



Physical activity and personality development across adulthood and old age: Evidence from two longitudinal studies



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ARTICLE INFO

Article history:

Available online 21 December 2013

Keywords:

Personality change
Physical activity
Normative development
Stability

ABSTRACT

Personality traits are associated with a number of health-related factors; less is known about how such factors contribute to adult personality development. Based on evidence for the protective role of physical activity for individual functioning, the present study tests whether physical activity contributes to personality stability and change. Using longitudinal data from the Midlife in the United States study ($N = 3758$) and the Health and Retirement Study ($N = 3774$), we found that more physically active individuals declined less on conscientiousness, extraversion, openness and agreeableness, and had higher rank-order stability and profile consistency over time. These findings suggest that physical activity may help preserve personality stability and prevent maladaptive personality changes across adulthood and old age.

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1. Introduction

A physically active lifestyle has a profound influence on individuals' health. Meta-analytic studies indicate that regular participation in physical activity across the lifespan is associated with a 20–40% reduction in risk of all-cause mortality (Kodama et al., 2013; Löllgen, Böckenhoff, & Knapp, 2009; Nocon et al., 2008; Samitz, Egger, & Zwahlen, 2011), and the prevalence of chronic conditions is lower among physically active adults (Brown et al., 2012; Lee et al., 2012). Observational and intervention studies also suggest that a physically active lifestyle promotes better cognitive function (Colcombe & Kramer, 2003; Weuve et al., 2004) and reduces risk of cognitive impairment, dementia and Alzheimer's disease (Kramer, Erickson, & Colcombe, 2006; Scarmeas et al., 2009). A physically active lifestyle has a range of mental health benefits too. Physical activity is protective against depression (Conn, 2010), and, among clinically depressed patients, the effect of physical activity on reduction in depressive symptoms is comparable with that observed in patients on antidepressant medication (Blumenthal et al., 2007, 2012). Physically active adults also report less stress (Rueggeberg, Wrosch, & Miller, 2012) and greater psychological well-being (Netz, Wu, Becker, & Tenenbaum, 2005). Despite strong evidence for the effect of physical activity on

emotional, cognitive and physical functioning across the lifespan, the extent to which an active lifestyle contributes to personality trait development in adulthood is an open question.

Personality traits are associated with participation in physical activity (Hoyt, Rhodes, Hausenblas, & Giacobbi, 2009; Rhodes & Smith, 2006; Stephan, Boiché, Canada, & Terracciano, in press). Cross-sectional and longitudinal research consistently find that, among the major dimensions of personality, extraversion and conscientiousness are the strongest personality correlates of a physically active lifestyle (Gallagher, Yancy, Denissen, Kühnel, & Voils, 2013; Hoyt et al., 2009; Rhodes & Smith, 2006; Stephan et al., in press). Openness also predicts higher frequency of physical activity while neuroticism has an inverse relation (Rhodes & Smith, 2006; Stephan et al., in press); there is no clear evidence for an association between physical activity and agreeableness (Rhodes & Smith, 2006).

There are reasons to expect that the relation between personality and physical activity may not be unidirectional and that a physically active lifestyle may contribute to personality development. Physical activity has implications for a range of psychological, cognitive and health-related variables that have been associated with personality stability and change (Costa, Bagby, Herbst, & McCrae, 2005; Löckenhoff, Terracciano, & Costa, 2009; Pocnet, Rossier, Antonietti, & Von Gunten, 2013; Sutin, Zonderman, Ferrucci, & Terracciano, 2013; Sutin et al., 2013). Specifically, a physically active lifestyle buffers or reduces the risk of several conditions that challenge personality stability in adulthood. Physical activity is associated with lower risk of physical and mental disorders that may decrease conscientiousness, extraversion, openness and

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increase neuroticism over time (Costa et al., 2005; Sutin et al., 2013). It is also associated with lower risk of cognitive decline and dementia, which are related to caregivers' reports of increased neuroticism and decreased extraversion and conscientiousness (Duchek, Balota, Storandt, & Larsen, 2007; Pocnet et al., 2013). Active individuals may also cope better with environmental changes that challenge personality stability, such as adverse life events and social changes (Löckenhoff et al., 2009; Sutin, Costa, Wethington, & Eaton, 2010).

This evidence suggests that physical activity may be informative for personality change and stability over time, but to date no study has examined whether physical activity contributes to personality development. Although the precise pattern of personality development across adulthood is open to debate, declines in neuroticism and increases in conscientiousness during middle adulthood tend to be common across studies (Donnellan & Lucas, 2008; Lucas & Donnellan, 2009, 2011; McCrae, Terracciano, & Members of the Personality Profiles of Cultures Project, 2005; Roberts, Walton, & Viechtbauer, 2006; Soto, John, Gosling, & Potter, 2011; Terracciano, Costa, & McCrae, 2006). Recent findings have also suggested that changes that deviate from normative trajectories (e.g., increases in neuroticism) have negative psychological, cognitive and health-related correlates, including mortality (Graham & Lachman, 2012; Human et al., 2013; Mroczek & Spiro, 2007; Turiano et al., 2012). In contrast, personality stability is considered a resource for individuals' functioning with advancing age (Graham & Lachman, 2012; Human et al., 2013). Therefore, it is critical to identify factors that may accelerate positive changes, prevent maladaptive changes, and preserve stability with aging.

The present study examined whether engagement in physical activity is associated with personality development across adulthood and old age. We took a comprehensive approach to personality development and considered indices of intra-individual rank order stability and profile consistency, in addition to the commonly reported group-level mean change in traits. Mean-level change measures the extent to which individuals increase or decrease on a trait dimension over time, whereas indices of stability focus on the degree to which individual differences on a given trait or on a configuration of traits is maintained over time.

Age-related declines in physical, cognitive, and mental health, as well as environmental changes are associated with maladaptive personality trajectories, such as decreases in conscientiousness, extraversion and openness and increases in neuroticism (Costa et al., 2005; Pocnet et al., 2013; Sutin et al., 2013). Given its relation with reduced risk of chronic conditions, cognitive decline, and lower prevalence of mental disorders and lower receptivity to environmental stressors, we expected physical activity to preserve the stability of personality traits, while a sedentary lifestyle would be associated with changes in non-desirable directions. We hypothesized that a physically active lifestyle would be associated with less mean level change in extraversion, conscientiousness, openness to experience, and lower neuroticism over time. In addition, we hypothesized that physical activity would contribute to higher intra-individual stability of traits and profile consistency. The above hypotheses were tested using data from two large longitudinal surveys that differ in age, time and physical activity assessment, the Midlife in the United States (MIDUS) and the Health and Retirement Study (HRS) surveys.

2. Method

2.1. Participants

2.1.1. MIDUS

Data were drawn from the Midlife in the United States longitudinal survey (MIDUS I and II; Brim, Ryff, & Kessler, 2004). The first

wave of the MIDUS study collected survey data in 1994–1995 from a total of 7108 English-speaking adults in the United States, aged 20–75 years. Participants completed a 30-min telephone interview and a self-administered questionnaire that included the variables of interest of the present study. Of the 7108 participants in MIDUS 1, 4963 adults (~70% of the original sample) were successfully contacted to participate in a second wave of data collection in 2004–2005. We analyzed only individuals who provided complete data for both waves on the variables of interest. The final sample was composed of 3758 individuals aged from 20 to 75 years old at baseline (55% women; Mean age = 47.20; SD = 12.34). Attrition analysis revealed that those with complete data were older, $t(7047) = -5.64$, $p < .001$, $d = 0.13$, more educated, $t(7093) = -13.43$, $p < .001$, $d = 0.32$, had more frequent physical activity, $t(6260) = -6.74$, $p < .001$, $d = 0.17$, lower disease burden, $t(6306) = 3.78$, $p < .001$, $d = 0.10$, lower neuroticism, $t(6263) = 2.52$, $p < .05$, $d = 0.06$, lower agreeableness, $t(6269) = 1.98$, $p < .05$, $d = 0.04$, and higher conscientiousness, $t(6268) = -7.16$, $p < .001$, $d = 0.18$.

2.1.2. HRS

The Health and Retirement study (HRS) is a nationally representative and prospective panel study that surveys Americans aged 50 years and older. Participants in the present study were drawn from the eighth (2006) and tenth (2010) waves. In 2006, participants in the enhanced face-to-face interview received a psychosocial questionnaire that they completed and returned by mail to the University of Michigan. Approximately 7550 participants completed the baseline personality measure. The final sample was composed of 3774 participants (59% women, Mean Age = 69.70, SD = 9.79) who provided complete data at both waves. Participants in the longitudinal sample were younger, $t(7537) = 14.81$, $p < .001$, $d = 0.34$, had lower disease burden, $t(7109) = 9.12$, $p < .001$, $d = 0.21$, had more frequent physical activity, $t(6625) = -15.30$, $p < .001$, $d = 0.38$, and had higher education, $t(7451) = -15.56$, $p < .001$, $d = 0.36$, than the drop out sample. In addition, they were more extraverted, $t(7300) = -2.23$, $p < .05$, $d = 0.05$, open, $t(7154) = -4.34$, $p < .001$, $d = 0.11$, conscientious, $t(7261) = -8.86$, $p < .001$, $d = 0.21$, and less neurotic, $t(7387) = 2.85$, $p < .01$, $d = 0.06$, than those who did not have complete data.

2.2. Measures

2.2.1. Personality

Personality was assessed in both samples using the Midlife Development Inventory (MIDI; Lachman & Weaver, 1997). In the MIDUS, participants were asked how much 25 adjectives that assessed neuroticism, conscientiousness, extraversion, openness, and agreeableness described themselves on a scale ranging from 1 "not at all" to 4 "a lot" (For more details, see Graham & Lachman, 2012). The same scale was used in the HRS, except one additional item was added to the conscientiousness scale. Cronbach alphas for each trait at Wave 1 and Wave 2 respectively were as follows (coefficients for the HRS are in parentheses): .75 (.71) and .74 (.71) for neuroticism, .77 (.74) and .76 (.76) for extraversion, .77 (.78) and .76 (.79) for openness, .56 (.67) and .58 (.69) for conscientiousness, and .81 (.79) and .80 (.80) for agreeableness.

2.2.2. Physical activity

At baseline, participants in the MIDUS sample were asked to report how frequently they participated in vigorous (e.g., running or lifting heavy objects) and moderate leisure physical activity (e.g. slow or light swimming, brisk walking) during both the summer months and the winter months using a scale ranging from 1 (never) to 6 (several times a week or more). The physical exercise score was the mean of summer and winter ratings for each type of activity. In the HRS, participants rated how frequently they

participated in vigorous and moderate activities with two items using a scale ranging from 1 (hardly ever or never) to 4 (more than once a week). Answers to the two items were averaged.

2.3. Data analysis

To test whether physical activity was associated with change in personality traits, multiple regression analyses were conducted for each trait as the criterion and baseline physical activity as predictor. Age (in years), sex (coded as 1 for men and 0 for women), ethnicity (coded as 1 for white and 0 for other), educational level, and disease burden were included as covariates given their relation with personality change (e.g. Löckenhoff et al., 2008; Sutin et al., 2013). For each sample, we regressed personality at follow-up on baseline personality, age, age squared, sex, ethnicity, education, disease burden and the baseline physical activity score. The contribution of physical activity on personality stability was conducted using several indices of stability (Terracciano, Costa, & McCrae, 2006; Terracciano, McCrae, & Costa, 2010). First, individual stability (IS) coefficients were computed for each individual using Asendorpf's (1992) formula: $1 - [(z_1 - z_2)^2 / 2]$, where z_1 and z_2 are scores for a trait standardized across the full sample at the first and second administrations. The mean of Asendorpf's coefficient across all respondents is equal to the retest correlation, so each coefficient represents the individual's contribution to overall rank-order stability. Because IS scores are less reliable, we also created an overall variable for each individual as the mean IS across all the trait scales, named IS_{MIDI}. Separate regression analyses were conducted in each sample with the IS for each trait and the overall mean as the criteria and baseline physical activity as a predictor, controlling for age, age squared, sex, ethnicity, education, and disease burden. Profile stability was computed using the double-entry intra-class correlation (ICC) across the five personality traits (McCrae, 2008; Terracciano et al., 2010). Chan et al. (2012) revealed that the results obtained with the ICC are essentially the same, or even more conservative, than those obtained with other methods. Regression analysis were conducted in each sample with the baseline physical activity as a predictor and the ICC as the criterion, controlling for age, age squared, sex, ethnicity, education, and disease burden. Additional analyses tested whether age, sex, ethnicity, education, and disease burden moderated the relationship between physical activity and personality change.¹

3. Results

Descriptive statistics for all variables at Time 1 and Time 2 are presented in Table 1.

3.1. Physical activity and mean-level personality change

Partially consistent with our hypothesis, more frequent physical activity at baseline in the MIDUS was associated with change in extraversion ($\beta = .03$, $p < .05$) and conscientiousness ($\beta = .07$, $p < .001$); physical activity was unrelated to changes in neuroticism ($\beta = .00$, $p = .99$), openness ($\beta = .02$, $p = .06$) and agreeableness ($\beta = .01$, $p = .49$) (Table 2). These relations should be interpreted in the context of overall personality change in the MIDUS sample. Extraversion declined over the 10-year period, whereas conscien-

¹ Additional analyses were conducted in the HRS to test whether changes in physical activity were related to indices of personality stability and change. Increases in physical activity were associated with mean level changes in extraversion, conscientiousness and openness, but were unrelated to intra-individual stability and profile consistency. These analyses were not conducted in the MIDUS because of the differences in the items used to assess physical activity across the two waves of the survey.

Table 1

Means and standard deviations for the variables under study at Time 1 and Time 2 in the MIDUS ($N = 3758$) and the HRS (3774).

Variables	Time 1	Time 2
MIDUS		
Sex (% female)	55%	–
Ethnicity (% white)	94%	–
Education	7.14 (2.47)	–
Disease burden	2.31 (2.36)	–
Age	47.20 (12.34)	–
Physical activity	4.77 (1.15)	–
Agreeableness	3.48 (0.49)	3.45 (0.50) ^a
Extraversion	3.19 (0.55)	3.10 (0.57) ^a
Neuroticism	2.22 (0.66)	2.06 (0.62) ^a
Conscientiousness	3.45 (0.43)	3.47 (0.45) ^b
Openness	3.01 (0.51)	2.90 (0.53) ^a
HRS		
Sex (% female)	59%	–
Ethnicity (% white)	88%	–
Education	13.17 (2.70)	–
Disease burden	1.78 (1.26)	–
Age	65.70 (9.79)	–
Physical activity	2.56 (1.00)	–
Agreeableness	3.53 (0.46)	3.51 (0.49) ^a
Extraversion	3.21 (0.54)	3.16 (0.56) ^a
Neuroticism	2.05 (0.59)	1.98 (0.59) ^a
Conscientiousness	3.39 (0.45)	3.38 (0.48) ^a
Openness	2.97 (0.53)	2.90 (0.55) ^a

^a Significantly lower than the baseline value.

^b Significantly higher than the baseline value.

tiousness slightly increased (Table 1). Therefore, the observed positive relations indicated that frequent physical activity at baseline was associated with less of a decline in extraversion and an increase in conscientiousness. The effect of physical activity on extraversion was stronger than the effect of disease burden and education, and for conscientiousness it was stronger than age, sex, education, disease burden, and ethnicity. Additional analysis revealed that physical activity was more strongly associated with an increase in conscientiousness among less educated individuals ($\beta_{interaction} = -.03$, $p < .01$) and those with higher disease burden ($\beta_{interaction} = .03$, $p < .05$).

The results from the HRS also partially confirmed our hypothesis. Consistent with the MIDUS, physical activity at baseline was associated with change in extraversion ($\beta = .07$, $p < .001$) and conscientiousness ($\beta = .04$, $p < .01$). It was also associated with change in openness ($\beta = .04$, $p < .001$) and agreeableness ($\beta = .03$, $p < .05$) but was unrelated to change in neuroticism ($\beta = -.02$, $p = .15$) (Table 2). In HRS, the average mean level of extraversion, conscientiousness, openness, and agreeableness declined over the 4-years period; these results thus indicated that physical activity at baseline was associated with less of a decline in extraversion, conscientiousness, openness, and agreeableness. Of note, the effect of physical activity on change in these traits was stronger or comparable to those of age, sex, education, disease burden, and ethnicity. In contrast to MIDUS, sociodemographic factors and disease burden did not moderate any of these relations.²

3.2. Physical activity and intra-individual stability of personality

Baseline physical activity in MIDUS had a positive association with intra-individual stability of personality for extraversion ($\beta = .04$, $p < .05$) and conscientiousness ($\beta = .07$, $p < .001$) over the 10-years interval (Table 3). These effects were almost comparable to or greater than those of age, sex, education, disease burden, and

² The pattern of results was almost the same without the covariates, except that the relation between physical activity and mean-level change in agreeableness in the HRS and mean-level change in extraversion in the MIDUS were not significant.

Table 2
Summary of regression analysis predicting follow-up personality traits from baseline physical activity in the MIDUS (N = 3758) and the HRS (N = 3774).

Variables	Agreeableness	Extraversion	Neuroticism	Conscientiousness	Openness
MIDUS					
Sex	−0.12***	−0.03**	−0.04**	−0.04**	0.00
Age	0.07***	0.06***	−0.09***	−0.00	0.04**
Age squared	−0.05***	−0.05***	0.02	−0.05***	−0.06***
Educational level	−0.04**	−0.02	−0.03*	0.00	0.06***
Disease burden	−0.01	−0.02	0.06***	−0.06***	0.01
Ethnicity	−0.01	−0.05***	−0.01	−0.01	−0.03**
Baseline personality trait	0.60***	0.68***	0.60***	0.59***	0.67***
Baseline physical activity	0.01	0.03*	0.00	0.07***	0.02
Adjusted R ²	.43	.49	.42	.39	.49
HRS					
Sex	−0.09***	−0.04***	−0.03*	−0.05***	−0.03*
Age	−0.04**	−0.01	−0.00	−0.04**	−0.04***
Age squared	−0.01	−0.02*	0.01	−0.01	−0.01
Educational level	0.02	0.02	−0.03*	0.05***	0.07***
Disease burden	0.00	−0.02	0.03*	−0.03*	−0.03*
Ethnicity	0.01	−0.02	0.04**	−0.02	−0.03*
Baseline personality trait	0.63***	0.69***	0.62***	0.63***	0.67***
Baseline physical activity	0.03*	0.07***	−0.02	0.04**	0.04***
Adjusted R ²	.44	.52	.41	.44	.51

* p < .05.
** p < .01.
*** p < .001.

ethnicity. Physical activity was also positively related to the overall IS_{MIDI} ($\beta = .05, p < .01$) (Table 3). Additional analysis revealed that physical activity was more strongly associated with intra-individual stability of conscientiousness among individuals with higher disease burden ($\beta_{interaction} = .04, p < .05$) and with intra-individual stability of agreeableness among less educated individuals ($\beta_{interaction} = -.03, p < .05$). Physical activity was also more strongly associated with the overall IS_{MIDI} among less educated individuals ($\beta_{interaction} = -.03, p < .05$).

The effects in HRS were consistent with the overall pattern of results in the MIDUS, with a significant positive relation between physical activity and the intra-individual stability of extraversion ($\beta = .08, p < .001$), conscientiousness ($\beta = .09, p < .001$) and the overall IS_{MIDI} ($\beta = .11, p < .001$) (Table 3). Fig. 1 presents the intra-

individual stability of extraversion and conscientiousness in the HRS and the MIDUS for individuals in the top and the bottom 25% of the distribution of physical activity. Physical activity was also positively related to the intra-individual stability of agreeableness ($\beta = .05, p < .01$), openness ($\beta = .08, p < .001$) and neuroticism ($\beta = .07, p < .001$) (Table 3). For most of the associations observed, the effect size of physical activity was stronger than the effects of age, sex, disease burden, and ethnicity. Furthermore, the effect for openness, extraversion, and the mean IS was almost comparable to that of education (Table 3). Consistent with the MIDUS findings, physical activity was more strongly related to intra-individual stability of conscientiousness among individuals with higher disease burden ($\beta_{interaction} = .03, p < .05$). In addition, this relationship was stronger among older individuals ($\beta_{interaction} = .04, p < .05$).

Table 3
Summary of regression analysis predicting intra-individual stability of personality traits and profile consistency from baseline physical activity in the MIDUS (N = 3758) and the HRS (N = 3774).

Variables	IS _{Agreeableness}	IS _{Extraversion}	IS _{Neuroticism}	IS _{Conscientiousness}	IS _{Openness}	IS _{MIDI}	Profile consistency
MIDUS							
Sex	−0.07***	−0.04*	−0.01	−0.05***	0.00	−0.06***	−0.11***
Age	0.10***	0.06**	0.07***	0.04*	0.05**	0.11***	0.21***
Age squared	−0.07***	−0.00	−0.05**	−0.04*	−0.05**	−0.08***	−0.08***
Educational level	0.06***	0.07***	0.02	0.07***	0.08***	0.10***	0.10***
Disease burden	0.01	−0.04**	−0.05**	−0.05**	−0.04*	−0.06***	−0.15***
Ethnicity	0.05**	0.05**	0.02	0.02	0.07***	0.06***	0.02
Baseline physical activity	0.02	0.04*	0.00	0.07***	0.03	0.05**	0.05**
Adjusted R ²	.02	.01	.01	.01	.02	.03	.07
HRS							
Sex	−0.11***	−0.06***	−0.03	−0.07***	−0.02	−0.09***	−0.14***
Age	−0.00	−0.00	0.05**	−0.02	0.01	0.01	0.07***
Age squared	−0.02	−0.03	−0.03	−0.04*	−0.03*	−0.04*	−0.05**
Educational level	0.07***	0.08***	0.04*	0.08***	0.10***	0.11***	0.16***
Disease burden	−0.03	−0.03	−0.05**	−0.07***	−0.04*	−0.06***	−0.10***
Ethnicity	0.02	0.02	0.02	0.04*	0.02	0.04*	0.01
Baseline physical activity	0.05**	0.08***	0.07***	0.09***	0.08***	0.11***	0.12***
Adjusted R ²	.02	.02	.01	.03	.02	.04	.07

IS: Intra-individual stability. IS was computed as: $1 - [(z_1 - z_2)^2 / 2]$. IS_{MIDI} is the mean IS of the five factors. Profile consistency was computed using the double-entry intra-class correlation (ICC) across the five personality traits.

* p < .05.
** p < .01.
*** p < .001.

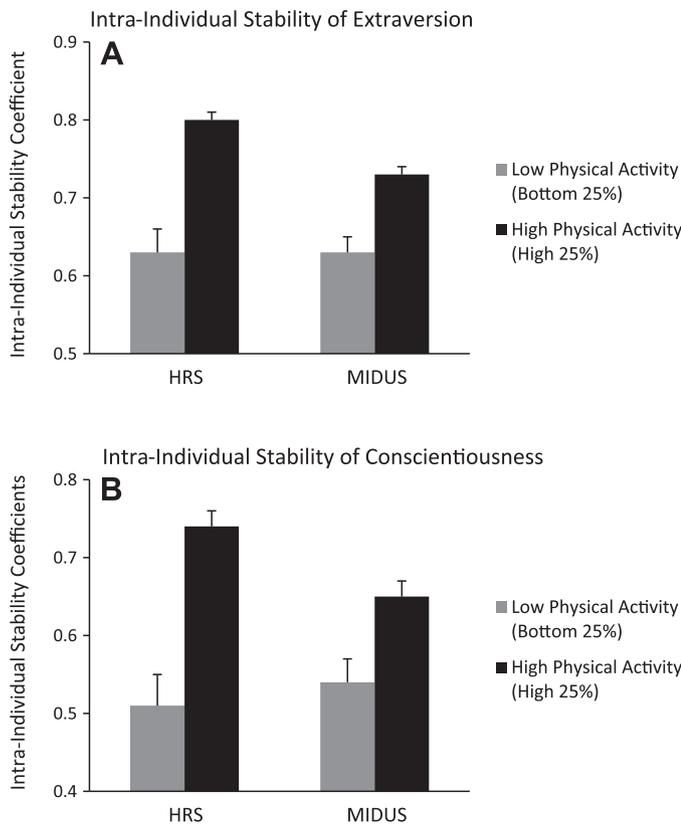


Fig. 1. Intra-individual stability of extraversion and conscientiousness for low (bottom 25%) and high (high 25%) physical activity in the HRS and the MIDUS.

3.3. Physical activity and profile consistency

Consistent with our hypothesis, physical activity was positively related to profile consistency both in the MIDUS ($\beta = .05, p < .01$) and the HRS ($\beta = .12, p < .001$), while controlling for the covariates (Table 3). The effect size of physical activity was small in the MIDUS, but in HRS it was stronger than age, disease burden and ethnicity (Table 3). Fig. 2 presents personality profile consistency in the HRS and the MIDUS for individuals in the top and the bottom 25% of the distribution of physical activity. Further analysis revealed that physical activity was more strongly related to profile consistency among individuals with lower educational level in the HRS ($\beta_{interaction} = -.04, p < .05$), whereas sociodemographic factors and disease burden did not moderate the association observed in the MIDUS.

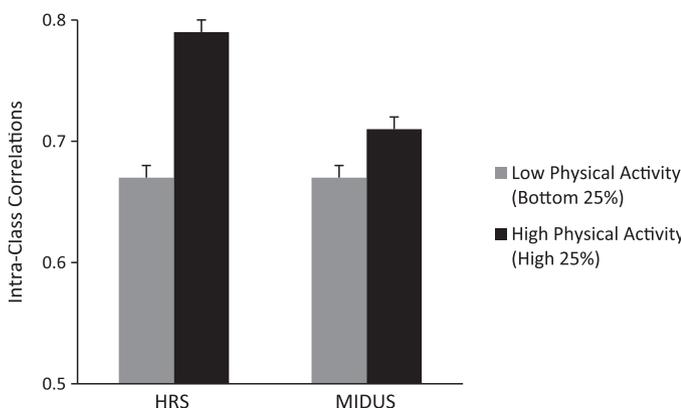


Fig. 2. Personality profile consistency for low (bottom 25%) and high (high 25%) physical activity in the HRS and the MIDUS.

4. Discussion

Using two large and diverse longitudinal studies, the present research suggests that physical activity is associated with personality development across adulthood and old age. The results from both samples were consistent with the hypothesis that an active lifestyle helps to maintain a more resilient personality profile. A sedentary lifestyle, in contrast, was associated with lower stability and greater declines in conscientiousness, extraversion, openness and agreeableness. The positive correlates of physical activity – lower risk of disease and cognitive decline and less vulnerability to social and environmental stressors, may help to promote positive personality development across adulthood. At same time, the changes in personality associated with a sedentary lifestyle may increase risk for poor outcomes across multiple domains, from psychological well-being to longevity.

Extraversion and Conscientiousness have previously been found to be the strongest personality correlates of physical activity (Rhodes & Smith, 2006). Our findings, replicated in two independent samples, indicate that physical activity likewise contributes to the development of these two traits in adulthood. Individuals higher in extraversion and conscientiousness tend to have more energy (Terracciano et al., 2013), and physical activity may help preserve the energetic capacities required not only to cope with aging, but also to behave in extraverted and conscientious ways. In addition, physical activity may contribute to extraversion and conscientiousness through a number of biological and cognitive processes. Regular physical activity reduces disease burden, cognitive decline and risk of depression, which are associated with declines in extraversion (Costa et al., 2005; Pocnet et al., 2013). Biological changes, such as released beta-endorphins (Angelopoulos, 2001) and brain-derived neurotrophic factor (Cotman & Berchtold, 2002), may be involved in the relative maintenance of the tendency to experience positive emotions over time. Physical activity contributes to better health, which has been associated with an increase in conscientiousness (Löckenhoff et al., 2009; Takahashi, Edmonds, Jackson, & Roberts, 2013). In addition, the preservation of executive control processes, such as planning, scheduling and inhibitory process (Colcombe & Kramer, 2003) may be reflected in the maintenance of higher propensity to be self-disciplined, planful, and organized over time. The contribution of physical activity to changes in conscientiousness could also be explained by a corresponsive principle (Roberts & Wood, 2006). That is, the self-discipline and organization required for a physically active lifestyle (Gallagher et al., 2013; Rhodes & Smith, 2006) may foster conscientiousness over time. Psychosocial factors, such as a higher sense of self-efficacy resulting from physical activity (McAuley, Jerome, Marquez, Elavsky, & Blissmer, 2003) may also preserve individuals' tendency to behave in a conscientious manner. Interestingly, additional analysis revealed a compensatory role of an active lifestyle from factors that challenge the stability of conscientiousness. Physical activity was related to higher intraindividual stability of conscientiousness among individuals with higher disease burden in both the HRS and the MIDUS. The cognitive and mental health benefits of activity may counteract the deleterious effects of disease on the stability of conscientiousness.

The health, cognitive, and social consequences of a physically active lifestyle also likely contribute to the 4-year changes in openness and agreeableness observed in the HRS. Building upon recent research (Sutin et al., 2013), the reduced risk of disease burden associated with an active lifestyle may be a potential explanation for the observed change in openness. Furthermore, the frequent exposure to a variety of bodily, social, and emotional experiences in the context of physical activity may foster exploratory tendencies and the search for novel and varied experiences. An active

lifestyle reduces cognitive decline (Kramer et al., 2006) and promotes cognitive flexibility (Colcombe & Kramer, 2003), which may be beneficial for the maintenance of openness to experience over time. Finally, complementary to its predominant physical component, physical activity generates social interactions that may contribute to the maintenance of the prosocial orientation that is characteristic of agreeableness. Physical activity was also associated with higher stability of neuroticism in the HRS, but surprisingly we found no association in the MIDUS sample. In a recent study (Bowen, Balbuena, Baetz, & Schwartz, in press), physical activity was found to be associated with declines in neuroticism. More studies are needed to better understand whether there is an effect of physical activity on neuroticism; it is possible that the null finding in the MIDUS is a false negative.

Individuals who are physically active also have higher profile consistency. In contrast to other indices that focus on a single trait, profile consistency is person-centered and provides information on the stability of the configuration of traits within an individual across time. Therefore, our finding suggests that the shape of the personality profile of active individuals may be relatively better preserved in adulthood. These are important results given that lower profile consistency is a risk factor for pathology (De Fruyt et al., 2006; Hopwood et al., 2009). Moreover, this relation was found in both samples over two different time periods in adulthood. It is likely that the range of benefits of a physically active lifestyle may combine to preserve the entire profile of individuals more than specific traits assessed separately.

The present study adds to existing knowledge on personality development. Previous research has focused primarily on the effect of age (Lucas & Donnellan, 2011), ethnicity and education (Löckenhoff et al., 2008), life experiences and normative life events (Jackson, Thoemmes, Jonkmann, Lüdtke, & Trautwein, 2012; Löckenhoff et al., 2009), social roles (Roberts, Wood, & Smith, 2005), physical health (Sutin et al., 2013), and cognitive status (Pocnet et al., 2013) on personality development. Using a comprehensive coverage of indices of stability and change in two large longitudinal samples that differed in age and retest interval, the present research revealed that the lifestyle adopted by individuals is related to how their personality develops across adulthood and old age. In particular, a sedentary lifestyle with advancing age appears to be a risk factor for maladaptive personality trajectories. The replication of the relations between a physically active lifestyle and indices of stability and changes over both a 4 and 10 year period suggests a long-term contribution of this behavior to personality development. Furthermore, the present study found that this contribution was generally comparable or even stronger than other recognized predictors, such as age, education, disease burden and ethnicity (Lucas & Donnellan, 2011; Löckenhoff et al., 2008; Terracciano et al., 2010).

Despite its strengths, the current study had limitations that should be considered when interpreting the results. First, the generalizability of our findings is limited to some extent by the positive selection of the longitudinal participants in both samples. The effects of physical activity observed in the present study may underestimate the true contribution to personality development given that participants without complete data were less physically active, and thus could have experienced more change in their personality. Second, the physical activity assessment was self-reported, and thus could be biased by memory or over- or underestimation of the real level of physical activity. Third, the observational nature of the present study limits the interpretation of the effect of physical activity on personality development. Intervention studies, such as randomized controlled trials, are needed to further test whether a physical activity program leads to changes in personality traits, as well as potential mediating and moderating variables. In addition, the present study focused only

on the predictive value of the level of physical activity on personality development. It would be important to test whether changes in physical activity are associated with personality stability and change. A multi-wave design would provide more reliable information on the reciprocal dynamic between personality and physical activity than the two-wave design used in the current research. Although the measure of personality has acceptable psychometric properties, it only assessed the five broad dimensions. Future research would benefit from adopting a facet-level analysis to provide a more in-depth picture of the relation between physical activity and personality stability and change. Finally, although the effect size for the relation between physical activity and indices of personality stability and change were almost comparable or higher to those of other established predictors, they are in the modest range. This finding is consistent with existing meta-analysis of the predictive role of personality for participation in physical activity (Rhodes & Smith, 2006). The size of this relation suggests that physical activity may be a distal factor for personality change and stability, perhaps acting through cognitive, biological and psychological pathways. Future longitudinal research is needed to test such a mediational model.

In sum, this study indicates that a physically active lifestyle contributes to personality development across adulthood and old age. The results were consistent with the hypothesis that physical activity promotes personality stability and mitigates mean-level declines in extraversion, conscientiousness, openness, and agreeableness. Interventions directed toward the promotion of physical activity may be promising to prevent maladaptive personality changes and their deleterious consequences for a range of domains of functioning.

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