Within- and between individual variability of personality characteristics and physical exercise

RUNNING HEAD: Personality states and physical exercise

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Abstract

Using two independent samples, the study investigated links of within- and between-individual variability in personality states in three personality domains—Neuroticism, Extraversion, and Conscientiousness—with physical activity. Activity was defined as self-reported quantity of exercising or walking/cycling. More physical activity was associated with people reporting higher levels of Extraversion and Conscientiousness than they usually did, with the associations clearly replicating across samples and generalizing to all items of these domains. This pattern tended to reflect associations at the level of between-individual differences. When the three domains simultaneously predicted activity, within-individual variance in Neuroticism also emerged as a positive predictor, whereas between-individual level associations waned. The findings are consistent with within-individual differences in personality ratings reflecting meaningful, context-sensitive variability.

Keywords: within-individual variability; personality states; personality traits; exercising; physical activity.

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Personality psychology has been and still is mostly about differences between people. However, it is becoming increasingly clear that individuals do not just differ from each other, but they also differ from themselves by varying over time and across situations (Fleeson, 2012; Fleeson & Jayawickreme, 2015). Individuals' personalities may thus be more comprehensively conceptualized as sets of distributions of personality states than sets of static trait scores (Fleeson, 2007). People reliably differ in the properties of these distributions such as their means (Fleeson, 2001) and perhaps also shapes (Fleeson, 2001; Judge, Simon, Hurst, & Kelley, 2014). At the same time, most people can, and indeed do, occupy many positions on the state continua at different time-points. In fact, it has been suggested that there may be even more variability in personality characteristics within individuals than between them (Fleeson, 2007; Sherman, Rauthmann, Brown, Serfass, & Jones, 2015).

If so, a natural question is: Does the observed within-individual variability in personality in how people report their personality characteristic levels reflect substantive variance—something real and context-sensitive in how people differ from moment to moment—rather than some sort of nuisance variance that should be of little interest to researchers? It is no trivial possibility that such within-individual variability reflects, to a greater or lesser extent, random noise. For example, if people report on a personality state at multiple time-points, their responses are expected to vary to some extent due to measurement error alone. And apart from error, the variability may reflect some sort of stochastic processes of not identifiable origin or consequences.

Observed *between*-individual differences in personality characteristics are often rendered interpretable as reflecting substantive variance by correlating them to various kinds of non-personality variables. If scores of a personality trait predict, say, longevity, it seems plausible that the scores capture something real about people (Ozer & Benet-Martínez, 2006; Roberts, Kuncel, Shiner, Caspi, & Goldberg, 2007). This logic may hold even if we remain agnostic as to what the scores actually reflect—a unitary latent trait or just a composite of more specific characteristics (Mõttus, 2016). The same reasoning can be applied to within-individual variance: if feeling more self-disciplined than usual is linked with making more sensible behavioral choices at that time—choosing a healthier meal over something lucrative but unhealthy, finishing a tedious job, going for a jog instead of watching a TV show—it could reflect substantive temporal dynamics in people's behaviors, thoughts and feelings rather than just nuisance variance. This does not even require that the direction (or presence) of causality in such associations be clear: merely the presence of meaningful links would support personality variance being context-relevant.

Indeed, there is evidence for variability in personality states within individuals being meaningfully linked with non-personality variables such as situational characteristics. For example, Fleeson (2007) found a number of associations between variability in Emotional Stability, Extraversion, Agreeableness and Conscientiousness on one hand and several situational features (anonymity, task orientation, other's social status, friendliness) on the other. Likewise, Sherman and colleagues (2015) reported a number of meaningful links between concurrent situational features and personality states, over and above individual differences in typical state levels and situational experiences. For instance, people tended to report higher levels of Conscientiousness and lower levels of Honesty, relative to their typical levels of these characteristics, in situations that called for dutiful behavior or involved

deception, respectively. In a similar vein, workplace experiences and demands have been linked with fluctuations in personality states (Huang & Ryan, 2011; Minbashian, Wood, & Beckmann, 2010), as have been goals (McCabe & Fleeson, 2012) and social roles (Bleidorn, 2009). Wichers and colleagues (2012) studied time-series data on positive and negative affect in relation to changes in physical activity in a relatively large sample of female twins. They reported that increases in physical activity were associated with subsequent levels of positive affect, but not with negative affect. Consistent findings have been reported in other studies (Bossmann, Kanning, Koudela-Hamila, Hey, & Ebner-Priemer, 2013; Feuerhahn, Sonnentag, & Woll, 2014; Kanning, Ebner-Priemer, & Schlicht, 2013), but not all (Kühnhausen, Leonhardt, Dirk, & Schmiedek, 2013).

To the extent that physical activity is linked to positive affect, it seems possible that it is also associated with other manifestations of personality that vary within individuals—possibly excluding negative affective states (Wichers et al., 2012). For example, one study reported associations between activity and feeling less tired and more energetic (Dunton et al., 2014). It is also conceivable that activity and exercising are linked to the personality manifestations subsumed under the domain of Conscientiousness, as the association exists at the level of individual differences (Rhodes & Smith, 2006). For instance, relatively lower levels of self-discipline may contribute towards postponing a gym visit or, in contrast, completing a workout may help to feel more achieved and disciplined than usual.

Based on this rationale, the present study sought to investigate links between personality states from three Five-Factor Model (FFM; McCrae & John, 1992) personality domains, Neuroticism, Extraversion and Conscientiousness, and self-reported physical exercising at the level of within-individual variability. These three domains were selected because they have been most consistently linked with physical exercise at the level of

between-individual variance (Rhodes & Smith, 2006). Although the two levels of analyses can often yield very different results (Kievit, Frankenhuis, Waldorp, & Borsboom, 2013; Kanning, Ebner-Priemer, & Schlicht, 2013), expecting some isomorphism across them seems a sensible starting point. In addition to domain scores, facets of the domains (operationalized as single items) were considered, because many associations between personality characteristics and non-personality variables are facet- or item-specific, and when this happens the associations should arguably be interpreted exactly at this level (Mõttus et al., 2015; Mõttus, 2016; Vainik, Mõttus, Allik, Esko, & Realo, 2015). To the extent that associations between personality states and physical exercising could be identified, this would contribute towards establishing within-individual variability in personality characteristics as something reflecting veridical, context-relevant processes rather than just, for example, measurement error or some stochastic, epiphenomenal processes. Naturally, the associations could also be of substantive interest. For instance, they could elucidate our understanding of the very nature of personality variance or inform attempts to raise individuals' activity levels.

The present study is based on two independent samples, which allowed us to cross-validate the findings. In the second sample, participants also reported on how much they had been walking or cycling, in addition to exercising, which allowed us to test the generalizability of personality-physical activity associations beyond exercising (which is something that mostly happens once a day at most) to other and likely more common forms of activity.

Method

Participants

Sample 1 consisted of 26 people (14 females, 8 males, for 4 sex was unknown) who provided 1,323 observations (*N*) in total. Participants' ages ranged from 21 to 58 (mean [*M*] = 33.00; standard deviation [*SD*] = 12.33, for 5 age was unknown). The majority of participants were recruited from among undergraduate and graduate students or their friends, although some participants were recruited from among the participants of another experiment. Participants provided signed informed consent and were told that they could withdraw from the study at any point of time. Participants who requested feedback at the end of study were given information on their personality states which they varied the most in.

Sample 2 consisted of 62 people (36 females, 26 males) who provided 2,193 observations in total. Participants' ages ranged from 18 to 65 (mean [*M*] = 22.87; standard deviation [*SD*] = 7.45). The participants were recruited by a team of undergraduate students from among the people they knew or could access via other means. Most of the participants were students. Participants provided signed informed consent and were told that they could withdraw from the study at any point of time.

Materials

Personality states: There exists no established measure for within-individual variability of personality characteristics (personality states). Therefore, one was created by drawing inspiration from the facet-level structure of the NEO Personality Inventories (NEO; McCrae & Costa, 2010). Since the aim was to measure personality states falling within the Neuroticism, Extraversion and Conscientiousness domains of the FFM, a selection of the NEO facets defining these domains were employed as basis for constructing the personality

state measure. For example, all Neuroticism facets were covered with a total of seven questions (two questions for the Impulsiveness facet), whereas four (or five in Sample 2) Extraversion facets and four Conscientiousness facets were covered. See Tables 1 and 2 for questions; note that in Sample 2 a question on "friendliness" was added and the wordings of other questions were altered. The instruction asked participants to answer each question based on the time-interval since the previous measurement ("Since the last responding [Question]"). In Sample 2, the full question was shown for the first item ["Since the last responding, how worried have you felt"], whereas for following questions only the variable part of the question was shown in order to have as little text on screen as possible [e.g., " … organized?" or "… in control of your emotions?"]. The items were responded using a sliding scale with endpoints marked "Not at all" and "Very". The sliding scale recorded values on the scale from 0 to 100.

Physical activity: Information on participants' physical exercising was also based on self-reports. In a similar manner to measuring personality states, participants were asked "[Since the last responding] How many hours of exercise have you done?" The responses were recorded as follows: 0 = "No exercise", 1 = "Ten minutes or less"; 2 = "Ten to thirty minutes"; 3 = "Thirty minutes to an hour"; 4 = "More than an hour". In the second sample, participants were additionally asked "[Since the last responding] How much have you walked or cycled?" , with the response options being 0 = "Not at all", 1 = "Ten minutes or less"; 2 = "Ten to thirty minutes"; 3 = "Thirty minutes to an hour"; 4 = "More than an hour".

Table 1. *Questions and descriptive statistics in Sample 1.*

Facet		*M*	*SD*	*Skew*	*ID*
	Neuroticism				
Anxiety	How worried have you been?	32.82	24.21	0.48	36.75
Angry Hostility	How angry have you been?	21.72	21.69	1.29	24.37
Depression	How depressed have you been?	26.39	23.87	0.92	39.88
Depression	How guilty have you felt?	25.72	24.41	0.94	41.04
Self-Consciousness	How self-conscious have you felt?	33.74	25.69	0.55	45.89
Impulsiveness	How frustrated have you felt?	35.60	27.12	0.48	25.62
Impulsiveness	How well have you controlled your emotions?	64.15	22.85	-0.50	42.29
	Extraversion				
Gregariousness	How outgoing have you been?	50.67	22.58	-0.31	35.17
Activity	How energetic have you been?	46.52	23.46	-0.08	27.92
Excitement-Seeking	How adventurous have you been?	47.66	23.96	-0.15	41.07
Positive Emotions	How happy have you been?	63.50	20.35	-0.58	38.43
	Conscientiousness				
Competence	Have you achieved your goals?	52.26	22.65	-0.34	34.68
Order	How organized have you been?	54.97	22.32	-0.35	35.10
Achievement Striving	How ambitious have you been?	50.36	22.55	-0.34	31.95
Self-Discipline	How self-disciplined have you been?	50.82	20.19	-0.32	13.78
Self-Discipline	How focused have you been?	52.91	21.50	-0.43	33.56
	Psychical exercise				
	How many hours of exercise have you done?	1.61	1.11	1.90	19.55

NOTE: Total number of observations = 1,323. Facet = Corresponding NEO Personality Inventory facet; *M* = mean; *SD* = standard deviation; Skew = skewness; *ID* = percentage of variance due to between-individual differences. The general instruction pertaining to each question was: “Since the last responding: [the question]”

Table 2. *Questions and descriptive statistics in Sample 2.*

Facet		*M*	*SD*	*Skew*	*ID*
	Neuroticism				
Anxiety	How worried have you felt?	33.30	25.45	0.45	36.83
Angry Hostility	... angry?	26.09	23.32	0.93	39.40
Depression	... depressed?	24.88	23.05	0.86	49.14
Depression	... guilty?	29.08	25.05	0.76	49.73
Self-Consciousness	... self-conscious?	34.36	27.00	0.59	55.48
Impulsiveness	... frustrated?	37.49	26.14	0.39	32.40
Impulsiveness	... in control of your emotions?	64.17	24.88	-0.48	54.03
	Extraversion				
Gregariousness	... outgoing?	53.13	22.96	-0.20	31.11
Activity	... energetic?	48.31	23.57	-0.03	17.39
Excitement-Seeking	... adventurous?	44.35	21.46	0.08	30.71
Positive Emotions	... happy?	64.50	20.55	-0.54	35.72
Friendliness	... friendly?	64.72	19.05	-0.58	31.40
	Conscientiousness				
Competence	... achieved your goals?	51.61	22.57	-0.06	26.58
Order	... organized?	50.55	22.47	-0.15	29.82
Achievement Striving	... ambitious?	50.26	21.50	-0.21	24.30
Self-Discipline	... self-disciplined?	48.46	22.03	-0.06	21.21
Self-Discipline	... focused?	51.06	22.16	-0.14	23.56
	Psychical activity				
	How many hours of exercise have you done?	0.63	1.21	1.83	18.16
	How much have you walked or cycled?”	1.13	1.15	0.79	17.78

NOTE: Total number of observations = 2,166 to 2,183. Facet = Corresponding NEO Personality Inventory facet; *M* = mean; *SD* = standard deviation; Skew = skewness; *ID* = percentage of variance due to between-individual differences. The general instruction pertaining to each question was: “Since the last responding: [the question]”

Procedure

MovisensXS app for the Android platform was used for collecting information on participants' personality states and physical exercising. Participants used their own devices (in Sample 1) or were optionally given one by researchers (Sample 2). Participants were given instructions on how to install the MovisensXS app on their device and help was provided if necessary. Participants' devices were coupled to the study by means of a unique QR code (generated byt the MovisenseXS web-based platform), which was sent to them via e-mail; the devices of some participants were coupled by students carrying out data collection. The app prompted participants to answer the questions three times each day in Sample 1 and five times a day in Sample 2 (between 9am and 9pm on weekdays, and 10am and 10pm on weekends), with a minimum of 2 hours between prompts. For Sample 1, the prompts were absolutely random within the said constraints, whereas for Sample 2 the first and last daily prompts were fixed at the start and end times of sampling (respectively for 9am and 9pm on weekdays, and 10am and 10pm on weekends). In addition to completing the questions, participants could choose to postpone responding, in which case they were re-prompted in 20 minutes, or to ignore it altogether. In Study 1, the participants were asked to provide responses for three weeks, after which they were offered to stop receiving prompts (and uninstall the app) or to continue participating for as long as they wanted. In Sample 2, all participants were asked to take part of the study for a fixed period of 10 days, although they could stop earlier and a few went over 10 days. On average (median), participants of Sample 1 provided ratings for 24 days (ranging from 8 to 50 days). Due to a technical glitch, two participant did not provide some ratings for the happiness item. Their responses to this item were substituted on the basis of all other personality ratings they had provided. Specifically, in the remaining participants, happiness ratings were predicted from the rest of

the fifteen ratings and the resulting regression formula was used to predict the missing happiness scores in the persons in question. In Sample 2, the median number of participation days was 10, ranging from 1 to 14.

The data is made available alongside the manuscript.

Results

Descriptive statistics

In Sample 1, participants provided ratings for between 10 and 104 time-points (median = 51). Only four participants provided less than 25 (10, 15, 16, and 24) and only 3 provided more than 75 data-points (90, 104, and 104). The median time-lag between consecutive measurements was 7.65 hours (interquartile range from 3.85 to 18.05 hours), which included periods when participants were not prompted to respond (i.e., night-time). The descriptive statistics of the study variables in Sample 1 are given in Table 1. Regarding physical exercise, participants reported no exercise for 69.39%, less than 10 minutes of exercise for 14.06%, ten to thirty minutes of exercise for 8.16%, thirty to sixty minutes of exercise for 2.87% and more than an hour of exercise for 5.52% of observations. In Sample 2, participants provided ratings for between 4 and 54 time-points (median = 38). Nine participants provided less than 25 and 3 participants supplied less than 10 measurements. The median time-lag between consecutive measurements was 3.62 hours (interquartile range from 2.43 to 10.08 hours), which included nights. The descriptive statistics of the study variables in Sample 2 are given in Table 2. Regarding physical exercise, participants reported no exercise for 72.71%, less than 10 minutes of exercise for 10.39%, ten to thirty minutes of exercise for 4.57%, thirty to sixty minutes of exercise for 5.68% and more than an hour of exercise for 6.65% of observations. For walking/cycling, the respective numbers were 38.00%, 27.79%, 21.61%,

7.49% and 4.66%, unsurprisingly suggesting that participants reported on average more walking/cycling than exercising.

Structure of within-individual variability in personality states

The covariation structure of within-individual variability in personality states was first studied in order to see whether aggregating items (facets) into scale scores ostensibly reflecting FFM-type factors was justified. This could not be assumed *a priori*, because the FFM factors have been designed to summarize between-individual differences. Maximum likelihood exploratory factor analysis followed by oblique rotation was carried out on items scores that had been standardized within individuals (i.e., for every individual, ratings had a scale of $M = 0$ and $SD = 1$). This means that individual differences in trait scores were completely removed from these analyses. Parallel analyses and the inspection of scree plot suggested retaining three factors in both samples.

Loading patterns of the three factors (Table 3) suggested that the solutions were very similar in the two samples. The first factor was primarily defined by ratings of frustration, depressiveness, anger, worry, guilt, lack of controlling emotions, self-consciousness and lack of happiness, the second was mostly defined by ratings of being organized, self-disciplined, focused, achieving and ambitious, whereas the third factor tended to be defined by being adventurous, outgoing, energetic, happy and ambitious (and friendliness in Sample 2). Similarly to the findings at the level of individual differences (van der Linden, te Nijenhuis, & Bakker, 2010), the factors had strong inter-correlations: Neuroticism correlated -.26 (-.32) and -.41 (-.43) with Conscientiousness and Extraversion, and the latter two correlated .57 (.51) in Sample 1 (Sample 2). The items were scored into the three FFM traits accordingly (as for items with sizable cross-loadings, ambitiousness was aggregated into

Conscientiousness and happiness into Extraversion). The item referring to being control of emotion was reverse-keyed, before aggregation and taken to further analyses.

Table 3. *Factor loadings of personality state items in Sample 1 (Sample 2).*

Item	Factor 1 [Neuroticism]	Factor 2 [Conscientiousness]	Factor 3 [Extraversion]
Frustrated	**.73 (.67)**	-.01 (-.04)	.04 (.01)
Depressed	**.67 (.53)**	-.01 (-.01)	-.14 (-.17)
Angry	**.65 (.66)**	.04 (-.01)	.07 (.03)
Worried	**.59 (.56)**	.01 (.01)	-.02 (-.02)
Guilty	**.51** (.35)	-.14 (-.25)	.08 (.11)
Controlling emotions	**-.41 (-.41)**	.18 (.16)	.02 (.09)
Self-conscious	**.41 (.43)**	-.06 (.01)	.04 (.08)
Organized	-.04 (-.05)	**.75 (.65)**	-.02 (-.02)
Self-disciplined	.02 (.00)	**.73 (.68)**	-.06 (-.08)
Focused	.03 (.05)	**.69 (.61)**	.07 (.09)
Achieved goals	-.12 (-.16)	**.61 (.58)**	.05 (.05)
Ambitious	.11 (.09)	**.40 (.43)**	**.42** (.32)
Adventurous	.00 (.07)	-.04 (.13)	**.71 (.50)**
Outgoing	-.04 (-.01)	.06 (.00)	**.61 (.68)**
Energetic	.02 (.05)	.15 (.27)	**.58 (.46)**
Happy	**-.44 (-.40)**	-.01 (-.01)	**.49 (.45)**
Friendly	(-.19)	(-.03)	**(.54)**

NOTE: Loadings at least |0.40| are marked in bold.

Such factor analysis was, of course, based on the assumption that the same model fitted every individual. In order to get a sense of the extent to which this assumption was correct, a multiple-group confirmatory factor analysis was carried out by treating seven individuals from Sample 1 who had provided ratings for more than 60 time-points as independent "groups" (568 observations in total). The model was specified as per Table 1, with one factor defined by eight Neuroticism indicators, the other by five Conscientiousness and the third by

five Extraversion indicators (happiness defined both Neuroticism and Extraversion, and ambitiousness defined both Extraversion and Conscientiousness). With data from all seven participants collapsed into a single group, the model fitted data marginally well, with Comparative Fit Index (CFI) and Root Mean Square Error of Approximation (RMSEA) being .93 and 0.060, respectively. When the seven multiple groups were introduced, but no equality constraints other than latent means were imposed, the fit indices worsened to .82 (CFI) and 0.116 (RMSEA). When equality constraints on factor loadings were also introduced, the fit indices further worsened to 0.78 (CFI) and 0.119 (RMSEA); according to chi-square test the difference between the two multiple-group models was significant at $p < .0001$ ($X_\Delta = 232.56$, $df_\Delta = 90$)[1].

These findings suggest that the assumption of measurement models being invariant across individuals did not hold, because the models were not invariant across at least a subset of individuals. As a result, the analyses based on aggregate scores should be interpreted cautiously and will be qualified by analyses at the level of individual items. It must be noted, however, that these analyses (as well as the following ones) have a caveat: they are based on the assumption that different observations within individuals are independent, which, in fact, they are not because of previous states influencing the subsequent ones.

Quantifying between-individual variability

Previous studies have reported that on average 36% of variance in personality states is due to individual difference (e.g., Sherman et al., 2015). In order to replicate these findings, unconditional (random intercept only) multi-level models were fitted on raw item scores and

1 In principle, a noticeable worsening of model fit could have been observed by chance. In order to estimate the likelihood of this, the multi-group models were re-ran 100 times with the grouping variable randomly reshuffled across individuals. In none of the cases was the worsening of model fit comparable to the one actually observed, suggesting that the measurement models for these seven people were likely to be non-invariant beyond chance.

factor scores using the *lme4* package (Bates, Mächler, Bolker, & Walker, 2015). Across 16 items, variability due to individual differences ranged from 13.8% to 45.9% in Sample 1 (median 35.1%; see Table 1) and from 17.4% to 55.5% (median 31.4%; see Table 2) in Sample 2. In addition to having similar distributions, the estimates from the two samples for the 16 overlapping items also ranked similarly, with a Spearman correlation of .72. For the three factors, the between-individual variance estimates varied from 36.8% to 46.1% in Sample 1 and from 30.6% to 54.6% in Sample 2. Ovrall, these estimates are in line with those from Sherman and colleagues (2015), providing converging evidence that typically about a third of variance in ratings can be ascribed to differences between individuals, whereas the rest reflects to unknown degrees either substantive within-individual variability or some sort of noise. For the exercising variable, 19.6% and 18.2% of variance was due to individual differences, respectively in Samples 1 and 2; the figure was 17.8% for walking/cycling.

Associations between personality characteristics and activity

Using a multi-level model design, reported levels (pertaining to different durations) of physical exercise and walking/cycling were predicted from personality items and composite traits in a way that effectively separated between-individual level associations from within-individual level associations (Enders & Tofighi, 2007; Sherman et al., 2015). Specifically, personality characteristics where entered into models twice, with the first instance of the variable representing within-individual standardized scores (no between-individual differences) and the second variable representing person-level average scores (no within-individual differences). The resulting coefficients showed, respectively, whether differences from individuals' typical levels on the variables and the typical levels themselves were related to activity. Both activity variables were ordinal-categorical in nature, representing a continuous underlying characteristics (amount of activity time), and were specified as such in

the models. Distances between response thresholds were allowed to vary freely, because there was no reason to *a priori* assume that, for example, difference between no active time at all *vs* up to ten active minutes was identical to difference between 30 to 60 minutes *vs* more than an hour of activity. The associations were specified as random in that they were allowed to differ across participants (both intercepts and slopes). This means that the models estimated both fixed effects, which represented the average associations across all individuals, and random effects, which represented the deviations of the associations from the fixed effects at the level of single individuals.

The models were estimated using a Bayesian framework as implemented in the R-package *brms* (Buerkner, 2016). This approach allowed us to treat outcomes as ordinal variables (modeled via with logit link) and fit complex models with numerous simultaneous predictors, while also allowing for correlated random error structures (e.g., the *lme4* package struggles with such models). Multiple simultaneous predictors were required because personality characteristics were highly correlated. Allowing for random effect correlations was required because it was possible that for some people multiple personality characteristics were linked with activity more strongly than for some other people. Associations for which 95% credible intervals did not span zero were interpreted as "significant" in the frequentist statistics sense. Although numerous association were tested, replication across samples was taken as evidence for the credibility of the associations. After the transformations described above (removing either within- or between-individual differences), predictor variables were re-standardized. The effect sizes are presented as odds ratios (ORs). Here, an OR is interpretable as increase in the odds of participants selecting any response reflecting more activity over all responses reflecting less activity per standard deviation increase in the personality variables. Uninformative (flat) priors were used for the fixed effects, whereas half

(positive) student-t distribution with 3 degrees of freedom was used as priors for the standard deviations of the effects, because variances cannot be negative. The estimation was based on five chains with each containing 2,000 iterations (1,000 for burn-in); no thinning was used. The chains always converged well with *rhat* values close to 1.

We first fitted "bivariate" models where the activity variable (exercising or walking/cycling) was predicted by only one set of personality variables (one variable representing within- and the other between-individual differences) at the time. However, because there were strong inter-correlations among personality characteristics, the bivariate models where supplemented by "multivariable" models where activity was predicted by all FMM traits, or all items, at the same time; it was possible that some or many bivariate associations were confounded by other personality characteristics.

In both samples, higher levels of Extraversion and Conscientiousness at both levels of variability were linked with higher reported duration of exercising, with effect sizes (ORs) varying form 1.41 to 1.94; for (low) Neuroticism, credible intervals spanned zero except for between-individual variability in Sample 1 (Tables 4 and 5). In other words, more extraverted and conscientious people were more likely to exercise and when people reported being higher on these traits than usual they also reported having exercised more.

At the level of items, the findings were also remarkably consistent across the two samples, with the Spearman correlations of .83 and .76 across the 16 ORs for overlapping items, respectively for within- and between-individual associations. For within-individual-level associations, being outgoing, energetic, adventurous, happy, organized, ambitious, self-disciplined and focused, and having achieved ones goals more than usual were linked with more exercising in both samples. That is, the associations of Extraversion and

Conscientiousness generalized to all of their items. Additionally, in the (larger) Sample 2, exercising was linked with lower-than-usual depressiveness, frustration, guilt and being more in control of ones emotions, and to higher-than-usual self-consciousness and friendliness. For between-individual associations, people who reported, on average, higher level of energy, adventurousness, self-discipline and being focused were more likely to report higher levels of exercising in both samples, whereas there were additional links for being worried and self-conscious in Sample 1 and for being organized and ambitious and having more likely achieved ones goals in Sample 2. We formally assessed the degree to which the associations at within- and between-individual levels of analyses converged by calculating the Spearman correlations between corresponding item-level effect sizes. The correlations were .76 and .87, respectively in Samples 1 and 2, suggesting that the associations at the two levels of analyses converged well in terms of their relative magnitude. That is, how more-exercising people differed from their less-exercising peers was similar to how people differed from their typical selves after having exercised.

A similar pattern emerged in the associations between personality characteristics and the reported duration of walking/cycling (Table 6): it was linked with higher-than-usual Conscientiousness and Extraversion and being, on average, more conscientious. More walking/cycling was linked with higher-than-usual levels of all Extraversion and Conscientiousness items as well as with being more self-conscious, controlling better one's emotions and feeling less guilt. Also, those who reported being on average more ambitious and self-disciplined also reported more walking/cycling. The overall pattern of relative effect sizes was very similar to those pertaining to exercising: across the 17 items, the Spearman correlations of effect sizes were .93 and .87 for within- and between-individual level associations. Also, across the 17 items, effect sizes for within-individual associations tended

to rank similarly to between-individual level associations, with a Spearman correlation of .73.

Table 4. *Bivariate associations of exercising quantity with personality characteristics in Sample 1.*

	FE	St. Er	LCI	UCI	SD	OR
Neuroticism	*-0.08*	*0.12*	*-0.31*	*0.16*	*0.44*	*0.92*
Neuroticism (A)	*-0.53*	*0.26*	*-1.04*	*-0.04*		*0.59*
Worried	-0.07	0.11	-0.29	0.14	0.36	0.93
Worried (A)	-0.53	0.26	-1.08	-0.02		0.59
Angry	0.02	0.13	-0.24	0.27	0.51	1.02
Angry (A)	-0.46	0.24	-0.94	0.01		0.63
Depressed	-0.22	0.11	-0.46	0.00	0.38	0.80
Depressed (A)	-0.45	0.26	-0.97	0.05		0.64
Guilty	-0.12	0.08	-0.28	0.04	0.17	0.88
Guilty (A)	-0.24	0.27	-0.76	0.28		0.78
Self-conscious	-0.03	0.10	-0.24	0.17	0.34	0.97
Self-conscious (A)	-0.71	0.24	-1.19	-0.26		0.49
Frustrated	-0.06	0.08	-0.22	0.11	0.21	0.94
Frustrated (A)	-0.29	0.24	-0.79	0.19		0.75
Emotional control	-0.11	0.09	-0.29	0.06	0.22	0.89
Emotional control (A)	-0.23	0.28	-0.76	0.33		0.80
Extraversion	*0.66*	*0.15*	*0.36*	*0.98*	*0.62*	*1.94*
Extraversion (A)	*0.64*	*0.27*	*0.11*	*1.19*		*1.90*
Outgoing	0.43	0.11	0.21	0.66	0.36	1.54
Outgoing (A)	0.38	0.26	-0.14	0.90		1.46
Energetic	0.67	0.14	0.41	0.95	0.55	1.96
Energetic (A)	0.66	0.24	0.17	1.13		1.93
Adventurous	0.42	0.15	0.14	0.72	0.62	1.53
Adventurous (A)	0.82	0.25	0.35	1.35		2.27
Happy	0.37	0.10	0.17	0.55	0.26	1.44
Happy (A)	0.45	0.25	-0.05	0.96		1.57
Conscientious	*0.41*	*0.10*	*0.20*	*0.60*	*0.31*	*1.50*
Conscientious (A)	*0.56*	*0.25*	*0.06*	*1.04*		*1.76*
Achieved goals	0.35	0.10	0.15	0.56	0.32	1.42
Achieved goals (A)	0.55	0.27	-0.01	1.09		1.73
Organized	0.30	0.12	0.08	0.53	0.42	1.35
Organized (A)	0.46	0.27	-0.09	1.00		1.58
Ambitious	0.29	0.10	0.09	0.49	0.28	1.34
Ambitious (A)	0.38	0.26	-0.15	0.88		1.46
Self-disciplined	0.27	0.09	0.09	0.43	0.20	1.30
Self-disciplined (A)	0.52	0.24	0.05	0.99		1.68
Focused	0.41	0.12	0.18	0.65	0.44	1.51
Focused (A)	0.61	0.23	0.15	1.09		1.85

NOTE: Aggregate trait scores are in italic. A = association for within-individual average score. FE= fixed (average) effect; St. Err = standard error of the fixed effect; LCI = 2.5% credible interval; UCI = 97.5% credible interval; SD = standard deviation of random effects; OR = odds ratio. Emotional control indicates lack of emotional control.

Table 5. *Bivariate associations of exercising quantity with personality characteristics in Sample 2.*

	FE	St. Er	LCI	UCI	SD	OR
Neuroticism	*-0.14*	*0.08*	*-0.30*	*0.02*	*0.30*	*0.87*
Neuroticism (A)	*-0.01*	*0.17*	*-0.33*	*0.32*		*0.99*
Worried	-0.07	0.08	-0.23	0.08	0.31	0.93
Worried (A)	-0.10	0.17	-0.43	0.24		0.91
Angry	-0.06	0.07	-0.21	0.07	0.19	0.94
Angry (A)	-0.03	0.17	-0.37	0.31		0.97
Depressed	-0.23	0.08	-0.40	-0.07	0.35	0.80
Depressed (A)	-0.09	0.17	-0.44	0.26		0.91
Guilty	-0.14	0.07	-0.27	-0.01	0.13	0.87
Guilty (A)	0.00	0.15	-0.29	0.31		1.00
Self-conscious	0.17	0.07	0.03	0.31	0.31	1.19
Self-conscious (A)	0.21	0.16	-0.11	0.54		1.24
Frustrated	-0.17	0.08	-0.32	-0.03	0.29	0.85
Frustrated (A)	0.05	0.17	-0.28	0.39		1.05
Emotional control	-0.23	0.07	-0.37	-0.09	0.24	0.80
Emotional control (A)	-0.12	0.17	-0.47	0.23		0.88
Extraversion	*0.59*	*0.10*	*0.40*	*0.79*	*0.54*	*1.80*
Extraversion (A)	*0.35*	*0.16*	*0.03*	*0.68*		*1.41*
Outgoing	0.35	0.09	0.18	0.52	0.40	1.42
Outgoing (A)	0.23	0.16	-0.08	0.55		1.26
Energetic	0.76	0.12	0.52	1.00	0.67	2.13
Energetic (A)	0.44	0.18	0.10	0.79		1.56
Adventurous	0.37	0.08	0.22	0.53	0.33	1.45
Adventurous (A)	0.41	0.16	0.11	0.73		1.51
Happy	0.29	0.08	0.13	0.46	0.34	1.34
Happy (A)	0.10	0.17	-0.22	0.43		1.10
Friendly	0.28	0.08	0.13	0.45	0.33	1.33
Friendly (A)	0.21	0.16	-0.11	0.53		1.23
Conscientious	*0.56*	*0.07*	*0.42*	*0.71*	*0.25*	*1.74*
Conscientious (A)	*0.54*	*0.15*	*0.23*	*0.85*		*1.71*
Achieved goals	0.48	0.07	0.34	0.63	0.20	1.61
Achieved goals (A)	0.35	0.16	0.03	0.67		1.41
Organized	0.34	0.08	0.19	0.50	0.31	1.40
Organized (A)	0.39	0.15	0.09	0.70		1.47
Ambitious	0.48	0.07	0.34	0.63	0.20	1.62
Ambitious (A)	0.41	0.16	0.10	0.75		1.51
Self-disciplined	0.37	0.07	0.23	0.52	0.25	1.45
Self-disciplined (A)	0.56	0.15	0.27	0.84		1.74
Focused	0.34	0.07	0.22	0.48	0.19	1.41
Focused (A)	0.52	0.15	0.21	0.80		1.67

NOTE: Aggregate trait scores are in italic. A = association for within-individual average score. FE= fixed (average) effect; St. Err = standard error of the fixed effect; LCI = 2.5% credible interval; UCI = 97.5% credible interval; SD = standard deviation of random effects; OR = odds ratio. Emotional control indicates lack of emotional control.

Table 6. *Bivariate associations of walking/cycling quantity with personality characteristics in Sample 2.*

	FE	St. Er	LCI	UCI	SD	OR
Neuroticism	*0.03*	*0.06*	*-0.09*	*0.15*	*0.36*	*1.03*
Neuroticism (A)	*0.08*	*0.13*	*-0.17*	*0.34*		*1.09*
Worried	0.06	0.06	-0.05	0.18	0.27	1.06
Worried (A)	0.02	0.12	-0.23	0.26		1.02
Angry	0.04	0.05	-0.06	0.13	0.21	1.04
Angry (A)	0.06	0.12	-0.18	0.30		1.06
Depressed	-0.07	0.05	-0.17	0.03	0.24	0.94
Depressed (A)	0.09	0.13	-0.16	0.34		1.09
Guilty	-0.12	0.05	-0.22	-0.02	0.22	0.89
Guilty (A)	0.13	0.12	-0.10	0.36		1.14
Self-conscious	0.21	0.07	0.08	0.35	0.41	1.23
Self-conscious (A)	0.16	0.13	-0.09	0.41		1.17
Frustrated	0.04	0.06	-0.08	0.16	0.35	1.04
Frustrated (A)	0.06	0.13	-0.19	0.32		1.07
Emotional control	-0.15	0.05	-0.26	-0.05	0.24	0.86
Emotional control (A)	0.01	0.12	-0.23	0.25		1.01
Extraversion	*0.45*	*0.06*	*0.32*	*0.57*	*0.35*	*1.57*
Extraversion (A)	*0.20*	*0.12*	*-0.04*	*0.45*		*1.22*
Outgoing	0.34	0.05	0.23	0.44	0.25	1.40
Outgoing (A)	0.19	0.12	-0.05	0.43		1.21
Energetic	0.47	0.06	0.34	0.60	0.37	1.60
Energetic (A)	0.24	0.13	-0.01	0.49		1.27
Adventurous	0.36	0.06	0.25	0.47	0.28	1.43
Adventurous (A)	0.22	0.12	-0.03	0.46		1.24
Happy	0.17	0.06	0.05	0.28	0.32	1.19
Happy (A)	0.04	0.12	-0.19	0.28		1.05
Friendly	0.24	0.05	0.14	0.35	0.24	1.28
Friendly (A)	0.06	0.12	-0.17	0.29		1.06
Conscientious	*0.44*	*0.06*	*0.31*	*0.55*	*0.35*	*1.55*
Conscientious (A)	*0.26*	*0.12*	*0.03*	*0.50*		*1.30*
Achieved goals	0.36	0.05	0.26	0.46	0.25	1.44
Achieved goals (A)	0.14	0.12	-0.09	0.38		1.15
Organized	0.33	0.05	0.23	0.44	0.25	1.40
Organized (A)	0.19	0.12	-0.04	0.42		1.21
Ambitious	0.34	0.06	0.23	0.45	0.29	1.40
Ambitious (A)	0.32	0.12	0.09	0.56		1.37
Self-disciplined	0.27	0.06	0.16	0.38	0.29	1.31
Self-disciplined (A)	0.22	0.11	0.01	0.45		1.25
Focused	0.24	0.05	0.14	0.35	0.26	1.27
Focused (A)	0.18	0.12	-0.06	0.41		1.19

NOTE: Aggregate trait scores are in italic. A = association for within-individual average score. FE= fixed (average) effect; St. Err = standard error of the fixed effect; LCI = 2.5% credible interval; UCI = 97.5% credible interval; SD = standard deviation of random effects; OR = odds ratio. Emotional control indicates lack of emotional control.

When the three FFM traits were allowed to *simultaneously* predict exercising, within-individual variability in Neuroticism and Extraversion had positive links with credible intervals that did not span zero in both Samples 1 and 2, and this was also the case for both within- and between-individual level associations for Conscientiousness in Sample 2; for within-individual variance in Conscientiousness the credible intervals marginally spanned zero in Sample1 (Tables 7 to 8). At the level of items, only the within-individual level association for being energetic converged across samples in terms of having credible intervals that did not span zero; this item aside, the Spearman correlation of within-individual association effect sizes across the remaining 15 overlapping items in the two samples was -.02. Walking/cycling was positively associated with within-individual variability in all domains as well as with being self-conscious, energetic, adventurous, organized and having achieved ones goals (Table 9). Overall, thus, the associations were most consistent for Extraversion and, in particular, its item referring to feeling energetic, whereas multivariable models also consistently revealed a suppression effect for Neuroticism. Thus, other FFM traits being equal, when participants felt more neurotic and extraverted (and energetic in particular) than usual, they were also likely to have exercised and walked/cycled more, and the effect also tended to be present for Conscientiousness.

Again, we formally assessed the degree to which the associations at within- and between-individual levels of analyses converged by calculating the Spearman correlations between corresponding item-level effect sizes. The correlations were -.24, .09 and .06, respectively for exercising in Samples 1 and 2 and for walking/cycling in Sample 2, suggesting that the associations at the two levels of analyses no longer converged when multiple characteristics were simultaneously used as predictors of activity. Notably, there were almost no “significant” between-individual associations for neither activity variables in

multivariable models. This may be caused by multi-collinearity among the traits at this level of analyses: for example, the individual-level average scores of the three FFM traits had inter-correlations ranging from |.43| to |.71| in Samples 1 and 2. Nturally, there were also substantial correlations among items, because many of them were designed to measure the same traits. As a result, the results of multivariable models may need to be interpreted cautiously.

Table 7. *Associations of exercising quantity with personality characteristics in Sample 1: Results from multivariable models*

	FE	St. Er	LCI	UCI	SD	OR
Neuroticism	*0.27*	*0.14*	*0.01*	*0.55*	*0.51*	*1.31*
Neuroticism (A)	*-0.32*	*0.37*	*-1.06*	*0.37*		*0.73*
Worried	0.21	0.18	-0.14	0.57	0.67	1.23
Worried (A)	-1.50	1.39	-4.46	1.17		0.22
Angry	0.06	0.17	-0.27	0.39	0.55	1.06
Angry (A)	-0.58	0.93	-2.45	1.28		0.56
Depressed	-0.06	0.17	-0.42	0.25	0.45	0.94
Depressed (A)	0.37	1.39	-2.56	3.08		1.45
Guilty	-0.02	0.11	-0.24	0.20	0.23	0.98
Guilty (A)	1.09	1.36	-1.62	3.82		2.97
Self-conscious	0.07	0.10	-0.12	0.27	0.17	1.07
Self-conscious (A)	-0.48	0.79	-2.26	1.04		0.62
Frustrated	0.24	0.12	0.01	0.47	0.16	1.27
Frustrated (A)	0.44	1.03	-1.51	2.65		1.55
Emotional control	0.00	0.13	-0.26	0.24	0.31	1.00
Emotional control (A)	0.03	0.74	-1.50	1.49		1.03
Extraversion	*0.72*	*0.18*	*0.37*	*1.08*	*0.74*	*2.05*
Extraversion (A)	*0.36*	*0.45*	*-0.51*	*1.23*		*1.43*
Outgoing	0.15	0.13	-0.10	0.40	0.29	1.16
Outgoing (A)	-0.45	1.05	-2.68	1.61		0.64
Energetic	0.70	0.20	0.32	1.10	0.72	2.01
Energetic (A)	-0.80	1.10	-3.13	1.29		0.45
Adventurous	0.05	0.14	-0.22	0.35	0.43	1.05
Adventurous (A)	2.20	1.60	-0.82	5.57		9.03
Happy	0.21	0.14	-0.07	0.50	0.30	1.23
Happy (A)	-0.94	1.34	-3.77	1.75		0.39
Conscientious	*0.19*	*0.11*	*-0.01*	*0.40*	*0.22*	*1.21*
Conscientious (A)	*0.23*	*0.53*	*-0.86*	*1.25*		*1.26*
Achieved goals	0.21	0.14	-0.07	0.50	0.36	1.23
Achieved goals (A)	0.25	1.35	-2.17	3.20		1.28
Organized	-0.02	0.16	-0.33	0.30	0.47	0.98
Organized (A)	-1.07	1.66	-4.64	2.01		0.34
Ambitious	-0.16	0.12	-0.40	0.07	0.18	0.85
Ambitious (A)	-0.52	1.31	-3.17	2.13		0.59
Self-disciplined	0.00	0.13	-0.25	0.25	0.27	1.00
Self-disciplined (A)	1.37	1.27	-1.24	3.85		3.94
Focused	0.19	0.13	-0.06	0.45	0.29	1.21
Focused (A)	0.81	1.36	-1.94	3.58		2.25

NOTE: Aggregate trait scores are in italic. A = association for within-individual average score. FE= fixed (average) effect; St. Err = standard error of the fixed effect; LCI = 2.5% credible interval; UCI = 97.5% credible interval; SD = standard deviation of random effects; OR = odds ratio. Emotional control indicates lack of emotional control.

Table 8. *Associations of exercising quantity with personality characteristics in Sample 2: Results from multivariable models*

	FE	St. Er	LCI	UCI	SD	OR
Neuroticism	*0.22*	*0.09*	*0.04*	*0.39*	*0.30*	*1.25*
Neuroticism (A)	*0.29*	*0.20*	*-0.10*	*0.70*		*1.34*
Worried	0.04	0.10	-0.16	0.24	0.44	1.04
Worried (A)	-0.74	0.46	-1.63	0.17		0.48
Angry	0.09	0.09	-0.09	0.26	0.19	1.09
Angry (A)	-0.21	0.55	-1.31	0.85		0.81
Depressed	-0.07	0.09	-0.24	0.11	0.22	0.93
Depressed (A)	-0.32	0.56	-1.39	0.79		0.73
Guilty	0.00	0.08	-0.15	0.15	0.14	1.00
Guilty (A)	0.33	0.40	-0.46	1.12		1.39
Self-conscious	0.27	0.09	0.08	0.45	0.39	1.31
Self-conscious (A)	0.46	0.38	-0.29	1.21		1.58
Frustrated	-0.05	0.09	-0.22	0.12	0.19	0.95
Frustrated (A)	0.31	0.57	-0.82	1.44		1.36
Emotional control	-0.05	0.08	-0.21	0.12	0.16	0.95
Emotional control (A)	0.21	0.39	-0.56	0.98		1.23
Extraversion	*0.51*	*0.12*	*0.29*	*0.75*	*0.60*	*1.67*
Extraversion (A)	*0.09*	*0.23*	*-0.38*	*0.53*		*1.09*
Outgoing	-0.02	0.10	-0.20	0.19	0.33	0.98
Outgoing (A)	-0.12	0.44	-0.99	0.75		0.89
Energetic	0.67	0.15	0.39	0.97	0.84	1.95
Energetic (A)	0.03	0.43	-0.80	0.86		1.03
Adventurous	0.08	0.08	-0.09	0.24	0.25	1.08
Adventurous (A)	0.59	0.37	-0.12	1.33		1.80
Happy	0.02	0.09	-0.15	0.21	0.21	1.02
Happy (A)	-0.47	0.56	-1.57	0.66		0.63
Friendly	-0.03	0.09	-0.21	0.15	0.25	0.97
Friendly (A)	0.27	0.51	-0.74	1.26		1.31
Conscientious	*0.44*	*0.08*	*0.29*	*0.59*	*0.18*	*1.55*
Conscientious (A)	*0.59*	*0.21*	*0.18*	*1.01*		*1.80*
Achieved goals	0.30	0.10	0.12	0.50	0.27	1.35
Achieved goals (A)	0.19	0.41	-0.60	0.99		1.21
Organized	0.01	0.09	-0.17	0.20	0.31	1.01
Organized (A)	-0.39	0.48	-1.36	0.55		0.68
Ambitious	0.27	0.09	0.10	0.44	0.15	1.31
Ambitious (A)	-0.29	0.38	-1.05	0.45		0.75
Self-disciplined	0.14	0.09	-0.03	0.32	0.23	1.15
Self-disciplined (A)	0.72	0.43	-0.11	1.59		2.05
Focused	-0.02	0.09	-0.19	0.16	0.25	0.98
Focused (A)	0.21	0.53	-0.85	1.22		1.23

NOTE: Aggregate trait scores are in italic. A = association for within-individual average score. FE= fixed (average) effect; St. Err = standard error of the fixed effect; LCI = 2.5% credible interval; UCI = 97.5% credible interval; SD = standard deviation of random effects; OR = odds ratio. Emotional control indicates lack of emotional control.

Table 9. *Associations of walking/cycling quantity with personality characteristics in Sample 2: Results from multivariable models*

	FE	St. Er	LCI	UCI	SD	OR
Neuroticism	*0.33*	*0.07*	*0.19*	*0.47*	*0.37*	*1.39*
Neuroticism (A)	*0.24*	*0.15*	*-0.06*	*0.55*		*1.27*
Worried	0.12	0.06	0.00	0.23	0.17	1.13
Worried (A)	-0.04	0.30	-0.64	0.55		0.96
Angry	0.07	0.06	-0.05	0.19	0.18	1.07
Angry (A)	-0.20	0.36	-0.90	0.50		0.82
Depressed	0.01	0.06	-0.11	0.13	0.13	1.01
Depressed (A)	0.37	0.38	-0.36	1.11		1.45
Guilty	-0.07	0.06	-0.19	0.05	0.20	0.93
Guilty (A)	0.23	0.28	-0.31	0.78		1.26
Self-conscious	0.25	0.06	0.13	0.38	0.30	1.28
Self-conscious (A)	0.14	0.26	-0.37	0.64		1.15
Frustrated	0.11	0.07	-0.02	0.24	0.26	1.12
Frustrated (A)	-0.03	0.39	-0.77	0.75		0.97
Emotional control	-0.06	0.06	-0.17	0.05	0.16	0.94
Emotional control (A)	-0.21	0.26	-0.73	0.29		0.81
Extraversion	*0.43*	*0.07*	*0.28*	*0.57*	*0.33*	*1.54*
Extraversion (A)	*0.14*	*0.17*	*-0.20*	*0.48*		*1.15*
Outgoing	0.13	0.06	0.00	0.25	0.18	1.14
Outgoing (A)	0.14	0.31	-0.44	0.74		1.15
Energetic	0.29	0.07	0.16	0.42	0.28	1.34
Energetic (A)	0.15	0.31	-0.45	0.77		1.16
Adventurous	0.17	0.06	0.06	0.29	0.16	1.19
Adventurous (A)	-0.08	0.24	-0.55	0.38		0.92
Happy	-0.03	0.07	-0.18	0.11	0.26	0.97
Happy (A)	0.32	0.40	-0.45	1.12		1.38
Friendly	0.07	0.07	-0.07	0.19	0.21	1.07
Friendly (A)	-0.41	0.37	-1.13	0.31		0.66
Conscientious	*0.37*	*0.06*	*0.25*	*0.50*	*0.28*	*1.45*
Conscientious (A)	*0.25*	*0.17*	*-0.07*	*0.59*		*1.28*
Achieved goals	0.23	0.07	0.10	0.37	0.23	1.26
Achieved goals (A)	-0.04	0.27	-0.56	0.49		0.96
Organized	0.16	0.06	0.04	0.28	0.14	1.00
Organized (A)	0.04	0.33	-0.63	0.67		1.00
Ambitious	0.09	0.06	-0.03	0.21	0.15	1.00
Ambitious (A)	0.32	0.26	-0.19	0.82		1.00
Self-disciplined	0.05	0.06	-0.07	0.18	0.15	1.05
Self-disciplined (A)	0.31	0.29	-0.26	0.89		1.36
Focused	-0.09	0.06	-0.21	0.03	0.15	0.91
Focused (A)	-0.25	0.36	-0.95	0.45		0.78

NOTE: Aggregate trait scores are in italic. A = association for within-individual average score. FE= fixed (average) effect; St. Err = standard error of the fixed effect; LCI = 2.5% credible interval; UCI = 97.5% credible interval; SD = standard deviation of random effects; OR = odds ratio. Emotional control indicates lack of emotional control.

Discussion

This study focused on associations of three FFM personality domains—Neuroticism, Extraversion and Conscientiousness—and their items with physical activity at both within- and between-individual levels of variability. That is, in addition to individual differences, which is the most common level of analyses in personality research, we investigated whether feeling, say, more adventurous than usual at a particular point of time was linked with having done more or less exercise/walking/cycling at nearly the same time. While a number of studies have linked individual differences in these three FFM traits with physical activity (Rhodes & Smith, 2006), less attention has been paid on links with within-individual variability, which is known to be pervasive and sizable (Fleeson, 2007; Sherman et al., 2015). It is argued here that associations of personality traits with external variables such as exercising can help to establish within-individual personality variability as substantive variance (i.e., personality states) on one hand, and that such associations may help to better understand how personality characteristics are linked with activity—an aspect of lifestyle with important public health implications (Blair, 2009).

Structure of within-individual variability in personality manifestations

Within-individual variability in personality items was patterned along the lines of FFM, which was not surprising, given that the personality measure was designed on the basis of this model. Of course, associations between variables, including structural models that arise from such associations, can be very different at within- and between-individual levels of analysis (Kievit et al., 2013), but this appears not to be the case of the considered personality manifestations. This patterning justified the use of FFM trait scores as summaries of within-individual variability in personality. However, there was also evidence for the measurement

models for FFM traits not being invariant across participants, suggesting that individuals may differ in their personality structures—even if their "average structure" is reminiscent of that of individual differences. This finding is consistent with a previous study on the topic (Borkenau & Ostendorf, 1998), but also suggests that the trait-scores and their associations with exercising should be interpreted cautiously and at least confirmed or qualified by item-level analyses.

Personality characteristics and physical activity

The associations between personality characteristics and physical activity depended on whether the analyses were carried out for a single characteristic at the time (what we called *bivariate* models) or by simultaneously considering multiple characteristics (what we called *multivariable* models). In the bivariate models, a very consistent pattern emerged across the two independent samples and types of physical activity. In both samples, when people where more extraverted and conscientious then usual, they reported having exercised more, and the same pattern of appeared when activity was operationalized as walking/cycling instead of exercising. Also, the associations generalized to all items of the domains.

Moreover, this pattern of association at the level of within-individual variability tended to be similar to that observed at the level of individual differences. People who, on average, reported higher levels of Extraversion and Conscientiousness also tended to report more activity, although the association fell short of “significance” (credible intervals spanning zero) for the Extraversion-walking/cycling combination. The similarity in the findings at the two levels of analyses was also observed in the analyses of item-specific associations, although some associations were not “significant”. This finidng may not be surprising, but it is not trivial, because there is no a priori reason to assume that the associations would be

similar (Kanning et al., 2013; Kievit et al., 2013). In principle, it could have been that generally more extraverted individuals are also generally more active, but mostly at times when they have been *less* extraverted than is usual for them (e.g., to regain their level of extraversion or overcome boredom), yielding a *negative* within-individual association.

These replicable findings are clearly consistent with within-individual variability in personality characteristics reflecting something real in how people differ from themselves over time. When people are more active than usual, they appear to consistently report somewhat different personality characteristic levels compared to moments when they have been less active, and these differences appear to follow the pattern of how more active people differ from their less active peers. If individuals' variability over time in how they respond to personality items reflected only measurement error or otherwise stochastic processes, such a replicable pattern would have been unlikely to emerge.

However, the pattern of findings became different when all FFM domains where simultaneously related to activity variables. Across both samples and forms of activity, Extraversion and Conscientiousness mostly retained their positive links with activity at the level of within-individual variability, but, surprisingly, they become accompanied by a consistent *positive* association with Neuroticism. Moreover, most of the between-individual associations were substantially weakened. At this point, it is very difficult to verify whether the positive correlation between Neuroticism and activity reflects a veridical association—other considered traits equal, activity truly contributes to, or is partially caused by, the combination of characteristics aggregated into our operationalization of Neuroticism—or is simply a statistical artefact due to relatively high (up to .71) correlations among the FFM traits, observed in this sample for within-individual variability and elsewhere for between-individual variance (van der Linden et al., 2010). In order to shed light on this question,

measures that better disentangle these FFM traits should be employed. Unfortunately, such measures are hard to come by (cf. Bäckström, Björklund, & Larsson, 2014).

Across items, only one association was consistent in the multivariable models: reports of exercising or walking/cycling were always associated with feeling more-than-usual energetic. This suggests that subjectively perceived energy level is something that is particularly sensitive to physical activity—or contributes to it. This is, of course, not surprising, given that being objectively energetic is part of being physically active. However, despite proably being trivial, the association is consistent with within-individual variability in self-reported personality characteristics reflecting meaningful variance.

Implications

Of course, it would be naïve to expect one single study and a few significant associations (or lack of them thereof) to settle the question of whether observable within-individual variability in personality characteristics reflects substantive and useful variability as opposed to simply nuisance variance. Establishing the meaningfulness of within-individual variance requires a thorough and theoretically motivated research program. However, it seems fair to suggest that this study represents one step in this program. It should also be noted that the question of *whether* within-individual variance reflects meaningful processes as opposed to just some form of noise is a gross simplification. The question should more properly be conceptualized as estimating the *degree* of one *vs* the other. In fact, approaches that allow quantifying the levels of measurement error in time-series data have begun to emerge (e.g., Schuurman, Houtveen, & Hamaker, 2015).

Do these findings contribute to our understanding of how personality characteristics are linked with physical exercise or activity in general? Potentially yes. These findings do

suggest that it is not the case that only relatively stable individual differences in personality traits are linked—and maybe predispose people—to either being more or less physically active. Individuals' ups and downs in one or more personality characteristics, which may be related to identifiable environmental factors (Fleeson, 2007; Sherman et al., 2015) and could thereby possibly be targeted for change, are also linked—and possibly either predispose or react, or both—to activity. That is, among other things, the findings may suggest that levels of activity constitute one factor contributing to personality variance or, alternatively, manipulating people's personality states may, in principle, make it possible to increase the likelihood that they start exercising.

Strengths and limitations

The primary strengths of the study include the use of two independent samples and two operationalizations of physical activity, which allowed us to internally replicate the findings—with a considerable degree of success. A strength of the analytical design was the ability to quantify associations at two conceptually independent levels of analysis—variance within- and between individuals—and directly compare the findings. At least when the highly inter-correlated traits were not used simultaneously to predict activity, we could demonstrate that the two levels of analyses yielded very consistent findings.

The present study also has a number of limitations. First, although the effective number of observations (more than a thousand in both samples and 3,516 in total across the two samples) was large enough to allow for detecting relatively small associations—which are generally to be expected in personality-behavior research—the sample size was modest for studying between-individual differences. This also means, that the findings may not be well generalizable beyond the present samples, although it must be noted that the observed level

of replication somewhat alleviates this concern. Second, physical activity (exercising) was based on self-reports, which may not only be inaccurate due to individuals imperfect memory but may also be systematically biased. Future studies linking personality variability to exercising or activity should substitute or supplement self-report based measures of activity with objective measurements. Third, it must noted that physical exercising may have a fundamental difference from personality characteristics as it may have more constrained natural boundaries in terms of how it can vary over time. Most individuals exercise no more than once a day and only for a limited period of time—often even much less. As a result, the exercising variable can be very skewed, which constrains researchers ability to detect its links with other variables. Perhaps objective measurements of physical activity in naturalistic settings would help to mitigate this problem to some extent as variability in activity is detected in greater detail. However, our second operationalization of activity—walking/cycling—pertained to more common forms activity and, accordingly, had a less skewed distribution. Fourth, an important limitation of this study and other studies that only model contemporaneous associations between time series-based variables is the assumption that consecutive measurements are independent from each other. Clearly, they are not as at least personality characteristics are likely to display autocorrelations. For example, when something has triggered a person to feel depressed, this state is likely to last longer than a few hours. This may be less of a problem for variables such as exercising, because people mostly exercise only once a day or less.

It might be argued that within-individual difference in reported personality states do not report changes in personality per se, but only in the self-perceptions of personality. As a result, physical activity may be linked with how individual perceive their personality at the time, but not with personality variance as such. This may be true, but the present findings are

unable to speak to this issue. Disentangling real personality change from self-perceived change—to the extent that the distinction exists in the first place—would require measurnig personality characteristics in an objective manner.

Conclusions

By employing two independent samples and two operationalizations of physical activity, the present study addressed within- and between-individual variability in personality characteristics and its links with physical exercising. There was consistent evidence for more self-reported activity being linked with a number of positive personality characteristics, in particular feeling energetic. By linking within-individual variability in personality characteristics with potentially relevant contextual variables, the study constitutes one step in the program of establishing within-individual variance as reflecting meaningful psychological processes.

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