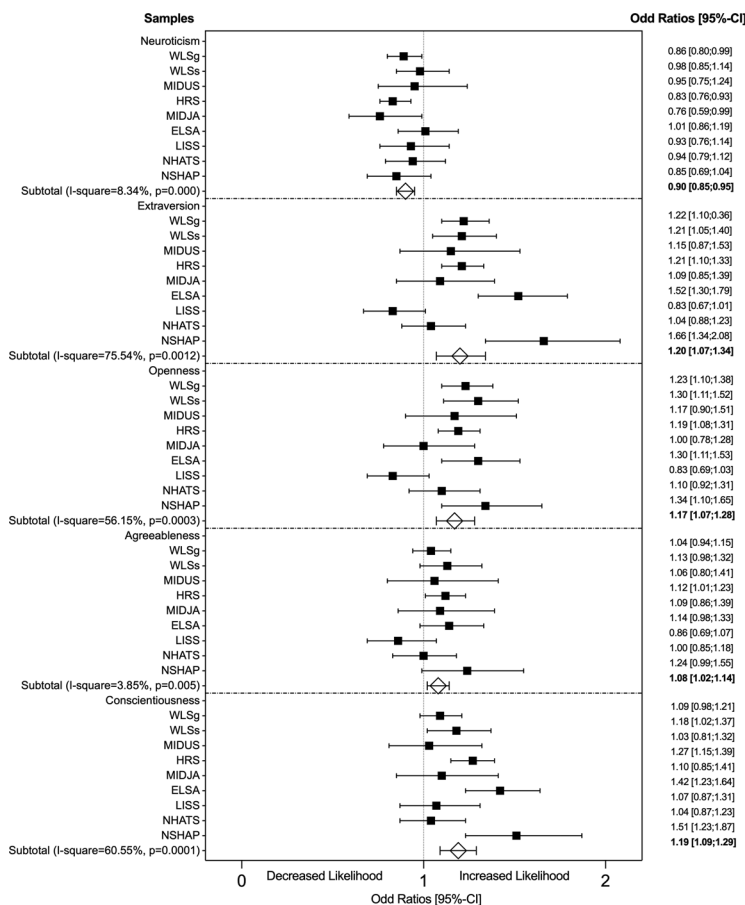
^aAdjusted for age, sex, education.

^bAdjusted for age, sex, education, and race.

*p < .05,

**p < .01,

***p < .001.



Note. Squares represent sample-specific Odds Ratios and diamonds represent pooled Odds Ratios from random-effects meta-analyses. Bars represent 95% confidence interval (CI) [Lower limit-Upper limit]. For each model personality traits are standardized and models are adjusted for sex, age, education. For MIDUS, HRS, ELSA, NHAT, NSHAP models are also adjusted for race.

WLSg : Wisconsin Longitudinal Study Graduate (*United-States*; 2003/2005-2011, n=1932), **WLSs** : Wisconsin Longitudinal Study Sibling (*United-States*; 2004/2007-2011, n=984), **MIDUS** : Midlife in the United States Survey (*United-States*; 2004/2005-2013/2014, n=264), **HRS** : Health and Retirement Study (*United-States*; 2005/2008-2014/2016, n=1612), **MIDJA** : Midlife in Japan Survey (*Japan*; 2008-2012, n=358), **ELSA** : English Longitudinal Study of Ageing (*England*; 2010-2016, n=666), **LISS** : Longitudinal Internet Study for the Social Sciences (*Netherlands*; 2008-2017, n=360), **NHATS** : National Social Life, Health, and Trends Study (*United-States*; 2013/2014-2016/2017, n=563), **NSHAP** : National Social Life, Health, and Aging Project (*United-States*; 2010/2011-2015/2016, n=361).

Figure 1. Association between personality traits and physical activity initiation.

Again, the meta-analysis supported the associations observed in the individual studies with heterogeneity in the effects between samples ranging from low to high. Indeed, there was small to moderate heterogeneity in the effect sizes across samples for Agreeableness ($I^2=14.17$), Openness ($I^2=28.18$), Conscientiousness ($I^2=47.90$) and Neuroticism ($I^2=54.26$). The I^2 statistic indicates a large heterogeneity in the effects across samples for Extraversion ($I^2=73.98$). The results of logistic regression analyses performed to test the associations between personality traits and physical activity cessation are presented in Table 3. A forest plot summarising the associations between each personality traits and the likelihood of drop out PA is presented in Figure 2.

Table 3. Summary of logistic regression analyses predicting drop out from physical activity from baseline personality traits among initially physically active participants.

	WLSG ^a	WLS ^a	MIDUS ^b	HRS ^b	MIDJA ^a	ELSA ^b	LISS ^a	NHATS ^b	NSHAP ^b	Point Estimate	χ^2
Neuroticism	1.13* (1.03–1.25)	0.94 (0.82–1.09)	1.10 (0.94–1.29)	1.14*** (1.07–1.21)	1.35* (1.01–1.80)	1.21*** (1.11–1.32)	0.99 (0.88–1.13)	1.05 (0.91–1.20)	1.28* (1.05–1.56)	1.11*** (1.05–1.18)	54.26
Extraversion	0.88* (0.79–0.97)	0.90 (0.78–1.04)	0.85* (0.73–0.99)	0.87*** (0.82–0.93)	0.95 (0.73–1.25)	0.73*** (0.67–0.79)	1.08 (0.95–1.22)	0.83** (0.73–0.96)	0.76** (0.63–0.93)	0.86*** (0.80–0.94)	73.98
Openness	0.87** (0.78–0.96)	0.92 (0.79–1.07)	0.91 (0.79–1.06)	0.91** (0.86–0.97)	0.93 (0.69–1.25)	0.88** (0.81–0.95)	0.86* (0.76–0.98)	0.77*** (0.67–0.88)	0.70*** (0.58–0.86)	0.87*** (0.83–0.91)	28.18
Agreeableness	0.86** (0.78–0.95)	0.97 (0.84–1.12)	0.89 (0.76–1.04)	0.93* (0.87–0.99)	0.91 (0.69–1.20)	1.03 (0.94–1.12)	0.89 (0.79–1.02)	0.93 (0.81–1.07)	0.86 (0.71–1.05)	0.93*** (0.89–0.97)	14.17
Conscientiousness	0.93 (0.85–1.03)	0.90 (0.77–1.03)	0.89 (0.76–1.03)	0.86*** (0.80–0.91)	1.09 (0.82–1.44)	0.81*** (0.75–0.88)	0.95 (0.83–1.08)	0.78*** (0.69–0.90)	0.74** (0.62–0.90)	0.87*** (0.82–0.92)	47.90

Note. **WLSG:** Wisconsin Longitudinal Study Graduate (United States; 2003/2005–2011, **n = 1915**), **WLS:** Wisconsin Longitudinal Study Sibling (United States; 2004/2007–2011, **n = 985**), **MIDUS:** Midlife in the United States Survey (United States; 2004/2005–2013/2014, **n = 2169**), **HRS:** Health and Retirement Study (United States; 2006/2008–2014/2016, **n = 6534**), **MIDJA:** Midlife in Japan Survey (Japan; 2008–2012, **n = 260**), **ELSA:** English Longitudinal Study of Ageing (England; 2010–2016, **n = 5235**), **LISS:** Longitudinal Internet Study for the Social Sciences (Netherlands; 2008–2017, **n = 1821**), **NHATS:** National Social Life, Health, and Trends Study (United States; 2010/2011–2015/2016, **n = 1157**), **NSHAP:** National Social Life, Health, and Aging Project (United States; 2010/2011–2015/2016, **n = 1157**).

Coefficients are Odds Ratios standardised (95% Confidence intervals in parentheses).

Point Estimate summary Odds Ratios calculated from random-effects meta-analyses.

The χ^2 statistic represents the percentage of heterogeneity between samples.

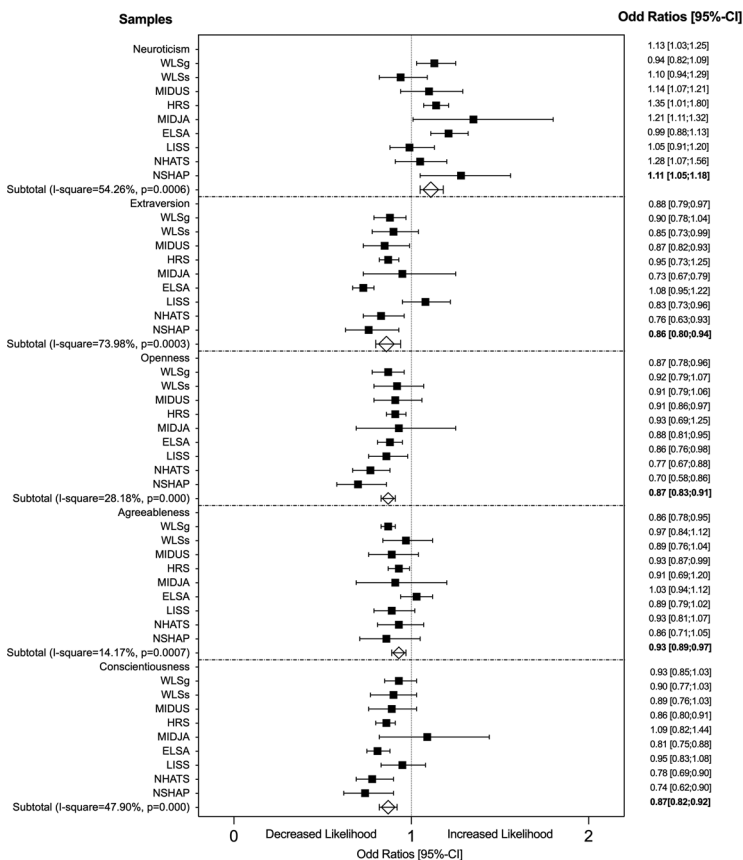
^aAdjusted for age, sex, education.

^bAdjusted for age, sex, education, and race.

* $p < .05$,

** $p < .01$,

*** $p < .001$.



Note. Squares represent sample-specific Odds Ratios and diamonds represent pooled Odds Ratios from random-effects meta-analyses. Bars represent 95% confidence interval (CI) [Lower limit-Upper limit]. For each model personality traits are standardized and models are adjusted for sex, age, education. For MIDUS, HRS, ELSA, NHAT, NSHAP models are also adjusted for race.

WLSg : Wisconsin Longitudinal Study Graduate (United-States; 2003/2005-2011, n=1915), **WLSs** : Wisconsin Longitudinal Study Sibling (United-States; 2004/2007-2011, n=985), **MIDUS** : Midlife in the United States Survey (United-States; 2004/2005-2013/2014, n=2169), **HRS** : Health and Retirement Study (United-States; 2006/2008-2014/2016, n=6534), **MIDJA** : Midlife in Japan Survey (Japan; 2008-2012, n=260), **ELSA** : English Longitudinal Study of Ageing (England; 2010-2016, n=5235), **LISS** : Longitudinal Internet Study for the Social Sciences (Netherlands; 2008-2017, n=1821), **NHATS** : National Social Life, Health, and Trends Study (United-States; 2013/2014-2016/2017, n=1336), **NSHAP** : National Social Life, Health, and Aging Project (United-States; 2010/2011-2015/2016, n=1157).

Figure 2. Association between personality traits and physical activity cessation.

4. Discussion

Using nine large longitudinal samples of adults, the present study examined the association between personality and change in PA over 3 to 10 years of follow-up across adulthood. Consistent with our hypotheses, conscientiousness, extraversion, and openness were related to a higher likelihood of initiating PA among individuals who were initially inactive and to a lower likelihood of terminating PA over time among those who were physically active. Neuroticism was related to reduced likelihood of initiating PA and a higher probability of becoming inactive over time. In addition, higher agreeableness was associated with an increased likelihood of initiating and maintaining PA over time. Thus, these results add to previous cross-sectional studies (Sutin et al., 2016; Wilson & Dishman, 2015) and reveal that personality traits

may also motivate the initiation or termination of PA over time. More precisely, this study supports patterns of cross-sectional relations (Sutin et al., 2016; Wilson & Dishman, 2015) showing that higher extraversion, conscientiousness, and openness may be protective for PA participation. Similarly, our results are consistent with previous studies (Sutin et al., 2016; Wilson & Dishman, 2015) highlighting that higher neuroticism constitutes a risk factor for less PA. Furthermore, the associations between agreeableness and PA have been more mixed in the literature (Sutin et al., 2016; Wilson & Dishman, 2015), which was also observed across the individual samples in the current study. Still, however, when aggregated across studies, these results suggest that higher agreeableness may help promote more PA participation (Artese et al., 2017; Sutin et al., 2016).

The most consistent relationships between personality and change in PA status were observed for extraversion and openness. Individuals who are energetic and enthusiastic, as well as those who are curious and search for variety, were more likely to start and maintain PA over time. The basic tendencies associated with extraversion and openness may explain their association with the initiation of PA. Individuals high in extraversion, for example, are characterised by excitement seeking, energy and a need for positive emotions and stimulation (McCrae & John, 1992) that may lead them to start and maintain PA over time. In addition, extraverted individuals may engage and maintain PA because it facilitates social interactions and relationships and may satisfy their propensity to sociability. Studies within the self-determination theory framework (Ryan & Deci, 2000) have found that higher extraversion is related to intrinsic motivation for PA (Ingledeu et al., 2004). This form of motivation refers to engaging in PA for the inner satisfaction and pleasure tied to the activity itself and is a strong contributor to persistence in PA (Teixeira et al., 2012). Individuals high in openness are characterised by curiosity and the search for novel ideas and experiences (McCrae & John, 1992) that may also motivate the initiation of PA as a mean of experiencing something new. In addition, the variety of sensations and feelings experienced in the activity could explain why open individuals are more likely to maintain their PA over time. In addition, higher openness is related to lower external regulation (Ingledeu & Markland, 2008), suggesting that PA may satisfy open individuals' need for autonomy that results in the persistence of the behaviour.

As expected, higher conscientiousness was also related to the initiation and maintenance of PA over time. Individuals who are self-disciplined and thoughtful may perceive PA as a mean to achieve desired goals, which may stimulate the initiation and maintenance of the behaviour. In addition, conscientiousness is related to self-determined forms of motivation that are implicated in the adoption and maintenance of PA (Ingledeu & Markland, 2008). Conscientious individuals are organised and planful, which are necessary skills to maintain PA over time (Zhang et al., 2019). Furthermore, high conscientiousness elicits compliance to sociocultural norms and rules (Gebauer et al., 2014). As such, individuals higher in conscientiousness may be more likely to follow public health recommendations and guidelines for PA involvement.

The current study also highlights significant associations between agreeableness and a higher probability of initiating and maintaining PA over time. Individuals with high levels of agreeableness have a propensity to be accommodating, cooperative, and compliant (Costa & McCrae, 1992). For example, persons higher in agreeableness

were more likely to respect dominant socio-cultural norms (Gebauer et al., 2014) and to conform to authority (Bègue et al., 2015). Given these characteristics, individuals with higher levels of agreeableness might be more inclined to comply with government recommendations for PA. Furthermore, agreeable people are concerned with maintaining positive and harmonious interpersonal relationships (Jensen-Campbell & Graziano, 2001). Therefore, these individuals could find within the practice of PA an opportunity to strengthen social interaction and cohesion, which may partly explain the maintenance of this behaviour in these individuals over time.

Finally, neuroticism was related to a lower likelihood of PA initiation and maintenance. Individuals high on neuroticism are characterised by distress and anxiety that have been found to impede PA involvement (Stults-Kolehmainen & Sinha, 2014). Studies of older adults have found that higher neuroticism is associated with fear of falling, which is a strong determinant of avoidance of activities (Mann et al., 2006). Pain may be another mechanism that explains this relation. Higher neuroticism is related to the experience of persistent pain (Sutin et al., 2016) that could limit both the initiation and maintenance of PA. From a motivational perspective, neuroticism is associated with the less self-determined forms of motivation for PA (Ingledeew et al., 2004) that interfere with the adoption and maintenance of this behaviour (Teixeira et al., 2012).

4.1. Limitations and perspectives

There are methodological considerations that deserve special attention. First, there was evidence of heterogeneity in effect sizes between studies. This heterogeneity could be due to various elements, such as the different instruments used to assess personality traits and PA (i.e. measurement scale, PA recall period and PA modalities) between the samples. Moreover, the different lengths of follow-up could also explain some of the observed heterogeneity. Finally, in addition to age, sex, education and race, environmental factors, specifically the place of PA within the different cultures could also influence association between personality and PA change. Moreover, we used self-reported questionnaires to assess PA. The main limitation of these measures is that individuals may overestimate their PA practice (Prince et al., 2008). Therefore, in order to achieve a more complete understanding of the associations between personality and changes in PA status, future research should replicate these findings with objective assessments of PA. In addition, the majority of these measures focussed on moderate and vigorous intensity PA. However, PA behaviour is complex in that it encompasses several dimensions and there is evidence that other exercise modalities, such as light intensity activities, are also important to the health and longevity of individuals (Chastin et al., 2019; Loprinzi, 2017). Furthermore, given the heterogeneity of PA measures across samples, we chose to define as 'physically active' those participants who reported at least some PA. As such, it is likely that some 'insufficiently active' individuals, according to the WHO recommendations (WHO, 2020), were included in this category. Measures including frequency, duration and intensity of PA, should be used to define a threshold consistent with these health recommendations. In addition, PA trajectories are likely to vary according to health status, socioeconomic status, or health behaviours (i.e. smoking or alcohol consumption) (Aggio et al., 2018;

Barnett et al., 2008; Lounassalo et al., 2019). These variables should be considered as potential confounders or mediators in future studies to gain a better appreciation of the effect of personality traits on changes in PA status. Finally, although personality was associated with PA change, evidence from HRS, WLG, and MIDUS suggests that PA could, in return, change personality traits (Stephan et al., 2014, 2018). These considerations should be taken into account when interpreting the results of the current study, as they suggest that changes in personality could contribute to PA change (Jokela et al., 2018).

Despite these limitations, the present study has several strengths, including the use of nine large longitudinal samples of adults from different cultures, replicable evidence for an association between personality and change in PA status that emerged from different personality and PA measures, and across different follow-up period, which indicated that the results are not limited to specific populations, measures or follow-up periods. For these reasons, the current study makes an important contribution to improving knowledges about psychological factors that may influence changes in PA status, by demonstrating for the first time that personality traits may also influence the transition from one PA status to another over time. In addition to advancing scientific knowledge, the results could have applied implications. For example, the assessment of personality could be used to identify the persons most at risk of dropping out of PA and thus to promote prevention among these individuals. Moreover, these findings highlight the importance of considering individuals' personality when designing interventions to promote the adoption and long-term maintenance of PA. In this aim, different elements could be considered such as (1) adopting a discourse on PA that resonates with the personality characteristics of individuals (Why et al., 2010), (2) implementing personality-appropriate behaviour change techniques (Belmon et al., 2015), or (3) providing exercise modalities that are consistent with individual preferences (i.e. PA intensity, duration, environment) (Courneya & Hellsten, 1998; Meira et al., 2021; Wilson & Dishman, 2015).

5. Conclusion

In sum, this study highlights that the investigation of personality constitutes an interesting perspective for understanding changes in physical activity status over the life course. Specifically, higher extraversion, openness, conscientiousness and agreeableness could be protective factors for physical activity insofar as they were related to the initiation and maintenance of physical activity over time, whereas higher neuroticism could precipitate physical activity cessation. As such, the current study contributes to a better understanding of the psychological characteristics of individuals that could be targeted by interventions directed towards the promotion of physical activity.

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Authors' contributions

Pauline Caille performed statistical analyses, contributed to the interpretation of data and to the writing of the manuscript. Yannick Stephan and Antonio Terracciano performed statistical analyses and contributed to the writing and revising of the manuscript. Nelly Héraud, Angelina Sutin, Martina Luchetti and Brice Canada contributed to the writing and revising of the manuscript.

Disclosure statement

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Data availability statement

The data that support the findings of this study are publically available on websites mentioned below:

HRS	http://hrsonline.isr.umich.edu/	ELSA	https://www.elsa-project.ac.uk/
MIDUS	http://midus.wisc.edu/index.php	LISS	https://www.lissdata.nl/
WLSG/S	http://www.ssc.wisc.edu/wlsresearch/data/	NHATS	http://www.nhats.org
MIDJA	http://midus.wisc.edu/index.php	NSHAP	https://www.norc.org/Research/Projects/Pages/national-social-life-health-and-agingproject.aspx

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