 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 (Ogden, Carroll, Kit, & Flegal, 2014). Efforts to reduce the prevalence of overweight and obesity have now been a high priority public health issue in the U.S. for several years (Frieden, Dietz, & Collins, 2010; Healthy People, 2014) and several of the prominent social programs focused on this issue consider children and adolescents as populations that are ripe for intervention (Frieden et al., 2010). 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 (Siervogel et al., 2003). This period is often psychologically challenging. Adolescents are more likely to be dissatisfied with their body, experience fear of weight gain, and have appearance and body shape concerns, and these concerns predispose them to the development of eating disorders (Striegel-Moore, Silberstein, & Rodin, 1986). The trend of increasing obesity prevalence among adolescents, coupled with its adverse physical and mental health outcomes, underscores the need for obesity prevention efforts. 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, Goldberg, Vogt, & Dubanoski, 2007). As such, a more informed understanding of relations among key constructs within this developmental period is crucial.

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, Wall, Neumark-Sztainer, & Story, 2009) and individual differences (Bogg & Roberts, 2004; Liang, Matheson, Kaye, & Boutelle, 2014) are each protective factors for obesity, however, the unique and combined variance of these attributes has rarely been considered.

## The relationship between SES and BMI

While the operationalization and measurement of socioeconomic status is notably inconsistent, there is general consensus that SES includes education, income, and occupational prestige (Shanahan, Hill, Roberts, Eccles, & Friedman, 2014). Because adolescents do not have income, researchers typically use measures of parental education,occupation, and/or household income as markers of adolescent SES (Shrewsbury & Wardle, 2008).

The relationship between SES and BMI has been widely investigated. Several studies have found that obesity among children and adults in industrialized countries is negatively associated with income and education (e.g., Molnar, Gortmaker, Bull, & Buka, 2004; Wang et al., 2007); the opposite relationship has been found in some developing countries, including urban India or Ghana (Fokeena & Jeewon, 2012). The list of proposed mechanisms placing low-income children at increased risk for obesity includes the consumption of fewer healthy and more fatty foods (Smith & Baghurst, 1992). 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 (Drenowatz et al., 2010). Unfortunately, additional research has shown that SES is inversely related to sedentary behavior and to rates of overweight status in 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).

## BMI and individual differences

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 (see Bogg & Roberts, 2004; Terracciano et al., 2009) and are more physically active (Rhodes & Smith, 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. Higher scores on extraversion have also been found to contribute to obesity (e.g., Kakizaki et al., 2008; Sutin, Ferrucci, Zonderman, & Terracciano, 2011).

Previous studies investigating the association between BMI and cognitive abilities, another source of individual differences, found that individuals with lower levels of cognitive abilities have higher BMI (Cournot et al., 2006). 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, Elias, Sullivan, Wolf, & D’Agostino, 2005; Lawlor, Clark, Smith, & Leon, 2006; Mond, Stich, Hay, Krämer, & Baune, 2007; Sabia, Kivimaki, Shipley, Marmot, & Singh-Manoux, 2008). This association remains significant even after controlling for important confounding factors, such as physical activity or maternal intelligence.

## SES and individual differences

Considerable research suggests that individuals raised in low SES households have higher levels of neuroticism, lower openness to experience and maladaptive coping mechanisms (Bosma, Mheen, & Mackenbach, 1999; Körner, Geyer, Gunzelmann, & Brähler, 2003). These individuals are also more likely to engage in risky health behaviors and have higher levels of hostility (Barefoot et al., 1991) whereas children from families with higher SES are less impulsive on average (Delaney & Doyle, 2012), significantly less likely to be risk-seeking (Deckers, Falk, Kosse, & Schildberg-Hörisch, 2015), and more altruistic (Deckers et al., 2015).

A growing body of research has documented that socioeconomic status predicts a variety of children’s outcomes including cognitive ability and academic achievement (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, Martelli, Vuelta, & Colombo, 2005). Although cognitive ability has been shown to be highly heritable (e.g., 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).

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

Given the known relationships between SES and both BMI and individual differences in temperament and cognitive ability. it should be no surprise that the relationship between BMI and individual differences is unclear. Further complicating the relationships 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, Grann, & Lichtenstein, 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 both percentile and categorical assessments of BMI to allow for both linear and non-linear relationships between psychosocial constructs and health.

# Discussion

The current study included many analyses, providing a wealth of potential conclusions. We discuss our interpretations starting with the conclusions we are most confident in and working towards conclusions that have less evidentiary value.

First, we begin with the conclusions we have strong confidence in. We believe it is undisputable at this point that higher parental socioeconomic status (SES) is associated with lower risk of adolescent girls and boys being underweight, overweight, and obese, implying that SES may be protective against weight problems on both ends of the spectrum. This finding was robust to the inclusion of nearly all traits, and conforms with prior findings in the literature.

In addition, we conclude that some personality traits are independently associated risk for being underweight, compared to normal, even accoutning for parental SES. We are especially confident in the associations between trait neuroticism and the highly associated narrow traits well-being and emotional stability among adolescent girls, and the well-being, sensation seeking, and attention seeking among adolesecnt boys.

Next, there is some evidence that personality traits may also be independently associated with risk for being overweight or obese. We have reduced confidence in these findings given that these associations were sensitive to the imputation of missing data in our study.

## Findings in context – application

## Findings in context -- research

It is notable that many teens were unwilling (or perhaps unable) to provide their height and/or weight on an anonymous self-report assessment of personality. Body size is scrutinized among adolescents and, for some individuals, may be stimatized by their peers, so it is unsuprirising that at least some individuals chose not to report these values. However roughly half of our sample of US adolescents skipped one or both of these questions, suggesting large bias in self-report studies attempting to measure these variables. All studies of BMI in adolescents must take great care to attend to missigness in data and, ideally, avoid the use of self-report as the primary means by which these data are colleted.

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 (see Duckworth, Weir, Tsukayama, & Kwok, 2012; Barrick & Mount, 1991; and Lodi-Smith & Roberts, 2007 for examples). This suggests that some of the direct effects of personality or SES on weight are obscured by controlling for the other; indeed, the range of coefficients for SES across models implies that the choice of trait covariate may have substantial impact on the conclusions drawn in a particular study.

## Limitations

The primary limitations of the current study are the use of self-reported height and weight, which imposes bias through inaccuracy and missingness, and self-selection into the study. Regarding the former, several results were robust to sensitivity analysis, including the effect of parental socioeconomic status, the lack of interaction effects, and many relationships between personality traits and risk for being underweight compared to normal.Regarding self-selection, however, we are somewhat limited in our ability to test the boundaries of our effects. We note here that broadly, people who voluntarily visit this website represent a broad range of ethnic backgrounds and geographic locations, although it tends to skew more educated than the general population in adult samples (citation masked).

# Conclusion