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## Associations between personality traits, physical activity level, and muscle strength

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### Abstract

Associations among personality as measured by the Five Factor Model, physical activity, and muscle strength were assessed using data from the Baltimore Longitudinal Study of Aging ( $N=1220$ , *age: mean* = 58, *SD* = 16). General linear modeling with adjustment for age, sex, race, and body mass index, and bootstrapping for mediation were used. We found neuroticism and most of its facets to negatively correlate with strength. The extraversion domain and its facets of warmth, activity, and positive-emotions were positively correlated with strength, independent of covariates. Mediation analysis results suggest that these associations are partly explained by physical activity level. Findings extend the evidence of an association between personality and physical function to its strength component and indicate health behavior as an important pathway.

### Keywords

Personality; Neuroticism; Extraversion; Agreeableness; Physical activity; Muscle strength

## 1. Introduction

Although personality has been consistently linked to physical health outcomes including mobility limitations and disability (Brenes et al., 2005; Brenes, Rapp, Rejeski, & Miller, 2002; Krueger, Wilson, Shah, Tang, & Bennett, 2006; Wilson et al., 2006), whether personality traits have an impact early on in the disability process is still unclear. According to the Nagi's Disablement Model, development of disability is a progressive process in which active pathology leads to impairment, which in turn leads to functional limitations and finally to disability (Nagi, 1965). Impairments, the second step in the pathway refers to abnormalities or loss in body systems such as the musculoskeletal system. In young age, available muscle strength exceeds that required to perform normal activities of daily life. However, later in life, declines in muscle strength – the force generated by muscle contraction – diminish the range of activities individuals can perform (Doherty, 2001; Kallman, Plato, & Tobin, 1990) including mobility (Ferrucci et al., 1997) and other

activities of daily living such as personal care activities (Rantanen, 2003). Moreover, lower extremity muscle strength (i.e. quadriceps) has been associated with other health outcomes such as knee osteoarthritis (Slemenda et al., 1997) and falls, especially among adults with chronic conditions (Durmus et al., 2010) and is a strong predictor of mortality risk in older adults (Newman et al., 2006).

The role that personality may play in the process that leads to mobility disability is best described by the Verbrugge and Jette's Model of disability, which expands the Nagi's taxonomy to include risk factors and intra- and extra-individual modifiers (Verbrugge & Jette, 1994). This model suggests that personality can directly contribute to development of mobility disability in two ways. First, it can influence the likelihood of developing chronic or acute illnesses (pathology level), which would then initiate the process that leads to musculoskeletal impairments, mobility limitation and disability. Second, once pathology is present, personality can speed up or slow down the progression from pathology to disability.

Although how personality relates to these processes is still unclear, health behaviors and particularly sedentary behavior are perhaps among the most important mechanisms. Within the Five-Factor Model (FFM) of personality (Digman, 1990), neuroticism, extraversion, and conscientiousness have been reported as reliable correlates of physical activity (Bogg & Roberts, 2004; De Moor, Beem, Stubbe, Boomsma, & De Geus, 2006; Saklofske, Austin, Rohr, & Andrews, 2007), being at least as important as other more extrinsic correlates of physical activity (Rhodes & Smith, 2006).

Individuals characterized by negative emotions such as anxiety (McWilliams & Asmundson, 2001), anger and hostility (Anton & Miller, 2005; Higgins et al., 1991), loneliness (Shankar, McMunn, Banks, & Steptoe, 2011) and hopelessness (Valtonen et al., 2009) may be less likely to engage in physical activities compared to those with lower scores on these traits. Among the extraversion facets, activity (Rhodes, Courneya, & Jones, 2002, 2004) and sensation seeking (De Moor et al., 2006; Jack & Ronan, 1998) received the most support as positive correlates of physical activity. A meta-analysis of conscientiousness and health-related behaviors found that being achievement-oriented and persistent (captured by NEO-PI's achievement striving facet); organized, efficient, and regimented (captured by NEO-PI's order and self-discipline facets); and self-controlled (i.e. NEO-PI's deliberation facet) were the strongest correlates of physical activity among 194 studies analyzed (Bogg & Roberts, 2004). On the other hand, physical inactivity has been shown to strongly predict decline in muscle strength, reduced walking speed, and mobility-related disability (see a review by Buchner, 1997), suggesting that level of physical activity may at least in part explain some of the individual differences in muscle strength and other functional outcomes.

In spite of the evidence for relationships between personality, physical activity, and muscle strength, to our knowledge, only one study reported on the association between personality and muscle strength (Jorm et al., 1993). In that study, Jorm and colleagues investigated correlations between neuroticism and extraversion and muscle strength in a sample of older community-dwelling Australian men and women. Neuroticism but not extraversion was found to negatively correlate to strength in women only. More studies are needed to confirm these associations as well as the importance of the remaining three of the FFM personality traits and muscle strength and to assess the potentially mediating role of physical activity. Moreover, investigation at the facet level would provide insight into what specific components of the five personality traits are important in relation to physical activity and muscle strength.

In the current study, we evaluated cross-sectional associations between the five personality traits along with their six facets, physical activity, and muscle strength in the Baltimore

Longitudinal Study of Aging (BLSA). We hypothesized that personality would be associated with muscle strength and that health behavior would mediate this association (i.e. Personality → Health behavior → Muscle strength). More specifically, we expected neuroticism and most of its facets to be associated with lower muscle strength. In contrast, we expected extraversion particularly its facets of activity and excitement seeking; and conscientiousness and most of its facets to be positive correlates.

Although no relationship with physical activity was found for agreeableness in a recent meta-analysis of personality correlates of physical activity (Rhodes & Smith, 2006), based on evidence of a positive association of agreeableness with other healthy behaviors (Terracciano & Costa, 2004; Terracciano, Lockenhoff, Crum, Bievenu, & Costa, 2008), we also expected that highly agreeable individuals would have greater strength than less agreeable individuals. Persons characterized by traits such as altruism, compliance, and modesty may be more likely to engage in positive interpersonal relations, which might be conducive of higher levels of physical activity. Though more studies are needed before openness to experience can be reliably linked to physical activity, at least two studies have found a positive association between the two (Courneya, Friedenreich, Sela, Quinney, & Rhodes, 2002; Rhodes, Courneya, & Jones, 2003). This along with a few other reports of positive associations with self-perceived health (Goodwin & Engstrom, 2002) and survival (Iwasa et al., 2008) led us to hypothesize that high scorers on openness and particularly high scorers on actions (who prefer novel and various types of activities and therefore might be more likely to engage in physical activities) to also have greater strength.

## 2. Materials and methods

### 2.1. Participants and procedures

The BLSA is an ongoing longitudinal study of community-dwelling volunteers living primarily in the Baltimore–Washington area, who have been continually recruited starting in 1958. In 1978 women volunteers were systematically added to the previously exclusive male study population. Follow-up times vary depending on participants' age from every 1 year for the oldest old (80 + years) to every 5 years for younger participants (<60 year). These procedures were slightly modified in 2006 to every 4 years for the younger group. A usual clinic visit lasts 2–3 days and includes among others, a battery of performance, cognitive, personality, and psychological tests administered to all participants assuming they do not meet exclusion criteria. A general description of the sample and the recruitment criteria of the BLSA have been reported previously (Lissner, Andres, Muller, & Shimokata, 1990; Shock et al., 1984). No exclusionary health criteria were used in this study given that in the BLSA health-related factors were not found to be important in explaining muscle strength (Metter, Conwit, Tobin, & Fozard, 1997). The BLSA protocol has been continuously approved by the appropriate Institutional Review Board over the life of the study, and all subjects signed institutional review board-approved informed consents.

We identified 1220 BLSA participants (47% *men*; 66% *white*) with valid NEO-PI-R personality and knee muscle strength data assessed between October 1992 and April 2007, and retained only the first visit in which both personality and muscle strength were assessed. However, because the BLSA does not employ the usual 'wave approach' but rather enrolls eligible adults aged 20 + years on a continuous basis and follows them up according to their current age, the baseline for each participant varied and covered the entire study period. In other words, we used only one point in time for each participant, but that could have fallen anywhere within the study period. That would include young participants just joining the study, as well as more senior participants who had personality and knee muscle strength both assessed for the first time. Therefore, our sample ranged in age from 20 to 94 years

(*mean* = 58 years; *SD* = 16 years), was on average overweight, and scored on all five personality traits in the range considered average in the general population (Table 1).

## 2.2. Relative knee muscle strength

Detailed descriptions of the muscle strength testing in the BLSA have been published previously (Lindle et al., 1997; Lynch et al., 1999). Briefly, muscle strength of the knee was measured in the dominant leg using a Kin-Com isokinetic dynamometer (Kin-Com version 125E Plus, Chattecx Corporation, Chattanooga, TN). Maximal voluntary concentric peak torque (Newton-meter; Nm) of the knee extensor (quadriceps) muscles was measured at angular velocities of 0.52 rad/s (30 deg/s). Peak torque was measured three times and the highest value was used in the analysis. Participants were excluded from strength testing if they had bilateral joint replacement, severe osteoporosis (femoral neck bone density  $.50 \text{ g/cm}^2$  (females) and  $.59 \text{ g/cm}^2$  (males) and/or lumbar bone density  $.72 \text{ g/cm}^2$  (females) and  $.76 \text{ g/cm}^2$  (males) or joint pain on passive motion. Relative knee muscle strength was calculated as knee muscle strength divided by weight (Nm/kg), often referred to as strength normalized for weight.

## 2.3. Personality traits

Personality traits were measured using the Revised NEO Personality Inventory (NEO-PI-R) (Costa & McCrae, 1992), which consists of 240-item statements to which participants indicate their level of agreement with regard to how well the statement describes their beliefs, attitudes and behaviors using a 5-point scale ranging from strongly disagree to strongly agree. The NEO-PI-R assesses six facets for each of the five personality traits of neuroticism, extraversion, openness to experience, agreeableness, and conscientiousness. This taxonomy has a robust factor structure that has been replicated in the BLSA and other samples from more than 50 cultures (McCrae & Terracciano, 2005). In the BLSA sample, the internal consistencies for the five NEO-PI-R traits were .91, .87, .87, .88, and .92 for N, E, O, A, and C, respectively, and previous research has shown high levels of stability, with corrected  $r_{tt} > .90$  over a 10-year interval (Terracciano, Costa, & McCrae, 2006). Raw scores were converted to *T*-scores (*mean* = 50, *SD* = 10) using the combined-sex norms for adults reported in the NEO Manual (Costa & McCrae, 1992).

## 2.4. Physical activity

Information on total moderate and high intensity physical activity was assessed via self-report. The assessment approach and units of measurement changed in 2002, such that depending on when their baseline assessment fell within the study period (1992–2007) this variable was measured for some participants as METs \* min/week and for others as kcal/week. To account for this measurement difference, we ranked participants on physical activity level (i.e. sex-specific tertiles) within the period their baseline measurement was taken (before or after 2002).

## 2.5. Covariates

Several factors believed to be associated with both personality and muscle strength were considered as potential confounders. They included age (in years), sex (male vs. female), race (white vs. others), and body mass index (BMI). Weight was measured to the nearest 10th of a kilogram with a metric measuring scale without shoes. Height was measured to the 10th of a centimeter using a stadiometer and body mass index (BMI) was calculated as weight/height<sup>2</sup> (kg/m<sup>2</sup>). Many risk factors for reduced muscle strength have been identified including socio-demographic factors (e.g. age, sex, and race) and excess body weight (Forrest, Zmuda, & Cauley, 2007; Goodpaster et al., 2006; Newman et al., 2003; Rantanen et al., 1999; Visser et al., 2002) and were therefore controlled for in our analyses.

## 2.6. Data analysis

Sample characteristics were evaluated using simple descriptive tests for continuous (mean  $\pm$  SD) and categorical ( $N$ (percentage)) variables. Associations between the five personality traits and relative muscle strength beyond the effect of covariates were investigated by general linear modeling. To test whether each domain was associated with the outcome independent of the effect of the other four traits a model that included all five traits was tested as well. Gender differences in muscle strength have been reported (Miller, MacDougall, Tarnopolsky, & Sale, 1993), therefore we also tested each of these personality traits for interaction with sex (personality \* sex interaction terms were added to the GLM models) to ensure that important gender differences were not overlooked. Additionally, for the traits that were found associated with the outcome, further analyses were conducted to assess associations at the facet level. All analyses were adjusted for age, sex, race, and BMI.

Finally, we used bootstrapping analysis techniques (SAS code available from <http://www.comm.ohio-state.edu/ahayes/SPSS%20programs/indirect.htm>) to assess the mediating effect of physical activity on the associations between personality traits and relative muscle strength with adjustment for covariates. As a mediation technique, bootstrapping involves re-sampling the data a pre-set number of times (in our analysis we ran 5000 re-samples) and estimating the indirect effect in each re-sample to obtain an empirical approximation of the sampling distribution of the indirect effect along with confidence intervals around it (Preacher & Hayes, 2008). Bootstrapping provides a quantification of the indirect effect and does not assume a normal sampling distribution of the indirect effect. All analyses were performed using the SAS 9.1 statistical package (SAS Institute, Inc., Cary, North Carolina, USA) and significance was tested using the  $p$  level of  $<0.05$ .

## 3. Results

As hypothesized, personality traits pertaining to the dimensions of neuroticism and extraversion were associated with muscle strength, independent of age, sex, race, and BMI (Table 2). The domain of neuroticism was negatively associated with muscle strength. More specifically, each one standard deviation increase in neuroticism was associated with 0.050 ( $p < 0.001$ ) lower muscle strength. This association was only slightly reduced by the inclusion of extraversion, openness, agreeableness, and conscientiousness in the model ( $\beta = -0.042$ ,  $p = 0.003$ ) and was not moderated by gender ( $p = 0.631$ ). On the other hand, a positive association was observed for extraversion ( $\beta = 0.037$ ,  $p = 0.004$ ), which remained significant after the other four personality traits were considered ( $\beta = 0.028$ ,  $p = 0.036$ ). As was the case with neuroticism, there was no significant interaction between extraversion and gender ( $p = 0.675$ ).

Similar associations were observed for the neuroticism facets of anxiety ( $\beta = -0.042$ ,  $p = 0.001$ ), angry hostility ( $\beta = -0.042$ ,  $p = 0.001$ ), depression ( $\beta = -0.042$ ,  $p = 0.002$ ), self-consciousness ( $\beta = -0.042$ ,  $p = 0.001$ ), and vulnerability ( $\beta = -0.028$ ,  $p = 0.039$ ) (Fig. 1). All the neuroticism facets retained significance when extraversion, openness, agreeableness, and conscientiousness were included in the models with the exception of vulnerability ( $\beta = -0.028$ ,  $p = 0.085$ ). As Fig. 2 suggests, of the extraversion facets, warmth ( $\beta = 0.035$ ,  $p = 0.006$ ), activity ( $\beta = 0.026$ ,  $p = 0.042$ ) and positive emotions ( $\beta = 0.047$ ,  $p < 0.001$ ) were significant correlates of strength, although the effect of warmth was reduced ( $\beta = 0.020$ ,  $p = 0.188$ ) when neuroticism, openness, agreeableness and conscientiousness were taken into account. Similarly to the five traits, gender was not found to moderate the effects of the significant neuroticism and extraversion facets (data not shown).

We further investigated whether risky personality traits would combine to increase the risk of lower muscle strength. Risky traits were defined as a  $t$  score of 56 or more for

neuroticism and its facets and as a score of less than 45 on extraversion and its facets based on recommendations in the Manual (Costa & McCrae, 1992). Only domains and facets found to be significant in the main analysis were included in this exploratory analysis leading to a total of 10 risky traits. Eighteen percent of participants had no risky traits, 33% had one, 31% had two or three, and 18% had four or more. This exploratory analysis revealed that the number of risky personality traits is negatively associated with muscle strength after covariates are adjusted for (Fig. 3). More specifically, having the highest number of risky traits was associated with significantly lower strength compared to having no ( $p < 0.001$ ) and one risky trait ( $p = 0.001$ ), but was not significantly different compared to having two or three risky traits ( $p = 0.111$ ), although a trend was found ( $p = 0.001$ ). This negative association was further confirmed when number of risky traits was analyzed as a continuous variable ( $\beta = -0.032$ ,  $p < 0.001$ ).

Table 3 presents the mediation results for the personality traits associated with physical activity, the mediator of interest. Out of the 10 significant personality correlates of muscle strength, only self-consciousness ( $\beta = -0.051$ ,  $p = 0.038$ ) and extraversion, warmth, activity, and positive emotions (all at  $p < 0.05$ ) were associated with physical activity, thus the mediation analysis was restricted to these five personality constructs. We found physical activity to positively correlate with muscle strength independently of the effect of personality, socio-demographic, and health-related factors (direct effect of physical activity column in Table 3). The reduction in the effect of personality on muscle strength by inclusion of physical activity in the models ranged from 7% to 42% [calculated as (total – direct effect)/total effect]. Although small, the reduction in the effect size for positive emotions (7%) and self-consciousness, extraversion and warmth (all at 10%) coupled with a reduction in the significance level for these effects indicates partial mediation by physical activity. The biggest impact of physical activity was seen for the facet of activity, whose effect was reduced by 42% and deemed insignificant ( $p = 0.290$ ). According to the bias corrected confidence intervals (last column in Table 3), all the indirect effects of personality traits (via physical activity) were statistically significant.

#### 4. Discussion

Findings from this study extend the body of evidence suggesting an association between personality traits and physical function to a performance-based assessment of muscle strength. We found neuroticism and extraversion, both at the domain and facet level, to correlate with knee extensor muscle strength, suggesting a potentially important role for these personality traits in the process that leads to disability in old age. Our findings also point to physical activity as a potential mediator of some of the observed relationships.

Over the past decade, evidence of a negative association between neuroticism and physical function has mounted. Individuals with higher scores on neuroticism are more likely to report mobility limitations and disability than those with lower scores (Chapman, Duberstein, & Lyness, 2007; Jang, Haley, Mortimer, & Small, 2003; Jang, Mortimer, Haley, & Graves, 2002; Kempen et al., 1999; Murberg, Bru, Svebak, Aarsland, & Dickstein, 1997). However, whether an association exists between neuroticism and objective measures of physical function, particularly the strength component had been less investigated. Our finding of a negative association between the domain of neuroticism and muscle strength is in line with the Jorm report. We found this association to persist even when other risk factors for lower muscle strength (i.e. age, sex, race, and BMI) are taken into account, and to be independent of the effect of other personality traits. Moreover, by exploring facet-level associations, we found that this relationship extends to most of the six components of neuroticism, suggesting this personality trait as one of the most significant personality correlates of muscle strength.

Individuals with personalities characterized by a tendency toward negative emotions such as anxiety, hostility, depression, self-consciousness, and vulnerability tend to lead unhealthy lifestyles. These individuals may, for example, avoid physical activity or display poor exercise adherence (Courneya & Hellsten, 1998). However, in our sample only the facet of self-consciousness was associated with physical activity level, which explained in part its effect on muscle strength. Our finding of a negative association with physical activity suggests that in order to avoid feeling uncomfortable, inferior and the threat of ridicule, these individuals may choose to not engage in or adhere to exercise regimens, which in turn may lead to diminished muscle strength. The lack of an association with physical activity for the domain of neuroticism and its facets of anxiety, hostility, depression, and vulnerability, was unexpected. Reports of positive correlations with exercise barriers such as lack of energy (Courneya & Hellsten, 1998) would suggest that most of these facets, particularly depression, would be associated with physical inactivity. Other non-behavioral mechanisms may include psychophysiological stress and chronic inflammation. Higher neuroticism has been linked to higher resting cortisol levels (Miller, Cohen, Rabin, Skoner, & Doyle, 1999), which have been associated with lower isometric knee extension strength in middle aged and especially in healthy men over the age of 65 (Izquierdo et al., 2001). A positive association with circulating levels of pro-inflammatory markers such as IL-6 has also been reported for neuroticism (Sutin et al., 2010). In turn, higher levels of IL-6 may predict future disability in non-disabled older adults likely through a detrimental effect on muscle strength (Ferrucci et al., 1999). These potential pathways should constitute the focus of future studies.

Extraversion was also a significant correlate of muscle strength, although in a direction opposite to that of neuroticism. This finding is consistent with reports of extraversion as being a significant correlate of physical function using measures further along in the disablement pathway, such as self-reported limitations in activities of daily living (Krueger et al., 2006). However, it does contradict the report by Jorm and colleagues who found no association between the domain of extraversion and muscle strength in either women or men. The contradictory results might stem from differences in the age of study participants and/or the measure of muscle strength studied.

Furthermore, we found the impact of extraversion to be best captured by its facets of warmth, activity, and positive emotions. These effects were explained by participation in physical activities. The facet of activity was the strongest personality correlate of physical activity, which reduced its effect on muscle strength almost in half. Participation in physical activities is certainly a highly plausible behavior in high scorers on this facet, who are characterized by a rapid tempo and a sense of energy and of keeping busy. These persons may seek out physical activity as a means of 'feeding' their need for being active, excited and adventurous (Rhodes & Smith, 2006). The tendencies to be affectionate and friendly toward others and to generally be cheerful and optimistic, characteristic to high scorers on warmth and positive emotions, may indicate a predisposition for engaging in a broad range of positive behaviors which could include physical activities impacting muscle strength. For example, more positive interpersonal attitudes and interactions among these individuals might promote better physical health and thus greater physical strength. The latter is supported by a reported positive correlation of extraversion with socializing/meeting people as an exercise motive (Courneya & Hellsten, 1998). However, given that only partial mediation was noted, physical activity is unlikely to be the only mechanism linking personality to muscle strength. Perhaps other pathways explaining the personality–health association may be at play and should be investigated in future studies.

Examination of number of risky traits found those with at least one and particularly those with multiple such traits to have increasingly lower muscle strength, probably due to a higher risk of unhealthy behaviors among individuals with combinations of negative

personality traits (e.g. high neuroticism, low extraversion and low agreeableness) (Terracciano & Costa, 2004; Vollrath & Torgersen, 2008). When examining these results, we should consider whether although statistically significant, the small differences in muscle strength between the group with the highest number of 'risky' traits and the one with no such traits may not necessarily be meaningful. However, findings from a recent study of knee extension strength cut-points for maintaining mobility suggest that even differences in relative strength as low as 0.2 Nm/kg (combined men and women) may significantly predict risk of mobility disability, low walking speed, and higher risk of dying (Manini et al., 2007). Interactive effects have been previously reported (Terracciano & Costa, 2004) supporting the idea that combinations of negative personality traits may increase the risk of negative health outcomes beyond the additive effect of each individual trait. These and other interactions between risky personality traits should be investigated in the future.

Study findings should be interpreted in light of the limitations described below. First, the cross-sectional nature precludes making inferences on the potential impact of personality on strength decline. These associations should be further examined in studies with longitudinal designs. Second, because of the selective nature of the BLSA population our results would be more applicable to the segment of the population that is well-educated and health conscious. Important strengths include the relatively large sample size, wide age-range, and the in-depth analysis investigating both domain-and facet-level personality traits.

In conclusion, we found that several personality traits were associated with muscle strength partially through an effect on physical activity level. Moreover, having multiple negative traits appears to increase the risk of lower muscle strength. Given the importance of muscle strength in maintaining functional independence and that muscle strength can be improved, it may be instructive to examine how positive elements of personality may be applied in developing programs aimed at maintaining strength and physical function. Furthermore, interactions between personality typologies in relation to muscle strength should constitute the focus of future research as they may help identify specific configurations that put individuals at risk for strength decline and other negative health outcomes.

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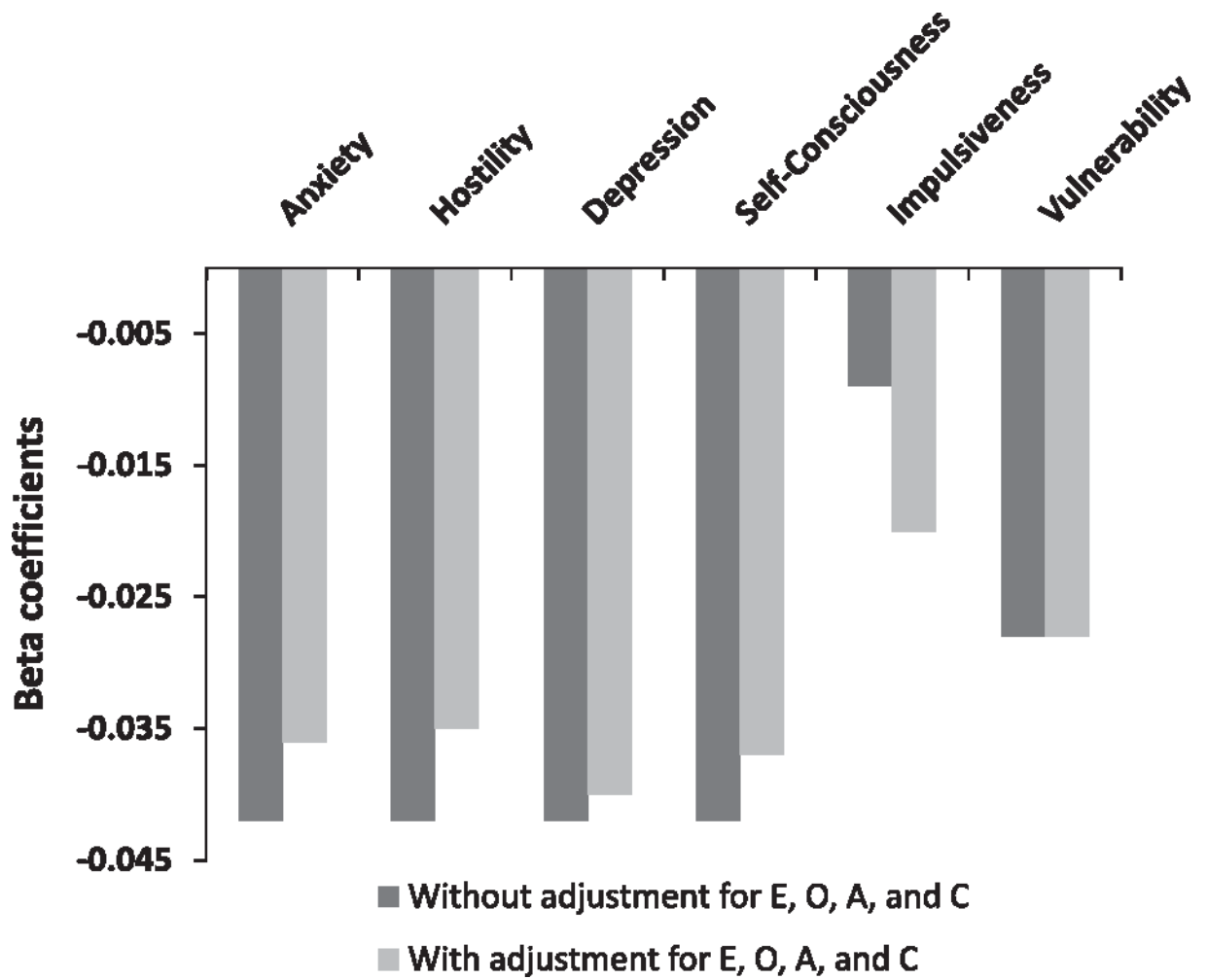
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**Fig. 1.** Association of neuroticism facets and muscle strength. *Notes:* All neuroticism facets were associated with muscle strength at the  $p$  level of  $<0.05$  except for Impulsiveness which was not significant ( $p = 0.520$ ). Significant facets retained significance after E, O, A, and C were accounted for in the analysis with the exception of vulnerability ( $p = 0.085$ ). Muscle strength measured as Nm/kg.

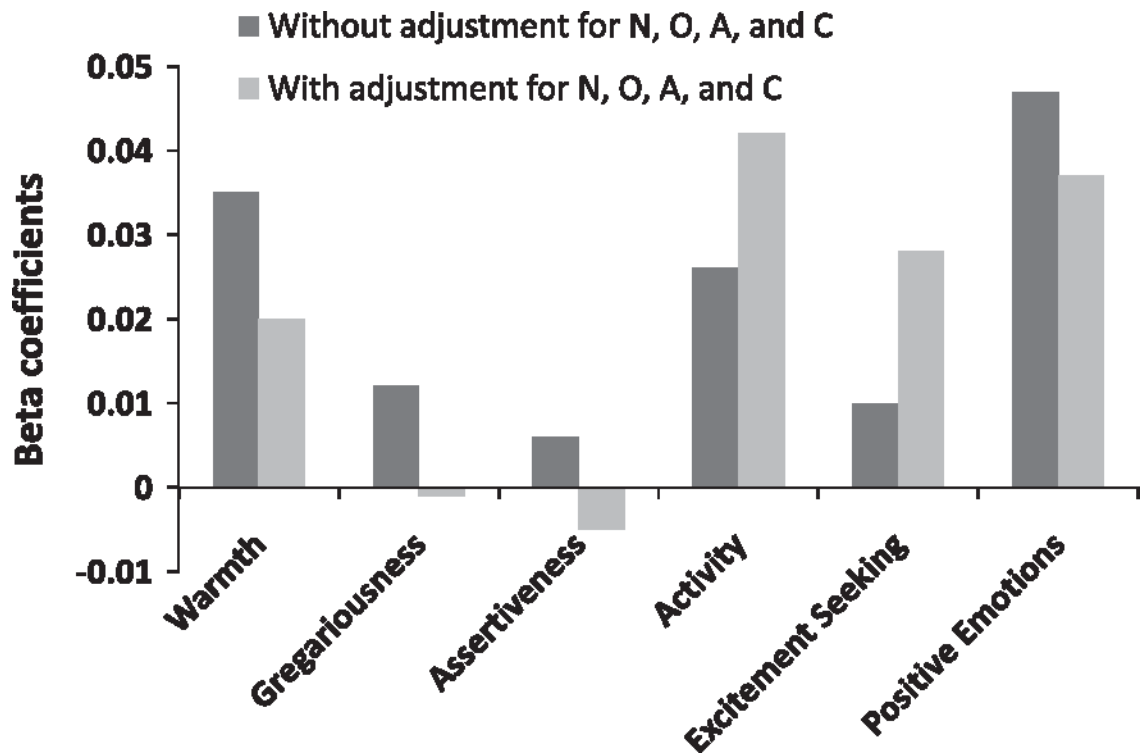


Fig. 2. Association between extraversion facets and muscle strength. *Notes:* The Extraversion facets of Warmth ( $p = 0.006$ ), Activity ( $p = 0.042$ ), and Positive Emotions ( $p < 0.001$ ) were positively associated with muscle strength. They remained significant after N, O, A, and C were adjusted for with the exception of Warmth ( $p = 0.188$ ).

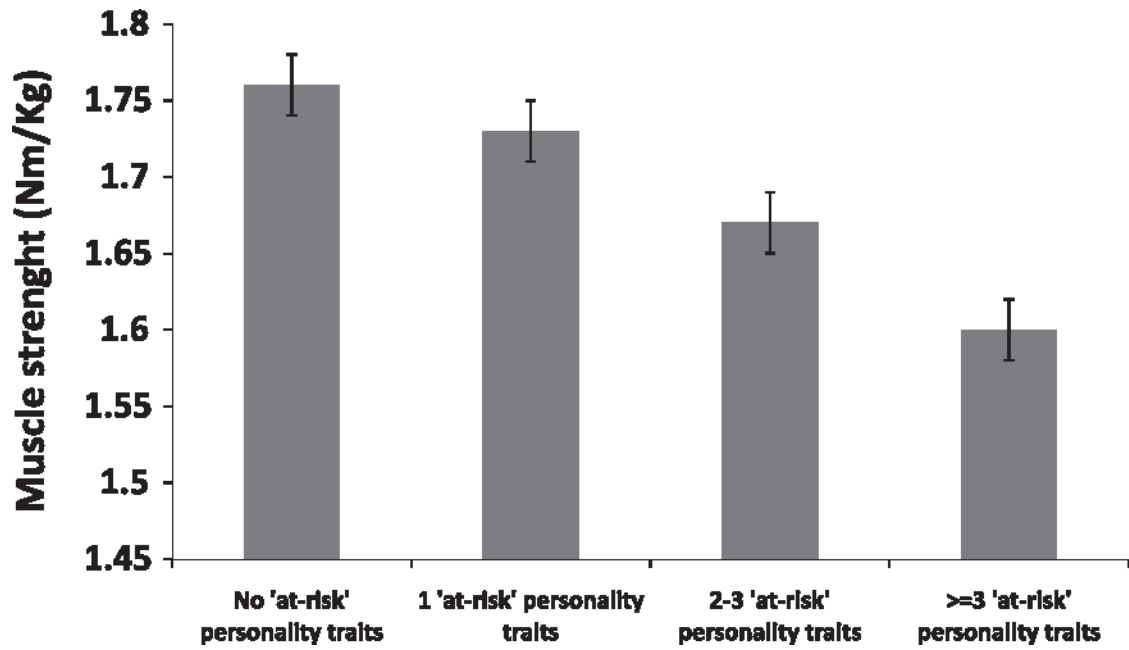


Fig. 3. Mean muscle strength by number of 'at-risk' personality traits. *Notes:* Bars represent 95% CI around means. Means adjusted for age, sex, race, and BMI.

**Table 1**Baseline characteristics of study participants ( $n = 1220$ ).

Characteristic	Mean (SD) or %
Age, years	58.3 (16.0)
Sex, male, $N$ (%)	605 (49.6)
Race, white, $N$ (%)	806 (66.1)
BMI ( $\text{kg}/\text{m}^2$ )	26.6 (4.4)
Neuroticism	46.8 (9.3)
Extraversion	49.8 (10.1)
Openness	53.4 (10.5)
Agreeableness	50.4 (9.7)
Conscientiousness	50.8 (10.5)
Knee muscle strength (Nm)	129.3 (52.9)

**Table 2**  
GLM estimates for associations of personality domains and Knee Strength beyond the effect of covariates.

Personality trait	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Intercept	3.53 (<0.001)	3.81 ( $p < 0.001$ )	3.34 ( $p < 0.001$ )	3.47 ( $p < 0.001$ )	3.41 ( $p < 0.001$ )	3.60 ( $p < 0.001$ )	3.56 ( $p < 0.001$ )
Age	-0.02 ( $p < 0.001$ )	-0.02 ( $p < 0.001$ )	-0.02 ( $p < 0.001$ )	-0.02 ( $p < 0.001$ )	-0.02 ( $p < 0.001$ )	-0.02 ( $p < 0.001$ )	-0.02 ( $p < 0.001$ )
Male	0.49 ( $p < 0.001$ )	0.47 ( $p < 0.001$ )	0.50 ( $p < 0.001$ )	0.49 ( $p < 0.001$ )	0.50 ( $p < 0.001$ )	0.49 ( $p < 0.001$ )	0.50 ( $p < 0.001$ )
Race	0.07 ( $p = 0.019$ )	0.07 ( $p = 0.013$ )	0.07 ( $p = 0.019$ )	0.07 ( $p = 0.019$ )	0.07 ( $p = 0.018$ )	0.07 ( $p = 0.028$ )	0.07 ( $p = 0.018$ )
BMI	-0.04 ( $p < 0.001$ )	-0.04 ( $p < 0.001$ )	-0.04 ( $p < 0.001$ )	-0.04 ( $p < 0.001$ )	-0.04 ( $p < 0.001$ )	-0.04 ( $p < 0.001$ )	-0.04 ( $p < 0.001$ )
Neuroticism	-	-0.05 ( $p < 0.001$ )	-	-	-	-	-0.04 ( $p = 0.003$ )
Extraversion	-	-	-0.04 ( $p < 0.004$ )	-	-	-	0.03 ( $p = 0.036$ )
Openness	-	-	-	0.01 ( $p = 0.466$ )	-	-	0.003 ( $p = 0.836$ )
Agreeableness	-	-	-	-	0.02 ( $p = 0.073$ )	-	0.02 ( $p = 0.122$ )
Conscientiousness	-	-	-	-	-	-0.01 ( $p = 0.402$ )	-0.01 ( $p = 0.478$ )

Notes: BMI = body mass index.

Model 1 tests the effect of the set of covariates on muscle strength.

Model 2 adds Neuroticism to Model 1.

Model 3 adds Extraversion to Model 1.

Model 4 adds Openness to Experience to Model 1.

Model 5 adds Agreeableness to Model 1.

Model 6 adds Conscientiousness to Model 1.

Model 7 adds all 5 personality traits to Model 1.



**Table 3**

Mediation results from bootstrapping analyses (Beta coefficients (*p* value)).

Personality	Correlation with physical activity	Direct effect of physical activity	Total effect of personality	Direct effect of personality	Indirect effect of personality <sup>a</sup>
Self-consciousness	-0.051 (0.038)	0.060 (<0.001)	-0.031 (0.028)	-0.028 (0.046)	(-0.007; -0.0004)
Extraversion	0.053 (0.028)	0.059 (<0.001)	0.031 (0.024)	0.028 (0.042)	(0.0004; 0.008)
Warmth	0.058 (0.017)	0.058 (0.001)	0.039 (0.006)	0.035 (0.011)	(0.001; 0.008)
Activity	0.109 (<0.001)	0.059 (0.001)	0.026 (0.042)	0.015 (0.290)	(0.003; 0.013)
Positive emotions	0.047 (0.044)	0.058 (0.001)	0.044 (0.001)	0.041 (0.002)	(0.0004; 0.007)

<sup>a</sup>Bias corrected Confidence Interval (CI) for indirect effects of personality traits through physical activity. Total effect of personality is calculated without adjustment for physical activity. Direct effect of physical activity is calculated with adjustment for personality. Direct effect of personality is calculated with adjustment for physical activity. All models are further adjusted for age, sex, race, and BMI. Only personality traits that are correlated with physical activity are shown.