Body Mass Index and Subjective Social Status: The Coronary Artery Risk Development in Young Adults Study

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Objective: Subjective social status (SSS), or perceived social status, may explain, in part, the relationship between socioeconomic status (SES) and obesity. The objective of this study was to test whether SSS mediates the relationship between two indicators of SES (income and education) and body mass index (BMI).

Methods: A cross-sectional, structural equation path analysis was applied to the Coronary Artery Risk Development in Young Adults (CARDIA) study (n = 2,624). The analysis tested whether SSS (MacArthur scale), education, and income were associated with BMI at the year 20 examination (adjusting for sex, age, and race), and it was hypothesized that the associations of education and income with BMI would be at least partly mediated by SSS.

Results: SSS had a significant direct effect on BMI (β = -0.21, P = 0.018). Education had a significant direct relationship with SSS (β = 0.11, P < 0.001) and a small but significant indirect relationship with BMI through SSS (β = -0.02, P = 0.022). Although income did not have a significant direct relationship with BMI, it did have a significant indirect relationship through SSS (β = -0.05, P = 0.019).

Conclusions: Results are consistent with the hypothesized model in which SSS partially mediates the relationship between SES indicators and BMI.

Introduction

Traditional indicators of socioeconomic status (SES), such as income and education, are inversely associated with obesity, although this finding is inconsistent across populations and may depend on economic development of the region and on age, race, and sex (1). For example, in the United States, the inverse relationship between SES and obesity tends to be more pronounced in women and less pronounced in minority populations (2). The relationship between SES and obesity is complex and not entirely understood; in part, this is because multiple causal relations may underlie the SES-obesity association (3). Lower SES may causally lead to obesity (4), obesity may cause a decline in achieved SES (5-7), or obesity and low SES may share a common prior cause. Although each of these causal relations may contribute to the association between SES and obesity in developed countries, Fontaine et al. (3) used an adoption study to show that some (but not all) of the relationship between SES and obesity appeared to be caused by unique contributions from SES to obesity that were not attributable to the rearing environment. Given the evidence that at least some of the association between SES and obesity is due to the causal link from SES to increased body weight, understanding the specific mechanism of action is important.

SES may contribute to overweight and obesity in industrialized countries because low-SES populations generally have less access to a “healthy” environment that includes healthy foods and safe and comfortable exercise opportunities (8). Additional findings from the fields of ecology and evolutionary biology suggest that perceived food insecurity elicited by an adequate but unpredictable food supply and social subordination results in increased body fat stores, perhaps as an adaptive strategy to ensure survival in difficult times (9,10). In socially

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Additional Supporting Information may be found in the online version of this article.

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housed monkeys, both dominant and subordinate animals prefer a high-energy-density diet, but subordinate animals consume more of a high-energy-density diet and more energy overall than dominant animals (11). In line with the hypothesis that perceived food insecurity leads to greater energy intake in the context of an inconsistent food supply, food insecurity is also associated with overweight status in women (12). These findings suggest that the perception of the food environment and social position may interact and be key influences on body fatness and eating behavior (13).

Consistent with this hypothesis, subjective social status (SSS), or one’s perceived rank in the social hierarchy, is often more highly associated with health outcomes including body mass index (BMI, kg/m²) than are objective measures of SES (14-17). Prior research has identified several determinants of SSS, including feelings of financial insecurity, occupational position, satisfaction with standard of living, educational attainment, sense of control in one’s job, and household income (18). Although one’s own assessment of social status may be based on psychological factors such as subjective wellbeing, the primary determinants of SSS appear to be the traditionally used objective measurements of SES, such as education and income, as well other variables that capture an individual’s perception of whether he or she has “enough” resources (feelings of financial security, job satisfaction, and standard-of-living satisfaction) (19). Financial insecurity and desire for money have been demonstrated to result in an increased desire for food (20). Thus, it is plausible that a desire for financial resources and a better standard of living that accompanies low SSS may result in increased food-seeking behavior or altered food choices and that SSS may be a more sensitive proxy for social stressors that may trigger overeating and/or increased fat storage than the commonly used objective SES measures. Bratanova et al. (21) found that participants asked to read about and personally identify with financial scarcity in their society consumed more calories than participants asked to read and write about material abundance in their society. In a pilot study on the effects of social status on energy intake, Cardel et al. (22) found that participants assigned to a low-status condition consumed 130 more kilocalories on average than the high-status group, though this group difference was not statistically significant. Furthermore, in a series of four experiments, Cheon et al. (23) found that participants induced to feel low SES relative to others in imagined interactions demonstrated a preference for high-calorie foods in selection or actual consumption scenarios.

Given the above research on social standing, food insecurity, and body weight, we hypothesized that SSS mediates, at least in part, the relationship between two objective measures of SES, income and education, and obesity. While previous research suggests that SSS mediates the relationship between SES and health outcomes, including self-rated health and depression (24), no prior research has, to our knowledge, tested whether SSS mediates the association between SES and obesity. Given research showing that the relationship between SSS and BMI differs by sex and race/ethnicity, with stronger associations among whites and females, we also tested whether the indirect effects of income and education through SSS differ by sex and race/ethnicity (16,25).

Methods

Data
Data came from the Coronary Artery Risk Development in Young Adults (CARDIA) study, an eight-wave longitudinal study beginning in 1985 to 1986 of 5,115 black and white adults aged 18 to 30 at baseline (1985-1986) (26,27). CARDIA is uniquely suited to questions of SES and health because the original sample was approximately balanced in the proportion of participants with and without a high school education (27). We included those examined in year 20 of the CARDIA study. Participants were excluded from the analysis if any condition that would significantly impact body weight/body composition was present: for example, if pregnant, currently taking diabetes medication, having a significantly reduced ability to exercise due to health impairment, reporting any previous cancer diagnosis, having had previous bariatric surgery, or identifying as transgender. After applying these exclusion criteria, the analytic sample consisted of 2,624 adults. Cases with missing data for BMI (n = 11), education (n = 13), income (n = 42), and SSS (n = 46) were retained and contributed to maximum likelihood estimates using full information maximum likelihood. Full information maximum likelihood assumes, as does multiple imputation, that data are missing at random (28).

Measures
Our primary outcome of interest was BMI. BMI was calculated from measured height and weight. SSS was the main predictor of interest. SSS was measured by using the MacArthur Scale of SSS (29), a 10-rung ladder representing a visual analog scale in which participants indicate where in the social hierarchy, from bottom to top, they perceive themselves to be. Participants were given the following instructions: “Think of this ladder as representing where people stand in the United States. At the top of the ladder are the people who are the best off, those who have the most money, the most education, and the most respected jobs. At the bottom are the people who are worst off, who have the least money, least education, and the least respected jobs or no job. The higher up you are on this ladder, the closer you are to the people at the very top and the lower you are, the closer you are to the people at the very bottom. Where would you place yourself on this ladder?”

We adjusted for education, income, race, age, and sex. Education was measured as years of education completed, indicated on a continuous scale from 1 to 20+. Income was measured on a nine-point ordinal scale, from combined household income of less than $5,000 up to $100,000+. Race was self-reported and dichotomously coded (black = 1), as was sex (female = 1). Age was measured in years.

Models tested
As described and justified in greater detail below, we tested two models: (1) a mediation model using all measures as predictors of BMI and paths from education and income to SSS and (2) a second mediation model that additionally included paths from sex to SSS (Figure 1).

Statistical analysis
We first calculated means, standard deviations (SD), and intercorrelations of all variables in the analysis. We evaluated a model, as per our hypothesis, (Model 1) in which SSS, sex, age, race, education and income were associated with BMI and in which the association between education and income with BMI would be at least partly mediated by SSS. A structural equation path analysis was performed to assess whether education and income had direct or indirect effects on BMI through SSS (30). Analyses were estimated by using PROC CALIS in SAS software, version 9.4 (SAS Institute Inc., Cary, North Carolina).
Carolina). Please see the Supporting Information for the SAS syntax used to estimate the second mediation model (Model 2). Significant indirect effects of education and income indicated that SSS partially mediates the effect between education, income, and BMI. We use the term “effect” to indicate hypothesized statistical effects, which are indicative of associations; we do not suggest that our model includes all necessary variables or that the study design could be used to estimate true causal effects.

We also tested whether the indirect effects of education and income differed by sex by estimating a multigroup path analysis and testing whether differences in the indirect effects were significantly different from zero by using bootstrap standard errors (SE) and bias-corrected confidence intervals from 1,000 samples (31). This is referred to as Model 2. Bootstrapped estimates were generated by using Stata/IC version 14.0.

Goodness-of-fit statistics were calculated for each estimated model. As discussed in the results below, we estimated the initial mediation model (Model 1), in which the only predictors of SSS were education and income. Based on modification indices, we estimated a second mediation model (Model 2) in which SSS was also predicted by sex. The model \( \chi^2 \) test statistic indicates whether a specified model is a good fit to the data, with small \( \chi^2 \) values indicating poor model fit (30). Given that large samples can generate \( \chi^2 \) values that may be prone to error, as well as other limitations (32), we have additionally reported the following goodness-of-fit indices: the comparative fit index (CFI), the standardized root mean square residual (SRMR), and the root mean square error of approximation (RMSEA). Values of CFI greater than 0.94 indicate a good fit between the data and model (33). Values of SRMR and RMSEA less than 0.055 indicate good model fit (34).

Results

Table 1 presents the descriptive statistics of the complete cases (\( N = 2,530 \)) in the analytic sample for our models. Mean age was 45.0 years, 54.3% of the analytic sample were female, and 48.7% were black, with a mean BMI of 28.9 kg/m\(^2\). The mean score on the SSS scale (which ranges from 1-10) in year 20 was 6.0. On average, respondents had 15 years of education and an income of 6.8 on a scale from 1 to 9 (6 corresponding to $50,000 through $74,999 and 7 corresponding to $75,000 through $99,999). Figure 1 presents the mediation model with direct effects of SSS on BMI and paths from education, income, and race to SSS (Model 2). Table 2 is the correlation matrix of the analytic sample with complete records, and Table 3 contains goodness-of-fit indices for both the initial (Model 1) and revised mediation model (Model 2).

Model 1 tests whether BMI is a function of several exogenous variables (education, income, sex, and race) and the endogenous variable SSS. All exogenous variables were allowed to covary with each other. Estimated path coefficients were significantly different from zero (\( \chi^2 = 12.31, df = 3, P = 0.0064 \)). Squared multiple correlation values indicated that the predictor variables were associated with...
6.2% of the variation in BMI and 20.0% of the variation in SSS. The CFI, SRMR, and RMSEA (90% CI: 0.05-0.08) all indicated good model fit with the data. Examination of Lagrange multipliers indicated that the model fit could be significantly improved by adding paths from sex to SSS. We thus estimated a revised mediation model (Model 2) with this additional path. A \( \chi^2 \) difference test confirmed that the addition of this path resulted in a significant improvement in model fit (\( \Delta \chi^2 \mid \Delta df, 1 \) = 11.8, \( P = 0.0006 \)). Goodness-of-fit statistics for the revised mediation model were within the range of good model fit (CFI = 1.000, SRMR = 0.0024, and RMSEA = < 0.0000).

Table 4 presents unstandardized estimates of hypothesized direct and indirect effects from the revised model from Model 2, and Figure 1 presents the path diagram, with labels for each path to aid interpretation of coefficients listed in Table 4. In Model 2, direct effects of sex (b = -0.190, \( P = 0.0006 \)) on SSS were significant, indicating that, on average, female sex is associated with lower SSS. SSS had a significant direct effect on BMI (b = 0.21, \( P = 0.0181 \)); thus, individuals who reported a higher SSS had, on average, a lower BMI, which consistent with our hypothesized model and previous reports (14-17).

Based on the improvement in fit and goodness-of-fit statistics, we use Model 2 to test whether SSS mediates the effect of income and education on BMI. Education had a small but significant indirect effect on BMI through SSS (b = -0.02, \( P = 0.0219 \)). Although income did not have a significant direct effect on BMI, it did have a significant indirect effect through SSS (b = -0.05, \( P = 0.0192 \)). The indirect effect of income on BMI comes from its large direct effect on SSS (b = 0.24, \( P < 0.0001 \)). The significant indirect effects of education and income with BMI indicate that SSS at least partially mediates the relationship between objective measures of SES and BMI. Finally, race had a significant direct effect on BMI (b = 2.92, \( P < 0.0001 \)), but age and sex did not have significant direct effects. There was no evidence that the indirect effects of income and education differed by sex in Model 2.

**Discussion**

Results from our path analysis are consistent with the hypothesis that SSS mediates the relationship between objective measures of

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**Table 2** Correlation matrix of variables used in analysis, CARDIA sample at year 20; \( N = 2,530 \) (complete cases)

| Measure | BMI   | SSS   | Education | Income | Female | Black | Age |
|---------|-------|-------|-----------|--------|--------|-------|-----|
| BMI     | 1     |       |           |        |        |       |     |
| SSS     | -0.10*| 1     |           |        |        |       |     |
| Education | -0.13*| 0.32* | 1         |        |        |       |     |
| Income  | -0.09*| 0.41* | 0.43*     | 1      |        |       |     |
| Female  | 0.04* | -0.09*| 0.02      | -0.10* | 1      |       |     |
| Black   | 0.24* | -0.18*| -0.34*    | -0.32* | 0.07* | 1     |     |
| Age     | -0.01 | 0.04* | 0.10*     | 0.06*  | -0.005| -0.16*| 1   |

*Bivariate correlation \( P < 0.05 \).

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**Table 3** Goodness-of-fit statistics for estimated models

| Model   | \( \chi^2 \) | df | \( \chi^2 \), \( P \) | \( \Delta \chi^2 \) | \( \Delta df \) | CFI   | SRMR  | RMSEA |
|---------|---------------|----|------------------------|-----------------|----------------|-------|-------|-------|
| Baseline | 1,848.14      | 21 | < 0.0001               |                 |                |       |       |       |
| Model 1  | 12.31         | 3  | 0.0064                 | 1,835.8         | 18             | 0.9949| 0.0118| 0.0344|
| Model 2  | 0.5368        | 2  | 0.7646                 | 11.8            | 1              | 1.000 | 0.0024| 0.0000|

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**Table 4** Path coefficients for Model 2

| Path                     | Coefficient (path label) | SE   | \( P \)     |
|--------------------------|--------------------------|------|------------|
| Direct effects           |                          |      |            |
| Education \( \rightarrow \) SSS | 0.11 (a)                 | 0.01 | < 0.0001   |
| Education \( \rightarrow \) BMI | -0.14 (b)                | 0.06 | 0.0142     |
| Income \( \rightarrow \) SSS | 0.24 (c)                 | 0.01 | < 0.0001   |
| Income \( \rightarrow \) BMI | 0.12 (d)                 | 0.07 | 0.0868     |
| Sex (female = 1) \( \rightarrow \) SSS | -0.19 (e)                | 0.06 | 0.0006     |
| Sex \( \rightarrow \) BMI | 0.38 (f)                 | 0.25 | 0.1302     |
| Race (black = 1) \( \rightarrow \) BMI | 2.92 (g)                 | 0.27 | < 0.0001   |
| Age \( \rightarrow \) BMI | 0.05 (h)                 | 0.03 | 0.1106     |
| SSS \( \rightarrow \) BMI | -0.21 (i)                | 0.09 | 0.0181     |
| Indirect effects         |                          |      |            |
| Education \( \rightarrow \) BMI | -0.02 (a \rightarrow i) | 0.01 | 0.0219     |
| Income \( \rightarrow \) BMI | -0.05 (c \rightarrow i) | 0.02 | 0.0192     |
| Sex \( \rightarrow \) BMI | 0.04 (e \rightarrow i)  | 0.02 | 0.0517     |
SES and BMI. This finding is similar to that within a previous report that SSS mediates the relationship between income and education and several other health outcomes (24). Not surprisingly, given that income and education are both important predictors of SSS (18,19,29), both had large direct associations with SSS in our model. In the mediation model, education, income, and sex had a significant association with BMI indirectly through its association with SSS. Our findings are consistent with a theoretical model in which the association between traditional measures of SES with BMI may be operating through its association with an individual’s perception of their social status.

As hypothesized, SSS had a small but significant direct association with BMI after adjusting for income and education. This suggests that perception may be involved in the associations of social factors and resources on body fatness. It has long been understood that a key regulator of the response to a given environment is determined by an organism’s perception of that environment (35). This fact may have important implications for the way the relationship between the environment and health is understood, and for the way it is addressed, and suggests that targeting perception of the environment, rather than the environment itself, may have some impact on health outcomes.

For example, calorie restriction increases the lifespan in many species, and some evidence from our work and the work of others suggests that an increased lifespan is driven by the perception of energetic resources in the environment (10). Exposing calorically restricted fruit flies to the smell of food, to generate the perception of food availability, reverses the association of caloric restriction on lifespan (36). Similarly, we demonstrated in an Alzheimer’s mouse model that inducing the sensation of hunger by using a ghrelin agonist in well-fed mice is sufficient to attenuate cognitive decline (37). If complex processes such as aging and longevity can be influenced by the perception of energetic resources, we argue that it is plausible that perception of social standing as it relates to resources as measured by SSS may influence body size and body fatness as well.

Several limitations need to be considered when interpreting our findings. First, these findings are observational associations and cannot establish causation. While we use the term “effect” to describe statistical estimates, we do so within the context of the estimated model, not to imply true causal effects. We also used techniques that are focused on the central part of the BMI distribution and that assume a linear relationship between SSS and BMI. Because the BMI distribution may have an elongated right tail in some samples, it is possible that this analysis does not capture the influence of SSS at this upper end of the distribution. Of the participants included in our analysis, 15.8% had a BMI > 35 kg/m². In addition, because energy expenditure through physical activity and energy intake are two major factors in energy balance, it is plausible that SSS could operate through its association with one or both of these variables. Future studies with more accurate and complete measures of these variables would be helpful to explore this possibility.

Another important caveat to consider is that although our findings are statistically significant, the explanatory power of SSS to predict BMI is small. Because adult BMI is likely influenced by a myriad of biological, environmental, and social factors, such small associations of one factor are frequently found and are not surprising. Thus, the significance of the potential degree of impact of SSS on BMI should not be overestimated and should be considered in the context of many interacting factors. This model should be tested in other data sets and via experimentation when possible.

Finally, it is important to consider that our findings may not be applicable to other populations. The dynamics between income and perception of social status may be different, for example, in countries at varying stages of economic development or varying levels of income disparity. Therefore, we can only draw conclusions about the association and mediating associations of SSS with BMI in this cohort from the United States in this timeframe of rapidly increasing BMI, and our findings may not be generalizable to other countries, populations, or time periods.

Future studies should attempt to replicate our findings in other longitudinal studies, determine the interactions of SSS with sex and race on BMI, and determine whether the relationship between SSS and BMI is causal. Although SSS is a perception that may not be easily subjected to manipulation and controlled trials (and may operate over long periods), there may be methods and interventions to increase SSS and determine the effect on eating behavior, physical activity, and body weight outcomes.

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