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Conscientiousness, hair cortisol concentration, and health behaviour in older men and women

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ABSTRACT

Conscientious is associated with greater longevity and other favourable health outcomes, but the processes underlying these links are poorly understood. Health behaviours such as physical activity and avoidance of smoking and excessive alcohol consumption may contribute, but direct associations with neuroendocrine and inflammatory processes may also be relevant. We tested the associations between conscientiousness and hair cortisol concentration in 2318 older men and women (mean age 66.2 years) from the English Longitudinal Study of Ageing. Conscientiousness was positively associated with physical activity and fruit and vegetable consumption, and negatively related to alcohol intake, sedentary behaviour, body mass index and depressive symptoms (all $p < 0.001$). We found an inverse association between conscientiousness and hair cortisol concentration that was independent of age, sex, education and wealth ($\beta = -0.053$, $p = 0.012$), and the relationship remained significant with additional adjustment for health behaviour and depressive symptoms ($\beta = -0.048$, $p = 0.025$). The observation that greater conscientiousness was correlated with lower hair cortisol indicates that this trait might impact central nervous regulation of hypothalamic-pituitary-adrenocortical function, with effects that are possibly advantageous for health.

1. Introduction

Conscientiousness is a trait characterized by self-discipline, dependability, and planfulness coupled with tendencies to follow socially prescribed norms and to be goal-directed (Roberts et al., 2009). Conscientiousness appears to be an important determinant of longevity among older adults (Kern and Friedman, 2008). For example, in an analysis of the Health and Retirement Study (HRS), conscientiousness predicted increased longevity after adjustment for age, gender, education, cognitive functioning, and reported health state (Hill et al., 2011). A large investigation aggregating seven cohort studies from Europe, the USA and Australia showed that low conscientiousness predicted increased mortality after age, sex, other personality traits and health behaviours were taken into account (Jokela et al., 2013). Conscientiousness was also associated with reduced mortality in the Midlife in the United States (MIDUS) study, mediated in part by low alcohol consumption, less smoking, and lower waist circumference (Turiano et al., 2015). Similar findings have been reported from the Whitehall II cohort study (Hagger-Johnson et al., 2012). Deary et al. (2008) reported that participants who were rated as dependable in childhood were more likely to be alive at age 65 years. Conscientiousness is also related to better health, including reduced incidence of diabetes, more positive self-rated health, and fewer depressive symptoms (Hakulinen et al., 2015a; Jokela et al., 2014; Turiano et al., 2012).

One pathway relating conscientiousness to favourable health outcomes may be lifestyle choice. As noted above, associations between conscientiousness and mortality are mediated in part by health behaviour (Jokela et al., 2013; Turiano et al., 2015). Conscientiousness has been linked with reduced involvement in detrimental health behaviours such as smoking, heavy alcohol consumption, illegal substance use and risk-taking activity, while being positively correlated with physical activity, prudent diet, adherence to medication and other protective behaviours (Allen et al., 2017; Bogg and Roberts, 2004; Hakulinen et al., 2015b,c; Molloy et al., 2014; Strickhouser et al., 2017; Sutin et al., 2016a).

A second possibility is that there are direct psychobiological processes linking conscientiousness with health outcomes. Conscientiousness is associated with reduced exposure to situations that elicit stress and with more effective coping with stressors (Bogg and Roberts, 2013; Connor-Smith and Flachsbart, 2007). There is also evidence that greater conscientiousness is correlated with reduced inflammation, as indexed by C-reactive protein or interleukin (IL) 6 in the

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HRS, MIDUS, the National Longitudinal Study of Adolescent Health in the USA, and a study in Sardinia (Elliot et al., 2017; Luchetti et al., 2014; Sutin et al., 2010; Turiano et al., 2013). Cortisol is a key biomarker relating psychosocial factors with health, since it is sensitive to stress and is implicated in a range of cardiometabolic, inflammatory, neural and endocrine disorders (Girod and Brotman, 2004; McEwen, 2007). However, evidence relating cortisol with conscientiousness is limited (Bibbey et al., 2013; Bogg and Slatcher, 2015; Nater et al., 2010).

Hair cortisol concentration has emerged over recent years as an indicator of tonic cortisol output over several weeks, and is not subject to the acute variations related to momentary events and moods that influence salivary levels (Stalder and Kirschbaum, 2012; Stalder et al., 2017). It may therefore be particularly suitable for investigations of a relatively stable construct such as conscientiousness. Accordingly, we analysed the association between conscientiousness and hair cortisol concentration in 2318 participants in the English Longitudinal Study of Ageing (ELSA), a nationally representative sample of men and women aged 50 and older living in England. We hypothesized that conscientiousness would be inversely related to hair cortisol concentration. Cortisol in hair has also been associated with health behaviours such as smoking and physical activity (Wosu et al., 2013), raising the possibility that relationships with conscientiousness are driven by differences in health behaviour. We therefore also tested with relationship between cortisol and health behaviours, and evaluated whether associations with conscientiousness remained robust after health behaviours had been taken into account. Depressive symptoms are also potential confounders, since they are associated with elevations of hair cortisol concentration (Abell et al., 2016), so were included in the analytic models.

2. Method

2.1. Participants

Data were analysed from the English Longitudinal Study of Ageing (ELSA), a study of men and women aged 50 or more living in England that started in 2002 with an original sample of 12,099. Comparisons of the sociodemographic characteristics of participants against the national census show that the sample was representative of the English population (Steptoe et al., 2013). The study sample is periodically refreshed to maintain the age profile of the cohort. Conscientiousness was measured in 8755 of the 9090 participants in wave 5 (2010/11), while samples of hair were collected as part of a nurse visit to participants' homes in wave 6 of ELSA (2012/13). Of the 7699 individuals visited at home, hair samples were successfully collected from 5451; the remainder either had insufficient hair, a medical condition that precluded hair sampling, or refused to have their hair cut. There were insufficient funds to assay all hair samples, so it was decided to prioritise individuals who had participated in the maximum number of previous waves of data collection. Cortisol was assayed from 2583 individuals, and 2391 had data on both conscientiousness and hair cortisol, with 265 having missing data on key covariates. The main analyses of hair cortisol were therefore carried out on 2318 people. It has previously been shown that people who attend follow-up assessments over several years are likely to be younger more educated, wealthier and in better health than those who miss appointments (Steptoe et al., 2013). Consequently, participants in these analyses were significantly younger (means 66.20 vs 68.15 years, $p < 0.001$), better educated and wealthier ($p < 0.001$) than those who were excluded. They also had higher conscientiousness scores on average (means 2.32 vs 2.28, $p = 0.002$). ELSA was approved through the National Research Ethics System, and all participants gave informed consent.

2.2. Hair sample collection and analysis

Hair samples were obtained as part of the visit by a research nurse to participants' homes. A scalp hair strand of 3 cm was collected from the posterior vertex position by cutting the hair as close to the scalp as possible with fine medical scissors. These were placed onto aluminium foil, and stored in a dry, dark place before shipping to the Technische Universität Dresden, Germany. The wash procedure and steroid extraction were undertaken using high performance liquid chromatography– mass spectrometry (LC/MS), as described by Gao et al. (2016), with a minimum of 7.5 mg ± 0.2 mg of hair, cut from each 3 cm hair segment. Hair cortisol concentration was expressed in pg/mg. Based on an average monthly hair growth of around 1 cm, the scalp-nearest hair segment of 3 cm represents averaged cortisol accumulated over an approximate timespan of three months prior to sampling. Hair-specific factors that could affect hair cortisol concentration (washing frequency, hair colour and curvature, hair treatment) were assessed by self-report.

2.3. Conscientiousness

Conscientiousness was assessed using the Midlife Development Inventory (MIDI) Personality Scales, a set of measures have been used widely in previous cohort studies such as the Midlife in the United States (MIDUS) and Health and Retirement Study (HRS) (Lachman and Weaver, 1997). Participants were asked how much each of 26 adjectives described themselves on a scale ranging from 1 (*not at all*) to 4 (*a lot*). Four items (e.g. organized, responsible) contributed to the conscientiousness scale, and the Cronbach alpha for the scale in this study was 0.67.

2.4. Health behaviours

Smoking status was classified on the basis of current tobacco smoking. Alcohol was assessed by questions concerning the number of pints of beer, lager or cider, the number of glasses of wine, and the number of measures of spirits that the participant had consumed over the previous 7 days. These were summed to derive a measure of units of alcohol in the past week. Respondents were asked about the number of portions of vegetables and fruit that they ate on a typical day, using a validated measure (Cappuccio et al., 2003), with missing data from 44 respondents. Physical activity was assessed by asking participants about mild intensity (e.g. laundry, home repairs), moderate intensity (e.g. cleaning the car, walking at a moderate pace) and vigorous intensity (e.g. digging with a spade, cycling, aerobics) activity. Respondents indicated frequency of participation in four categories (hardly ever or never, one to three times per month, once per week, or more than once per week). The examples at different intensities were selected as being among the most commonly reported in previous UK-based population studies, and were categorized on the basis of metabolic equivalents (MET), with scores between 2–3.5, 3.5–6 and greater than 6 corresponding to mild, moderate and vigorous activity (Ainsworth et al., 2000). In the present analyses, we classified people as physically active if they reported moderate or vigorous activity once a week or more, and as sedentary if they reported no light, moderate or vigorous hardly ever or never.

2.5. Other variables

Educational attainment and wealth were assessed as indicators of socioeconomic position. Education was divided into five categories ranging from no qualifications to University graduate or higher. Wealth was derived from a detailed assessment of the participant's economic resources, and included financial, housing and physical wealth (such as land, business wealth and jewellery), but excluded pension wealth, and was divided into quintiles for the purposes of analysis. Wealth is a strong indicator of socioeconomic resources among older people (Banks

et al., 2003). It Depressive symptoms were measured using the 8-item Centre for Epidemiologic Studies Depression Scale (CES-D) as used in the HRS and other studies (Steffick, 2000), with higher scores indicating more depressive symptoms. Body mass index (BMI) was derived from measures of height and body weight made by research nurses in participants' homes in Wave 6 (2012/13), and was available for 1500 respondents.

2.6. Statistical analysis

Hair cortisol concentrations were skewed, so were log transformed before analysis. The scores for skew and kurtosis were 0.79 and 0.26 respectively. Associations between conscientiousness, depressive symptoms and health behaviours were analysed in separate linear regressions for continuously distributed variables (depressive symptoms, alcohol units, fruit and vegetable consumption) and logistic regressions for binary variables (smoking, vigorous/moderate activity and sedentary behaviour), adjusting for age and sex. Results are presented as standardized regression coefficients with standard errors (SE) for linear regressions, and odds ratios with 95% confidence intervals for logistic regressions, with the lowest conscientiousness score as the reference value. The relationships between hair cortisol and depressive symptoms and health behaviours were analysed in separate regressions involving each factor together with age, sex, education and wealth.

Associations between conscientiousness and hair cortisol concentration were analysed with multivariable linear regressions on the full sample of 2318, testing three models. In Model 1, hair cortisol concentration was regressed on conscientiousness with no covariates. Age, sex, education and wealth were included in model 2, while model 3 included the additional variables that were found to be associated with conscientiousness (depressive symptoms, alcohol intake, physical activity and sedentary behaviour). Fruit and vegetable consumption and BMI were not included in these analyses because they would reduce the sample size. We therefore carried out a second set of linear regressions on the reduced sample of 1471, including fruit and vegetable consumption and BMI in model 3. Results are presented as standardized regression coefficients with SE. Preliminary analysis indicated that hair treatments (dyeing, washing frequency, colouring) did not affect the associations between conscientiousness and cortisol concentration, so they were not included in the analytic models.

It is possible that the relationship between conscientiousness is altered by the presence of other personality factors. We therefore carried out a sensitivity analysis adding the other four factors of the 'big 5' personality constructs – neuroticism, extraversion, openness to experience and agreeableness – to the model. These factors were assessed using the same MIDI Personality Scales as conscientiousness.

Preliminary comparisons were made between people included and excluded from the analyses of hair cortisol. A total of 2583 had hair cortisol measures, but 225 had missing data on conscientiousness or key covariates. There were no differences in conscientiousness, cortisol concentration, age, or education between the groups, but 10.0% of men were not included in the analyses compared with 7.8% of women ($p = 0.040$). Additionally, wealth was greater among those included in the cortisol analyses ($p < 0.001$).

3. Results

The characteristics of participants are summarized in Table 1. Average age was 66.20 yrs, ranging from 52 to over 90, and nearly 60% of respondents were women. The majority had low educational attainment, and reported high levels of fruit and vegetable consumption and physical activity. There were 10.7% smokers, and the sample was overweight on average.

The regressions of conscientiousness on depressive symptoms, health behaviours, and BMI are shown in Table 2. Depressive symptoms showed a negative association with conscientiousness ($\beta = -0.190$, SE 0.02, $p < 0.001$), indicating that more conscientious respondents reported fewer depressive symptoms independently of age and sex. Consciousness was associated with healthier lifestyle choices, with more conscientious individuals being physically active, non-sedentary, drinking less alcohol, and eating more fruit and vegetables (all $p < 0.001$). They also had lower body weights ($p < 0.001$). The association between conscientiousness and smoking was negative but not statistically significant ($p = 0.074$). Hair cortisol concentration was positively related to sedentary behaviour ($\beta = 0.069$, SE 0.02, $p < 0.001$) and BMI ($\beta = 0.133$, SE 0.03, $p < 0.001$), and negatively correlated with physical activity ($\beta = -0.054$, SE 0.02, $p = 0.010$), but not with depressive symptoms or the other behaviours.

Table 3 summarizes the regressions of hair cortisol concentration on conscientiousness and other factors in the full sample. Model 1 confirms the inverse association between conscientiousness and hair cortisol ($\beta = -0.060$s.e. 0.021, $p = 0.004$), indicating that the concentration of cortisol in hair was lower in more conscientious participants. When age, sex, education, and wealth were added as co-variables (Model 2), the negative relationship remained ($\beta = -0.053$ (0.021), $p = 0.012$). Wealth also had an independent negative relationship with hair cortisol concentration ($p = 0.009$). Model 3 added depressive symptoms and health behaviours. The regression coefficient for conscientiousness was

Table 1
Characteristics of the study sample.

	N	Mean ± Std. Deviation	Frequency (%)
Conscientiousness (scale 0–3)	2318	2.32 ± 0.47	
Age (years)	2318	66.20 ± 7.30	
Sex (male)	2318		944 (40.7%)
(female)			1374 (59.3%)
Education (no qualifications)	2318		473 (20.4%)
(basic qualifications)			565 (24.4%)
(high school diploma)			405 (17.5%)
(some college)			378 (16.3%)
(graduate)			497 (21.4%)
Wealth (1 = lowest)	2318		448 (20.0%)
(2)			450 (20.0%)
(3)			449 (20.0%)
(4)			449 (20.0%)
(5 = highest)			449 (20.0%)
Hair cortisol concentration (log, pg/mg)	2318	0.92 ± 0.63	
Depressive symptoms	2318	1.27 ± 1.78	
Units of alcohol (per week)	2381	2.72 ± 5.35	
Fruit/Veg consumption (portions/day)	2274	5.16 ± 2.56	
BMI	1500	27.49 ± 5.41	
Vigorous/moderate activity (≥1/week)	2318		1580 (68.2%)
Sedentary activity	2318		81 (3.5%)
Current smoking	2318		248 (10.7%)

Table 2
Associations between conscientiousness and health behaviour. Standardized regression coefficient (standard error) or odds ratio (95% CI) adjusted for age and sex.

	Regression Coefficient (SE)	Odds Ratio (95% confidence intervals)	P
Depressive symptoms	−0.190 (0.020)		< 0.001
Smoking		0.78 (0.59–1.03)	0.074
Alcohol units per week	−0.013 (0.020)		< 0.001
Vigorous/moderate activity		1.80 (1.50–2.17)	< 0.001
Sedentary behaviour		0.57 (0.37–0.89)	< 0.001
Fruit and vegetable consumption	0.081 (0.021)		< 0.001
BMI	0.124 (0.026)		< 0.001

Table 3
Regressions on hair cortisol concentration Standardized regression coefficients (standard error).

	Model 1		Model 2		Model 3	
	B (s.e.)	p	B (s.e.)	P	B (s.e.)	p
Conscientiousness	−0.060 (0.021)	0.004	−0.053 (0.021)	0.012	−0.048 (0.21)	0.025
Age			−0.001 (0.021)	0.98	−0.003 (0.021)	0.87
Sex[a]			−0.012 (0.021)	0.56	−0.008 (0.022)	0.73
Education			0.009 (0.023)	0.69	0.015 (0.023)	0.53
Wealth			−0.058 (0.022)	0.009	−0.051 (0.023)	0.026
Depressive symptoms					−0.007 (0.022)	0.77
Alcohol consumption					0.015 (0.022)	0.48
Moderate/vigorous activity					−0.034 (0.022)	0.13
Sedentary activity					0.059 (0.022)	0.007

N = 2318.
[a] Reference category: men.

slightly reduced but remained significant ($\beta = -0.048$, $p = 0.025$). The other factors independently associated with higher hair cortisol concentration were lower wealth ($p = 0.026$) and sedentary behaviour ($p = 0.007$).

A second multivariable regression model included two further variables (fruit and vegetable consumption and BMI) in a reduced sample of 1471 (Table 4). The associations between conscientiousness and hair cortisol concentration were maintained in this smaller sample, and remained significant following multivariable adjustment ($\beta = -0.066$, $p = 0.015$). Neither wealth nor sedentary behaviour was independently associated with cortisol in model 3 in this reduced sample, but there was a strong positive relationship with BMI ($p < 0.001$). Notably, the regression coefficient for BMI was substantially larger than for conscientiousness and sociodemographic or behavioural factors.

The sensitivity analysis including other personality factors did not change the relationship between conscientiousness and hair concentration. Neuroticism, extraversion, openness to experience, and agreeableness were not associated with cortisol, and the regression coefficient for conscientiousness did not change significantly.

4. Discussion

This study investigated the pathways through which conscientiousness might contribute to favourable health outcomes in a large sample of older men and women. Bogg and Roberts (2013) have proposed that conscientiousness might influence chronic disease and longevity through reducing 'health-degrading behaviours' such as physical inactivity and excessive alcohol consumption, or through psychophysiological mechanisms including neuroendocrine and immune activation. We found evidence for both pathways. Conscientiousness was associated with more prudent health behaviours such as moderate alcohol consumption, physical exercise, eating fruit and vegetables and being less overweight and obese. It was also inversely related to hair cortisol concentration after taking age, sex, and sociodemographic factors (education and wealth) into account. Since cortisol has previously been associated with health behaviours, we conjectured that one explanation for the relationship between conscientiousness and cortisol could be healthier lifestyle. However, the relationship remained robust after health behaviours had been included in the model, with little attenuation of the association. This is consistent with direct psychobiological links between conscientiousness and cortisol concentration in hair.

The health behaviour results are consistent with a growing body of literature indicating that conscientious individuals tend to be physically active, engage in few health-risk behaviours, and eat healthy diets (Artese et al., 2017; Bogg and Roberts, 2004; Lunn et al., 2014). We did not replicate previous results relating low conscientiousness with smoking, but the proportion of smokers was small in this sample. We observed an inverse association between conscientiousness and BMI which did not emerge as significant in an earlier review (Bogg and Roberts, 2004). In a recent meta-analysis of studies across a wide age range, Sutin et al. (2016a) reported that conscientiousness was related to greater physical activity, but less consistently with sedentary behaviour. The discrepancy with our results may relate to different ways of measuring sedentary behaviour.

The behaviours we assessed play a major role in the development of noncommunicable diseases at older ages, including CHD, diabetes chronic lung disease and several cancers (Danaei et al., 2009; Forouzanfar et al., 2015). Longitudinal research is needed to establish

Table 4
Regressions on hair cortisol concentration Standardized regression coefficients (standard error).

	Model 1		Model 2		Model 3	
	B (s.e.)	p	B (s.e.)	P	B (s.e.)	p
Conscientiousness	−0.087 (0.026)	0.001	−0.085 (0.027)	0.001	−0.066 (0.27)	0.015
Age			−0.034 (0.027)	0.21	−0.024 (0.027)	0.37
Sex[a]			0.031 (0.027)	0.24	0.032 (0.028)	0.26
Education			0.010 (0.029)	0.74	0.017 (0.029)	0.57
Wealth			−0.071 (0.028)	0.012	−0.042 (0.029)	0.15
Depressive symptoms					0.012 (0.027)	0.66
Alcohol consumption					−0.013 (0.027)	0.65
Moderate/vigorous activity					−0.013 (0.028)	0.63
Sedentary activity					0.050 (0.027)	0.067
Fruit and vegetable consumption					−0.021 (0.026)	0.43
BMI					0.114 (0.027)	< 0.001

N = 1471.
[a] Reference category: men.

whether these associations between conscientiousness and health behaviour persist over prolonged periods and contribute to survival and healthy life expectancy.

Evidence for direct psychophysiological correlates of conscientiousness is accumulating. An analysis of the HRS demonstrated an inverse relationship between conscientiousness and an index of allostatic load (Stephan et al., 2016), while inverse associations with blood pressure and total cholesterol were found in the Add Health cohort (Sutin et al., 2016b). A meta-analysis of three studies also documented that more conscientious individuals have lower concentrations of C-reactive protein and interleukin (IL) 6 (Luchetti et al., 2014), and similar findigns have been reported for MIDUS (Turiano et al., 2013). These studies involved large samples, a wide range of ages and both men and women, suggesting that associations are robust. Cortisol is a key indicator of hypothalamic-pituitary-adrenocortical (HPA) axis function and plays a key role in coronary heart disease, diabetes, obesity, and other adverse health outcomes (Girod and Brotman, 2004; Hackett et al., 2016). Given the sensitivity of cortisol to stress and other behavioural factors, an inverse relationship with conscientiousness might be expected, but results have been inconsistent. Some studies have reported no association of conscientiousness with cortisol responses to acute stress (Bibbey et al., 2013; Oswald et al., 2006), while Dahm et al. (2017) found that higher conscientiousness was related to increased cortisol stress responsivity in men. There was a complex association of cortisol sampled over the day and conscientiousness in a sample of working parents (Nater et al., 2010), but no relationship with the cortisol waking response (Laceulle et al., 2015; van Santen et al., 2011). Bogg and Slatcher (2015) showed that the cortisol decline over the day was correlated with higher conscientiousness, but that associations were attenuated when physical activity was taken into account.

These studies all assessed cortisol in saliva which fluctuates markedly over the day and in response to different activities. Hair cortisol concentration reflects cortisol output over weeks, and is also a product of nocturnal as well as diurnal cortisol release. It may therefore be well suited to the investigation of associations with a relatively stable psychological characteristic such as conscientiousness. Our finding that conscientiousness was inversely related to hair cortisol concentration is therefore significant in documenting a link with sustained activation of health-related neuroendocrine pathways. It would be interesting to compare these findings with results involving salivary cortisol in a single study.

We took socioeconomic indicators as well as age and sex into account, since previous work has demonstrated that hair cortisol concentration tends be to higher in men than women and in older people, while being lower among more affluent individuals (Serwinski et al., 2016; Stalder et al., 2017). The association between conscientiousness and hair cortisol concentration was independent of these factors. We were also concerned that the association might be confounded by depressive symptoms and by health behaviours. Depressive symptoms are less intense in more conscientious people (Hakulinen et al., 2015; Kotov et al., 2010), while also being related to lower cortisol concentration in population studies (Abell et al., 2016). Associations between hair cortisol and adiposity and physical inactivity have also been described, and were confirmed in the present study (Abell et al., 2016; Stalder et al., 2017). But as can be seen in Tables 3 and 4, these variables had only a modest impact on the relationship between conscientiousness and hair cortisol concentration. Our study has a number of limitations. Although hair was sampled two years after the other variables, no causal conclusions can be drawn, since both hair cortisol and conscientiousness were measured only once. Health behaviours were measured by self-report, and reporting biases may have been present; in particular, the reported levels of fruit and vegetable consumption and physical activity are high. Some of the assessments of health behaviour, notably alcohol consumption, were based on the previous week, whereas hair cortisol reflects a longer time period. Measures of BMI were not available in the complete sample, so analyses involved a reduced sample size. It is possible that health behaviours in part mediate the associations between conscientiousness and hair cortisol, but the cross-sectional design makes this impossible to test reliably, so no formal mediation analysis was carried out. More than 95% of the ELSA sample is of white European origin, so ethnic differences could not be analysed, and associations between conscientiousness and hair cortisol may not be the same in other sectors of the population. Additionally, not all the people with hair could be included in the cortisol analyses. The excluded participants were slightly older on average, and were less educated and wealthy than those who were included. Although the full range of conscientiousness ratings were represented, we do not know what impact this selection process had on the results.

Nevertheless, our findings add to the accumulating evidence linking conscientiousness with biological processes relevant to health. The observation that greater conscientiousness was correlated with lower hair cortisol concentration independently of sociodemographic factors, depressive symptoms and health behaviours indicates that this trait might impact central nervous regulation of HPA function, with effects that are possibly advantageous for health.

Conflicts of interest

None of the authors have any conflicts of interest to declare related to the findings of this study.

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Contributors

All authors contributed significantly to the conception, design, analyses or interpretation of data and were involved in revising it critically for intellectual context. The submission of this paper was approved by all researchers.

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