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Personality Typology in Relation to Muscle Strength

Magdalena I. Tolea,

Clinical Research Branch, Longitudinal Studies Section, National Institute on Aging, Baltimore, MD, USA. National Institute on Aging, 3001 S Hanover Street, 5th Floor, Baltimore, MD 21225, USA

Antonio Terracciano,

Intramural Research Program, Laboratory of Personality and Cognition, National Institute on Aging, Baltimore, MD, USA

Yuri Milaneschi,

Clinical Research Branch, Longitudinal Studies Section, National Institute on Aging, Baltimore, MD, USA

E. Jeffrey Metter, and

Clinical Research Branch, Longitudinal Studies Section, National Institute on Aging, Baltimore, MD, USA

Luigi Ferrucci

Clinical Research Branch, Longitudinal Studies Section, National Institute on Aging, Baltimore, MD, USA

Magdalena I. Tolea: toleam@mail.nih.gov

Abstract

Background—Physical inactivity plays a central role in the age-related decline in muscle strength, an important component in the process leading to disability. Personality, a significant determinant of health behaviors including physical activity, could therefore impact muscle strength throughout adulthood and affect the rate of muscle strength decline with aging. Personality typologies combining “high neuroticism” ($N \geq 55$), “low extraversion” ($E < 45$), and “low conscientiousness” ($C < 45$) have been associated with multiple risky health behaviors but have not been investigated with regards to muscle strength.

Purpose—The purpose of this study is to investigate associations between individual and combined typologies consisting of high N , low E , and low C and muscle strength, and whether physical activity and body mass index act as mediators.

Method—This cross-sectional study includes 1,220 participants from the Baltimore Longitudinal Study of Aging.

Results—High N was found among 18%, low E among 31%, and low C among 26% of the sample. High levels of N , particularly when combined with either low E or low C , were associated with lower muscle strength compared with having only one or none of these personality types. Facet analyses suggest an important role for the N components of depression and hostility. Physical activity level appears to partly explain some of these associations.

Conclusion—Findings provide support for the notion that the typological approach to personality may be useful in identifying specific personality types at risk of low muscle strength and offer the possibility for more targeted prevention and intervention programs.

Keywords

Personality; Muscle strength; Physical activity; Cross-sectional studies

Introduction

Among older adults, decline in muscle strength represents an important component in the process leading to disability [1]. Among healthy elderly, knee extensor strength annual declines of up to 4% [2] can have a significant impact on functional ability [3, 4]. Empirical evidence suggests that good muscle strength in midlife protects against disability in later life [5], which highlights the importance of maintaining muscle strength throughout life. Although other factors may lead to muscle weakening, age-related declines in physical activity appear to play a central role [5, 6].

Through its association with health behaviors which are known predictors of muscle strength decline [6, 7], personality could influence the ability to maintain muscle strength and prevent future loss. For example, of the five NEO Personality Inventory (NEO-PI-R) dimensions, high neuroticism (*N*), low extraversion (*E*), and low conscientiousness (*C*) have been individually linked to behaviors such as smoking [8–10], drug use [9, 11], physical activity [9, 12, 13], and health-behavior consequences such as overweight and obesity [14, 15] which in turn may lead to muscle strength decline. In spite of the fact that there is evidence supporting an association between personality (i.e., *N*, *E*, and *C*) and health [16–21] and physical function [22–24], whether this extends to the strength component of physical function is less clear. In fact, we are aware of only one study reporting a negative association between neuroticism and grip strength in women [25].

Although a preference for a trait (i.e., continuous) versus type (i.e., categorical) approach in investigations of personality effects on health and physical function has recently emerged, the latter resonates better with clinicians [26] and facilitates dissemination of findings on personality to the general public [27]. By creating easily identifiable clusters of personality preferences, a typological approach may, therefore, facilitate investigation of personality effects on different health outcomes including physical function. For example, in a longitudinal analysis of the association between the five NEO-PI-R personality domains and incident disability among older persons, by using the 90th percentile as representing high and the 10th percentile as low scores, Krueger and colleagues were able to show that individuals high on *E* and *C* may have a reduced risk of disability [24]. Moreover, a recent study comparing the trait versus the type approaches on their long-term predictive validity found both approaches to be equally predictive of different longitudinal outcomes [27].

The value of using a typological approach in the investigation of personality effects on physical function especially when combining personality preferences is further supported by findings of a tendency toward engagement in multiple unhealthy behaviors by individuals with personality types that combine high *N*, low *E*, and low *C*. In two different populations of university students, Vollrath and Torgersen found that persons with personality typologies that combine high *N* with low *C* and low *C* with high *E* tend to engage in multiple, risky health behaviors [28, 29]. The authors proposed that engagement in behaviors such as smoking and drinking may be facilitated by a need for stimulation with low self-control, or a way to reduce tensions stemming from *N* coupled with inability to control urges [29]. In contrast, high *C* might prevent extraverted and neurotic personalities

from taking health risks [28, 29]. The higher likelihood of engagement in multiple unhealthy behaviors by persons with these personality types could lead to an increased risk of low muscle strength and promote development of disability. Moreover, in the stress and coping literature, typologies combining *N*, *E*, and *C* have been suggested as useful approaches to understanding how individuals experience and manage stress. The combination of high *N* and low *C* whether in combination with low (insecure) or high impulsive) *E* was reported to be associated with vulnerability to stress, unfavorable affectivity, and dysfunctional coping style [30, 31]. Also, high perceived stress levels were reported in persons with personality types that combine high *N* with low *E* and poor coping in those with low *E* and low *C* [32]. This proneness toward stress and poor coping mechanisms further suggest that personalities combining these three unfavorable traits may be important correlates of poor muscle strength.

The current cross-sectional study was initiated to investigate associations of high *N*, low *E*, and low *C* personality types with muscle strength, individually as well as in combinations. We decided to consider low rather than high *E* as a risky typology because although extraverted individuals are more likely to smoke, drink, and have unsafe sex [28, 29], they also are more likely to engage in physical exercise and to have positive attitudes toward exercise [12, 13]. Therefore, in the context of muscle strength where behaviors that relate to physical activity have more significance, low *E* should be considered a risky personality type. Moreover, we sought to understand whether physical activity and body mass index (BMI) might mediate the associations between personality and muscle strength. We expected that individuals with high *N*, low *E*, and low *C* as well as those with a combination of high *N*/low *E*, high *N*/low *C*, or low *E*/*C* to show lower muscle strength compared with individuals without these personality types and combinations and also that lifestyle would explain at least in part these associations.

Methods

Participants

The Baltimore Longitudinal Study of Aging (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. Although initially only men were recruited into the study, women have been systematically added since 1978. At each clinic visit which lasts approximately 2.5 days, participants undergo extensive evaluations including medical evaluations and physiological, functional, personality, and cognitive testing. A general description of the sample and the recruitment criteria of the BLSA have been reported previously [33, 34]. The BLSA protocol has been continuously approved by the appropriate institutional review board over the life of the study. All subjects signed institutional review board-approved informed consents. Using all available BLSA data at the time this project was undertaken, we identified 1,406 participants who underwent knee-strength testing and had valid strength data. We further excluded participants without personality data ($N=186$), which led to an analytic sample of 1,220 BLSA participants with valid data on both personality and muscle strength (spanning from October 1992 to April 2007).

Muscle Strength

Detailed descriptions of the muscle strength testing in the BLSA have been published previously [35, 36]. Briefly, muscle strength of the knee was measured in the dominant leg using an 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°/s). Peak torque was measured three times, and the highest value was used in the analysis.

Although all BLSA participants were considered for knee-muscle-strength testing, excluded were those with bilateral joint replacement, severe osteoporosis (femoral neck bone density of $.50 \text{ g/cm}^2$ (females) and $.59 \text{ g/cm}^2$ (males) and/or lumbar bone density of $.72 \text{ g/cm}^2$ (females) and $.76 \text{ g/cm}^2$ (males), active neck and back pain, frequent and severe joint pain, or any recent (6 months or less) major surgery or other condition that might be aggravated by testing. Compared with muscle-strength-tested participants, those with missing data (on muscle strength) were similar in terms of sex (% male, 49% vs. 52%; $p=0.365$) and racial (% white, 71% vs. 79%; $p=0.066$) profile as well as proportion engaging in high-level physical activities (30% vs. 35%; $p=0.054$) but tended to be older (mean age, 72% vs. 62%; $p<0.001$) and slightly heavier (mean BMI, 28% vs. 26.8%; $p=0.007$). Relative knee muscle strength was calculated as knee muscle strength divided by weight (Nm/kg), which is sometime also referred to as strength normalized for weight.

Personality

The dimensions of *N*, *E*, and *C* and their facets were measured using the NEO-PI-R [37] based on statements to which participants indicate their level of agreement with regard to how well the statement describes their beliefs, attitudes and behaviors using a five-point scale ranging from strongly disagree to strongly agree. The domain of neuroticism includes the facets of anxiety, angry hostility, depression, self-consciousness, impulsiveness, and vulnerability. The domain of extraversion includes the facets of warmth, gregariousness, assertiveness, activity, excitement seeking, and positive emotions. Lastly, the conscientiousness facets are: competence, order, dutifulness, achievement striving, self-discipline and deliberation. The NEO-PI-R is administered at each study visit to all BLSA participants. The inventory has a robust factor structure that has been replicated in the BLSA and other samples from more than 50 cultures [38]. In the BLSA sample, the internal consistencies for the three NEO-PI-R domains were .91, .87, and .92 for *N*, *E*, and *C*, respectively, and previous research has shown high levels of stability, with corrected $r_{tt}>.90$ over a 10-year interval [39]. Raw scores were converted to *t* scores (mean=50, SD=10) using the combined-sex norms for adults reported in the NEO Manual [37]. At each study visit, all BLSA participants are asked to fill out the 240-item NEO-PI-R questionnaire.

Based on recommendations from the Manual, these *t* scores were dichotomized at the score of 55 to define high *N* (≥ 55) and at the score of 45 to define low *E* and low *C* (<45). The high *N* (0=no and 1=yes), low *E* (0=no and 1=yes), and low *C* (0=no and 1=yes) types were then combined in groups of two to create three variables (high *N*/low *E*, high *N*/low *C*, and low *E*/low *C*) each with the following three categories: neither trait (e.g., low *N* and high *E*), either trait (e.g., high *N* and high *E* or low *N* and low *E*), or both traits (high *N* and low *E*). This categorization scheme allows comparison of combinations of two risky personality traits against having only one trait or none in relation to muscle strength. For example, we were able to compare being both high on *N* and low on *E* against being either high on *N* or low on *E*, or neither on muscle strength.

Other Variables

Since age, sex (male vs. female), and ethnic minority status (white vs. others) are thought to be associated with both personality and muscle strength, they were included in the analyses as potential confounders. We also included two health-related variables as potential mediators of the personality and muscle strength association. 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 BMI was calculated as weight/height² (kg/m²). Information on total moderate and high intensity physical activity was assessed via self-report. Since the assessment approach and units of measurement changed

in 2002 from METs*min/week to kcal/week, we derived a hybrid physical activity variable based on sex-specific tertiles of participation for the two different activity assessments.

Data Analysis

Characteristics of the study participants are presented as percentages and mean $\pm$ SD for categorical and continuous variables, respectively. Associations between personality types and relative muscle strength were analyzed by linear regression modeling with adjustment for age, sex, and ethnic minority status and additionally for BMI and physical activity. The second set of variables was added with the goal of investigating potential mediation by relative weight and physical activity level.

The four-step Baron and Kenny mediation analysis [40] were then performed for those personality types for which there was evidence that additional adjustment for lifestyle factors led to reduction in the effect size and significance of the main association. According to this model, a variable (Z) acts as a mediator of the relationship between a predictor (X) and an outcome (Y) when: (1) variations in X account for variations in Y ; (2) variations in X account for variations in Z ; (3) variations in Z account for variations in Y ; and (4) the original association between X and Y is no longer significant when Z is controlled. As suggested by Judd and Kenny [41], we tested these associations through a series of regression models.

We next conducted facet analyses for the personality types found to be significantly associated with muscle strength. Facet-level analyses are important in that they help identify what specific components of personality domains might be significant in relation to different health outcomes. Statistical significance was considered at a p level of <0.05 . All analyses were conducted using SAS 9.1 Statistical Package (SAS Institute, Inc., Cary, NC, USA).

Results

Study participants were on average 58 ± 16 years old, equally distributed by sex, white (66%), overweight (mean BMI= 26.6 ± 4 kg/m²), and had N , E , and C scores in a range considered average in the general population (t scores of 45–55) according to the NEO Manual. A total of 189 (16%), 378 (31%), and 322 (26%) participants scored high on N , low on E , and low on C , respectively. Moreover, 6% were both high on N and low on E , 4% were high on N and low on C , and 9% were low on both E and C . Persons high on N tended to be younger and female, those low on E to be older, male, and to have a lower BMI, while those low on C more likely to be white. The high N /low E group tended to be younger and to have a lower BMI, those with High N /Low C younger, female, and white, and those low on both E and C were older, male, and white compared with those with no or either risk traits (Table 1).

In linear regression models predicting muscle strength (Table 2), having high N was associated with lower muscle strength above the effect of age, sex, and ethnic minority status (model 1) as well as BMI and physical activity (model 2). Low E was associated with lower muscle strength only when lifestyle practices were added to the model (model 2) and level of C was not associated with muscle strength in the presence of significant covariates. Compared with individuals with neither high N nor low E , those with both traits had lower muscle strength (beta estimate=0.16, $p=0.007$) after the effect of socio-demographic factors was taken into account (model 1). When the analysis was further adjusted for BMI and physical activity, the group with both high N and low E had lower muscle strength compared with those with either one of the traits (beta estimate=0.17; $p=0.008$) or no risk trait (beta estimate=0.21; $p<0.001$). Similarly, having high N in combination with low C was associated with lower muscle strength compared with having none of these traits (beta

estimate=0.18; $p=0.013$) after adjustment for socio-demographic variables. Further adjustment for BMI and physical activity reduced the effect by 40% (beta estimate=0.11) and deemed it insignificant ($p=0.135$) suggesting potential mediation by lifestyle-related factors. A graphical presentation of the age-, sex-, and ethnic minority status-adjusted associations is available in Fig. 1. Furthermore, having none, one, or both of low *E* and low *C* did not make any difference in terms of muscle strength therefore this personality typology was not further investigated.

Since inclusion of the two lifestyle factors as a block appeared to explain a significant portion of the effect of the high *N*/low *C* personality typology on muscle strength, we conducted a more detailed mediation analysis for this typology. Table 3 presents the four-step Baron and Kenny mediation analysis separately for the two mediators. In our sample, BMI was not associated with the high *N*/low *C* typology (beta estimate=-0.993; $p=0.118$ for either vs. both traits; beta estimate=-0.992; $p=0.110$ for none vs. both traits) and therefore could not explain its effect on muscle strength. However, an association was observed for physical activity, which was also associated with muscle strength independently of the effect of the high *N*/low *C* typology (beta estimate=0.073; $p=0.019$). Furthermore, the effect of the high *N*/low *C* typology on muscle strength was reduced by 26% and became no longer significant by inclusion of physical activity in the model (beta estimate= 0.178; $p=0.013$ vs. beta estimate=0.132; $p=0.088$ comparing no trait against both traits).

Given that we found no evidence for an association with muscle strength for low *E* and low *C* either alone or in combination, in tandem with the evidence of significance of high *N* by itself or in combination with either low *E* or low *C* type, we interpreted these findings as suggesting that it is the high *N* component that appears to be important. Therefore, we next analyzed the six facets of *N* to identify what aspect(s) of *N* appear(s) to correlate with muscle strength when a typological approach is employed. As Table 4 details, for all facets with the exception of vulnerability a high score is associated with lower muscle strength. When combined with low *E* (beta estimate=0.208; $p<0.001$ for no vs. both traits; beta estimate=0.196; $p=0.002$ for either vs. both traits) or low *C* (beta estimate=0.173; $p=0.013$ for no vs. both traits; beta estimate=0.141; $p=0.049$ for either vs. both traits), clear dose-response associations were found for the facets of high depression and high hostility, respectively. This is captured by the beta estimate for the no-trait group (compared with both-trait group) that is higher than that for the either-trait group. Significant differences were also found between the no versus both traits groups when high hostility was combined with low *E*, high self-consciousness was combined with either low *E* or low *C*, and high anxiety, high depression, and high impulsiveness with low *C*.

Discussion

Using a typological approach we investigated cross-sectional associations between personality, lifestyle-related factors and muscle strength. We found lower muscle strength among individuals characterized by high neuroticism either by itself or in combination with low extraversion or low conscientiousness. Although further validation is needed, physical activity appears to explain in part the association between personality and muscle strength.

Our approach to creating personality typologies was inspired by that proposed by Torgersen and colleagues [29, 30, 32, 42] although it differs from it in two regards. First, the cut-off points used to define high *N*, low *E*, and low *C* were not based on medians but on the cutoffs proposed by the creators of the NEO-PI-R instrument [37]. Second, we investigated combinations of two personality types rather than three. A similar approach has previously been used in a BLSA investigation of the association between personality traits and smoking. By combining scores on *N* and *C*, Terracciano and Costa found that the highest

proportions of current smokers were in the groups defined by low *C* in combination with either high or low *N*. In contrast, those with high *C* were less likely to be current smokers regardless of their *N* level [43]. Moreover, in another study, the configuration of high *E* and high psychoticism has been found to predict heavy drinking better than either trait alone [44].

Our hypotheses of negative associations between muscle strength and individual typologies and their combinations were partly supported. Our finding of significance of neuroticism using a typological approach supports similar findings using a trait approach [25]. Moreover, our findings also suggest that a typological approach combining three unfavorable personality traits can be useful in detecting individual differences in muscle strength and identify subgroups of individuals at the highest risk of poor muscle strength. When combined with either low *E* or low *C*, we found high *N* to confer a stronger risk of low muscle strength as compared with having none or only one of these personality types, even when differences in age, sex and ethnic minority status are accounted for. At the more detailed facet level, the depression and hostility components of *N* appear to play the most significant role in combination with low *E* and low *C*, respectively. However, other *N* components such as anxiety, self-consciousness and impulsiveness may also be relevant. Individuals characterized by a combination of these traits and low *E* or low *C* tend to be weaker compared with those without these combinations (Table 4).

The mechanisms explaining these relationships are likely complex. We uncovered a potential mediating role of physical activity in the association between the configuration of high *N* with low *C* and muscle strength. The less positive attitudes toward exercise reported for high *N* persons [13] combined with procrastination and easy discouragement stemming from low *C* are likely not conducive of engagement in physical activities which is reflected in the lower strength found in this group. This finding adds physical inactivity to the list of unhealthy behaviors currently linked to this particular personality typology including smoking, drinking, illicit drug usage and engagement in unsafe sex [28, 29]. Moreover, its reported association with higher vulnerability to stress and poor coping strategies [30, 31] should be investigated in future studies as a potential pathway explaining the association with muscle strength. Other potential pathways that require further empirical investigation include compromised social interactions. High scorers on *N* are likely to initiate or respond inadequately to conflictual social encounters [45] while low scorers on *C* may engage less in social support behaviors [46]. Therefore, a combination of these factors is likely to lead to fewer opportunities to engage in physical activities and the subsequent reduced strength. The association between high *N* combined with low *E* and muscle strength was not explained by physical activity and BMI. Perhaps, the higher levels of perceived stress reported for this personality configuration [32] as well as potentially compromised social interactions likely in neurotic and introverted persons represent more likely pathways and should constitute the focus of future studies.

Besides the limitations inherited in the typological approach including a loss of statistical power [47], our study could also be criticized for not investigating the full range of the NEO-PI-R dimensions. However, although there is some evidence that the negative effect of *N* on job dissatisfaction is more significant in the presence of low agreeableness (*A*), no effect of the interaction was found on reported physical ill health [31]. Moreover, to the best of our knowledge there have been no reports of the effect of interactions involving *A* or openness to experience (*O*) on health behaviors or other health outcomes and therefore we were not able to develop any working hypothesis to be tested. The potential interactive effect of *A* and *O* with the other three NEO-PI-R domains should be the focus of future investigations. Other limitations include the cross-sectional design and the poor external generalizability of the data due to inclusion of relatively healthy and well educated BLSA

participants. Strengths include the large sample size, the wide age-range of the study population, the application of internationally validated instruments and the facet-level investigation.

In conclusion, the current research suggests that high neuroticism particularly when combined with low *E* or low *C* may play an important yet unrecognized role in the process of muscle strength decline and disability, and that health behaviors may help explain the disadvantage associated with certain combinations of unfavorable traits. The typological approach reaches beyond the effect of individual traits and creates more comprehensive pictures of the interplay between traits and their role in regards to muscle strength. These findings have clinical implications in that interventions to increase muscle strength could be more efficient if designed to also take into consideration one's personality configurations. For example, individuals high on depression or self-consciousness and low on *E* or low on *C* who might feel easily discouraged, prone to ridicule, more relaxed in tempo and have difficulty adhering to treatments, would probably benefit from regimens that are simpler and easier to complete [17]. Longitudinal associations between personality and muscle strength should constitute the focus of future research. This would answer questions related to whether the protective effect of personality goes beyond level of strength and extends to change in strength with its relevant clinical implications.

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Fig. 1. Age-, sex-, and ethnic minority status-adjusted mean muscle strength by groups of risk traits

Table 1

Study participant characteristics by personality typology

Personality typology	Number of participants	Age		BMI		Male (%)		White (%)		High physical activity (%)	
		Mean±SD	p Value	Mean±SD	p Value	Number of participants	p Value	Number of participants	p Value	Number of participants	p Value
High <i>N</i>											
No	1,031	59.4±15.8	<0.001	26.7±4.3	0.086	52.0	<0.001	65.5	0.305	35.8	0.623
Yes	189	52.4±16.2		26.1±4.8		36.5		69.3		35.7	
Low <i>E</i>											
No	842	52.8±15.4	<0.001	26.8±4.4	0.003	45.8	<0.001	64.4	0.062	37.7	0.079
Yes	378	61.8±17.0		26.0±4.3		57.9		69.4		31.4	
Low <i>C</i>											
No	898	58.5±15.4	0.466	26.5±4.4	0.343	49.8	0.827	63.1	<0.001	37.2	0.144
Yes	322	57.7±17.7		26.8±4.6		49.1		74.2		31.7	
High <i>N</i> /low <i>E</i>											
No trait	731	57.7±0.6	0.016	26.9±0.2	0.005	47.9	0.057	63.8	0.110	37.9	0.356
Either trait	411	59.9±0.8		26.2±0.2		54.0		69.3		32.2	
Both traits	78	55.1±1.8		25.4±0.5		42.3		70.5		34.3	
High <i>N</i> /low <i>C</i>											
No trait	762	59.4±0.6	<0.001	26.6±0.2	0.430	52.2	0.030	62.3	0.002	36.6	0.227
Either trait	405	57.4±0.8		26.4±0.2		46.2		72.1		35.5	
Both traits	53	49.5±2.2		27.0±0.6		37.7		73.6		24.4	
Low <i>E</i> /low <i>C</i>											
No trait	627	57.2±0.6	0.009	26.8±0.2	0.062	46.1	0.030	61.6	<0.001	39.1	0.068
Either trait	486	59.0±0.7		26.2±0.2		52.5		69.3		33.2	
Both traits	107	61.9±1.5		26.7 (0.4)		57.0		77.6		27.8	

N neuroticism, *E* extraversion, *C* conscientiousness

Table 2

Associations between personality typology and relative muscle strength

	<i>N</i>		<i>E</i>		<i>C</i>		High <i>N</i> /low <i>E</i>		High <i>N</i> /low <i>C</i>		Low <i>E</i> /low <i>C</i>	
	Low vs. high		High vs. low		High vs. low		No vs. both		No vs. both		No vs. both	
	Beta estimate±SE	<i>p</i> Value	Beta estimate±SE	<i>p</i> Value	Beta estimate±SE	<i>p</i> Value	Beta estimate±SE	<i>p</i> Value	Beta estimate±SE	<i>p</i> Value	Beta estimate±SE	<i>p</i> Value
Model 1	0.11±0.04	0.005	0.03±0.03	0.299	0.03±0.03	0.302	0.16±0.06	0.007	0.13±0.06	0.030	0.18±0.07	0.075
Model 2	0.11±0.04	0.007	0.07±0.03	0.034	−0.001±0.03	0.965	0.21±0.06	<0.001	0.17±0.06	0.008	0.11±0.07	0.315
											0.07±0.05	0.161
											0.04±0.05	0.193
												0.483

All models are adjusted for age, sex, and ethnic minority status

N neuroticism, *E* extraversion, *C* conscientiousness

Table 3

Four-step Baron and Kenny mediation analysis of the association between high *N*/low *C* and muscle strength (all models are adjusted for age, sex, and ethnic minority status)

Step 1 ^a	Beta estimate		SE	
No trait	0.178		0.072 *	
Either trait	0.130		0.073	
Both traits	Reference group			
Step 2 ^b	Physical activity		BMI	
	Beta estimate	SE	Beta estimate	SE
No trait	0.352	0.127 **	−0.992	0.620
Either trait	0.331	0.130 *	−0.993	0.634
Both traits	Reference group			
Step 3 ^c	Physical activity		BMI	
	Beta estimate	SE	Beta estimate	SE
Effect of mediator	0.073	0.019 ***	−0.039	0.003 ***
Step 4 ^d	Physical activity		BMI	
	Beta estimate	SE	Beta estimate	SE
No trait	0.132	0.077	0.139	0.067 *
Either trait	0.097	0.079	0.091	0.069
Both traits	Reference group			

*
 $p < 0.05$;

**
 $p < 0.01$;

 $p < 0.001$

^a Model predicting the total effect of high *N*/low *C* on muscle strength

^b Model predicting the effect of high *N*/low *C* on mediator

^c Model predicting the effect of mediator on muscle strength controlling for high *N*/low *C*

^d Model predicting the direct effect of high *N*/low *C* on muscle strength controlling for mediator

Table 4

Personality typologies combining neuroticism facets with low *E* or low *C* and their association with relative muscle strength

Personality typology	Beta estimate	SE	<i>p</i> Value
High <i>N</i>			
Low vs. high anxiety	0.078	0.037	0.035
Low vs. high angry hostility	0.091	0.040	0.023
Low vs. high depression	0.144	0.042	<0.001
Low vs. high self-consciousness	0.078	0.035	0.027
Low vs. high impulsiveness	0.097	0.035	0.006
Low vs. high vulnerability	0.055	0.041	0.175
High <i>N</i> /low <i>E</i>			
High hostility/low <i>E</i>			
No trait	0.141	0.062	0.024
Either trait	0.108	0.064	0.093
Both traits	Reference group		
High depression/low <i>E</i>			
No trait	0.208	0.059	<0.001
Either trait	0.196	0.062	0.002
Both traits	Reference group		
High self-consciousness/low <i>E</i>			
No trait	0.105	0.048	0.029
Either trait	0.081	0.051	0.111
Both traits	Reference group		
High <i>N</i> /low <i>C</i>			
High anxiety/low <i>C</i>			
No trait	0.145	0.062	0.020
Either trait	0.116	0.064	0.069
Both traits	Reference group		
High hostility/low <i>C</i>			
No trait	0.173	0.070	0.013
Either trait	0.141	0.072	0.049
Both traits	Reference group		
High depression/low <i>C</i>			
No trait	0.151	0.061	0.013
Either trait	0.100	0.064	0.114
Both traits	Reference group		
High self-consciousness/low <i>C</i>			
No trait	0.113	0.057	0.048
Either trait	0.070	0.059	0.235
Both traits	Reference group		
High impulsiveness/low <i>C</i>			

Personality typology	Beta estimate	SE	<i>p</i> Value
No trait	0.124	0.052	0.016
Either trait	0.085	0.054	0.120
Both traits	Reference group		

Beta estimates are adjusted for age, sex, and ethnic minority status

N neuroticism, *E* extraversion, *C* conscientiousness, *SE* standard error