Body mass in adolescence: Stronger ties to socioeconomic status than personality

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# Author note

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Contributions: SJW – data analysis, writing of original draft, revising; ML – conceptualization of research questions, literature review, revising; DMC – data collection, conceptualization of research questions, revising.

Study Importance Questions

What is already known about this subject?

* SES, cognitive functioning, and broad (Big Five) personality traits are associated with adolescent BMI.

What are the new findings in your manuscript?

* Individual factors (cognitive functioning and personality traits) have associations with adolescent BMI independent of SES, and these associations are not moderated by SES.
* Narrow traits contribute to better out-of-sample prediction of adolescent BMI than broad traits.
* The relative independent association of SES to adolescent BMI is substantially larger than the associations of individual factors to BMI.

How might your results change the direction of research or the focus of clinical practice?

* Greater emphasis may be placed on developing interventions that break the SES-BMI connection, rather than interventions which either try to change personality or intervene on the personality-BMI link. In other words, SES-based interventions have greater potential impact on changing adolescent BMI.

Abstract

**Background:** It is unclear whether socio- and individual-factors are uniquely related to adolescent BMI or capture the same underlying process. Moreover, it may be that environment (SES) amplifies relationships between traits and BMI.

**Subjects/Methods:** Multiple regression analyses estimated the independent contributions of SES and individual factors to BMI percentile in a cross-sectional sample of 9 482 adolescents who provided information through a personality assessment website. In addition, we fit lasso regression models to a holdout test set of adolescents to estimate relative variance explained. **Results:** Across all models, SES was significantly associated with lower BMI percentile scores (all *p* < .001). Controlling for SES, cognitive functioning was associated with lower BMI percentile (*b*Girls*=* -1.32 [-2.10, -0.54], *p* = .001; *b*Boys*=* -1.84 [-3.10, -0.53], *p* = .005). Among adolescent girls, the broad trait Neuroticism (*b=* 1.75 [0.94, 2.52], *p* < .001) and related narrow traits, among others, were associated with BMI percentile.​ There were no consistent interactions between SES and personality. In holdout samples, the best performing models included SES, cognitive functioning, and narrow (not broad) traits. **Conclusions:** While individual difference factors may contribute independently to BMI, their relative contribution is much smaller than that of SES.

*Keywords:* adolescence, Body Mass Index, obesity, personality traits, socioeconomic status

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Obesity is an international public health crisis. Prominent social programs focused on this issue consider children and adolescents as populations that are ripe for intervention (1). Adolescence is associated with considerable changes in body composition: all the main components of body composition increase during this period (2). Moreover, this period is psychologically challenging. Many adolescents report body dissatisfaction, occasionally to the point of endorsing a profound dislike of one’s own body (3). They also experience elevated fears of appearance and body shape concerns and experience higher risk of developing eating disorders (4).

The primary aim of this work is to evaluate the wide range of individual differences contributing to elevated body mass index (BMI) across both sexes during adolescence. Numerous changes in BMI levels during adolescence are already well-documented, including several pointing to important sex differences, necessitating the use of age- and sex-specific norms (5). There is some evidence that socioeconomic status (6, 7), personality (8), and cognitive functioning (9) are each protective factors for obesity; however, the independent variance of these attributes have rarely been considered or compared.

## BMI and socioeconomic status

“Socioeconomic status” (SES) is an aggregate construct defined according to one’s level of resources or prestige in relation to others (10). While the operationalization of socioeconomic status is notably inconsistent, there is a consensus that SES includes education, income, and occupational prestige (11). Because children and adolescents are still in school, researchers typically use measures of parental education, parental occupation, and/or household income as markers of childhood SES (12).

The relationship between SES and BMI has been widely investigated. Several studies have found that obesity in children and adults in industrialized countries is negatively associated with income and education (13). Proposed mechanisms placing low-income children at increased risk for obesity relative to higher-income children include the consumption of less whole meal and brown bread and fewer fresh fruits and vegetables, but more fatty milk, eggs, and meats (14). Importantly, access to quality food is limited by proximity as much as income, as children living in food deserts suffer from higher BMI levels (15). Another mechanism may be sedentary behavior, as low SES children have been found to be less physically active and spend more time using screens (16); children in low-SES environments often have limited activities available to them (13, 17).

## BMI and personality

Certain personality traits are associated with behaviors that contribute to obesity such as unhealthy eating habits and physical inactivity. For example, individuals high on conscientiousness are likely to be more self-disciplined about their diet (8, 18) and are more physically active (19). Higher scores on extraversion and on openness to experience are associated with greater risk for being overweight (20). Findings regarding neuroticism are inconclusive. High levels of neuroticism are related to disinhibition and susceptibility to hunger (21). On the other hand, individuals who have higher scores on this trait tend to be underweight (18, 20) and more likely to suffer from eating disorders (8). Sutin and colleagues (22) suggested two possible explanations for this phenomenon: 1) there might be a curvilinear relationship between neuroticism and abnormal weight or 2) being overweight/underweight is associated with different aspects of neuroticism. This latter point in particular calls for research including more narrow traits.

## BMI and cognitive functioning

Previous studies found that individuals with lower levels of cognitive functioning have a higher BMI (23). The nature of the association between BMI and cognitive functioning is unclear. There is some evidence of shared genetic contributions between cognitive functioning and BMI and bodyweight (23), and evidence suggesting longitudinal links between cognitive functioning in childhood and BMI in adulthood (24). Importantly, the association between these constructs has been shown to be independent of education (24). Overall, there is evidence for both causal and non-causal (i.e., third variable) explanations of this is association.

## Relative contributions of SES and individual differences to BMI

As described above, both individual (personality and cognitive functioning) and demographic (SES) factors are linked with adolescent BMI, yet it is unclear to what extent individual factors are associated with BMI independent of SES. This is in part due to substantive associations between these constructs. Considerable research suggests that individuals raised in low SES households have higher levels of neuroticism, lower openness to experience, and maladaptive coping mechanisms (25). These individuals are also more likely to engage in risky health behaviors and score high on hostility (26) whereas children from families with higher SES are less impulsive (27).

It should be noted that these associations are likely bidirectional. Certainly, across the lifespan, there is strong evidence of the effects of personality on adult SES. Research shows children’s conscientiousness is a strong predictor of income and occupational status, even after controlling for IQ (28). Findings on other personality traits are inconsistent (22).

A growing body of research has documented that SES predicts a variety of children’s outcomes including physical health, cognitive functioning, and academic achievement (29). A number of studies have demonstrated that low-SES children performed worse in working memory or executive attention tasks in comparison to high-SES children (38, 39). SES also seems to have an important influence on children’s school performance that is potentially independent of cognitive functioning (32).

In the context of BMI, it is unclear whether associations between individual differences and BMI are merely proxies of the SES-BMI relationship documented elsewhere. To better interpret the potential effect of personality, a comparison of the relative size of effects of personality and SES to BMI is warranted, as this can guide researchers and policymakers to prioritize constructs with the greatest influence.

## SES as a moderator of the relationship between individual differences and BMI

Further complicating the relationships between SES, individual differences, and BMI are person-situation transactions, which may change the relationship between individual differences and outcomes. One example is the “strong-situation hypothesis” (33), which posits that some situations demand specific responses, overpowering any potential impact of personality. In the case of BMI, low SES may represent a strong situation in that individuals from poorer backgrounds have fewer dining or leisure options, and so food and activity choices reflect availability rather than preference. Some evidence suggests that phenotypic expression of personality is more closely associated with genetics among those with advantaged socioeconomic backgrounds (34), and that adolescent impulsivity has stronger effects among the disadvantaged (35). For some trait-behavior relationships, however, socioeconomic status has no effect (c.f., 36).

## The present study

In this study, we use a large sample of adolescents in the United States to examine the relationship between personality and cognitive functioning to BMI above and beyond the influence of SES; moreover, we examine whether the relationship between individual differences and BMI changes across socioeconomic strata. The current study aims to clarify the relationship between personality traits, cognitive functioning, SES, and BMI through the following methods: 1) examining both broad and narrow traits to better determine the aspects of personality which relate to BMI, 2) utilizing a measure of SES that accounts for both monetary resources and social status, and 3) using percentile assessments of BMI to account for developmental differences in weight. We expected higher SES to be associated with smaller BMI. We expected to find that adolescents with high BMI scores would also be higher in trait neuroticism, anxiety, and impulsivity, while lower in traits conscientiousness, intellect, self-control, adaptability, emotional stability, and cognitive functioning. Finally, we hypothesized that SES would moderate the relationship between cognitive functioning and BMI; we made no predictions regarding the interaction of SES with other individual differences ([osf.io/ypf7r](https://osf.io/ypf7r)).

# Methods

## Participants

Data were collected through [www.sapa-project.org](http://www.sapa-project.org), a personality assessment website (37). Participants included 616 270 visitors to the website between February 2017 and July 2019. The subsample used for these analyses included 9 482 adolescents between the ages of 11 and 17 (*M* = 15.9; *SD* = 1.3) living in the United States who self-reported their height and weight. (Supplemental material contains analyses investigating the potential bias resulting from height and weight missing not at random). More than half (68.8%) of the sample reported their biological sex as female. Respondents who selected “Other” and “Prefer not to answer” for biological sex were excluded as CDC BMI norms are unavailable for these categories. Descriptive statistics are presented in Table 1.

## Measures

**BMI Percentile** Self-reported height in inches (*M* = 65.76, *SD* = 4.02) was converted to meters, and self-reported weight in pounds (*M* = 141.51, *SD* = 35.39) was converted to kilograms. Participant BMI was then calculated by dividing kilograms to meters squared (*M* = 22.7, *SD* = 4.97). We chose not to use BMI score as our outcome, as the distribution of BMI tends to increase with development, meaning there is greater spread in BMI among older adolescents compared to younger. To account for both sex- and age-related differences in the distribution of BMI, we calculated each participant’s BMI percentile score based on the CDC norms for adolescents of that participant’s age and self-reported biological sex (38). BMI distribution in this sample was negatively skewed, although we have relatively large coverage across the entire range (Figure 1).

**Personality.** Personality traits were measured using the 135-item SAPA Personality Inventory (SPI-135; 39). This framework can be used to estimate scores on both broad and narrow traits. The current study leverages this feature to evaluate the relationships of both broad and narrow traits to BMI category and compare the predictive validity of each.

Broad (Big Five) trait scores were estimated using a sum-score method, in which all non-missing responses to items in a scale (14 items per scale) were averaged. There was evidence of good reliability for each trait *(αExtraversion =* .88; *αAgreeableness =* .83; *αConscientiousness =* .81; *αNeuroticism =* .86; *αOpenness =* .75). Narrow SPI-27 trait scores (5 items each) were estimated using an IRT-scoring approach. Calibration of the IRT parameters was performed using a separate sample (see 39). Estimates were scaled using *t*-scoring, resulting in means of 50 and standard deviations of 10 for the entire adolescent sample.

**Cognitive Functioning.** Participants were administered between 12 and 16 cognitive functioning items assessing Three-Dimensional Rotation, Verbal Reasoning, Matrix Reasoning, and Letter and Number Series from the International Cognitive Ability Resource (ICAR; 40). Trait scores were estimated using an IRT approach.

**Parent Socioeconomic Status (SES).** Participants reported their parents’ highest level(s) of education and occupational field(s). From the latter, we estimated income, based on median income for that field, and prestige, based on median prestige values for the field (41). All responses were standardized and averaged to create a composite score.

## Data analysis

To assess the degree to which SES and individual differences are uniquely associated with BMI percentile, we used a multiple regression model. We estimated 33 versions of this model, with each model including both SES and either one personality trait or cognitive function. In addition, we fit each of these models with an interaction term, to estimate whether the relationship of personality to SES depends on parental socioeconomic status. Specific hypotheses were preregistered at <https://osf.io/ypf7r>. Analyses were performed separately for adolescent boys and girls. All prediction variables were standardized within each se sample prior to analysis, so coefficient estimates can be interpreted as standardized effect sizes.

All analyses described above were performed on a subset of our sample (the training sets) containing a random 75% of each sample, stratified by BMI category.1 The remaining 25% of the samples (the test sets) were used in exploratory analyses to estimate the total variability in BMI percentile that is accounted for by these variables. For these analyses the training sets were used to estimate lasso regression models containing (1) SES alone, (2) SES and cognitive functioning, (3) SES and personality, or (4) SES, cognitive functioning, and personality (different models were used to estimate the set of Big Five and Narrow 27 traits). Lasso regression – which stands for “least absolute shrinkage and section operator” – is a form of penalized regression that improves out-of-sample prediction by shrinking small coefficients to 0 (42). These models were then used to predict outcomes in the test sets. The fit to the test data, as measured by the residual mean square error (RMSE) and R2 values, were used to evaluate the relative contributions of SES, cognitive functioning, and personality to BMI percentile.

# Results

**Is socioeconomic status independently associated with BMI category?**

We examine the partial regression coefficient of SES with BMI after controlling for individual differences. As hypothesized, higher parental SES was consistently significantly associated with lower BMI percentile for both adolescent girls and boys (all *p* < .001). On average, a one standard deviation increase in parental SES was associated with a 3.50 drop in BMI percentile among girls and a 3.68 drop in percentile among boys. This effect size appeared to be relatively homogenous across the models, suggesting that the relationship of SES to BMI was not attenuated or accentuated by controlling for specific personality traits. These results are summarized in Figure 2, which displays the SES coefficient estimate of each model. As a reminder, there are 33 models for each sex; each model regresses BMI percentile variable onto SES and one of the individual difference measures.

**Which personality traits are associated with BMI?**

Next, we examine the coefficients associated with all traits – here referring to cognitive functioning, the Big Five, and the Narrow 27 – in the models described above. In general, more traits had significant associations with BMI percentile for adolescent girls compared to boys. This is in part an issue of statistical power (there were more than twice as many girls as there were boys in the current sample), although we note that the sample of boys had 90% power to detect correlations as small as *r* = .06 and that effect sizes estimated in the sample of boys was smaller. All results are presented in Table 2 and represented visually in Figure 3.

Adolescent girls who had larger BMI percentiles tended to be higher in Neuroticism (*b* = 1.75), as hypothesized. Notably, this corresponded with significant associations of BMI percentile and many narrow traits, such Well-Being (*b* = -2.72), Irritability (*b* = 1.42), and Anxiety (*b* = 1.34). (Only the last of these associations was hypothesized). In addition, adolescent girls with larger BMI percentiles also reported higher Easy-Goingness (*b* = 1.57), which may reflect a lack of physical activity. Similarly, there was a small association between Extraversion and lower BMI percentile (*b* = -1.04), corresponding with associations of BMI percentile to Sociability (*b* = -1.21), although girls with larger BMIs also tended to score higher on Humor (*b* = 1.03). As hypothesized, Conscientiousness was associated with lower BMI (*b* = -1.35), evidenced by the relationship between BMI percentile and Industry (*b =* -0.81), Order (*b =* -2.26), and Self-Control (*b =* -2.79). and lower on Introspection (*b* = -1.05). Finally, cognitive functioning was negatively associated with BMI percentile (*b* = -1.32), as hypothesized.

There were no significant associations between BMI percentile and the Big Five traits among adolescent boys. Among the narrow traits, only Self Control was negatively associated with BMI (*b* = -1.94), like among adolescent girls. In addition, boys with larger BMIs tended to score higher on Conservatism (*b* = 1.32), which was the opposite of the relationship among girls (*b* = -0.94). Again, cognitive functioning was negatively associated with BMI percentile (*b* = -1.84). Contrary to our hypotheses, the following traits were unassociated with BMI across sex: Impulsivity, Intellect, Adaptability, and Emotional Stability.

**Does the relationship of personality to BMI depend on SES?**

By adding an interaction term to each of our 33 models, we test the degree to which the relationship of personality to BMI category changes as a function of parental SES. As depicted in Table 2, the overwhelming finding was that the interaction terms were mainly non-significant, including the hypothesized SES-Cognitive Functioning interaction. Given the number of models tested, it is likely that statistically significant effects are due to sampling variability. In other words, when the null hypothesis is true, we expect to see statistically significant coefficients a small proportion (~5%) of the time due to random variability; we have no reason to believe the significant effects found herein are due to anything other than this random chance. However, we note that among both adolescent boys and girls, SES was a significant moderator of the Conservatism-BMI relationship. This finding is in line with the hypothesis that high levels of SES accentuate personality-outcomes associations. However, Conservatism is most strongly associated with BMI among adolescent girls when SES is low (and the direction of the association is negative), which runs counter to this hypothesis. Overall, given the limited number of significant interactions, we conclude that there is little support to suggest that personality-BMI associations are stronger or weaker for different levels of SES.

**How does personality contribute to the accuracy of BMI prediction models?**

These exploratory analyses make use of lasso regression models and a hold-out sample to evaluate the contributions of individual differences above and beyond SES. These results can be seen in Table 3. Among adolescent boys, SES accounted for approximately 2.0% of the variability (*RMSE* = 30.09) in BMI percentile. This was only slight improved by the inclusion of cognitive functioning (2.4%; *RMSE* = 30.02) and Big Five traits (2.0%; *RMSE* = 30.11). However, inclusion of the Narrow 27 traits improved prediction to 5.2% (*RMSE* = 29.76), more than doubling the out-of-sample prediction. Similar results were found for adolescent girls, with the exception that SES was slightly more strongly associated with BMI percentile to begin with, and the Narrow 27 provided a more modest increase to the R2 value – a 22% change from .031 to .038.

# Discussion

The current study examines the relative independent associations of individual differences (cognitive functioning and personality traits) and socioeconomic status to adolescent BMI. We found large and consistent associations between parental SES and BMI, as well as notable associations between traits and BMI, especially for adolescent girls. There was little evidence that SES moderated the association of personality and BMI. Personality and SES independently contribute to the statistical prediction of BMI, although the relative contributions of these variables differed for adolescent boys and girls.

These findings are consistent with prior work documenting the inverse relationship between SES and BMI (13). We also replicate work linking higher BMI level to lower levels of cognitive functioning (23). Moreover, we demonstrate that higher levels of Conscientiousness and Order (adolescent girls), and Self-Control (all participants) are associated with a lower BMI, which is consistent with associations between Conscientiousness and health behaviors such as dieting and physical activity (8, 18).

However, our work is also inconsistent with some prior research. For example, we find Extraversion to be negatively associated (in the case of adolescent girls) or unassociated (adolescent boys) with BMI while others have found a positive relationship between BMI and extraversion (20, 43), although Humor in adolescent girls was positively associated with BMI. This prior work used samples of adults, so this may reflect differential associations between traits and body size across the lifespan. Regarding Neuroticism, we found a relatively strong relationship between a larger BMI and higher levels of Neuroticism, Anxiety, and Irritability among adolescent girls, consistent with research related to emotional eating (21) rather than being underweight (8, 18, 20). Notably, Neuroticism and related narrow traits were unrelated to BMI among adolescent boys. An important conclusion of our findings is that BMI is more strongly associated with narrow traits over broad ones. For example, only some narrow traits (Well-Being, Irritability) were associated with BMI in girls, while others (Adaptability, Emotional Stability) were not. This lends support to the notion that mixed findings for broader traits may reflect different associations of BMI to narrow traits (22).

In addition, we found no support for the hypothesis that personality had stronger relationships with BMI at different levels of SES. This effectively rules out the strong situation hypothesis (33) and the possibility that personality expression has the strongest effect on BMI among those with sufficient resources (35).

Among our most important results were the findings that SES contributed three times as much to the out-of-sample prediction of BMI as individual differences among adolescent girls, even when many narrow traits were used to assess individual differences. Inclusion of the Big Five did not increase the variance explained relative to SES. These findings suggest that environmental factors play a significant role in body size compared to individual differences in behavior. Importantly, all variables combined accounted for less than 5% of the variability in BMI, highlighting the limited impact of these variables broadly. This is no surprise, as BMI – much like all indicators of health – is highly multi-determined.

**Limitations**

Like all models, those tested in this manuscript required simplifications. A primary concern is the use of BMI as a metric of health. BMI is notedly a poor indicator of body fat (44) and the heterogeneity of health outcomes within BMI strata suggest that it should not be used as a diagnostic tool for individuals. However, BMI does potentially play a useful role as a more holistic indicator of general health (45). Given the limitations of BMI, we chose to focus on percentile, rather than category, in the current manuscript, to limit the likelihood that trait, cognition, or SES levels would be associated with seemingly clinical cut-offs of health. An additional concern is the measurement of parental SES, which relies on adolescents’ reports on a broad scale. The use of a more detailed measure of parental occupation likely would not improve this circumstance, as we expect variability in the degree to which adolescents know, understand, and can report on specific job titles or occupations of their caregivers. Future research may integrate both adolescent- and parent-reports of variables to assess the most reliable and accurate source of each construct, as well as test the degree to which other sources provide incremental information.

# Conclusion

Overall, we find parental SES has a strong, negative relationship with BMI percentile among adolescents. Cognitive functioning and some personality traits are associated with BMI above and beyond SES, although the size of these effects is relatively smaller than the SES-BMI associations. Together, these findings point to the relative importance of socioeconomic status compared to individual differences for BMI.

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**Footnotes**

1 CDC guidelines specify weight category based on BMI percentile: Underweight (0-5%), Normal (5-85%), Overweight (85-95%), and Obese (95-100%). We use these categories for the purpose of stratifying participants when splitting the samples into testing and training subsets. However, we chose to use the percentile scores as the outcome of interest, as these categories are based on somewhat arbitrary cut-off values and heterogeneity in body fat composition and health outcomes within categories cast doubt on their utility. Supplemental materials contain analyses using categories as outcomes, modeled using multinomial logistic regressions; few substantive differences in the results between the category outcome and percentile outcome were observed.

**Table 1.** Descriptive statistics of key demographic and BMI variables by sex. Standard deviations are shown in parentheses. Parent income and occupational prestige are estimated based on the occupational field reported.

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| Variable | Female  (*N* = 6,530) | Male  (*N* = 2,952) |
| Age | 15.84 (1.31) | 15.93 (1.25) |
| BMI | 23.07 (5.00) | 22.84 (4.90) |
| BMI percentile | 62.70 (27.61) | 60.00 (30.53) |
| Height (cm) | 162.99 (7.82) | 175.88 (9.19) |
| Weight (kg) | 61.23 (14.48) | 70.70 (17.24) |
| Parent 1 Education | 5.15 (2.26) | 5.13 (2.27) |
| Parent 1 Income | 61,625.23 (21,784.89) | 61,491.45 (22,195.84) |
| Parent 1 Occupational Prestige | 60.76 (14.64) | 60.20 (15.22) |
| Parent 2 Education | 4.72 (2.31) | 4.82 (2.26) |
| Parent 2 Income | 59,058.07 (22,926.91) | 57,247.11 (22,364.35) |
| Parent 2 Occupational Prestige | 57.87 (15.76) | 57.07 (15.59) |

**Table 2.** Results from regression models regressing BMI percentile onto trait scores and SES. In the additive models, the trait score coefficient represents the association of personality and BMI above and beyond SES. In joint models, we include an interaction term between personality and SES; the trait coefficient here represents the relationship of personality to BMI percentile *at average levels* of parental SES. \* *p* < .05. Confidence intervals (95%) are bootstrapped (1000 repetitions, quantile method).

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Female** | | |  | **Male** | | |
|  | **Additive Model** | **Joint Model** | |  | **Additive Model** | **Joint Model** | |
| **Trait** | **Trait coefficient** | **Trait coefficient** | **Trait x SES coefficient** |  | **Trait coefficient** | **Trait coefficient** | **Trait x SES coefficient** |
| Cognitive Ability | -1.33\* | -1.32\* | 0.09 |  | -1.84\* | -1.83\* | -0.08 |
|  | [-2.11, -0.54] | [-2.10, -0.54] | [-0.68, 0.86] |  | [-3.10, -0.53] | [-3.10, -0.52] | [-1.37, 1.20] |
|  | *p* = .001 | *p* = .001 | *p* = .812 |  | *p* = .005 | *p* = .005 | *p* = .904 |
| **SPI: Narrow 27** |  |  |  |  |  |  |  |
| Compassion | -0.19 | -0.2­0 | -0.38 |  | -0.31 | -0.34 | 0.44 |
|  | [-0.98, 0.61] | [-0.98, 0.61] | [-1.14, 0.37] |  | [-1.61, 1.01] | [-1.64, 0.98] | [-0.81, 1.65] |
|  | *p* = .619 | *p* = .628 | *p =* .316 |  | *p =* .629 | *p =* .597 | *p =* .511 |
| Irritability | 1.43\* | 1.42\* | 0.24 |  | 1.03 | 1.03 | 0.29 |
|  | [0.65, 2.20] | [0.64, 2.20] | [-0.49, 0.97] |  | [-0.26, 2.30] | [-0.26, 2.31] | [-0.98, 1.60] |
|  | *p <* .001 | *p <* .001 | *p =* .527 |  | *p =* .113 | *p =* .112 | *p =* .656 |
| Sociability | -1.21\* | -1.21\* | 0.33 |  | 0.31 | 0.39 | 1.22 |
|  | [-2.01, -0.41] | [-2.01, -0.41] | [-0.47, 1.11] |  | [-0.97, 1.58] | [-0.88, 1.69] | [-0.04, 2.46] |
|  | *p =* .002 | *p =* .002 | *p =* .401 |  | *p =* .637 | *p =* .544 | *p =* .066 |
| Well-Being | -2.70\* | -2.72\* | 0.81\* |  | -0.20 | -0.18 | 0.57 |
|  | [-3.48, -1.93] | [-3.50, -1.94] | [0.04, 1.58] |  | [-1.53, 1.14] | [-1.52, 1.15] | [-0.69, 1.78] |
|  | *p <* .001 | *p <* .001 | *p =* .039 |  | *p =* .764 | *p =* .785 | *p =* .365 |
| Sensation Seeking | -0.56 | -0.58 | 0.63 |  | -0.03 | -0.03 | -0.40 |
|  | [-1.37, 0.24] | [-1.38, 0.22] | [-0.13, 1.41] |  | [-1.33, 1.25] | [-1.35, 1.25] | [-1.68, 0.90] |
|  | *p =* .142 | *p =* .154 | *p =* .106 |  | *p =* .963 | *p =* .962 | *p =* .553 |
| Anxiety | 1.38\* | 1.34\* | -0.50 |  | -0.34 | -0.35 | 0.65 |
|  | [0.59, 2.18] | [0.54, 2.14] | [-1.29, 0.29] |  | [-1.61, 0.93] | [-1.62, 0.92] | [-0.60, 1.92] |
|  | *p =* .001 | *p =* < .001 | *p =* .214 |  | *p =* .597 | *p =* .584 | *p =* .326 |
| Honesty | -1.04\* | -1.03\* | 0.49 |  | -0.19 | -0.24 | 0.81 |
|  | [-1.79, -0.29] | [-1.78, -0.28] | [-0.24, 1.25] |  | [-1.43, 1.10] | [-1.47, 1.07] | [-0.40, 2.00] |
|  | *p =* .009 | *p =* .009 | *p =* .183 |  | *p =* .766 | *p =* .717 | *p =* .219 |
| Industry | -0.81\* | -0.81\* | -0.21 |  | 0.77 | 0.75 | 0.35 |
|  | [-1.61, -0.04] | [-1.61, -0.04] | [-0.97, 0.54] |  | [-0.49, 2.05] | [-0.50, 2.03] | [-0.96, 1.61] |
|  | *p =* .039 | *p =* .039 | *p =* .597 |  | *p =* .236 | *p =* .244 | *p =* .598 |
| Intellect | -0.45 | -0.44 | -0.22 |  | 0.27 | 0.22 | -0.55 |
|  | [-1.26, 0.33] | [-1.24, 0.34] | [-0.95, 0.51] |  | [-1.05, 1.55] | [-1.10, 1.49] | [-1.87, 0.80] |
|  | *p =* .270 | *p =* .258 | *p =* .573 |  | *p =* .684 | *p =* .742 | *p =* .394 |
| Creativity | -0.27 | -0.27 | 0.02 |  | 0.22 | 0.22 | 0.11 |
|  | [-1.06, 0.51] | [-1.06, 0.51] | [-0.76, 0.77] |  | [-1.10, 1.52] | [-1.10, 1.52] | [-1.28, 1.53] |
|  | *p =* .494 | *p =* .495 | *p =* .961 |  | *p =* .739 | *p =* .733 | *p =* .868 |
| Impulsivity | 0.77\* | 0.78 | 0.39 |  | 0.00 | 0.01 | -0.65 |
|  | [-0.04, 1.56] | [-0.03, 1.57] | [-0.42, 1.20] |  | [-1.28, 1.30] | [-1.26, 1.32] | [-1.98, 0.65] |
|  | *p =* .048 | *p =* .050 | *p =* .329 |  | *p =* .995 | *p =* .989 | *p =* .337 |
| Attention Seeking | -0.65 | -0.69 | 0.50 |  | -0.12 | 0.01 | 1.26 |
|  | [-1.44, 0.15] | [-1.47, 0.11] | [-0.25, 1.25] |  | [-1.46, 1.21] | [-1.32, 1.35] | [-0.04, 2.55] |
|  | *p =* .081 | *p =* .099 | *p =* .207 |  | *p =* .857 | *p =* .993 | *p =* .050 |
| Order | -2.27\* | -2.26\* | -0.80\* |  | -0.61 | -0.60 | -0.50 |
|  | [-3.03, -1.52] | [-3.03, -1.52] | [-1.54, -0.06] |  | [-1.92, 0.67] | [-1.90, 0.69] | [-1.81, 0.78] |
|  | *p =* < .001 | *p =* < .001 | *p =* .040 |  | *p =* .345 | *p =* .357 | *p =* .442 |
| Authoritarianism | 0.37 | 0.37 | 0.17 |  | 0.52 | 0.44 | 1.51\* |
|  | [-0.44, 1.17] | [-0.43, 1.17] | [-0.61, 0.96] |  | [-0.72, 1.78] | [-0.81, 1.68] | [0.25, 2.76] |
|  | *p =* .348 | *p =* .349 | *p =* .650 |  | *p =* .421 | *p =* .503 | *p =* .025 |
| Charisma | 0.41 | 0.41 | 0.19 |  | 1.04 | 1.04 | 0.49 |
|  | [-0.38, 1.20] | [-0.38, 1.20] | [-0.56, 0.94] |  | [-0.24, 2.39] | [-0.24, 2.38] | [-0.81, 1.75] |
|  | *p =* .300 | *p =* .299 | *p =* .631 |  | *p =* .111 | *p =* .112 | *p =* .464 |
| Trust | -0.28 | -0.28 | 0.02 |  | -0.31 | -0.40 | 0.96 |
|  | [-1.06, 0.51] | [-1.06, 0.50] | [-0.77, 0.80] |  | [-1.60, 0.97] | [-1.68, 0.90] | [-0.29, 2.21] |
|  | *p =* .471 | *p =* .471 | *p =* .958 |  | *p =* .627 | *p =* .541 | *p =* .141 |
| Humor | 1.03\* | 1.03\* | -0.30 |  | 0.66 | 0.66 | 0.66 |
|  | [0.23, 1.84] | [0.22, 1.84] | [-1.04, 0.44] |  | [-0.63, 1.96] | [-0.63, 1.96] | [-0.70, 2.02] |
|  | *p =* .009 | *p =* .010 | *p =* .423 |  | *p =* .313 | *p =* .313 | *p =* .331 |
| Emotional Expressiveness | -0.62 | -0.63 | 0.33 |  | -0.46 | -0.53 | 1.36\* |
|  | [-1.41, 0.16] | [-1.42, 0.16] | [-0.46, 1.09] |  | [-1.78, 0.78] | [-1.84, 0.73] | [0.06, 2.66] |
|  | *p =* .114 | *p =* .110 | *p =* .395 |  | *p =* .477 | *p =* .420 | *p =* .043 |
| Art Appreciation | 0.00 | 0.00 | -0.19 |  | -0.33 | -0.33 | -0.05 |
|  | [-0.75, 0.73] | [-0.75, 0.74] | [-0.95, 0.55] |  | [-1.60, 0.94] | [-1.60, 0.94] | [-1.36, 1.19] |
|  | *p =* .996 | *p =* > .999 | *p =* .636 |  | *p =* .614 | *p =* .613 | *p =* .937 |
| Introspection | -1.05\* | -1.05\* | 0.37 |  | -0.39 | -0.37 | 0.47 |
|  | [-1.80, -0.28] | [-1.81, -0.29] | [-0.37, 1.08] |  | [-1.69, 0.91] | [-1.66, 0.92] | [-0.74, 1.69] |
|  | *p =* .008 | *p =* .007 | *p =* .343 |  | *p =* .550 | *p =* .570 | *p =* .467 |
| Perfectionism | -0.60 | -0.61 | -0.58 |  | -0.93 | -0.93 | 0.60 |
|  | [-1.40, 0.19] | [-1.41, 0.17] | [-1.33, 0.20] |  | [-2.18, 0.33] | [-2.18, 0.33] | [-0.66, 1.83] |
|  | *p =* .130 | *p =* .124 | *p =* .137 |  | *p =* .154 | *p =* .153 | *p =* .353 |
| Self-Control | -2.79\* | -2.79\* | -0.07 |  | -1.94\* | -1.98\* | 1.00 |
|  | [-3.57, -1.99] | [-3.57, -1.99] | [-0.81, 0.67] |  | [-3.22, -0.65] | [-3.26, -0.70] | [-0.31, 2.34] |
|  | *p* < .001 | *p* < .001 | *p =* .851 |  | *p =* .003 | *p =* .002 | *p =* .134 |
| Conformity | 0.90\* | 0.89\* | -0.24 |  | 0.46 | 0.45 | -0.19 |
|  | [0.10, 1.70] | [0.09, 1.70] | [-1.01, 0.55] |  | [-0.85, 1.77] | [-0.86, 1.76] | [-1.48, 1.03] |
|  | *p =* .023 | *p =* .024 | *p =* .532 |  | *p =* .482 | *p =* .487 | *p =* .762 |
| Adaptability | 0.19 | 0.19 | 0.23 |  | -0.40 | -0.44 | 0.96 |
|  | [-0.58, 0.94] | [-0.58, 0.94] | [-0.50, 0.97] |  | [-1.72, 0.90] | [-1.76, 0.87] | [-0.36, 2.29] |
|  | *p =* .634 | *p =* .632 | *p =* .565 |  | *p =* .536 | *p =* .505 | *p =* .150 |
| Easy-Goingness | 1.57\* | 1.59\* | -0.33 |  | 1.09 | 1.19 | -1.41\* |
|  | [0.81, 2.35] | [0.82, 2.37] | [-1.11, 0.41] |  | [-0.17, 2.34] | [-0.08, 2.45] | [-2.67, -0.18] |
|  | *p* < .001 | *p* < .001 | *p =* .400 |  | *p =* .096 | *p =* .069 | *p =* .033 |
| Emotional Stability | -0.35 | -0.35 | 0.23 |  | 1.00 | 1.00 | -0.49 |
|  | [-1.13, 0.45] | [-1.14, 0.45] | [-0.55, 1.01] |  | [-0.33, 2.29] | [-0.33, 2.29] | [-1.73, 0.73] |
|  | *p =* .377 | *p =* .378 | *p =* .554 |  | *p =* .123 | *p =* .124 | *p =* .447 |
| Conservatism | -0.94\* | -0.97\* | 0.86\* |  | 1.32\* | 1.25 | 1.44\* |
|  | [-1.72, -0.16] | [-1.77, -0.19] | [0.05, 1.65] |  | [0.01, 2.65] | [-0.05, 2.58] | [0.10, 2.83] |
|  | *p =* .017 | *p =* .014 | *p =* .030 |  | *p =* .043 | *p =* .056 | *p =* .027 |
| **SPI: Big Five** |  |  |  |  |  |  |  |
| Agreeableness | -0.36 | -0.36 | -0.28 |  | -0.28 | -0.37 | 0.76 |
|  | [-1.14, 0.41] | [-1.13, 0.41] | [-1.06, 0.52] |  | [-1.56, 1.02] | [-1.65, 0.94] | [-0.50, 2.01] |
|  | *p =* .356 | *p =* .366 | *p =* .455 |  | *p =* .664 | *p =* .567 | *p =* .254 |
| Conscientiousness | -1.35\* | -1.33\* | -0.76 |  | -0.28 | -0.28 | 0.49 |
|  | [-2.12, -0.57] | [-2.10, -0.55] | [-1.54, 0.05] |  | [-1.58, 1.02] | [-1.58, 1.02] | [-0.73, 1.67] |
|  | *p =* .001 | *p =* .001 | *p =* .055 |  | *p =* .667 | *p =* .662 | *p =* .426 |
| Extraversion | -1.04\* | -1.06\* | 0.56 |  | 0.51 | 0.56 | 1.45\* |
|  | [-1.85, -0.24] | [-1.87, -0.27] | [-0.20, 1.31] |  | [-0.80, 1.80] | [-0.76, 1.86] | [0.13, 2.72] |
|  | *p =* .008 | *p =* .007 | *p =* .160 |  | *p =* .432 | *p =* .391 | *p =* .025 |
| Neuroticism | 1.75\* | 1.77\* | -0.48 |  | -0.20 | -0.20 | 0.17 |
|  | [0.94, 2.52] | [0.97, 2.55] | [-1.24, 0.29] |  | [-1.51, 1.11] | [-1.51, 1.12] | [-1.04, 1.43] |
|  | *p* < .001 | *p* < .001 | *p =* .224 |  | *p =* .753 | *p =* .757 | *p =* .783 |
| Openness | -0.50 | -0.50 | 0.04 |  | -0.02 | -0.04 | -0.16 |
|  | [-1.29, 0.30] | [-1.28, 0.30] | [-0.76, 0.83] |  | [-1.31, 1.25] | [-1.33, 1.24] | [-1.40, 1.09] |
|  | *p =* .206 | *p =* .207 | *p =* .921 |  | *p =* .971 | *p =* .951 | *p =* .807 |

**Table 3.**  Accuracy in the test set of models including combinations of variables. For reference, the original standard deviation of BMI percentile was 30.40 among adolescent boys and 27.43 among adolescent girls.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Adolescent Boys | |  | Adolescent Girls | |
| Model | RMSE | R2 |  | RMSE | R2 |
| SES | 30.09 | .020 |  | 27.02 | .031 |
| SES + Cognitive Ability | 30.02 | .024 |  | 26.95 | .036 |
| SES + Big Five | 30.11 | .020 |  | 27.02 | .030 |
| SES + Narrow 27 | 29.76 | .052 |  | 26.90 | .038 |
| SES + Cognitive Ability + Big Five | 30.04 | .024 |  | 26.97 | .035 |
| SES + Cognitive Ability + Narrow 27 | 29.83 | .045 |  | 26.87 | .041 |

**Figure Captions**

**Figure 1.** BMI percentile distributions by sex.

**Figure 2.** SES is negatively associated with BMI percentile regardless of which individual difference measure is included in the model. Bars represent 95% confidence interval of the SES coefficient estimates. Each bar is a different model (i.e., controlling for a different personality trait).

**Figure 3.** Associations between traits and BMI percentile above and beyond SES. Bars represent the coefficient of the personality trait, that is, controlling for SES. Bars are colored if they reach statistical significance (*p* < .05). 95% confidence intervals are indicated.