Healthy Neuroticism, Daily Physical Activity, and Daily Stress in Older Adults

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Abstract

People are typically less physically active when experiencing stress, an unavoidable aspect of life. Since physical activity has been associated with health benefits, it is important to understand what influences physical activity during stress. Research has demonstrated that individuals who are high in conscientiousness are more physically active; however, studies that have examined physical activity among people high in neuroticism have yielded mixed findings. Healthy neuroticism, a term used to describe individuals high in conscientiousness and neuroticism, may explain these mixed results. While individuals low in conscientiousness and high in neuroticism may become overwhelmed, stress may motivate people high in healthy neuroticism to be physically active as an investment in their future. We assessed older adults' (N = 60; M_{age} = 70.72; 76.70% cisgender women) personality at baseline as well as daily physical activity and daily stress over 14 days. Regression analyses investigated whether daily stress predicted daily physical activity and whether healthy neuroticism moderated the physical activity-stress association. Ultimately, this study found that daily stress did not predict daily physical activity; as stress increased, individuals higher in conscientiousness were less physically active, while individuals lower in conscientiousness were more active. These findings were inconsistent with our predictions and previous research. Consequently, we propose future research directions and potential explanations for these unforeseen findings.

Keywords: healthy neuroticism; conscientiousness; neuroticism; physical activity; stress

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Introduction

Stress, or mental and physical reactions to experiences perceived to be overwhelming, is an inescapable part of daily life. Further, stress has been inversely associated with beneficial health outcomes (Cohen et al., 1983) as well as healthy behaviours like physical activity, which means that individuals often exercise less when experiencing stress (Dunton et al., 2009). Since physical activity has been associated with positive health outcomes (Stieger et al., 2020), it is critial to understand the factors that influence the likelihood of individuals to engage in physical activity when experiencing stress. Conscientiousness and neuroticism, two of the “Big Five” personality traits, may play a role in the inverse relationship between physical activity and stress (2020). Individuals high in conscientiousness are typically future-oriented, productive, disciplined, and tend to engage in more physical activity than individuals low in conscientiousness (Graham et al., 2020; Ludwig et al., 2019). In comparison, studies that have examined physical activity among people high in neuroticism, who tend to be emotional and reactive to stress, have yielded mixed findings (Friedman, 2000). Extant literature on *healthy neuroticism*, a term used to describe the personalities of those high in both conscientiousness and neuroticism, has attributed these mixed results to the higher rates of physical activity during periods of stress among those high in healthy neuroticism (Friedman, 2000; Turiano et al., 2013; Weston & Jackson, 2015). However, current research has yet to provide adequate empirical support for this notion by examining the extent to which healthy neuroticism may moderate the association between daily physical activity and daily stress. The current study held two primary objectives: to identify whether daily physical activity was associated with daily stress and to investigate whether healthy neuroticism moderated the association between physical activity and stress. This research expands upon personality theory in its analysis of how healthy neuroticism may promote physical activity in the face of daily stress.

Physical Activity and Stress

Regular engagement in physical activity has been associated with considerable long-term health benefits (Stieger et al., 2020; World Health Organization, 2018). Physical activity has been associated with physical health, such as lower incidence of diabetes and stroke (2018), and mental health, such as reduced anxiety and depression (Stults-Kolehmainen & Sinha, 2014). However, a significant barrier to regular physical activity is the common day-to-day experience of stress (Dunton et al. 2009; Jones et al., 2017). Generally, stress has been understood to refer to psychological and physiological disruptions in response to situations perceived to be difficult, uncontrollable, and/or overwhelming (Cohen et al., 1983; Stults-Kolehmainen & Sinha, 2014). There are several ways in which day-to-day stress may deter individuals from engaging in regular physical activity. Individuals may have less time to devote to physical activity due to stressful events. Comparatively, capacity or motivation for physical activity may be reduced by the considerable mental and physical health costs correlated with stress, including depression and cardiovascular disease (Stults-Kolehmainen & Sinha, 2014). However, some individuals have been found to favour more physical activity during times of stress to maladaptive coping strategies, such as substance use, unhealthy eating, and sedentary behaviour. Further, physical activity has been associated with a reduced risk of stress-induced harms (e.g., immunosuppression) and an increased likelihood of adaptive coping with future stressors, likely due to the reduced stress reactivity seen among those who engage in regular physical activity (2014). Since stress is an unavoidable aspect of daily life, elucidating the conditions in which stress promotes physical activity is important, and personality traits may be relevant factors to consider.

Physical Activity, Conscientiousness, and Neuroticism

Personality traits describe differences in individuals' enduring patterns of thought, emotion, and behaviour (John & Srivastava, 1999). The Big Five traits (i.e., conscientiousness, neuroticism, extraversion, agreeableness, and openness to experience) comprise an empirically supported framework for understanding personality (1999). This framework has exceptional predictive utility with respect to meaningful life outcomes, including health and health behaviours (1999). Moreover, research indicates that, while the Big Five traits are relatively stable across the lifespan, they can be modified through intervention (Roberts et al., 2017; Roberts & Takahashi, 2011). Therefore, personality traits are an important consideration when deciphering the harmful, inverse relationship between physical activity and stress. Specifically, two of the Big Five traits, conscientiousness and neuroticism, demonstrate notable relationships with physical activity and stress (Stieger et al., 2020). As such, this article considers conscientiousness and neuroticism together, rather than separately, to illuminate contexts in which lifelong health can be promoted through the facilitation of physical activity during times of stress (Friedman, 2000).

Conscientiousness

Conscientiousness is characterized by industriousness, organization, responsibility, and self-control (Friedman, 2000). Individuals high in conscientiousness are more likely to engage in healthy behaviours, such as physical activity (Bogg & Roberts, 2004). Informed by the Invest-and-Accrue Model of conscientiousness (Hill & Jackson, 2016), stress can motivate individuals high in conscientiousness to both engage in healthy behaviours and avoid unhealthy behaviours as investments in their future accrual of health benefits. In support, two meta-analyses found that individuals higher in conscientiousness engaged in more physical activity than those lower in conscientiousness (Sutin et al., 2016; Wilson & Dishman, 2015). As might be expected of individuals who partake in regular physical activity, high conscientiousness has been associated with positive health outcomes, including longevity (Graham et al., 2017; Weiss & Costa, 2005) and lower rates of chronic conditions, such as arthritis and tuberculosis (Goodwin & Friedman, 2006; Weston et al., 2015). However, while conscientiousness has been consistently associated with the subsequent health benefits of physical activity, research that has examined neuroticism has yielded mixed findings (Gale et al., 2017; Onken & Nielsen, 2019).

Neuroticism

Neuroticism is characterized by emotional instability, negative affectivity, and pessimism (Friedman, 2000) as well as increased exposure and reactivity to stress (Bolger & Schilling, 1991; Hampson, 2012; Suls & Martin, 2005). As such, individuals high in neuroticism are at risk of adverse health outcomes, including mortality (Graham et al., 2017) and chronic conditions, such as high blood pressure and sciatica (Goodwin & Friedman, 2006; Weston et al., 2015). The stress-induced relationship between neuroticism and adverse health outcomes occurs through direct and indirect pathways (Friedman, 2000). For instance, stress-induced cortisol dysregulation has been associated with long-term disruptions in lipid metabolism (i.e., the breakdown and synthesis of lipids within cells) (Orth-Gomer & Schneiderman, 1996). In contrast, the health harms of the stress exposure and reactivity associated with high neuroticism may be indirectly potentiated through unhealthy coping behaviours, such as substance use, sedentary behaviour, and reduced physical activity (Hampson, 2012; Sutin et al., 2016; Wilson & Dishman, 2015). Yet, a wealth of research has refuted the notion that neuroticism is solely associated with diminished health; instead, recent studies have identified either nonexistent (Friedman et al., 2010; Iwasa et al., 2008; Jokela et al., 2013) or positive associations between health and neuroticism (Brickman et al., 1996; Gale et al., 2017; Korten et al., 1999; Tikhonoff et al., 2014; Weiss & Costa, 2005). Nevertheless, healthy neuroticism, or a combination of high conscientiousness and high neuroticism, may explain these contradictory findings (Friedman, 2000).

Healthy Neuroticism

Health and personality psychology researcher Howard Friedman originally proposed two profiles for categorizing people high in neuroticism based on their level of conscientiousness (2000). The first profile described individuals low in conscientiousness and high in neuroticism, who become overwhelmed by ongoing exposure to stress (Bolger & Schilling, 1991; Hampson, 2012; Suls & Martin, 2005), which leads to unhealthy coping strategies (e.g., sendentary behaviour) and greater adverse health outcomes (Allen et al., 2017). Friedman’s second profile described individuals high in both conscientiousness and neuroticism, who exhibit increased vigilance and/or stress regarding their health, which leads to a focus on healthy behaviours (e.g., physical activity) and, thus, the accrual of related health benefits (Jones et al., 2017). Friedman’s profiles are supported by the Invest-and-Accrue Model of conscientiousness developed by Hill and Jackson (2016). Within this model, individuals low in conscientiousness and high in neuroticism may become overwhelmed by stress, which may lead to reduced physical activity. In contrast, stress has been theorized to motivate those high in both conscientiousness and neuroticism to invest in their future by engaging in physical activity (Hill & Jackson, 2016). In essence, healthy neuroticism may allow (otherwise damaging) daily stress to elicit adaptive responses from individuals and, thereby, promote physical activity (Friedman, 2000; Hill & Jackson, 2016).

Research that has investigated healthy neuroticism is relatively novel. While some research has found scant evidence to establish a relationship between healthy neuroticism and health (Weston et al., 2019), several studies have yielded findings in support of healthy neuroticism (Terracciano & Costa, 2004; Turiano et al., 2013; Weston & Jackson, 2015). For instance, a recent coordinated analysis of 15 longitudinal research studies found that healthy neuroticism was associated with physical activity (Graham et al., 2020). While individuals low in conscientiousness and neuroticism benefitted the least from an intervention to increase physical activity, those high in healthy neuroticism benefitted greatly (Stieger et al., 2020). Still, research has yet to empirically test if the relationship between healthy neuroticism and physical activity represents differential stress responses among those high in neuroticism based on their level of conscientiousness (Friedman, 2000; Hill & Jackson, 2016). As such, this article aimed to address this gap in literature.

The Current Study

The current study examined whether there was an association between daily physical activity and daily stress and whether healthy neuroticism moderated the relationship. Our hypotheses were based on previous research that had examined conscientiousness, neuroticism (Friedman, 2000; Hill & Jackson, 2016), and the relationship between physical activity and stress (Dunton et al., 2009; Jones et al., 2017; Stults-Kolehmainen & Sinha, 2014). Specifically, we predicted that daily physical activity would be inversely associated with daily stress and that healthy neuroticism would attenuate that association. That is, we anticipated that the inverse relationship between physical activity and stress would be weaker among individuals high in both conscientiousness and neuroticism. In short, we hypothesized that individuals high in healthy neuroticism would engage in more daily physical activity despite daily stress.

Methods

Participants

Participants were healthy, community residing, older adults (N = 72; M_{age} = 70.75, range = 64-78; 75.00% cisgender women) from Victoria, British Columbia, who learned about this study through hardcopy and online recruitment posters. Eligible participants had to be both literate and fluent in English and could not have previously participated in similar research at the University of Victoria. Moreover, individuals who disclosed serious medical or health concerns (e.g., a psychiatric illness or head injury) that might impede sustained participation in the study, or exacerabate pre-existing conditions, were deemed ineligible. Lastly, participants who did not complete the baseline and daily measurement portions of the "Daily Experiences of Affect, Stress, and Health" (DASH) study (and/or completed ≤ four daily assessments) were also excluded, which resulted in a sample of 60 older adults (M_{age} = 70.72; 76.70% cisgender women).

Procedure

Within this DASH research study, conducted in 2019, participants attended a 2-hour baseline laboratory session at the Institute on Aging and Lifelong Health. Participants submitted their consent form and online self-report surveys via LimeSurvey (2021), which allowed us to assess demographic characteristics and personality traits, including conscientiousness and neuroticism. During the subsequent repeated measurement portion of the DASH study, physical activity and stress were assessed daily for 2 weeks. This approach, in which scores from 14 daily assessments were averaged, enabled more accurate measurements of daily physical activity and stress compared to the single assessments typically used in between-person studies (Jones et al., 2017; Reis & Gable, 2000). Participants received a nightly notification to complete a short (7-to-10 minute) self-report survey via Android phones equipped with the MyCogHealth mobile survey software (Institute on Aging and Lifelong Health, n.d.). Participants also wore Charge Fitbits (Fitbit, n.d.) for the 14-day measurement period. To ensure effective operation of the Android and Fitbit devices, research assistants trained participants to use both devices at baseline and gave participants supplementary take-home instructional guides. The DASH study was approved by the Human Research Ethics Board at the University of Victoria in the Spring of 2019 (under ethics protocol number 18-1069). Participants received an honorarium of $75 CDN.

Measures

Demographic Characteristics

Participants' demographic characteristics (i.e., age, gender) were assessed at baseline. Age was measured in years and gender was assessed through the following open-ended response item: "With which gender do you most identify?" Each participant's gender response was compared with their response to the item "What is your sex?" Each participant who responded as being of the "female" sex also identified as being a "woman," and each participant who responded as being of the "male" sex also identified as being a "man." As such, we recoded the dichotomous sex responses to represent participants' gender identities (i.e., 0 = *cisgender woman*, 1 = *cisgender man*).

Personality

Conscientiousness and neuroticism were assessed at baseline using the respective subscales of a standardized, 44-item, Big Five Inventory (BFI) (John & Srivastava, 1999). Conscientiousness was assessed through nine items (e.g., "I see myself as someone who does a thorough job," "…is a reliable worker," "…does things efficiently"). Neuroticism was assessed through eight items (e.g., "I see myself as someone who can be tense," "…worries a lot," "…gets nervous easily"). Participants responded to each item on a 5-point scale that ranged from 1 = *disagree strongly* to 5 = *agree strongly*. Negatively worded items were reverse coded so that higher scores indicated higher levels of each trait. Item responses were summed and divided by 9 and 8, respectively, to yield average trait scores that ranged from 1 to 5.

Physical Activity

Daily physical activity was assessed in three ways: Fitbits were used to calculate participants' daily minutes of moderate-to-vigorous physical activity and daily steps, and the nightly survey item "Approximately what duration of time was spent participating in moderate-to-vigorous physical activity today?" captured participants' self-reported daily minutes of moderate-to-vigorous physical activity, which ranged from 0 to 180 minutes. Participants' 14 daily scores for each variable were summed and divided by 14 to reflect their average daily (a) Fitbit-calculated minutes of moderate-to-vigorous physical activity, (b) Fitbit-calculated steps, and (c) self-reported minutes of moderate-to-vigorous physical activity.

Stress

Stress was assessed daily through the following four adapted items from the Perceived Stress Scale: "Over the course of the day, how often have you felt nervous or stressed?"; "…been upset because something happened unexpectedly?"; "…felt confident about your ability to handle your personal problems?"; and "…felt like you could not cope with all the things you have to do?" (Cohen et al., 1983). Participants responded to items on a scale that ranged from 0 = *never* to 100 = *often*. Negatively worded items were reverse coded so that higher scores indicated higher levels of stress. Item responses were summed and divided by four to yield an average stress score from

0 to 100. Participants' 14 daily scores were then summed and divided by 14 to capture participants' average levels of daily stress.

Analytic Strategy

To assess the internal consistency of the conscientiousness and neuroticism BFI subscales (John & Srivastava, 1999), or the extent to which the individual items that comprised each subscale measured the same construct, we calculated Cronbach's α values. In addition, for sample demographic characteristics and each study variable, we calculated descriptive statistics (i.e., values that describe the sample, dataset, and variables measured) and zero-order Pearson correlations (i.e., values that represent the linear relationship between two variables, whereby the effects of additional variables are not controlled for). Beyond preliminary analyses, we employed multiple linear regression three-way interaction modeling—a statistical technique that uses multiple predictor variables (and their interactions) to explain the findings of a single outcome variable. This approach was used to determine whether an association could be drawn between older adults' average daily physical activity and average daily stress. Furthermore, this method was used to deduce whether the interaction of conscientiousness and neuroticism moderated the association between daily physical activity and stress. Equation 1 depicts the primary regression model, which examined the influence of the three primary predictor variables (stress, conscientiousness, and neuroticism) on the outcome variable of physical activity. This model adjusted for the between-person variability introduced by individual differences in participants' demographic characteristics (age and gender):

$$\begin{aligned}\text{Physical Activity}_i = {} & \beta_0 + \beta_1(\text{Stress}_i) + \beta_2(\text{Conscientiousness}_i) + \beta_3(\text{Neuroticism}_i) \\ & + \beta_4(\text{Stress}_i \times \text{Conscientiousness}_i) + \beta_5(\text{Stress}_i \times \text{Neuroticism}_i) \\ & + \beta_6(\text{Conscientiousness}_i \times \text{Neuroticism}_i) \\ & + \beta_7(\text{Stress}_i \times \text{Conscientiousness}_i \times \text{Neuroticism}_i) + \beta_8(\text{Age}_i) \\ & + \beta_9(\text{Gender}_i) + e_i \end{aligned} \tag{1}$$

where Physical Activity_i represents participant i's mean daily minutes of Fitbit-calculated moderate-to-vigorous physical activity; Stress_i represents participant i's mean daily stress; $\text{Conscientiousness}_i$ represents participant i's conscientiousness score; Neuroticism_i represents participant i's neuroticism score; Age_i represents participant i's age; and Gender_i represents participant i's gender. To allow for the meaningful interpretation of the between-person interaction effects, all variables (apart from Physical Activity_i and Gender_i) were grand-mean-centred prior to analysis. Further, the regression coefficients were interpreted as follows: β_0 represents the intercept (or the mean daily physical activity when all nine predictor variables are equal to zero); β_1-β_3 represent the between-person associations between physical activity and stress, conscientiousness, and neuroticism, respectively; β_4 represents the between-person interaction of stress with conscientiousness; β_5 represents the between-person interaction of stress with neuroticism; β_6 represents the between-person interaction of conscientiousness with neuroticism; β_7 represents the between-person, three-way interaction between stress, conscientiousness, and neuroticism; to refine the unexplained variability, β_8 adjusts for individual differences in age and β_9 adjusts for individual differences in gender; and e_i represents the residual unexplained variance.

Although our Results section reports the primary analysis with and without accounting for the interaction terms and adjusting for demographic characteristics (to illustrate changes in the main effects of stress, conscientiousness, and neuroticism after adjusting for the interactions and covariates), hypotheses were tested using the fully adjusted regression model (see Equation 1). Moreover, to test the robustness of the findings from the primary regression model, we conducted two planned sensitivity analyses that twice repeated the primary analysis, substituting Fitbit-calculated moderate-to-vigorous physical activity with Fitbit-calculated steps, followed by self-reported moderate-to-vigorous physical activity. For each of the three models, we probed significant interactions (i.e., interaction effects between the primary predictors of physical activity that possess a < 5% likelihood of having occurred by chance). The probing was accomplished through testing simple slopes—a statistical technique used to understand the nature and direction of significant interaction effects (Preacher et al., 2006). All analyses were conducted in SPSS statistical analysis software (IBM Corp, 2021).

Results

The BFI subscales (John & Srivastava, 1999) demonstrated good internal consistency with Cronbach's α = .72 for conscientiousness and Cronbach's α = .83 for neuroticism. Descriptive statistics are reported in Table 1. The current sample of healthy, community residing, older adults was relatively homogeneous. Participants were primarily cisgender women, European/White, educated beyond high school, and reported notably high average daily physical activity and low average daily stress. Moderate-to-strong positive skew was identified for average daily Fitbit-calculated (Skewness = 1.23, *SE* = .31) and self-reported (Skewness = 1.49, *SE* = .31) moderate-to-vigorous physical activity. Additionally, mild-to-moderate positive skew was identified for average daily stress (Skewness = 0.84, *SE* = .31). Moreover, each participant reported a high conscientiousness score. When artificially dichotomized at the sample mean into *high–very high* conscientiousness and *low–high* neuroticism, participants were most commonly high in both conscientiousness and neuroticism (*n* = 18), and least commonly very high in conscientiousness and high in neuroticism (*n* = 12; see Figure 1).

Table 1

Descriptive Statistics

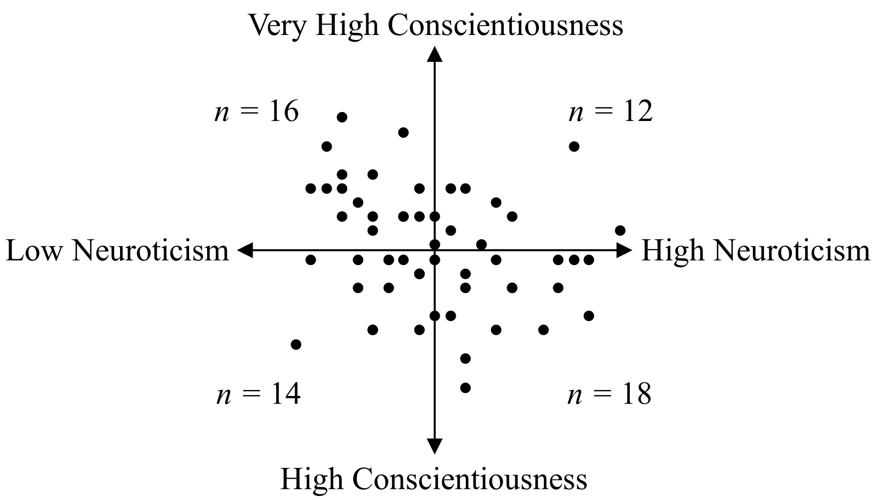
Variable	*N*	*M* (*SD*)	Range or %
Age	60	70.72 (3.53)	64.00–78.00
Gender			
Cisgender woman	46		76.70%
Cisgender man	14		23.30%
Ethnicity			
European/White	53		88.33%
East or Southeast Asian	3		5.00%
South Asian	1		1.67%
Other	3		5.00%
Education			
Post-graduate education	24		40.00%
Undergraduate degree	15		25.00%
Some college or university	12		20.00%

Variable	*N*	*M* (*SD*)	Range or %
Trade school	4		6.70%
High school	4		6.70%
No high school diploma	1		1.70%
Physical activity			
Mod-vig PA (Fitbit)	59	51.08 (33.69)	2.14–158.36
Steps	60	8113.68 (3082.98)	2316.79–16086.79
Mod-vig PA (SR)	60	54.08 (32.12)	11.43–180.00
Stress	60	19.01 (13.33)	1.54–53.85
Personality			
Conscientiousness	60	3.96 (0.45)	2.89–5.00
Neuroticism	60	2.62 (0.63)	1.50–4.13

Note. Mod-vig PA (Fitbit) = Fitbit-calculated moderate-to-vigorous physical activity; Mod-vig PA (SR) = self-reported moderate-to-vigorous physical activity.

Figure 1

Distribution of Conscientiousness and Neuroticism Scores



Note. N = 60.

We computed zero-order Pearson correlations between all study variables (see Table 2). A moderate, direct correlation appeared between average daily Fitbit-calculated and self-reported moderate-to-vigorous physical activity. Further, both measures of moderate-to-vigorous physical activity were strongly, directly associated with average daily steps. Age was weakly, inversely associated with average daily steps, and average daily stress was moderately, directly associated with neuroticism. No additional significant correlations appeared; thus, the three primary predictor variables (stress, conscientiousness, and neuroticism) were not correlated with any of the three physical activity outcome variables.

Table 2

Zero-Order Pearson Correlations of Study Variables

Variables	1	2	3	4	5	6	7	8
1. Age	†							
2. Gender	–.05	†						
3. Mod-vig PA (Fitbit)	–.03	.13	†					
4. Steps	–.26*	.10	.75***	†				
5. Mod-vig PA (SR)	–.19	.17	.36**	.56***	†			
6. Stress	–.01	–.12	–.10	–.11	–.09	†		
7. Conscientiousness	–.17	–.08	–.03	–.08	.11	–.09	†	
8. Neuroticism	.03	.00	.11	.03	.10	.33*	–.23	†

Note. Mod-vig PA (Fitbit) = Fitbit-calculated moderate-to-vigorous physical activity; Mod-vig PA (SR) = self-reported moderate-to-vigorous physical activity. *$p < .05$. **$p < .01$. ***$p < .001$.

Primary Analysis

The primary analysis employed multiple linear regression three-way interaction modeling to examine whether average daily stress predicted average daily physical activity, as well as whether the association was moderated by the interaction between conscientiousness and neuroticism. One participant's Fitbit-calculated minutes of moderate-to-vigorous physical activity data was compromised in the uploading process. Their data was excluded from the primary analysis, which resulted in 59 participants. Results from the primary analysis predicting average daily Fitbit-calculated moderate-to-vigorous physical activity are reported in Table 3. Model 1 reflects the main effects of average daily stress, conscientiousness, and neuroticism (R^2 = .03); Model 2 introduces the three 2-way and one 3-way interaction terms (R^2 = .12); and Model 3 adjusts for the effects of age and gender (R^2 = .13). This fully adjusted model explained little variance in average daily Fitbit-calculated moderate-to-vigorous physical activity (i.e., 13%). Since no significant effects emerged, probing interactions was not required.

Planned Sensitivity Analyses

The planned sensitivity analyses both employed multiple linear regression three-way interaction modeling to examine whether two alternative measures of average daily physical activity (Fitbit-calculated steps and self-reported moderate-to-vigorous physical activity) were predicted by average daily stress and whether the conscientiousness-neuroticism interaction moderated these relationships. Results from the fully adjusted models predicting average daily steps (R^2 = .22) and self-reported moderate-to-vigorous physical activity (R^2 = .15) are reported in Table 4. While modest in their explanatory ability, variance in their respective physical activity outcome variables proved more illustrative than data gleaned from the primary regression model, with the greatest proportion explained for average daily steps (i.e., 22%). The sole significant effect was a negative interaction between average daily stress and conscientiousness in the model predicting average daily steps.

Table 3

Multiple Linear Regression Three-Way Interaction Analysis Predicting Moderate-to-Vigorous Physical Activity

Variable	Model 1		Model 2		Model 3	
	Est. (*SE*)	95% CI	Est. (*SE*)	95% CI	Est. (*SE*)	95% CI
Intercept (β_0)	50.96 (4.43)***	42.08, 59.83	51.41 (4.86)***	41.66, 61.16	49.69 (5.79)***	38.06, 61.32
Stress (β_1)	–0.40 (0.36)	–1.12, 0.32	–0.09 (0.40)	–0.89, 0.72	–0.08 (0.41)	–0.90, 0.74
Conscientiousness (β_2)	–0.44 (10.17)	–20.82, 19.94	–5.21 (10.37)	–26.03, 15.62	–5.50 (10.66)	–26.93, 15.93
Neuroticism (β_3)	8.50 (7.62)	–6.76, 23.77	6.27 (7.78)	–9.35, 21.89	6.07 (7.93)	–9.87, 22.02
Stress × C (β_4)	†	†	–1.05 (0.83)	–2.72, 0.61	–1.03 (0.84)	–2.73, 0.67
Stress × N (β_5)	†	†	–0.47 (0.54)	–1.55, 0.61	–0.42 (0.57)	–1.56, 0.73
C × N (β_6)	†	†	–4.98 (16.41)	–37.92, 27.96	–6.75 (17.81)	–42.53, 29.04
Stress × C × N (β_7)	†	†	2.24 (1.55)	–0.88, 5.35	2.11 (1.60)	–1.09, 5.32
Age (β_8)	†	†	†	†	0.34 (1.41)	–2.60, 3.08
Gender (β_9)	†	†	†	†	6.15 (10.89)	–15.73, 28.03

Note. Stress × C = stress-conscientiousness interaction; Stress × N = stress-neuroticism interaction; C × N = conscientiousness-neuroticism interaction; Stress × C × N = stress-conscientiousness-neuroticism interaction; CI = confidence interval. ****p* < .001.

Table 4

Sensitivity Analyses Predicting Steps and Self-Reported Moderate-to-Vigorous Physical Activity

Variable	Steps		Mod-vig PA (SR)	
	Est. (*SE*)	95% CI	Est. (*SE*)	95% CI
Intercept (β_0)	8004.27 (491.39)***	7017.28, 8991.26	50.75 (5.33)***	40.05, 61.46
Stress (β_1)	–5.18 (34.61)	–74.68, 64.33	–0.29 (0.38)	–1.05, 0.46
Conscientiousness (β_2)	–1205.10 (912.75)	–3038.42, 628.21	6.96 (9.90)	–12.92, 26.84
Neuroticism (β_3)	103.75 (688.34)	–1278.82, 1486.33	10.08 (7.46)	–4.92, 25.07
Stress × C (β_4)	–148.73 (71.55)*	–292.44, –5.02	–1.03 (0.78)	–2.59, 0.53
Stress × N (β_5)	–35.42 (49.13)	–134.10, 63.27	–0.21 (0.53)	–1.28, 0.86
C × N (β_6)	–854.59 (1537.63)	–3943.01, 2233.84	–13.65 (16.67)	–47.13, 19.84
Stress × C × N (β_7)	117.22 (136.12)	–156.18, 390.62	–1.23 (1.48)	–4.19, 1.74
Age (β_8)	–193.47 (122.55)	–439.61, 52.68	–1.00 (1.33)	–3.67, 1.67
Gender (β_9)	339.95 (941.25)	–1550.60, 2230.51	10.36 (10.21)	–10.14, 30.86

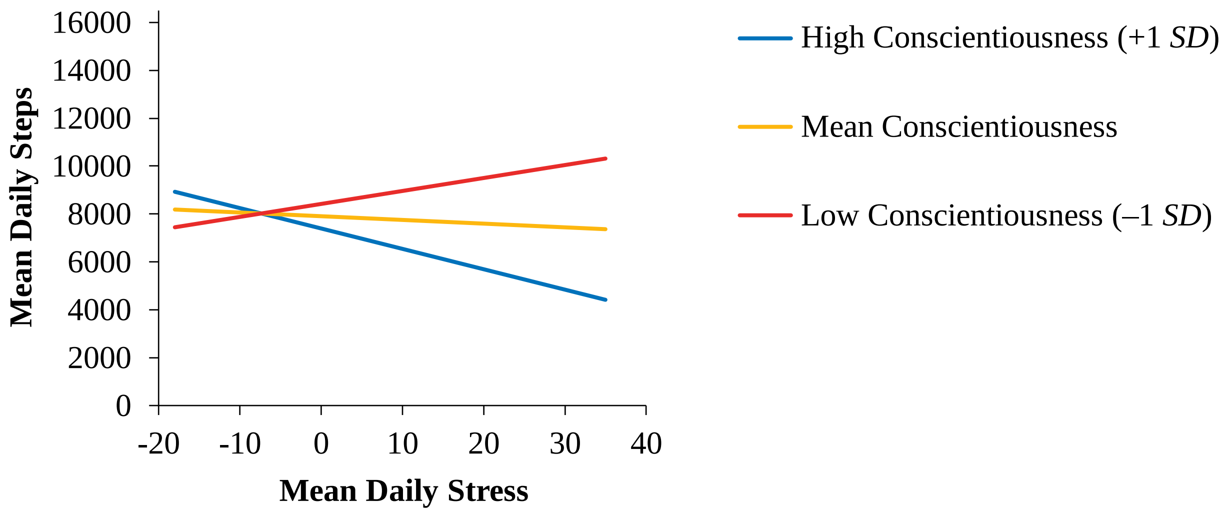
Note. Mod-vig PA (SR) = self-reported moderate-to-vigorous physical activity; Stress × C = stress-conscientiousness interaction; Stress × N = stress-neuroticism interaction; C × N = conscientiousness-neuroticism interaction; Stress × C × N = stress-conscientiousness-neuroticism interaction; CI = confidence interval. **p* < .05. ****p* < .001.

Stress-Conscientiousness Interaction Predicting Steps

The significant stress-conscientiousness interaction was probed via testing simple slopes (Preacher et al., 2006; see Figure 2). As average daily stress increased, average daily steps both decreased among individuals higher in conscientiousness and increased among individuals lower in conscientiousness. These findings contradicted our prediction that individuals higher in conscientiousness would engage in more physical activity when experiencing stress compared to individuals lower in conscientiousness.

Figure 2

Stress-Conscientiousness Interaction Predicting Steps



Discussion

The current study investigated whether average daily physical activity was associated with average daily stress and whether healthy neuroticism moderated the association. Based on past research (Friedman, 2000; Hill & Jackson, 2016; Jones et al., 2017; Stults-Kolehmainen & Sinha, 2014), we expected that, on average, individuals who experienced more daily stress would engage in less daily physical activity; further, we expected otherwise damaging daily stress to catalyze daily physical activity among participants high in both conscientiousness and neuroticism. Yet, these predictions were not supported by our analysis of 59 to 60 healthy, community residing, older adults. Indeed, average daily stress did not predict any of the three average daily physical activity variables, and there was no moderating effect of healthy neuroticism. Moreover, the primarily null regression findings aligned with the non-significant Pearson correlations between each physical activity outcome variable (Fitibit-calculated moderate-to-vigorous physical activity, daily steps, and self-reported moderate-to-vigorous physical activity) with the three primary predictor variables (stress, conscientiousness, and neuroticism). Therefore, in contrast to our hypotheses, physical activity appeared unrelated to both stress and healthy neuroticism consistently across the varied types of analyses executed in the current study. Furthermore, the observed regression findings appeared robust, with the three models demonstrating comparable non-significant outcomes apart from the significant stress-conscientiousness interaction predicting average daily steps. Informed by the Invest-and-Accrue Model of conscientiousness, we expected those high in conscientiousness to translate stress into motivation for physical activity (Hill & Jackson, 2016). In contrast, as average daily stress increased, participants higher in conscientiousness took fewer daily steps and participants lower in conscientiousness took more daily steps, on average. There are various explanations for both the consistently null findings and the unexpected stress-conscientiousness interaction predicting average daily steps.

Statistical limitations may have reduced our ability to detect effects in the three analyses. Examining between-person, three-way, interaction effects among 59 to 60 participants offered unsatisfactory statistical power and, therefore, reduced our ability to detect significant effects between healthy neuroticism, physical activity, and stress. Additionally, both average daily moderate-to-vigorous physical activity and average daily stress variable distributions were positively skewed, with scores clustering below the sample mean, which potentially imposed additional statistical power constraints. Although examining a larger sample would improve statistical power, within-person statistical approaches (such as multilevel modeling) would improve statistical power without requiring a markedly larger sample, since such approaches can acccount for more residual variability (stemming from individual differences) compared to between-person analytical approaches. Moreover, a within-person analysis would effectively investigate the moderating role of healthy neuroticism on the time-bound association between day-to-day physical activity and stress. By averaging the 14 daily physical activity and stress scores of participants, our between-person analysis may have missed the dynamic relationship between physical activity and stress in individuals' day-to-day lives. For example, our approach could not capture an inverse, time-bound, physical activity-stress association for someone low in conscientiousness and high in neuroticism who consistently attends a daily workout class, yet misses 2 consecutive days due to stressful events. By analyzing time-bound associations through a within-person statistical approach, more informed between-person comparisons could be made between individuals low in conscientiousness and high in neuroticism with individuals high in healthy neuroticism, whose daily physical activity does not decrease as daily stress increases. As such, future research would benefit from employing within-person statistical methods.

In addition to analytical constraints, confounding variables not accounted for in the current study may have been meaningful predictors of physical activity. For instance, research has suggested that both lifetime exercise habits and current physical condition are associated with the physical activity of older adults (Rhodes et al., 1999). As such, perhaps conscientious older adults with less established exercise habits or increased physical restrictions due to a chronic condition would direct motivation from stress towards healthy behaviours besides physical activity (such as meditation). Similarly, global and momentary perceived physical activity self-efficacy have been associated with the physical activity of older adults (Dunton et al., 2013). Therefore, if conscientious older adults do not perceive high physical activity self-efficacy (due to their lack of prior exercise experience or current physical limitations), they may again translate motivation from stress into a different healthy behaviour. Additionally, fatigue (Kop et al., 2005) and negative affect (Dunton et al., 2009) are related to reduced day-to-day physical activity. Thus, to accurately analyze the moderating role of healthy neuroticism in predicting daily physical activity from daily stress, it may be prudent for future research to adjust for the effects of potentially confounding variables (such as prior exercise habits, physical condition, self-efficacy regarding physical activity, fatigue, and negative affect).

While null findings consistently appeared while predicting three types of physical activity, the sensitivity analysis predicting average daily steps yielded a sole significant effect: a stress-conscientiousness interaction in which individuals higher in conscientiousness took fewer daily steps and individuals lower in conscientiousness took more daily steps as daily stress increased. Since "average daily steps" was the only non-skewed physical activity outcome variable, the regression model predicting steps may have been the only model with sufficient statistical power to detect a negative stress-conscientiousness interaction. Alternatively, since older adults tend to prefer low-cost physical activity (such as outdoor walking) to costly physical activity (such as aerobic machines), perhaps steps are a more valid metric of older adult physical activity than moderate-to-vigorous physical activity (Rhodes et al., 1999). If so, the absence of stress-conscientiousness interactions in predicting average daily moderate-to-vigorous physical activity may reflect true null effects rather than low statistical power.

Beyond discussing the presence of a significant stress-conscientiousness interaction predicting average daily steps, it is pertinent to address the potential implications of the unexpected findings. The observed interaction may illustrate one maladaptive aspect of being inordinately high in any personality trait (Hill & Jackson, 2016). For instance, individuals exceptionally high in conscientiousness may become overinvested in specific tasks or behaviours (James et al., 1983); rather than translating stress into an unrelated healthy behaviour (physical activity), they may direct all of their energy to an immediate stressor in an effort to "fix" that stressor through unrelenting effort (Stanton et al., 2010). This psychological disposition has been termed John Henryism. Beyond the indirect, adverse health impacts of being less physically active, John Henryism has been independently associated with cardiovascular problems (Bennett et al., 2004; Stanton et al., 2010), likely due to the autonomic arousal associated with effortful coping (James et al., 1983). The relationship between John Henryism and cardiovascular issues is prevalent among those who remain determined to fix situations in which they can exercise little agency (James et al., 1983; Stanton et al., 2010). This context may be relevant for highly conscientious older adults grappling with situations they cannot fix, such as their own cognitive decline or the death of a loved one.

Alternatively, the unforeseen stress-conscientiousness interaction predicting average daily steps may be explained by the distribution of conscientiousness scores in our sample. In our study, conscientiousness scores demonstrated little variability and were considerably higher than scores in comparable older adult samples (Chapman et al., 2017; Yoneda et al., 2022). Since little difference was detected between the higher and lower conscientiousness scores (with all participants scoring high in conscientiousness), the practical significance of the observed stress-conscientiousness interaction was presumably inconsequential. In addition to the restricted range of conscientiousness scores, the older adult sample was homogeneous in other ways. For example, participants experienced unusually low levels of average daily stress. Also, compared to most older adults, who fall short of the recommended 150 weekly minutes of moderate-to-vigorous physical activity (Dunton et al., 2009), particiants in this study were highly physically active, reporting approximately 350 average weekly minutes of moderate-to-vigorous physical activity. Furthermore, the sample recruited for this study was disproportionately comprised of European/White, highly educated, cisgender women. Therefore, this "Western, Educated, Industrialized, Rich, and Democratic" (WEIRD) sample (Henrich et al., 2010) is not representative of the diversity typically found within the broader Canadian population. Caution should therefore be taken when generalizing the findings from this study, and future research seeking to examine the moderating effect of healthy neuroticism on physical activity-stress would benefit from recruiting a more diverse sample.

Conclusions

A wealth of prior research has shown that heightened daily stress is typically associated with reduced daily physical activity (Dunton et al., 2009; Jones et al., 2017). Yet, research has also suggested that, among individuals high in both conscientiousness and neuroticism, stress may instead promote physical activity (Friedman, 2000). However, findings from the current study do not support either notion. Due to our between-person analysis of a relatively small sample (N = 60), analytical constraints may explain the lack of observed significant effects. In future research, statistical power would be improved by employing a within-person analysis, such as multilevel modeling. This approach would also offer a clearer picture of how physical activity and stress vary dynamically through time. Moreover, our broadly null findings were likely due to not adequately adjusting for confounding variables, many of which may have led to conscientious participants directing motivation from stress towards healthy behaviours other than physical activity. As such, future healthy neuroticism and stress research predicting one health behaviour may benefit from simultaneously examining and controlling for additional health behaviours.

Despite the consistently null findings, the current study yielded one significant effect; unexpectedly, this sole significant outcome contradicted the theory that underlies both healthy neuroticism (Friedman, 2000) and the Invest-and-Accrue Model of conscientiousness (Hill & Jackson, 2016), which posit that individuals high in conscientiousness override the negative stress responses of high neuroticism by translating stress into motivation for healthy behaviour. Instead, on average over a two-week period, we observed that participants higher in conscientiousness were less active and participants lower in conscientiousness were more active as stress increased. In addition to providing further evidence to a growing body of literature that refutes the premise of healthy neuroticism (Turiano et al., 2020; Weston et al., 2019; Weston et al., 2020), the findings from the current study also dispute Hill and Jackson’s (2016) Invest-and-Accrue Model of conscientiousness.

The implications of such unexpected findings are twofold: the outcomes highlight the possible harms associated with being extraordinarily high in conscientiousness (Stanton et al., 2010), which is less commonly discussed as posing potential drawbacks in current personality research. Also, the stress-conscientiousness interaction predicting average daily steps may be attributable to the aforementioned homogeneity of the recruited sample. Study participants were not only broadly alike in conscientiousness; they were also similar demographically and in their reported levels of average daily physical activity and stress. Thus, future research examining whether healthy neuroticism attenuates an inverse association between daily physical activity and stress among a diverse sample of participants is imperative for two reasons: first, doing so may ensure that findings are representative of and generalizable to broader populations; second, doing so may elucidate whether the observed stress-conscientiousness interaction was indicative of the restricted conscientiousness scores or was reflective of the potential harms associated with inordinately high conscientiousness.

It is important for ongoing personality and health psychology research to build upon this study to explain the relationships between physical activity, stress, conscientiousness, and neuroticism among demographically diverse samples. The knowledge gleaned will further inform the personality and health psychology research fields as well as offer meaningful insights for health behaviour promotion interventions. Research demonstrates that high conscientiousness is associated with healthy behaviour (Bogg & Roberts, 2004) and that personality traits are amenable to targeted interventions (Roberts et al. 2017; Roberts & Takahashi, 2011). As such, health behaviour promotion interventions to increase conscientiousness are well-supported throughout personality and health psychology research (Roberts et al. 2017; Roberts & Takahashi, 2011). In contrast, our findings showed less physical activity among more conscientious older adults experiencing day-to-day stress, which suggests that health behaviour promotion interventions targeting trait conscientiousness may, in certain contexts, yield negative effects (such as reduced physical activity). Therefore, future within-person research expanding upon our findings is vital to adequately inform efficacious, personality-focused, health behaviour promotion interventions.

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