Body Mass in Adolescence: The Role of Personality, Cognitive Ability, and Socioeconomic Status

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# Author note

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Abstract

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Obesity among children and adolescents is an international public health crisis. In the last 40 years, the prevalence of obesity has grown from 1 in 20 American adolescents to nearly 1 in 5 (Hales et al., 2017; Ogden et al., 2014). Currently, an estimated 19.3% of children and adolescents under the age of 19 were obese in 2018 (Fryar et al., 2018). Efforts to reduce the prevalence of obesity have been a high priority public health issue in the U.S. for several years (Frieden et al., 2010; Healthy People, 2000, 2014; Surgeon General, 2001), and several of the prominent social programs focused on this issue consider children and adolescents as populations that are ripe for intervention (Dietz & Gortmaker, 2001; Frieden et al., 2010; Khan et al., 2009). Yet, there is little evidence that these efforts are working (Ogden et al., 2014).

Adolescence is associated with considerable changes in body composition: all the main components of body composition (total body fat, lean body mass, bone mineral content) increase during this period (Loomba-Albrecht & Styne, 2009; Siervogel et al., 2003). Numerous studies (and anecdotal evidence from billions of former adolescents) suggest that this period is often psychologically challenging. Adolescents are more likely to be dissatisfied with their body (to the point of endorsing a profound dislike of one’s own body), experience fear of weight gain, and have appearance and body shape concerns, and these concerns predispose them to the development of eating disorders (Killen et al., 1994; Mäkinen et al., 2012; Quittkat et al., 2019; Story et al., 1991).

The trend of increasing obesity prevalence among adolescents, coupled with its adverse health outcomes, underscores the need for obesity prevention efforts, especially those targeting adolescents. Adolescence is a vulnerable period for weight gain and most of the complications that are commonly associated with adult obesity are tied to health behaviors formed in childhood and adolescence (Hampson et al., 2007). As such, a more informed understanding of relations among key constructs within this developmental period is crucial.

Although there are some alternatives to the assessment of obesity in children and adolescents, BMI – as an estimate of body fat – is a widely accepted index to determine overweight status and obesity in children, adolescents, and adults (Dietz & Bellizzi, 1999). BMI is calculated by dividing a person’s weight in kilograms by the square of their height in meters. Numerous changes in BMI levels during adolescence are already well-documented, including several pointing to important sex differences. For example, developmentally appropriate increases in body mass occur at different ages for each sex, necessitating the use of age- and sex-specific reference values (Bibiloni et al., 2013). Adolescent males and females differ substantially on average in terms of body fat percentages, with females typically having more body fat than males at the same BMI (Daniels et al., 1997; Karastergiou et al., 2012). Similarly, substantial differences have been reported between the eating habits of males and females, even when controlling for differences in knowledge of healthy eating practices and benefits (Djordjević-Nikić et al., 2013). Given these and related findings, much of the research in this area (including the work reported here) is conducted on each of the sexes independently.

The primary aim of this work is to identify and evaluate the wide range of individual differences contributing to elevated BMI across both sexes. There is some evidence that socioeconomic status (Sherwood et al., 2009; J. P. Smith, 2004), personality (Bogg & Roberts, 2004), and cognitive ability (Liang et al., 2014) are each protective factors for obesity, however, the unique (independent) and combined variance of these attributes has rarely been considered.

## BMI and socioeconomic status

The term “socioeconomic status” (SES) is an aggregate construct defined according to one’s level of resources or prestige in relation to others (Adler & Rehkopf, 2008; Krieger et al., 1997; Lynch et al., 2000). While the operationalization and measurement of socioeconomic status is notably inconsistent, there is a consensus that SES includes education, income, and occupational prestige (Shanahan et al., 2014). Because children and adolescents are still in school and do not have income, researchers typically use measures of parental education, parental occupation, and/or household income as markers of childhood/adolescent SES (Shrewsbury & Wardle, 2008).

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 (Booth et al., 1999; Bove & Olson, 2006; Molnar et al., 2004; Wang et al., 2007). The list of proposed mechanisms placing low-income children at increased risk for obesity relative to higher-income children includes the consumption of less whole meal and brown bread and fewer fresh fruits and vegetables, but more fatty milk, eggs, and meats (A. M. Smith & Baghurst, 1992; Steele et al., 1991). It has also been proposed that the inverse relationship between SES and BMI is driven by sedentary behavior as low SES children have been found to be less physically active and spend more time watching television and using a computer (Brown et al., 2015; Drenowatz et al., 2010; Morgenstern et al., 2009). Unfortunately, additional research has shown that SES is inversely related to sedentary behavior and to rates of overweight status in children over six years of age (Hanson & Chen, 2007; Inchley et al., 2005; Lioret et al., 2007) and adolescents (Lohman et al., 2006). Still other research points to sedentary behavior as a mediator of BMI in children of low SES status (O’Dea & Wilson, 2006), among more prominent main effects.

## BMI and personality

Research has shown that 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 (Bogg & Roberts, 2004; Terracciano et al., 2009) and are more physically active (Rhodes & Smith, 2006) whereas individuals with lower levels of conscientiousness tend to engage in emotional and external eating, which is a tendency to overeat in response to food-related cues like the smell or taste of food, regardless of the individual’s physical need for food (Evers et al., 2011; Heaven et al., 2001). Higher scores on extraversion have also been found to contribute to obesity (Kakizaki et al., 2008; Sutin et al., 2011). Similarly, individuals with higher scores on openness to experience were found to be less successful at managing their body weight and indicated a stronger drive toward overeating (Sullivan et al., 2007). In addition, higher scores on openness were negatively related to cognitive dietary restraint (van den Bree et al., 2006). Findings regarding neuroticism are inconclusive. Some researchers found that high levels of neuroticism are related to disinhibition and susceptibility to hunger (Provencher et al., 2008). On the other hand, individuals who have higher scores on this trait tend to be underweight (Kakizaki et al., 2008; Terracciano et al., 2009) and more likely to suffer from eating disorders (Bogg & Roberts, 2004). Sutin and colleagues (2015) 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. In summary, a growing body of research confirms that personality traits influence eating behavior and therefore moderate the association between personality and BMI.

## BMI and cognitive abilities

Previous studies investigating the association between BMI and cognitive abilities found that individuals with lower levels of cognitive abilities have a higher BMI (Cournot et al., 2006; Hirshman et al., 2004; Li, 1995). Adolescents who are obese are more likely to suffer from deficits in multiple cognitive domains such as attention, memory, and executive function and as a result have worse school outcomes in comparison to non-obese peers (Elias et al., 2005; Lawlor et al., 2006; Mond et al., 2007; Sabia et al., 2008). This association remains significant even after controlling for important confounding factors, such as physical activity or maternal intelligence. The mechanisms through which cognitive abilities may adversely affect BMI remain unclear. One hypothesis of the underlying mechanism is that lower levels of cognitive abilities may result in poor control over neurological centers associated with impulsivity which can lead to impaired control over food intake (Veldwijk et al., 2011). Alternatively, obesity may negatively influence cognitive function via physiological changes in brain tissue (Veldwijk et al., 2011). Therefore, there might be a bi-directional interaction between cognitive abilities and BMI. Because there is a hereditary component to both cognitive abilities and BMI, a number of genetic factors may be involved in explaining this association (Teasdale et al., 1992).

## Relative contributions of SES and individual differences to BMI

As described above, both individual (personality and cognitive ability) and demographic (SES) factors are linked with adolescent BMI, yet it is unclear to what extent individual factors are uniquely associated with BMI above and beyond 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, including external locus of control and lack of problem-focused coping (Bosma et al., 1999; Körner et al., 2003). These individuals are also more likely to engage in risky health behaviors and have higher levels of hostility (Barefoot et al., 1991; Kubzansky et al., 1999) whereas children from families with higher SES are less impulsive on average (Delaney & Doyle, 2012), significantly less likely to be risk-seeking (Deckers et al., 2015), and more altruistic (Bauer et al., 2014; Deckers et al., 2015).

It should be noted that associations between SES and personality are likely bidirectional. Certainly, across the lifespan, there is strong evidence of the effects of personality on socioeconomic status in adulthood. Research shows children’s conscientiousness is a strong predictor of income and occupational status, even after controlling for IQ (Duckworth et al., 2012). Individuals high on conscientiousness tend to save more money and are more hardworking, dependable, persistent, and goal-oriented (Barrick & Mount, 1991). In addition, they spend money more cautiously (Wilcox et al., 2011). Some studies have also shown empirical support for the influence of agreeableness on SES. Individuals high on agreeableness are more likely to choose professions that are paid less such as teaching, nursing or volunteer work (Larson et al., 2002; Lodi-Smith & Roberts, 2007). Findings on other personality traits are inconsistent (Sutin et al., 2015).

A growing body of research has documented that SES predicts a variety of children’s outcomes including physical and mental health, cognitive ability, and academic achievement (Adler & Rehkopf, 2008; Merikangas et al., 2010). Interestingly, the differences in cognitive abilities between children from families with high and low SES can be observed as early as infancy and persists, on average, throughout adolescence (Lipina et al., 2005). A number of studies have demonstrated that low-SES children performed worse in working memory or executive attention tasks in comparison to children from families with high SES (Blair et al., 2011; Hughes et al., 2009; Leonard et al., 2015; Mezzacappa, 2004). Although cognitive ability has been shown to be highly heritable (Haworth et al., 2010), SES also seems to have an important influence on children’s school performance that is potentially independent of cognitive ability (Conger & Donnellan, 2007).

In the context of BMI, it is unclear whether associations between individual differences and BMI represent unique patterns of causality, or whether these relationships are confounded by SES. In other words, are individual differences in personality and cognition merely proxies of SES in prior research documenting the relationship of traits to BMI? Moreover, much of the prior work documents the existence of relationships, but a comparison of the relative size of effects is warranted, as this can guide researchers and policy-makers to constructs with the greatest impact.

## 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 behavior or outcomes. One example is the “strong-situation hypothesis” (Cooper & Withey, 2009), which posits that some situations demand specific responses, overpowering any potential impact of personality. Strong situations limit personal expression or choice through constraint of resources or options. In the case of BMI, low SES may represent a strong situation in that individuals from poorer backgrounds have fewer dining options or leisure opportunities, and so food choices or activity levels reflect availability rather than preference. In addition to overpowering individual differences, situations may carry different psychological meaning for different persons due to their temperament (Wagerman & Funder, 2009). There is some evidence that socioeconomic status moderates personality expression. For example, phenotypic expression of personality is more closely associated with genetics among those with advantaged socioeconomic backgrounds (Tuvblad et al., 2006), and adolescent impulsivity has stronger effects among the disadvantaged (Lynam et al., 2000). For some trait-behavior relationships, however, socioeconomic status has no effect (c.f., Ayer et al., 2011).

## 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 ability 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 ability, SES, and BMI through the following methods: (1) examining both broad (Big-Five) and narrow traits to better determine the aspects of personality which relate to BMI, (2) utilizing a measure of SES that accounts for monetary resource and social status, and (3) using percentile assessments of BMI to account for developmental differences in weight.

# Methods

## Data Collection

## Participants

During the data collection period, 616,270 participants visited the personality assessment website. Of these, 9,482 were adolescents (between the ages of 11 and 17) living in the United States who provided their height and weight. This was the sample used for these analyses. The average age of participants was 15.87 (*SD* = 1.29) and 7,128 (68.77%) self-reported their sex as female. 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). While some would use a BMI score as the outcome of interest, this value is problematic, as there are group differences in BMI by sex. Moreover, 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 sex (Centers for Disease Control & Prevention, 2015). As is evident by the distributions of BMI percentiles depicted in Figure 1, BMI distribution in this sample was negatively skewed, although we have relatively large coverage across the entire range.

**Personality.** Personality traits were measured using the 135-item SAPA Personality Inventory (SPI-135; Condon, 2018). This scale can be used to estimate scores on both broad and narrow traits. The current study leverages this feature of the personality scale to assess the relationships of both broad and narrow traits to BMI category and compare the predictive validity of each.

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 *(αE =* .88; *αA =* .83; *αC =* .81; *αN =* .86; *αO =* .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 Condon, 2018). Estimates were scaled using t-scoring, resulting in means of 50 and standard deviations of 10 for the entire adolescent sample.

**Cognitive Ability.** Participants were administered between 12 and 16 cognitive ability items assessing Three-Dimensional Rotation, Verbal Reasoning, Matrix Reasoning, and Letter and Number Series from the International Cognitive Ability Resource (ICAR; Condon & Revelle, 2014). 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. 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, concurrently associated with BMI percentile, we used a series of multiple regression models. We estimated 33 versions of this model, with each model including both SES and either one personality trait or cognitive ability (thirty-three individual difference measures in total). 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 male and female adolescents. All prediction variables were standardized within each gender sample prior to analysis, so coefficient estimates can be interpreted as standardized effect sizes.

All analyses described above were performed on subset of our sample containing a random 75% of the adolescent girls and 75% of the adolescent boys, stratified by BMI category1. The remaining 25% of the same was used in exploratory analyses to estimate the total variability in BMI percentile that is accounted for by these variables. For these analyses the initial 75% (training set) were used to estimate lasso regression models containing (1) SES alone, (2) SES and cognitive ability, (3) SES and personality, or (4) SES, cognitive ability, 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 (Tibshirani, 1996). These models were then used to predict outcomes in the remaining 25% (test set). 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 ability, 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 difference measures (cognitive ability and personality traits). Higher parental SES was consistently significantly associated with lower BMI percentile for both adolescent girls and boys. 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 the inclusion of specific personality traits. These results are summarized in Figure 2. These figures display the SES coefficient estimate of each model; as a reminder, there are 33 models for each gender, each model regresses the BMI percentile variable onto SES and one of the thirty-three individual difference measures. In this figure, the 95% confidence interval around each estimate is represented with a vertical line. Lines are red if they do not contain 0 (the null hypothesis, represented by the horizontal dashed line). A solid horizontal line represents the average coefficient estimate across all models. Effect sizes are presented in ascending order.

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

Next, we examine the coefficients associated with personality traits – here referring to cognitive ability, 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 adolescent boys. This is in part an issue of power (there were more than twice as many adolescent girls as there were adolescent boys in the current sample), although we note that the sample of boys had 90% power to detect correlations as small as *r* = .06. 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). Notably, this corresponded with significant associations of BMI percentile and many narrow traits, such Well-Being (*b* = -2.72), Irritability (*b* = 1.42), Anxiety (*b* = 1.34). However, we also note that adolescent girls with larger BMI percentiles also reported higher Easy-Goingness (*b* = 1.57), complicating an interpretation that BMI is generally associated with negative affect. 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 complicated by the finding that girls with larger BMIs tended to score higher on Humor (*b* = 1.03). Conscientiousness was associated with lower BMI (*b* = -1.35), evidenced by the relationship between BMI percentile and Industry (*b =* -0.81), Order (*b =* -2.27), and Self-Control (*b =* -2.27). and lower on Introspection (*b* = -1.05). Finally, cognitive ability was negatively associated with BMI percentile (*b* = -1.32).

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), a finding similar to that 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 adolescent girls (*b* = -0.94). Again, cognitive ability was negatively associated with BMI percentile (*b* = -1.84).

**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. Given the number of models tested, it is likely than many are due to sampling variability, rather than representing robust findings. However, we note that among both adolescent boys and girls, SES was a significant moderator of the Conservatism-BMI relationship. We depict these relationships in Figure 4, which suggests that conservatism is most strongly and positively associated with BMI percentile for adolescent boys when SES is high. 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 (Tibshirani, 1996) and a hold-out sample to evaluate the contributions of individual difference measures 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 modestly improved by the inclusion of cognitive ability (2.4%; *RMSE* = 30.02) and not at all by 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 (22%) to the R2 value.

# Discussion

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

These findings are consistent with prior work documenting the inverse relationship between SES and BMI (Booth et al., 1999; Bove & Olson, 2006; Molnar et al., 2004; Wang et al., 2007). We also replicate earlier work linking higher BMI level to lower levels of cognitive ability (Cournot et al., 2006; Hirshman et al., 2004; Li, 1995). 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 (Bogg & Roberts, 2004; Evers et al., 2011; Heaven et al., 2001; Terracciano et al., 2009).

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 (Kakizaki et al., 2008; Sutin et al., 2011), although humor in adolescent girls was positively associated with body mass. 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 hunger susceptibility (Provencher et al., 2008) rather than being underweight (Bogg & Roberts, 2004; Kakizaki et al., 2008; Terracciano et al., 2009). Notably, neuroticism and related narrow traits were unrelated to BMI among adolescent boys.

In addition, we found no support for the hypothesis that individual differences in personality and cognition had stronger relationships with BMI at different levels of SES. This effectively rules out the strong situation hypothesis (Cooper & Withey, 2009) and the possibility that personality expression has the strongest effect on BMI among those with sufficient resources (Lynam et al., 2000).

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 and contributed about equal to individual differences in adolescent boys. 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 (Seburg et al., 2017; J. D. Smith et al., 2018).

**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 (Agrawal et al., 2021; Burkhauser & Cawley, 2008) and the heterogeneity of health outcomes within BMI strata suggest that it should not be used as a diagnostic tool for individuals (Tomiyama et al., 2016). However, BMI does potentially play a useful role in the public health assessment of large groups or trends (Nuttall, 2015) or as a more holistic indicator of general health (Gutin, 2018). Given the limitations of the 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 adolescent’s reports on a broad scale. The use of a more detailed measure of parental occupation likely would not improve this measure, 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 socioeconomic status (SES) has a strong, negative relationship with BMI percentile among adolescents. Cognitive ability and some personality traits are associated with BMI above and beyond SES, although the size of these effects is relatively smaller. Thus, both individual differences and environment inform adolescent BMI outcomes.

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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 gender. Standard deviations are shown in parentheses. Parent income and occupational prestige are estimated based on the occupational field reported.

|  |  |  |
| --- | --- | --- |
| Variable | Female  (*N* = 6,530) | Male  (*N* = 2,952) |
| Age | 15.84 (1.31) | 15.93 (1.25) |
| BMI | 23.07 (5.00) | 22.82 (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) |

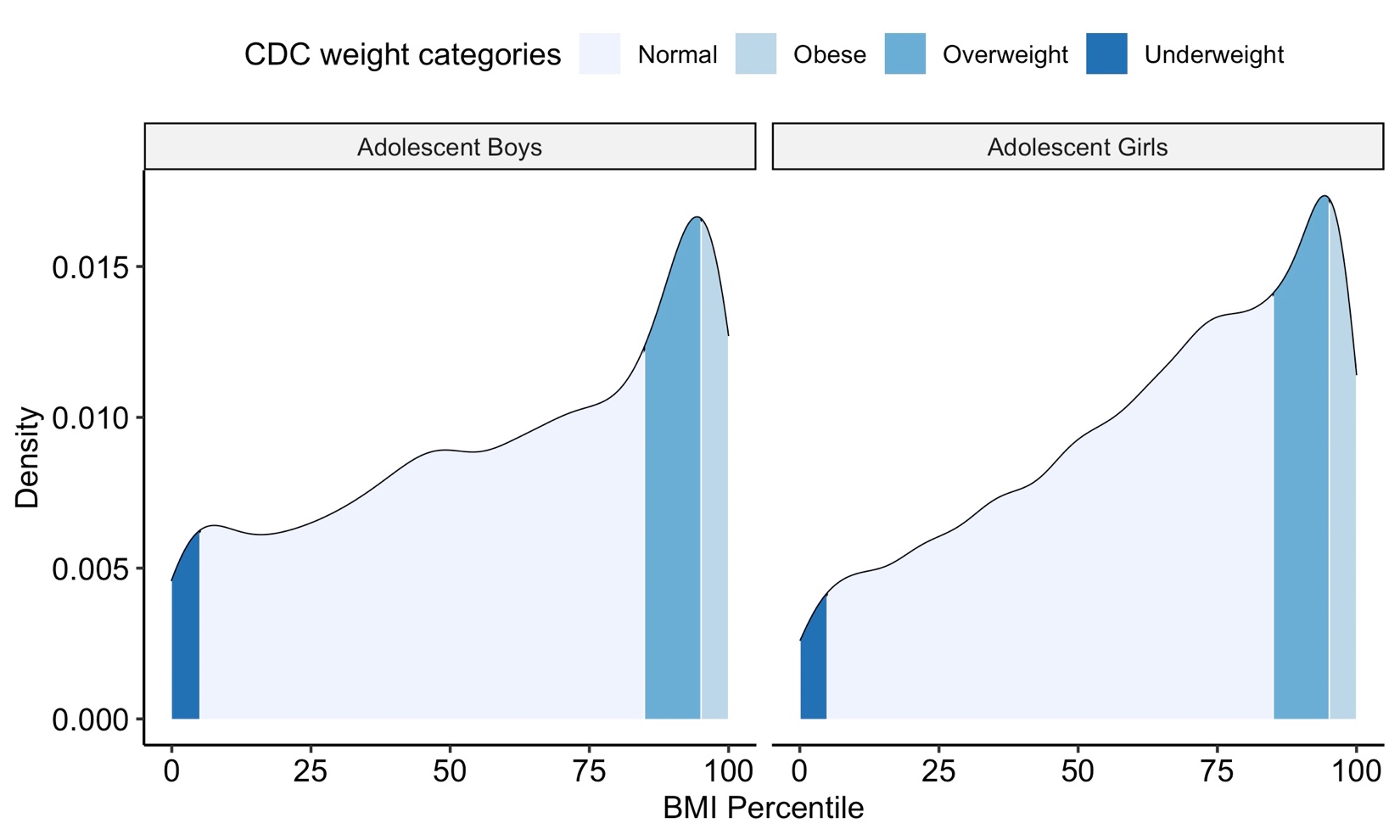
**Table 2.** Results from regression models regressing BMI percentile onto trait scores and SES. In the additive models, the trait score coefficient represents the association of personality and BMI above and beyond SES. In joint models, we include an interaction term between personality and SES; the 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] |
| **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] |
| 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] |
| 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] |
| 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] |
| 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] |
| 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] |
| 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] |
| 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] |
| 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] |
| 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] |
| 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] |
| 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] |
| Order | -2.26\* | -2.27\* | -0.80\* |  | -0.61 | -0.60 | -0.50 |
|  | [-3.02, -1.51] | [-3.03, -1.52] | [-1.54, -0.06] |  | [-1.92, 0.67] | [-1.90, 0.69] | [-1.81, 0.78] |
| 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] |
| 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] |
| Trust | -0.28 | -0.28 | 0.02 |  | -0.31 | -0.40 | 0.96 |
|  | [-1.06, 0.50] | [-1.06, 0.51] | [-0.77, 0.80] |  | [-1.60, 0.97] | [-1.68, 0.90] | [-0.29, 2.21] |
| Humor | 1.03\* | 1.03\* | -0.30 |  | 0.66 | 0.66 | 0.66 |
|  | [0.22, 1.84] | [0.23, 1.84] | [-1.04, 0.44] |  | [-0.63, 1.96] | [-0.63, 1.96] | [-0.70, 2.02] |
| Emotional Expressiveness | -0.63 | -0.62 | 0.33 |  | -0.46 | -0.53 | 1.36\* |
|  | [-1.42, 0.16] | [-1.41, 0.16] | [-0.46, 1.09] |  | [-1.78, 0.78] | [-1.84, 0.73] | [0.06, 2.66] |
| Art Appreciation | 0.00 | 0.00 | -0.19 |  | -0.33 | -0.33 | -0.05 |
|  | [-0.75, 0.74] | [-0.75, 0.73] | [-0.95, 0.55] |  | [-1.60, 0.94] | [-1.60, 0.94] | [-1.36, 1.19] |
| Introspection | -1.05\* | -1.05\* | 0.37 |  | -0.39 | -0.37 | 0.47 |
|  | [-1.81, -0.29] | [-1.80, -0.28] | [-0.37, 1.08] |  | [-1.69, 0.91] | [-1.66, 0.92] | [-0.74, 1.69] |
| Perfectionism | -0.61 | -0.6 | -0.58 |  | -0.93 | -0.93 | 0.60 |
|  | [-1.41, 0.17] | [-1.40, 0.19] | [-1.33, 0.20] |  | [-2.18, 0.33] | [-2.18, 0.33] | [-0.66, 1.83] |
| 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] |
| Conformity | 0.89\* | 0.90\* | -0.24 |  | 0.46 | 0.45 | -0.19 |
|  | [0.09, 1.70] | [0.10, 1.70] | [-1.01, 0.55] |  | [-0.85, 1.77] | [-0.86, 1.76] | [-1.48, 1.03] |
| 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] |
| Easy-Goingness | 1.59\* | 1.57\* | -0.33 |  | 1.09 | 1.19 | -1.41\* |
|  | [0.82, 2.37] | [0.81, 2.35] | [-1.11, 0.41] |  | [-0.17, 2.34] | [-0.08, 2.45] | [-2.67, -0.18] |
| Emotional Stability | -0.35 | -0.35 | 0.23 |  | 1.00 | 1.00 | -0.49 |
|  | [-1.14, 0.45] | [-1.13, 0.45] | [-0.55, 1.01] |  | [-0.33, 2.29] | [-0.33, 2.29] | [-1.73, 0.73] |
| Conservatism | -0.97\* | -0.94\* | 0.86\* |  | 1.32\* | 1.25 | 1.44\* |
|  | [-1.77, -0.19] | [-1.72, -0.16] | [0.05, 1.65] |  | [0.01, 2.65] | [-0.05, 2.58] | [0.10, 2.83] |
| **SPI: Big Five** |  |  |  |  |  |  |  |
| Agreeableness | -0.36 | -0.36 | -0.28 |  | -0.28 | -0.37 | 0.76 |
|  | [-1.13, 0.41] | [-1.14, 0.41] | [-1.06, 0.52] |  | [-1.56, 1.02] | [-1.65, 0.94] | [-0.50, 2.01] |
| Conscientiousness | -1.33\* | -1.35\* | -0.76 |  | -0.28 | -0.28 | 0.49 |
|  | [-2.10, -0.55] | [-2.12, -0.57] | [-1.54, 0.05] |  | [-1.58, 1.02] | [-1.58, 1.02] | [-0.73, 1.67] |
| Extraversion | -1.06\* | -1.04\* | 0.56 |  | 0.51 | 0.56 | 1.45\* |
|  | [-1.87, -0.27] | [-1.85, -0.24] | [-0.20, 1.31] |  | [-0.80, 1.80] | [-0.76, 1.86] | [0.13, 2.72] |
| Neuroticism | 1.77\* | 1.75\* | -0.48 |  | -0.20 | -0.20 | 0.17 |
|  | [0.97, 2.55] | [0.94, 2.52] | [-1.24, 0.29] |  | [-1.51, 1.11] | [-1.51, 1.12] | [-1.04, 1.43] |
| Openness | -0.50 | -0.50 | 0.04 |  | -0.02 | -0.04 | -0.16 |
|  | [-1.28, 0.30] | [-1.29, 0.30] | [-0.76, 0.83] |  | [-1.31, 1.25] | [-1.33, 1.24] | [-1.40, 1.09] |

**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 1.** BMI percentile distributions by gender.



**Figure 2.** SES is negatively associated with BMI percentile regardless of which individual difference measure is included in the model.

Chart, histogram

Description automatically generated

Figure 3. Associations between traits and BMI percentile above and beyond SES.

Chart, bar chart

Description automatically generated

**Figure 4.** SES moderates the relationship of conservatism and BMI percentile.

Chart

Description automatically generated