# The Influence of Body Weight on Social Network Ties among Adolescents

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## Abstract

Evidence of negative stereotypes, prejudice and discrimination towards obese individuals has been widely documented. However, the effect of a larger body size on social network ties or friendship formations is less well understood. In this paper, we explore the extent to which higher body weight results in social marginalization of adolescents. Using data from a nationally-representative sample of adolescents, we estimate endogeneity-corrected models including school-level fixed effects that account for bi-directionality and unobserved confounders to ascertain the effect of body weight on social network ties. We find that obese adolescents have fewer friends and are less socially integrated than their non-obese counterparts. We also find that such penalties in friendship networks are present among whites but not African-Americans or Hispanics, with the largest effect among white females. These results are robust to common environmental influences at the school-level and to controls for preferences, risk attitudes, low self-esteem and objective measures of physical attractiveness.



**JEL Classification**: I12, J10, Z13.

**Keyword**: Social Networks; Adolescents; Body Weight.

## 1. Introduction

Excess body weight among children and adolescents has been documented widely over the last two decades and is considered one of the most pressing public health concerns today (Cawley, 2010; Ogden et al., 2008). In addition to adverse health outcomes, the social consequences of obesity are also significant and affect adolescent well-being on multiple dimensions, independent of health outcomes (Strauss and Pollack, 2003). Evidence of negative stereotypes, prejudice and discrimination toward obese individuals in areas of employment, education, health care, the media, and interpersonal relationships has been well-documented in the literature (Averett and Korenman, 1996 and 1999; Cawley, 2004; Baum and Ford, 2004; Conley and Glauber, 2005; Morris, 2007; Mukhopadhyay, 2008; Puhl and Brownell, 2001). Adolescents are particularly susceptible to weight bias, which may significantly affect their emotional development (Puhl and Brownell, 2001).

A growing literature has documented the predominantly negative attitudes that are cast upon obese children (Puhl and Brownell, 2001). Compared to their non-obese counterparts, obese adolescents are more likely to be rated by their peers as being less intelligent, less attractive, meaner, lazier and less hygienic (Griffiths and Page, 2008). Obese adolescents also often report impaired social relationships, such as having fewer friends (Strauss and Pollack, 2003) and lack of intimacy and romantic relationships (Cawley et al., 2006; Heiland and Ali, 2010). In addition, many studies have found a higher prevalence of depressive symptoms and lower self-esteem among obese adolescents (Ali et al., 2010a; Puhl and Brownell, 2001). Female adolescents are especially susceptible to weight discrimination and are more likely to experience feelings of rejection and withdrawals due to body weight, compared to male adolescents (Strauss and Pollack, 2003). In addition, female adolescents are particularly preoccupied with body image, especially what physique 'others' consider as ideal and are thus more vulnerable to weight stigmatization on the basis of appearance (Kinsbourne, 2002; Turner, 2008).

Social networks, close relationships and perceived social support have all been linked to the healthy psychological development of adolescents (Kawachi and Berkman, 2001). Thus, friendship ties are an essential component for the social and emotional well-being of children and adolescents. Given the importance of peer interactions based on weight (Ali et al., 2010b), it is plausible that body weight status has significant implications for how well an adolescent is socially connected. Consistent with the evidence on the importance of social networks, Christakis and Fowler (2007) report evidence of a direct person-to-person spread of obesity in social networks. They find that the likelihood of becoming obese increases if a close friend became obese during the same period. Although it is difficult to infer causal relationships, evidence of a positive correlation between peer and individual weight outcomes has been reported for adolescents in a number of subsequent papers using complementary measures of weight status, peer group and using alternative data and study samples (Fowler and Christakis 2008; Renna et al. 2008; Trogdon et al., 2008; Halliday and Kwak 2009). In addition, Cohen-Cole and Fletcher (2008a) estimate models similar to Christakis and Fowler (2007), specifying BMI as a function of individuals' lagged BMI along with their peers' contemporaneous and lagged BMI. They find that the link between friends' BMI and own BMI becomes statistically insignificant after controlling for environmental factors using school-level fixed effects and caution that the associations suggested by similar models in Christakis and Fowler (2007) may not be evidence of a causal relationship. In a follow-up analysis, Cohen-Cole and Fletcher (2008b) report evidence of significant peer effects in implausible outcomes like ache, height and headache using a similar methodology utilized in Christakis and Fowler (2007) and caution against interpreting correlations in peer outcome as evidence of a causal link. In summary, the literature highlights the many challenges in identifying evidence of peer effects in obesity using observational data, despite a variety of sound empirical approaches.

Moreover, few studies have examined the social network ties of obese adolescents (Griffiths and Page, 2008; Strauss and Pollack, 2003) and how individual's own body weight impacts friendship ties and association with peers (Carr et al., 2008). In this respect, our study addresses a different and innovative research question and contributes to the emerging literature on importance of social networks by analyzing whether adolescents with higher body weight are more likely to be socially marginalized than their lower weight counterparts. Research on this topic has been limited by failing to control for confounding factors and selection of friends (Griffiths and Page, 2008; Strauss and Pollack, 2003; Carr et al., 2008), not fully separating the influence of environmental factors from the direct influence of body weight on social ties (Griffiths and Page, 2008; Carr et al., 2008), or using small samples that are not representative of the general population (Griffiths and Page, 2008; Carr et al., 2008).

Using data from a large nationally-representative sample of adolescents, we aim to explore the relationship between body size (measured by the adolescent's BMI percentile and obesity status) and social network ties to understand the extent of social isolation or marginalization that might be a result of larger body size. We extend previous work by estimating models of social networks that account for environmental confounding factors and the bi-directionality of the relationship between body size and social ties. In addition, our measure of social network ties is based on three indicators of social connectedness: Bonacich centrality (Bonacich, 1987), the number of friendship nominations received by the adolescent (in-degree measure) and the number of individuals nominated or identified by the adolescent as friends (out-degree measure).

We also examine differences in the effect of body size on social ties by race and gender. The literature suggests that the consequences of body weight status vary between African-American and white females, possibly reflecting cultural differences in ideal body size. More specifically, African-American females are less likely to perceive themselves as overweight than are females from other racial/ethnic groups and are more likely to identify a larger ideal body size than same-age white females (Burke and Heiland, 2008; Burke et al., 2010). To the extent that African-American female adolescents face weaker penalties as a consequence of higher body weight, we hypothesize a lower likelihood for them to be socially marginalized compared to females in other ethnic/racial groups (Hispanics and Whites). Also, given that males face weaker penalties due to their weight status than females, we expect males to experience less social isolation compared to their female counterparts. This study contributes to the literature on body weights and social network in three important respects: (i) we estimate weight-based social network penalties among adolescents using a large nationally-representative sample; (ii) we account for the endogeneity of the body weight measure and (iii) we compare these penalties across racial/ethnic groups and by gender.

## 2. Data and Methods

### 2.1 Data Source and Analysis Sample

The data for this study were drawn from the National Longitudinal Survey of Adolescent Health (henceforth "Add Health"). Add Health surveyed adolescents in 132 schools nationwide between grades 7 to 12. The in-school portion of the first wave of the survey (1994) contained a cross-section of about 90,000 adolescents. A subset of the initial sample (20,745 respondents in 1994) was also interviewed in their homes with a follow-up survey in 1996 (14,739 respondents). A unique feature of Add Health is that it contains detailed friendship network data. Add Health asked the respondents to nominate up to 5 close male friends and up to 5 close female friends and, since these friends were also surveyed, we were able to construct direct measures of the respondent's social ties in his/her peer networks. The average number of nominated friends per individual was 2.54 in the survey and approximately 85% of the friends were from the same school as the respondent. In addition, one parent (mostly mothers) for each adolescent was interviewed as part of the in-home parent survey in 1994. This parent survey was our primary source of the instruments for dealing with the problem of endogeneity of body weight measures. The sample for our analysis included all individuals who were interviewed in both waves of the survey with non-missing information on body weight[1] and other analysis variables

[1] 396 individuals had missing observations on body weights and were dropped from the analysis. In addition, there were 3,327 missing observations on family income, 51 on hours of TV viewing, 246 on drug use, and 39 on self-esteem (RSE) measure. These missing observations were replaced with the sample means and dummies indicating missing observations on these variables were included in the models below. After four additional observations with missing values on other covariates were dropped, the final analysis sample included 14,339 individuals.

(N = 14,339). Table 1 reports summary statistics for the outcome measure and all of the control variables used in our analysis.

[Insert Table 1 here]

**2.2. Measures**

*Outcome Variables*

Our outcome variables consisted of three measures of social connectedness. Our first measure was the number of friends that were nominated by the individual (out-degree measure). The second measure was the number of friendship nominations received by the individual (in-degree measure). The third measure was the Bonacich centrality score (Bonacich, 1987). The Bonacich centrality score captures the notion that centrality or popularity in social networks is not only a function of how many friends an individual has but also the number of friends one's friends have. In other words, Bonacich centrality score measures individual's centrality as a function of the centrality of those he/she is connected to. Thus, individuals who are connected to more central others would have higher Bonacich centrality score than those who are not. For example, suppose that individual *i* and *j* both have 5 close friends, but individual *i's* friends each have more friends compared to individual *j's* friends. In that case individual *i* would have a higher centrality score than individual *j;* i.e., individual *i* is more socially connected than individual *j*.

The Bonacich centrality score we used was based on the in-degree social network measure.[2] Since the measures based on in-degree rely on friendship nominations reported by others rather than those indentified by oneself (like out-degree), these measures should provide us with more objective and accurate indication of the social connectedness of the individual (Strauss and Pollack, 2003). Based on these definitions, a negative correlation between body weight and the Bonacich centrality score and in-degree measure would imply that obese adolescents are generally more likely to be socially marginalized; i.e., they are less likely to be nominated as friends and/or less likely to be connected to those who are well socially connected (have a lower Bonacich centrality score).

*Explanatory Variables*

The main explanatory variables of interest were BMI percentile (the respondent's percentile standing in the national BMI-for-age distribution) and whether the person is obese. Our measure 'obese' was calculated using the Center for Disease Control and Prevention (CDC) growth charts for 2000 and was based on the adolescent's BMI [$weight(kg)/height(m^2)$] relative to the national distribution and was age- and gender-specific. Adolescents who were at the $95^{th}$ percentile or above were classified as being obese.[3] Add Health contains interviewer- measured height and weight of the adolescents and thus our measure of body weight was not subject to self-reporting bias.

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[2] To compute Bonacich centrality score based on the in-degree, we replaced the adjacency matrix with its transpose in the formula for Bonacich centrality. We thank James Moody for this suggestion and for sharing his SPAN (SAS Programs for Analyzing Networks) module which was used to create this measure.

[3] We focus on this weight category because the social network penalty borne by obese adolescents is greater compared to other weight categories. As demonstrated in Appendix 1, the social penalty for being obese is about twice as high compared to being overweight. There is also a small social network penalty for being underweight (relative to normal weight).

Our control variables included demographic characteristics such as age, grade, whether the individual was the first child, whether he/she had any siblings and whether he/she was born in the United States. The parent survey of Add Health allowed us to control for a number of parental characteristics including whether the adolescent lived with biological parents, parental education and household income. Variables from the parent survey were also used to create measures of mother's obesity status, the individual's birth weight and whether the individual was breast fed (these variables were used as instruments; Section 2.3 further elaborates on this).

Besides these parental characteristics we also included an indicator of perceived interpersonal mistreatment as measured by the adolescent's self-report of whether people were unfriendly towards him or her. Previous literature had identified that an individual's perception of how others treat him/her has a significant influence on one's self-concept, which in turn influences social network ties (Carr et al., 2008). Other variables that potentially mediated the relationship between body size and friendship ties included substance abuse such as getting drunk in the past 12 months, using drugs in the last 30 days and being a smoker. We utilized data on cigarettes, drug and alcohol use in an attempt to proxy for otherwise unobserved heterogeneity in attitudes and personality (Renna et al., 2008).

We also included controls for whether the individual exercised at least three or more times during the past seven days, whether the individual played an active sport such as baseball, softball, soccer, swimming or football, hours of TV viewing and two measures of mental health. The first measure was an abridged Rosenberg Self-Esteem (RSE) Scale (Rosenberg, 1965). Add Health administered six of the ten questions typically used to measure the full RSE scale. For example, respondents were asked whether they felt "socially accepted", whether they had "a lot to be proud of" and whether they liked "themselves the way they are". Responses by the adolescents were: strongly agree (=5); agree (=4); neither agree nor disagree (=3); disagree (=2); or strongly disagree (=1). These responses were summed to produce a score of 6 to 30, with higher score indicating greater self-esteem (Sabia and Reese, 2008; Nelson and Gordon-Larsen, 2006; Shrier et al., 2001). Our second mental health indicator was based on the Center for Epidemiologic Studies Depression (CES-D) Scale (Radloff, 1977), which is a commonly-used measure of depressive symptoms.  Add Health administered 18 of the 20 items that typically comprise the CES-D Scale. Specifically, respondents were asked to indicate the frequency with which they had experienced certain feelings or emotions during the past week, such as how often they felt "life had been a failure," how often they felt "lonely," and how often they "talked less than usual." Possible responses were "rarely or none of the time" (=0); "some or a little of the time" (=1); "occasionally or a moderate amount of the time" (=2); and "most or all of the time" (=3). Responses to these 18 items were summed to produce a score ranging between 0 and 54. These measures of physical and mental health may capture important differences in individual characteristics, such as levels of self-esteem and personality type, which may be related to both friendship formation and body size.

Our final group of control variables included five dichotomous measures of the individual's physical attractiveness as reported by the interviewer. Add Health required the interviewers to describe the respondent as soon as possible after leaving the individual's home. In a unique set of questions, the interviewer was asked to grade the physical attractiveness and the personality of the respondent, providing us with more objective assessments of physical appearance and personality. Responses ranged from "very unattractive," "unattractive," "about average," "attractive" to "very attractive." We used the top two categories to construct indicators of an attractive personality and being physically attractive. The interviewer was also asked to comment on how well groomed the respondent was; we coded "well groomed" and "very well groomed" to indicate that the respondent appeared well groomed. Interviewer was also asked how candid the respondent was and we coded the respondent as being candid if the interviewer's response was very candid or moderately candid. In addition, the interviewer was asked how physically mature the respondent was compared with other adolescents of her age and the individual was coded as physically mature if the interviewer's response was "mature" or "very mature." Using such interviewer assessments allowed us to account for whether the influence of body size on social relationships was mediated by the physical attractiveness of the respondent.[4]

### 2.3 Methods

We estimated linear regression models of friendship network and body weight. In our model, the social connectedness of individual *i* in school *s*, interviewed by interviewer *k*, at time *t*, is given by

$$Y_{iskt} = \alpha + \beta_1 W_{iskt} + \beta_2 X_{iskt} + \beta_3 X_{iskt-1} + \beta_4 P_{iskt-1} + \beta_5 H_{ist} + \beta_6 A_{iskt} + \beta_7 \gamma_s + \beta_8 \delta_k + \varepsilon_{iskt} \quad (1)$$

[4] We also estimated all of the models without the mental health and physical attractiveness measures and discovered that omitting them made the coefficients on the weight status measures only slightly larger. This stability of the weight coefficients suggested that the effect of obesity was independent of the mental health and beauty measures.

where $Y_{iskt}$ and $W_{iskt}$ refer to measures of the adolescent's social network ties and weight status (BMI percentile or a binary indicator of being obese), respectively, measured in 1996 (i.e. $t$ = 1996). The vector of individual demographic characteristics measured in 1996 (W2) and 1994 (W1) and family characteristics measured in the parent survey in 1994 are denoted by $X_{iskt}$, $X_{iskt-1}$ and $P_{iskt-1}$, respectively. The vector $H_{iskt}$ captures the adolescents' health status using mental health indicators (the CES-D and RSE scale), whether the adolescent exercises regularly, whether the adolescent plays an active sport, hours of TV watched and indicators for substance abuse. $A_{iskt}$ denotes the attractiveness of the adolescent as rated by the Add Health interviewer $k$, $\gamma_s$ is a vector of school dummy variables that control for unobserved school type (school-level fixed effects), environmental confounders and school-wide network density and school size, $\delta_k$ is a vector of interviewer dummy variables that control for unobserved interviewer characteristics (interviewer fixed effects), and $\varepsilon_{iskt}$ is the error term. We seek to identify and measure the effect of weight status on individuals' formation of friendship ties or their position in the social network, $\beta_1$.

An estimate of the effect of $W_{iskt}$ on $Y_{iskt}$ from a simple ordinary least squares regression may be subject to bias from at least two sources. First, common unobserved environmental factors may lead to a spurious correlation between weight status and social ties. These could include such environmental factors as school size, region, economic or socio-cultural factors. For example, schools that are smaller in size or schools with few student organizations and clubs could reduce both the possibilities for social connections and the opportunities to expend energy. Unobserved environmental characteristics could also include confounding factors such as proximity to fast-food restaurants, availability of vending machines, other opportunities to expend energy (built environment, exercise facilities etc.), percentage of the population in poverty, and so on. These factors may be correlated with both $Y_{iskt}$ and $W_{iskt}$ and when unmeasured may lead to incorrectly attribute causal effects in individuals' social networks formation when none exist. Second, it is possible that the estimated effect of body size suffers from reverse causality or simultaneity bias. There is evidence that lack of social ties and social network participation are correlated with symptoms of depression (Kawachi and Berkman, 2001), which in turn can lead to poor weight outcomes (Mamun et al., 2009). If either of these problems is present, a fundamental assumption for consistency of least-squares estimation to give $\beta_1$ a causal interpretation will be violated. In this case, the error term, ε, will be correlated with both $Y_{iskt}$ and $W_{iskt}$ so that $E(\varepsilon_{iskt} \mid W_{iskt}) \neq 0$.

One advantage of using Add Health data is that we were able to control for environmental confounders at the school-level by introducing a vector of school binary indicator variables, $\gamma_s$. These school fixed effects would account for any common environmental characteristics at the school-level that may be correlated with both body weight and friendship formations. We were interested in controlling for such effects since it is likely that schools differ in the socioeconomic and demographic composition of their student body as well as in community-level characteristics and institutional features that are correlated with our variables of interest. For example, an adolescent who attends a school where poverty rates and violent crime are high, fast-food chains are abound, or public recreational facilities are scarce may be less likely to be socially connected and also have higher body weight.

To address the problem of simultaneity bias we pursue a complementary empirical strategy of utilizing instrumental variables. The instrumental variable estimator (IV) provides a consistent estimator under the assumption that the instruments (Z) are variables that are correlated with the endogenous variable, W, and that satisfy the condition E(ε|Z) = 0 (Newhouse and McCellan, 1998). It is possible to obtain the instrumental variable estimator through the two-stage least squares (2SLS) method, which is a method that obtains an exogenous predicted measure of weight status from a first stage regression and then inserts this measure into the social connectedness regression (stage 2). Our first stage regression estimates the following equation:

$$W_{iskt} = \eta + \alpha_1 Z_{iskt} + \beta_2 X_{iskt} + \beta_3 X_{iskt-1} + \beta_4 P_{iskt-1} + \beta_5 H_{iskt} + \beta_6 A_{iskt} + \beta_7 \gamma_s + \beta_8 \delta_k + \mu_{iskt} \quad (2)$$

The key to adopting the IV approach is having access to instruments (Z) that satisfy two properties: First, they affect (cause variation in) the variable whose impact we wish to ascertain; in our case the weight measure, $W_{iskt}$. Second, these instruments (Z) must have no direct effect on the outcome of interest ($Y_{iskt}$ in equation 1) so they must be independent of the omitted factors that drive that outcome. In other words, as long as Z is legitimately excludable from equation 1, this method can identify a causal relationship from weight status to social ties.

We follow the previous work (Ali et al., 2010b; Renna et al., 2008; Trogdon et al., 2008) and consider the following three variables as our candidate instruments: (i) the obesity status of the biological mother, (ii) the birth weight of the individual and (iii) whether the individual was breast fed. We hypothesize that these variables directly impact individual weight status but do not predict individual friendship formation. In particular, we assert that, for instance, while individuals who have obese parents are more likely to be obese themselves, the obesity status of the parent will only directly affect their weight status but not their social ties. This condition is violated if there are characteristics of the mother or other factors that affect their weight status while also directly influencing the friendship ties of the adolescent. It is unclear what such characteristics would be. For example, one might speculate that if low self-esteem and preferences for risk were unobserved and inter-generationally shared and were the determinants of both the social connectedness and weight status, then our instruments would be invalid. We include measures of low self esteem and risk preferences and a long array of other controls in our models to control for this and other potential sources of endogeneity. Combined with the school-level fixed effects, we expect our IV models to provide evidence suggestive of a causal effect of body size on individuals' social ties.

## 3. Results

*Social Network Map*

We begin our analysis by drawing social network maps for 2 of the 132 schools included in the analysis (Figure 1).[5] Each dot in the figure represents a respondent and the size of the dots and the number next to each dot represent the number of friendship nominations received. The black dots indicate obese adolescents and the white dots indicate adolescents who are non-obese. The two schools are similar in terms of the number of students that were selected from each to participate in the Add Health survey

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[5] These social network maps were created using the program PAJEK for large network analysis (available on the Internet at http://vlado.fmf.uni-lj.si/pub/networks/pajek) and James Moody's SPAN modules (Moody, 1999).

(approximately 80 students in each school). From the social network map we can observe two important patterns: (i) schools differ in the structure of the social networks of their students -- students from school A have less social ties than students from school B; (ii) obese adolescents received fewer friendship nominations and were less centrally located than their non-obese counterparts. The first observation is consistent with our expectation that school environment influences the structure of the social network. These observations suggest that obese adolescents are more likely to be socially marginalized and highlight the importance of controlling for unobserved school environmental factors.

[Insert Figure 1 here]

*Multivariate Analysis*

Table 2 presents OLS estimates (with robust standard errors) of the effect of body weight on social network ties for the entire sample. The first column presents the results for the Bonacich centrality score, the second column for the in-degree measure and the last column for the out-degree measure. Panel I of the table shows the results for obesity and Panel II shows the results for BMI percentile. It is important to note that our estimates include both school and interviewer fixed effects to account for unobserved school-level and interviewer heterogeneity.

Being obese is associated with a 0.082 decrease in the Bonacich centrality score and a 0.159 decrease in the in-degree measure. In other words, a 10% increase in the probability of being obese is associated with a 0.0082 decline in network centrality and having approximately 0.02 less friends compared to everyone else. The estimates also imply that obese individuals receive 30 percent fewer friendship nominations (the decline in the in-degree from the sample mean of 0.532 to 0.373). The obesity coefficient (0.159) in the OLS model explains 86% of the unadjusted difference in the in-degree between the non-obese and obese (0.136) in Table 1, suggesting that the direct obesity penalty is little affected by adjusting for the confounding factors. The results are similar when the linear BMI percentile measure is used. For example, a one percentile-point increase along the BMI-for-age distribution is associated with a 0.001 decline in network centrality score and in the in-degree measure. This result implies that moving from the middle of the weight distribution ($50^{th}$ percentile) to the obesity cutoff ($95^{th}$ percentile) is associated with 0.045 less friends, amounting to a nearly 8.5 percent drop in the mean number of friendship nominations (a reduction from 0.532 to 0.487). However, body weight appears to be uncorrelated with the out-degree measure[6]. This implies that the number of friends nominated or identified by the adolescent is independent of his or her weight status. Taken together, these estimates signify that one's position in their social network is correlated with body weight, with a higher body size being associated with larger penalties in terms of social ties.

We also find that individual-level characteristics such as playing an active sport and living in a two-parent household are positively correlated with social network ties. Being a smoker is negatively correlated with social connectedness, whereas alcohol consumption is positively correlated with it. Scoring high on the RSE scale is also positively associated with social ties, indicating that individuals with high self-esteem are

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[6] The out-degree measure is likely subject to more measurement error among the heavier individuals as they may overstate the number of their friends in order to reduce their cognitive dissonance. In addition, lower self esteem among the obese may make them count people as friends who really are not. This may explain why the relationship between weight and social networks is the weakest for the out-degree measure.

more socially connected. Interviewer assessment of attractiveness and personality exhibit the expected associations; adolescents who are rated as being physically attractive, having an attractive personality and being well groomed are more likely to exhibit a higher level of social connectedness. This finding is consistent with the literature (Hamermesh and Biddle, 1994; Mobius and Rosenblat, 2006; Carmalt et al., 2008; Cawley et al., 2006; Pearce et al. 2002; Mulford et al., 1998; Heiland and Ali, 2010) which found that having a physical appearance that is deemed attractive by others is a valuable asset in many situations of human interactions. In other words, nonmarket traits such as beauty enhance nonmarket productivity such as relationship formation (Heiland and Ali, 2010). Also consistent with the previous literature (Carr et al., 2008), perceived interpersonal mistreatment appears to be inversely correlated with network centrality.

[Insert Table 2 here]

Our OLS estimates cannot be interpreted to imply causation due to endogeneity of the relationship between weight status and social ties. Hence, to check whether the effect of body weight persists once we correct for endogeneity of the weight status, we estimate 2SLS models. The results are provided in Table 3. We find that body weight continues to play a significant role in social network ties, and the effect is larger than the OLS estimates. If individuals whose weight is most influenced by the instruments (maternal weight, breast feeding and birth weight) differ from their peers in terms of the social effect of body weight, then the 2SLS estimates will also reflect this difference. In this case the 2SLS estimates can be interpreted as local average treatment effects (LATE) (Imbens and Angrist 1994) with magnitudes being larger than the OLS estimates because individuals whose weight is most influenced by the instruments may exert greater influence on social network ties. LATE 2SLS estimates can also be interpreted as the average causal effect on the affected group (Angrist and Pischke 2009), where the affected group includes those whose weight status was changed by the instruments and excludes those whose weight was unaffected by the instruments.

The instruments are strongly correlated with body weight in the first stage; the F test for the instruments in the first stage is 70.3 ($p<0.001$) for the obesity model and 137.4 for the BMI percentile model. The F test also provides guidance as to whether the estimates are likely to be biased due to a weak instruments problem. We have also computed the Kleibergen-Paap (2006) rk statistic for the Stock and Yogo (2005) weak instruments test of the null hypothesis that the equation is weakly identified. "Weak identification" refers to the situation when the excluded instruments are only weakly correlated with the endogenous regressors. The values of the Kleibergen-Paap test statistics, which are equal to the first-stage F-statistic, indicated no weak instrument problem in the models reported in Table 3.[7] Our instruments also pass overidentification tests, which, under the usual assumptions, support their validity as variables excludable from the outcome equation. While the overidentification test should not be taken as conclusive evidence of the exogeneity of the instruments, it seems unlikely that there is any direct influence of individuals' birth weight, being breast fed and their parents' weight status on how well connected they are in their social network. Therefore, it is reasonable to argue that our instruments do not directly affect the adolescent's friendship formation independent of the indirect effect working through the weight status.

[7] These test statistics should be compared to the Stock-Yogo (2005) weak-instrument test critical values: 10% maximal IV size - 22.30, 15% maximal IV size - 12.83, 20% maximal IV size - 9.54, 25% maximal IV size - 7.80. Higher values of the test statistic mean that the weak instruments hypothesis is rejected with the more stringent criterion.

[Insert Table 3 here]

The rest of our analyses is performed using our preferred specification (2SLS with school and interviewer fixed effects), but after stratifying the sample by gender and race. Since the other covariates have similar estimates across all model specifications, we report the results for our main variables of interest only and focus the discussion on the adolescent's weight status. Since the out-degree measure appeared to be uncorrelated with body weight we omit reporting these results in the interest of brevity.

Separate analyses for males and females (Table 4) show that the effect of body weight on social network ties is nearly twice as large for females compared to males. Obese females have on average 0.885 less people nominating them as a friend, compared to non-obese females. This estimated obesity penalty is about four times larger than the raw difference in the number of friendship nominations between the non-obese and the obese females (0.550 and 0.351, respectively), suggesting that the individuals whose BMI is affected by the instruments also experience the biggest obesity penalty. The corresponding difference for males is smaller, 0.603. Bonacich centrality declines by almost 0.6 for obese females, much more when compared to a reduction of 0.3 for obese males. A similar pattern emerges from the analysis using the BMI percentile. The instruments perform well in most cases, as indicated by the overidentification and weak identification tests.

When we stratify the sample further by race, we notice that the effect of body size is only significant for non-Hispanic whites, with the effect once again being larger for females than for males. In addition, the coefficients for white males are only significant at the 10% level in most cases.[8] This implies that the penalty for extra weight in the friendship networks is largest for non-Hispanic white females.

[Insert Table 4 here]

## 4. Discussion and Conclusion

Using large nationally-representative samples of adolescents from Add Health, we investigate the effect of body size on social network ties. We find that being obese causes an adolescent to receive significantly fewer friendship nominations than their non-obese counterparts. Obesity also leads adolescents to be less central in their social network. In addition, our results indicate large differences by race/ethnicity and gender. Social marginalization due to body size appears to be most pronounced for non-Hispanic white females. We find smaller effects for non-Hispanic white males and no effect for either African-Americans or Hispanic adolescents (both females and males). These estimated relationships were robust to controlling for common environmental influences at the school-level and controls for preferences, risk attitudes, low self-esteem and objective measures of attractiveness.

The finding that body weight is predictive of social marginalization for non-Hispanic white females but not for other demographic subgroups is consistent with the emerging literature on race-specific penalties related to body weight (Burke and Heiland, 2008; Burke et al., 2010). This lends further support to the hypothesis that body size is an

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[8] As a robustness check we re-estimated the model using overweight or obese as the weight category (i.e., using individuals who are above the 85th percentile in the national BMI-for-age distribution). This result, as shown in Appendix Table 2, exhibits a similar race-gender specific penalty, but the magnitudes are smaller compared to the model with obesity. This further demonstrates that social marginalization is higher for those in the right tail of the weight distribution.

important attribute in the friendship market of white female adolescents, complementing other prized characteristics like fitness and health and broader measures of physical attractiveness. The lack of penalties for non-Hispanic black females that are above the range of BMI values considered normal by the CDC (for their age group) suggests that the range of body sizes deemed desirable in friendship markets may be wider for black females. This is consistent with evidence of greater weight tolerance and elevated body size norms among black women: black women have been found to be less likely than women in other racial/ethnic groups to perceive themselves as overweight, even after controlling for objective weight status and also to identify a larger ideal body size than same-age white women (Burke and Heiland, 2008; Burke et al., 2010). In addition, identity prescriptions within the black community generally cast women as selfless nurturers, an image that is associated with a larger body size (Hooks, 1981; Beauboeuf-LaFontant, 2003; and Lynch et al., 2007). Although this pattern of race-gender specific weight incentives/penalties has been documented before among females (Cawley, 2004; Averett and Korenman, 1996, 1999; Heiland and Ali, 2010; among others), it has not been studied as widely for males (Carr et al., 2008). Our study addresses this limitation by documenting evidence of a larger relationship penalty among white males compared to African-American males. This finding is consistent with the evidence that contemporary cultural images typically depict African-American males as athletes, gangsters, rappers – images often associated with large men (Rome, 2005). Among white males, by contrast, a larger physique is often portrayed as indicative of an incompetent, non-athletic man with a 'beer belly' (Hebl and Turchin, 2005).

As with any empirical strategy, our strategy is subject to criticism and thus it is prudent to regard our results as demonstrating a strong association between body weight and social network ties rather than demonstrating a casual relationship. If more evidence from future studies confirms our findings, the resulting body of literature may lead readers to infer causality. Our study only points in that direction provided that our assumptions hold. Another limitation of our study is that not all nominated friends were surveyed in the in-home portion of Add Health. To the extent that information on some of the friends is missing at random, this will introduce attenuation bias and thus the coefficients in this study provide conservative estimates of the effect of body size on friendship formations. In addition, the data do not allow us to assess the quality of the friendship. Future research should examine this and focus on the long run impact of weight-based social discrimination.

The patterns in social marginalization among obese adolescents that emerge from our analysis are important from a policy perspective, especially in light of the growing literature highlighting the role of social network ties or friendship in influencing economic status, educational attainment, mental health and general well being (Strauss and Pollack, 2003; Kawachi and Berkman, 2001; Holt-Lunstad et al., 2010). In addition to a policy focus on improving fitness and encouraging healthier food choices, our results suggest that adolescents with higher body weight might benefit from increased social activities with their school peers; activities such as participation in sports and fostering positive attitudes, including a sense of purpose and recognition of self-worth (emotions that are positively correlated with higher self-esteem) may facilitate greater integration in social networks.  School-based policies should also focus on the promotion of weight tolerance and reducing the stigma of obesity.

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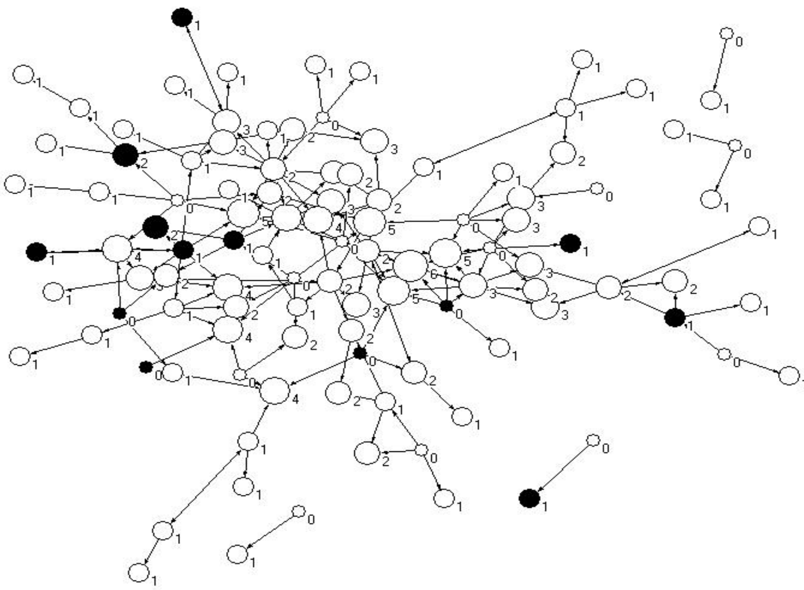
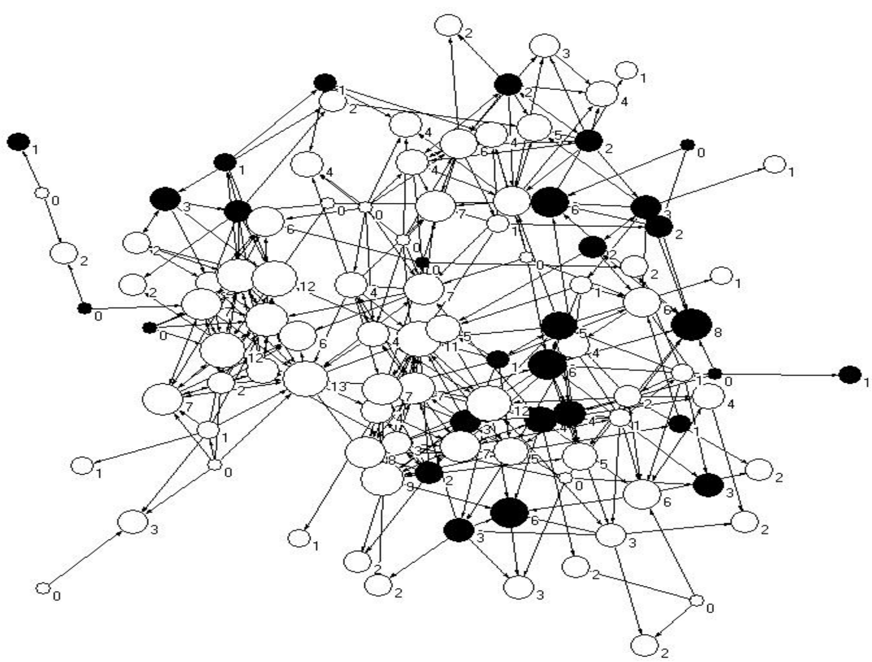
**Figure 1: Social Network Maps**

School A



School B



**Notes**: Drawing of a social network mapping for 2 of the 132 schools included in the analysis in W2 of Add Health. Each dot in the figure represents an Add Health respondent. Black dots indicate obese individuals and white dots indicate everyone else. The size of the dots and the number next to each dot represent the number of friendship nominations by others (in-degree).

**Table 1:** Descriptive statistics by weight status.

| Variable | Full sample | | Obese, W2 | | Non-obese, W2 | |
|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD |
| White | 0.626 | 0.484 | 0.583 | 0.493 | 0.632 | 0.482 |
| Black | 0.227 | 0.419 | 0.266 | 0.442 | 0.222 | 0.415 |
| Hispanic | 0.168 | 0.374 | 0.187 | 0.39 | 0.165 | 0.371 |
| Male | 0.489 | 0.5 | 0.537 | 0.499 | 0.483 | 0.5 |
| Age, W2 | 16.173 | 1.596 | 16.075 | 1.597 | 16.187 | 1.596 |
| Grade, W2 | 10.258 | 1.435 | 10.157 | 1.437 | 10.272 | 1.434 |
| Mother college | 0.26 | 0.438 | 0.22 | 0.414 | 0.265 | 0.441 |
| Father college | 0.219 | 0.414 | 0.151 | 0.358 | 0.229 | 0.42 |
| Log(pretax income) | 3.445 | 1.002 | 3.336 | 0.941 | 3.46 | 1.009 |
| Both biological parents | 0.52 | 0.5 | 0.513 | 0.5 | 0.521 | 0.5 |
| Born in US | 0.726 | 0.446 | 0.726 | 0.446 | 0.726 | 0.446 |
| First born | 0.493 | 0.5 | 0.498 | 0.5 | 0.493 | 0.5 |
| Has siblings | 0.808 | 0.394 | 0.799 | 0.401 | 0.81 | 0.393 |
| Chose school | 0.416 | 0.493 | 0.397 | 0.489 | 0.419 | 0.493 |
| Y.o. when moved | 8.4 | 5.58 | 7.947 | 5.692 | 8.465 | 5.561 |
| Hours of TV, W2 | 15.034 | 14.932 | 17.596 | 16.337 | 14.67 | 14.687 |
| Sports, W2 | 0.421 | 0.494 | 0.388 | 0.487 | 0.425 | 0.494 |
| Regular exercise, W2 | 0.51 | 0.5 | 0.475 | 0.5 | 0.515 | 0.5 |
| Smoking, W2 | 0.321 | 0.467 | 0.346 | 0.476 | 0.318 | 0.466 |
| Drinking, W2 | 0.436 | 0.496 | 0.412 | 0.492 | 0.439 | 0.496 |
| Drugs, W2 | 0.16 | 0.364 | 0.151 | 0.356 | 0.161 | 0.365 |
| CES-D score, W2 | 15.227 | 5.139 | 15.4 | 5.357 | 15.202 | 5.107 |
| RSE score, W2 | 25.066 | 3.519 | 24.788 | 3.616 | 25.106 | 3.504 |
| Physically attractive, W2 | 0.501 | 0.5 | 0.253 | 0.435 | 0.536 | 0.499 |
| Attractive personality, W2 | 0.506 | 0.5 | 0.408 | 0.492 | 0.52 | 0.5 |
| Well groomed, W2 | 0.427 | 0.495 | 0.278 | 0.448 | 0.448 | 0.497 |
| Candid, W2 | 0.866 | 0.34 | 0.853 | 0.354 | 0.868 | 0.338 |
| Mature, W2 | 0.42 | 0.494 | 0.466 | 0.499 | 0.414 | 0.493 |
| People unfriendly to you, W2 | 0.045 | 0.208 | 0.065 | 0.247 | 0.043 | 0.202 |
| Bonacich centrality, W2 | 0.275 | 0.615 | 0.196 | 0.443 | 0.286 | 0.635 |
| In-degree, W2 | 0.532 | 1.423 | 0.413 | 1.038 | 0.549 | 1.468 |
| Out-degree, W2 | 1.278 | 1.535 | 1.33 | 1.585 | 1.271 | 1.528 |
| BMI percentile, W2 | 58.583 | 29.856 | 97.668 | 1.366 | 53.043 | 27.753 |
| Obese, W2 | 0.124 | 0.33 | | | | |
| Mother obese | 0.142 | 0.349 | 0.292 | 0.455 | 0.12 | 0.326 |
| Birth weight | 6.789 | 1.279 | 6.966 | 1.324 | 6.764 | 1.27 |
| Breast fed | 0.388 | 0.487 | 0.349 | 0.477 | 0.394 | 0.489 |
| Dummy (Income missing) | 0.232 | 0.422 | 0.252 | 0.434 | 0.229 | 0.42 |
| Dummy (Hours of TV missing) | 0.004 | 0.06 | 0.004 | 0.067 | 0.003 | 0.058 |
| Dummy (Drugs missing) | 0.017 | 0.13 | 0.013 | 0.113 | 0.018 | 0.132 |
| Dummy (RSE missing) | 0.003 | 0.052 | 0.003 | 0.053 | 0.003 | 0.052 |
| N | 14339 | | 1780 | | 12559 | |

Note: Add Health W1 and W2 data. See text for the sample restrictions. Variables refer to W1 unless followed by "W2".

**Table 2:** OLS estimates of the effect of body weight status on various measures of social network ties.

| | Bonacich centrality, W2 | | In-degree, W2 | | Out-degree, W2 | | Bonacich centrality, W2 | | In-degree, W2 | | Out-degree, W2 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Coeff. | SE | Coeff. | SE | Coeff. | SE | Coeff. | SE | Coeff. | SE | Coeff. | SE |
| Obese, W2 | -0.082*** | (0.013) | -0.159*** | (0.026) | 0.024 | (0.033) | | | | | | |
| BMI percentile, W2 | | | | | | | -0.001*** | (0.000) | -0.001*** | (0.000) | 0.000 | (0.000) |
| White | -0.030* | (0.016) | -0.088*** | (0.030) | -0.064** | (0.030) | -0.029* | (0.016) | -0.088*** | (0.030) | -0.064** | (0.030) |
| Black | -0.066*** | (0.020) | -0.127*** | (0.035) | -0.161*** | (0.037) | -0.065*** | (0.020) | -0.123*** | (0.034) | -0.161*** | (0.037) |
| Hispanic | -0.012 | (0.018) | -0.028 | (0.038) | -0.053 | (0.036) | -0.011 | (0.018) | -0.025 | (0.037) | -0.053 | (0.036) |
| Male | -0.016 | (0.011) | -0.003 | (0.020) | -0.016 | (0.022) | -0.018 | (0.011) | -0.006 | (0.021) | -0.015 | (0.022) |
| Age, W2 | -0.038*** | (0.007) | -0.078*** | (0.012) | -0.141*** | (0.014) | -0.039*** | (0.007) | -0.079*** | (0.012) | -0.141*** | (0.014) |
| Grade, W2 | 0.035*** | (0.008) | 0.064*** | (0.014) | 0.113*** | (0.017) | 0.035*** | (0.008) | 0.064*** | (0.014) | 0.113*** | (0.017) |
| Mother college | 0.036*** | (0.014) | 0.054** | (0.026) | 0.064** | (0.025) | 0.035** | (0.014) | 0.052** | (0.026) | 0.065*** | (0.025) |
| Father college | -0.005 | (0.015) | -0.002 | (0.031) | 0.068** | (0.028) | -0.004 | (0.015) | -0.001 | (0.030) | 0.067** | (0.028) |
| Log(pretax income) | 0.005 | (0.006) | 0.006 | (0.008) | -0.005 | (0.010) | 0.005 | (0.006) | 0.006 | (0.008) | -0.005 | (0.010) |
| Both biological parents | 0.021* | (0.011) | 0.012 | (0.021) | 0.113*** | (0.023) | 0.021* | (0.011) | 0.012 | (0.021) | 0.113*** | (0.023) |
| Born in US | -0.033** | (0.016) | -0.073** | (0.033) | -0.024 | (0.028) | -0.033** | (0.015) | -0.072** | (0.032) | -0.024 | (0.028) |
| First born | -0.008 | (0.011) | -0.023 | (0.022) | 0.013 | (0.023) | -0.008 | (0.011) | -0.022 | (0.022) | 0.013 | (0.023) |
| Has siblings | 0.015 | (0.014) | 0.020 | (0.027) | 0.031 | (0.029) | 0.014 | (0.014) | 0.018 | (0.027) | 0.031 | (0.029) |
| Chose school | 0.006 | (0.011) | 0.029 | (0.022) | 0.023 | (0.022) | 0.006 | (0.011) | 0.028 | (0.022) | 0.023 | (0.022) |
| Y.o. when moved | -0.003** | (0.001) | -0.004 | (0.003) | -0.011*** | (0.002) | -0.002** | (0.001) | -0.004 | (0.003) | -0.011*** | (0.002) |
| Hours of TV, W2 | -0.000 | (0.000) | -0.002*** | (0.001) | -0.000 | (0.001) | -0.000 | (0.000) | -0.002*** | (0.001) | -0.000 | (0.001) |
| Sports, W2 | 0.034*** | (0.011) | 0.108*** | (0.022) | 0.084*** | (0.022) | 0.036*** | (0.011) | 0.112*** | (0.022) | 0.084*** | (0.022) |
| Regular exercise, W2 | -0.005 | (0.010) | -0.028 | (0.020) | 0.013 | (0.021) | -0.003 | (0.010) | -0.023 | (0.020) | 0.012 | (0.021) |
| Smoking, W2 | 0.006 | (0.012) | 0.035 | (0.023) | -0.093*** | (0.024) | 0.004 | (0.012) | 0.032 | (0.023) | -0.093*** | (0.024) |
| Drinking, W2 | 0.027** | (0.012) | 0.044 | (0.027) | 0.043* | (0.022) | 0.028** | (0.012) | 0.045* | (0.027) | 0.043* | (0.022) |
| Drugs, W2 | -0.004 | (0.015) | -0.031 | (0.028) | -0.043 | (0.030) | -0.002 | (0.015) | -0.028 | (0.028) | -0.044 | (0.030) |
| CES-D score, W2 | 0.002* | (0.001) | 0.003 | (0.003) | -0.001 | (0.002) | 0.002 | (0.001) | 0.003 | (0.003) | -0.001 | (0.002) |
| RSE score, W2 | 0.006*** | (0.001) | 0.010*** | (0.003) | 0.015*** | (0.003) | 0.006*** | (0.001) | 0.010*** | (0.003) | 0.015*** | (0.003) |
| Physically attractive, W2 | 0.029** | (0.013) | 0.055** | (0.025) | -0.017 | (0.026) | 0.036*** | (0.013) | 0.067*** | (0.025) | -0.019 | (0.026) |
| Attractive personality, W2 | 0.026** | (0.013) | 0.050** | (0.024) | 0.070*** | (0.025) | 0.025** | (0.013) | 0.047* | (0.024) | 0.071*** | (0.025) |
| Well groomed, W2 | 0.043*** | (0.014) | 0.089*** | (0.030) | 0.058** | (0.026) | 0.044*** | (0.014) | 0.090*** | (0.030) | 0.058** | (0.026) |
| Candid, W2 | 0.017 | (0.018) | 0.002 | (0.035) | 0.051 | (0.037) | 0.017 | (0.018) | 0.002 | (0.035) | 0.051 | (0.037) |
| Mature, W2 | -0.008 | (0.012) | -0.006 | (0.022) | -0.045* | (0.023) | -0.007 | (0.012) | -0.002 | (0.022) | -0.045* | (0.024) |
| People unfriendly to you, W2 | -0.051** | (0.022) | -0.065 | (0.042) | -0.158*** | (0.047) | -0.053** | (0.022) | -0.069 | (0.042) | -0.158*** | (0.047) |
| Dummy (Income missing) | -0.021* | (0.012) | -0.035 | (0.023) | -0.020 | (0.026) | -0.022* | (0.012) | -0.037 | (0.023) | -0.020 | (0.026) |
| Dummy (Hours of TV missing) | -0.082 | (0.060) | -0.062 | (0.116) | -0.164 | (0.140) | -0.080 | (0.061) | -0.058 | (0.117) | -0.165 | (0.140) |
| Dummy (Drugs missing) | -0.012 | (0.035) | -0.026 | (0.058) | -0.149** | (0.064) | -0.010 | (0.035) | -0.023 | (0.058) | -0.150** | (0.064) |
| Dummy (RSE missing) | -0.039 | (0.076) | -0.052 | (0.129) | -0.101 | (0.233) | -0.035 | (0.076) | -0.046 | (0.130) | -0.102 | (0.233) |
| Observations | 14339 | | 14339 | | 14339 | | 14339 | | 14339 | | 14339 | |
| R-squared | 0.156 | | 0.390 | | 0.471 | | 0.155 | | 0.390 | | 0.471 | |

Note: Add Health W1 and W2 data. See text for the sample restrictions. Robust standard errors in parentheses. Significance level: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

**Table 3:** IV estimates of the effect of body weight status on various measures of social network ties.

| | Bonacich centrality, W2 | | In-degree, W2 | | Out-degree, W2 | | Bonacich centrality, W2 | | In-degree, W2 | | Out-degree, W2 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Coeff. | SE | Coeff. | SE | Coeff. | SE | Coeff. | SE | Coeff. | SE | Coeff. | SE |
| Obese, W2 | -0.379*** | (0.095) | -0.671*** | (0.184) | -0.174 | (0.207) | | | | | | |
| BMI percentile, W2 | | | | | | | -0.004*** | (0.001) | -0.006*** | (0.002) | -0.001 | (0.002) |
| White | -0.030* | (0.016) | -0.089*** | (0.029) | -0.064** | (0.030) | -0.028* | (0.016) | -0.086*** | (0.029) | -0.063** | (0.030) |
| Black | -0.060*** | (0.020) | -0.117*** | (0.035) | -0.157*** | (0.037) | -0.046** | (0.020) | -0.093*** | (0.035) | -0.153*** | (0.038) |
| Hispanic | -0.007 | (0.018) | -0.018 | (0.037) | -0.050 | (0.035) | 0.003 | (0.018) | -0.002 | (0.036) | -0.047 | (0.036) |
| Male | -0.010 | (0.011) | 0.007 | (0.020) | -0.012 | (0.022) | -0.019* | (0.011) | -0.008 | (0.020) | -0.016 | (0.022) |
| Age, W2 | -0.042*** | (0.007) | -0.084*** | (0.012) | -0.144*** | (0.014) | -0.046*** | (0.007) | -0.090*** | (0.013) | -0.145*** | (0.014) |
| Grade, W2 | 0.035*** | (0.008) | 0.065*** | (0.014) | 0.113*** | (0.016) | 0.035*** | (0.008) | 0.065*** | (0.014) | 0.113*** | (0.016) |
| Mother college | 0.038*** | (0.014) | 0.058** | (0.026) | 0.066*** | (0.025) | 0.032** | (0.013) | 0.049* | (0.025) | 0.064*** | (0.025) |
| Father college | -0.012 | (0.015) | -0.014 | (0.030) | 0.063** | (0.028) | -0.012 | (0.015) | -0.013 | (0.030) | 0.064** | (0.028) |
| Log(pretax income) | 0.005 | (0.005) | 0.004 | (0.008) | -0.005 | (0.010) | 0.005 | (0.005) | 0.005 | (0.008) | -0.005 | (0.010) |
| Both biological parents | 0.025** | (0.011) | 0.019 | (0.021) | 0.116*** | (0.023) | 0.026** | (0.011) | 0.020 | (0.021) | 0.115*** | (0.023) |
| Born in US | -0.028* | (0.015) | -0.065** | (0.032) | -0.021 | (0.027) | -0.024 | (0.015) | -0.058* | (0.031) | -0.020 | (0.028) |
| First born | -0.008 | (0.011) | -0.022 | (0.022) | 0.014 | (0.023) | -0.005 | (0.011) | -0.018 | (0.022) | 0.014 | (0.023) |
| Has siblings | 0.015 | (0.014) | 0.020 | (0.026) | 0.030 | (0.029) | 0.008 | (0.014) | 0.008 | (0.027) | 0.028 | (0.029) |
| Chose school | 0.009 | (0.011) | 0.034 | (0.022) | 0.025 | (0.021) | 0.006 | (0.011) | 0.029 | (0.022) | 0.023 | (0.021) |
| Y.o. when moved | -0.004*** | (0.001) | -0.006** | (0.003) | -0.012*** | (0.002) | -0.003*** | (0.001) | -0.005** | (0.002) | -0.011*** | (0.002) |
| Hours of TV, W2 | -0.000 | (0.000) | -0.001** | (0.001) | 0.000 | (0.001) | -0.000 | (0.000) | -0.001*** | (0.001) | 0.000 | (0.001) |
| Sports, W2 | 0.030*** | (0.011) | 0.100*** | (0.021) | 0.082*** | (0.022) | 0.041*** | (0.011) | 0.119*** | (0.022) | 0.086*** | (0.022) |
| Regular exercise, W2 | -0.010 | (0.010) | -0.036* | (0.020) | 0.010 | (0.020) | 0.004 | (0.010) | -0.012 | (0.020) | 0.015 | (0.021) |
| Smoking, W2 | 0.011 | (0.012) | 0.045* | (0.023) | -0.089*** | (0.024) | 0.004 | (0.012) | 0.033 | (0.023) | -0.092*** | (0.024) |
| Drinking, W2 | 0.026** | (0.012) | 0.042 | (0.027) | 0.042* | (0.022) | 0.029** | (0.012) | 0.047* | (0.027) | 0.043** | (0.022) |
| Drugs, W2 | -0.011 | (0.015) | -0.042 | (0.028) | -0.048 | (0.030) | -0.004 | (0.015) | -0.030 | (0.028) | -0.045 | (0.030) |
| CES-D score, W2 | 0.002* | (0.001) | 0.003 | (0.003) | -0.001 | (0.002) | 0.002 | (0.001) | 0.003 | (0.003) | -0.001 | (0.002) |
| RSE score, W2 | 0.005*** | (0.001) | 0.009*** | (0.003) | 0.015*** | (0.003) | 0.005*** | (0.002) | 0.008*** | (0.003) | 0.015*** | (0.003) |
| Physically attractive, W2 | -0.013 | (0.019) | -0.017 | (0.036) | -0.045 | (0.039) | 0.007 | (0.016) | 0.022 | (0.031) | -0.032 | (0.032) |
| Attractive personality, W2 | 0.033** | (0.013) | 0.061** | (0.024) | 0.075*** | (0.025) | 0.028** | (0.013) | 0.052** | (0.024) | 0.072*** | (0.025) |
| Well groomed, W2 | 0.031** | (0.014) | 0.068** | (0.030) | 0.050* | (0.027) | 0.028* | (0.014) | 0.066** | (0.030) | 0.051* | (0.028) |
| Candid, W2 | 0.018 | (0.017) | 0.003 | (0.035) | 0.051 | (0.037) | 0.019 | (0.017) | 0.005 | (0.035) | 0.052 | (0.037) |
| Mature, W2 | 0.014 | (0.013) | 0.032 | (0.025) | -0.031 | (0.027) | 0.034** | (0.016) | 0.063** | (0.031) | -0.028 | (0.035) |
| People unfriendly to you, W2 | -0.038* | (0.022) | -0.044 | (0.043) | -0.150*** | (0.047) | -0.045** | (0.022) | -0.057 | (0.042) | -0.154*** | (0.047) |
| Dummy (Income missing) | -0.018 | (0.012) | -0.030 | (0.023) | -0.018 | (0.025) | -0.023* | (0.012) | -0.039* | (0.023) | -0.020 | (0.025) |
| Dummy (Hours of TV missing) | -0.085 | (0.060) | -0.067 | (0.117) | -0.167 | (0.139) | -0.075 | (0.062) | -0.050 | (0.119) | -0.163 | (0.138) |
| Dummy (Drugs missing) | -0.024 | (0.034) | -0.047 | (0.057) | -0.157** | (0.063) | -0.018 | (0.035) | -0.035 | (0.059) | -0.153** | (0.062) |
| Dummy (RSE missing) | -0.052 | (0.078) | -0.075 | (0.133) | -0.110 | (0.230) | -0.037 | (0.081) | -0.049 | (0.136) | -0.103 | (0.228) |
| Observations | 14339 | | 14339 | | 14339 | | 14339 | | 14339 | | 14339 | |
| R-squared | -0.005 | | 0.000 | | 0.035 | | -0.006 | | 0.003 | | 0.037 | |
| Overid test (p-value) | 0.194 | | 0.876 | | 0.262 | | 0.220 | | 0.468 | | 0.213 | |
| F-statistic (first stage) | 70.252 | | 70.252 | | 70.252 | | 137.385 | | 137.385 | | 137.385 | |
| IV F-test p-value | 0.000 | | 0.000 | | 0.000 | | 0.000 | | 0.000 | | 0.000 | |

Note: Add Health W1 and W2 data. See text for the sample restrictions. Robust standard errors in parentheses. Instruments for weight status include mother's obesity status, individual's birth weight and whether the individual was breast fed. Significance level: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

**Table 4:** IV estimates of the effect of body weight status on various measures of social network ties, by race and gender.

| | Females | | | | Males | | | |
|---|---|---|---|---|---|---|---|---|
| | Bonacich centrality | | In-degree | | Bonacich centrality | | In-degree | |
| | Coeff. | SE | Coeff. | SE | Coeff. | SE | Coeff. | SE |
| **Full sample** | | | | | | | | |
| Obese, W2 | -0.551*** | (0.157) | -0.885*** | (0.279) | -0.285** | (0.124) | -0.603** | (0.267) |
| Observations | 7321 | | 7321 | | 7018 | | 7018 | |
| Overid test (p-value) | 0.823 | | 0.332 | | 0.066 | | 0.541 | |
| F-statistic (first stage) | 29.353 | | 29.353 | | 38.670 | | 38.670 | |
| IV F-test p-value | 0.000 | | 0.000 | | 0.000 | | 0.000 | |
| | | | | | | | | |
| BMI percentile, W2 | -0.005*** | (0.001) | -0.007*** | (0.003) | -0.003** | (0.001) | -0.007** | (0.003) |
| Overid test (p-value) | 0.535 | | 0.093 | | 0.062 | | 0.533 | |
| F-statistic (first stage) | 64.980 | | 64.980 | | 59.545 | | 59.545 | |
| IV F-test p-value | 0.000 | | 0.000 | | 0.000 | | 0.000 | |
| | | | | | | | | |
| **Non-Hispanic Whites** | | | | | | | | |
| Obese, W2 | -0.698*** | (0.204) | -0.983** | (0.407) | -0.285** | (0.144) | -0.658* | (0.339) |
| Observations | 3984 | | 3984 | | 3838 | | 3838 | |
| Overid test (p-value) | 0.576 | | 0.975 | | 0.881 | | 0.999 | |
| F-statistic (first stage) | 18.304 | | 18.304 | | 26.535 | | 26.535 | |
| IV F-test p-value | 0.000 | | 0.000 | | 0.000 | | 0.000 | |
| | | | | | | | | |
| BMI percentile, W2 | -0.007*** | (0.002) | -0.009** | (0.004) | -0.003* | (0.002) | -0.007* | (0.004) |
| Overid test (p-value) | 0.825 | | 0.779 | | 0.833 | | 0.771 | |
| F-statistic (first stage) | 33.527 | | 33.527 | | 33.974 | | 33.974 | |
| IV F-test p-value | 0.000 | | 0.000 | | 0.000 | | 0.000 | |
| | | | | | | | | |
| **Non-Hispanic Blacks** | | | | | | | | |
| Obese, W2 | 0.062 | (0.233) | -0.248 | (0.285) | -0.126 | (0.319) | -0.212 | (0.617) |
| Observations | 1691 | | 1691 | | 1464 | | 1464 | |
| Overid test (p-value) | 0.612 | | 0.729 | | 0.004 | | 0.075 | |
| F-statistic (first stage) | 8.140 | | 8.140 | | 5.930 | | 5.930 | |
| IV F-test p-value | 0.000 | | 0.000 | | 0.001 | | 0.001 | |
| | | | | | | | | |
| BMI percentile, W2 | 0.002 | (0.003) | -0.002 | (0.004) | 0.002 | (0.003) | 0.002 | (0.007) |
| Overid test (p-value) | 0.686 | | 0.628 | | 0.005 | | 0.104 | |
| F-statistic (first stage) | 9.487 | | 9.487 | | 10.066 | | 10.066 | |
| IV F-test p-value | 0.000 | | 0.000 | | 0.000 | | 0.000 | |
| | | | | | | | | |
| **Hispanics** | | | | | | | | |
| Obese, W2 | -0.921 | (0.983) | -1.047 | (1.382) | 0.109 | (0.335) | 0.553 | (0.636) |
| Observations | 1204 | | 1204 | | 1200 | | 1200 | |
| Overid test (p-value) | 0.591 | | 0.188 | | 0.149 | | 0.484 | |
| F-statistic (first stage) | 1.081 | | 1.081 | | 3.191 | | 3.191 | |
| IV F-test p-value | 0.356 | | 0.356 | | 0.023 | | 0.023 | |
| | | | | | | | | |
| BMI percentile, W2 | -0.003 | (0.003) | -0.003 | (0.005) | 0.001 | (0.003) | 0.007 | (0.006) |

| | | | | |
|---|---|---|---|---|
| Overid test (p-value) | 0.488 | 0.130 | 0.146 | 0.588 |
| F-statistic (first stage) | 9.774 | 9.774 | 7.209 | 7.209 |
| IV F-test p-value | 0.000 | 0.000 | 0.000 | 0.000 |

Note: Add Health W1 and W2 data. See text for the sample restrictions. Robust standard errors in parentheses. Instruments for weight status include mother's obesity status, individual's birth weight and whether the individual was breast fed. Significance level: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Appendix Table 1: OLS estimates of the effect of body weight status (by category) on various measures of social network ties.

| | Bonacich centrality, W2 | | In-degree, W2 | | Out-degree, W2 | |
|---|---|---|---|---|---|---|
| | Coeff. | SE | Coeff. | SE | Coeff. | SE |
| Obese, W2 | -0.090*** | (0.013) | -0.178*** | (0.027) | 0.021 | (0.034) |
| Overweight, W2 | -0.037*** | (0.014) | -0.077*** | (0.024) | -0.014 | (0.029) |
| Underweight, W2 | -0.018 | (0.023) | -0.082** | (0.040) | -0.005 | (0.049) |
| White | -0.030* | (0.016) | -0.089*** | (0.030) | -0.064** | (0.030) |
| Black | -0.066*** | (0.020) | -0.128*** | (0.035) | -0.161*** | (0.037) |
| Hispanic | -0.012 | (0.018) | -0.027 | (0.038) | -0.053 | (0.036) |
| Male | -0.016 | (0.011) | -0.003 | (0.021) | -0.016 | (0.022) |
| Age, W2 | -0.039*** | (0.007) | -0.078*** | (0.012) | -0.142*** | (0.014) |
| Grade, W2 | 0.035*** | (0.008) | 0.064*** | (0.014) | 0.113*** | (0.017) |
| Mother college | 0.035*** | (0.014) | 0.053** | (0.026) | 0.064** | (0.025) |
| Father college | -0.005 | (0.015) | -0.002 | (0.031) | 0.067** | (0.028) |
| Log(pretax income) | 0.005 | (0.006) | 0.006 | (0.008) | -0.005 | (0.010) |
| Both biological parents | 0.021* | (0.011) | 0.013 | (0.021) | 0.113*** | (0.023) |
| Born in US | -0.033** | (0.016) | -0.071** | (0.032) | -0.024 | (0.028) |
| First born | -0.008 | (0.011) | -0.022 | (0.022) | 0.014 | (0.023) |
| Has siblings | 0.014 | (0.014) | 0.019 | (0.027) | 0.030 | (0.029) |
| Chose school | 0.006 | (0.011) | 0.029 | (0.022) | 0.023 | (0.022) |
| Y.o. when moved | -0.003** | (0.001) | -0.004* | (0.003) | -0.011*** | (0.002) |
| Hours of TV, W2 | -0.000 | (0.000) | -0.002*** | (0.001) | -0.000 | (0.001) |
| Sports, W2 | 0.034*** | (0.011) | 0.106*** | (0.022) | 0.084*** | (0.022) |
| Regular exercise, W2 | -0.005 | (0.010) | -0.028 | (0.020) | 0.013 | (0.021) |
| Smoking, W2 | 0.006 | (0.012) | 0.035 | (0.023) | -0.093*** | (0.024) |
| Drinking, W2 | 0.027** | (0.012) | 0.044 | (0.027) | 0.043* | (0.022) |
| Drugs, W2 | -0.004 | (0.015) | -0.031 | (0.028) | -0.044 | (0.030) |
| CES-D score, W2 | 0.002 | (0.001) | 0.003 | (0.003) | -0.001 | (0.002) |
| RSE score, W2 | 0.006*** | (0.001) | 0.010*** | (0.003) | 0.015*** | (0.003) |
| Physically attractive, W2 | 0.027** | (0.013) | 0.050** | (0.025) | -0.018 | (0.026) |
| Attractive personality, W2 | 0.026** | (0.013) | 0.047* | (0.024) | 0.070*** | (0.025) |
| Well groomed, W2 | 0.042*** | (0.014) | 0.086*** | (0.030) | 0.058** | (0.026) |
| Candid, W2 | 0.017 | (0.018) | 0.002 | (0.035) | 0.051 | (0.037) |
| Mature, W2 | -0.006 | (0.012) | -0.001 | (0.022) | -0.044* | (0.023) |
| People unfriendly to you, W2 | -0.051** | (0.022) | -0.066 | (0.042) | -0.158*** | (0.047) |
| Dummy (Income missing) | -0.022* | (0.012) | -0.035 | (0.023) | -0.020 | (0.026) |
| Dummy (Hours of TV missing) | -0.083 | (0.060) | -0.063 | (0.115) | -0.165 | (0.140) |
| Dummy (Drugs missing) | -0.013 | (0.035) | -0.029 | (0.058) | -0.150** | (0.064) |
| Dummy (RSE missing) | -0.037 | (0.076) | -0.048 | (0.129) | -0.101 | (0.233) |
| Observations | 14339 | | 14339 | | 14339 | |
| R-squared | 0.156 | | 0.391 | | 0.471 | |

Note: Add Health W1 and W2 data. See text for the sample restrictions. Robust standard errors in parentheses. Significance level: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

**Appendix Table 2:** IV estimates of the effect of being overweight or obese on various measures of social network ties, by race and gender.

| | Females | | | | Males | | | |
|---|---|---|---|---|---|---|---|---|
| | Bonacich centrality | | In-degree | | Bonacich centrality | | In-degree | |
| | Coeff. | SE | Coeff. | SE | Coeff. | SE | Coeff. | SE |
| **Full sample** | | | | | | | | |
| Overweight or Obese, W2 | -0.387*** | (0.109) | -0.620*** | (0.196) | -0.204** | (0.103) | -0.467** | (0.225) |
| Observations | 7321 | | 7321 | | 7018 | | 7018 | |
| R-squared | -0.014 | | -0.000 | | 0.007 | | 0.002 | |
| Overid test (p-value) | 0.742 | | 0.297 | | 0.035 | | 0.400 | |
| F-statistic (first stage) | 39.113 | | 39.113 | | 42.094 | | 42.094 | |
| IV F-test p-value | 0.000 | | 0.000 | | 0.000 | | 0.000 | |
| | | | | | | | | |
| **Non-Hispanic Whites** | | | | | | | | |
| Overweight or Obese, W2 | -0.555*** | (0.158) | -0.744** | (0.316) | -0.218** | (0.110) | -0.506* | (0.259) |
| Observations | 3984 | | 3984 | | 3838 | | 3838 | |
| R-squared | -0.049 | | 0.011 | | 0.010 | | 0.013 | |
| Overid test (p-value) | 0.774 | | 0.859 | | 0.859 | | 0.996 | |
| F-statistic (first stage) | 19.920 | | 19.920 | | 32.662 | | 32.662 | |
| IV F-test p-value | 0.000 | | 0.000 | | 0.000 | | 0.000 | |
| | | | | | | | | |
| **Non-Hispanic Blacks** | | | | | | | | |
| Overweight or Obese, W2 | 0.038 | (0.225) | -0.258 | (0.275) | 0.098 | (0.281) | 0.064 | (0.541) |
| Observations | 1691 | | 1691 | | 1464 | | 1464 | |
| R-squared | 0.030 | | 0.008 | | 0.027 | | 0.031 | |
| Overid test (p-value) | 0.601 | | 0.768 | | 0.004 | | 0.088 | |
| F-statistic (first stage) | 6.537 | | 6.537 | | 5.316 | | 5.316 | |
| IV F-test p-value | 0.000 | | 0.000 | | 0.001 | | 0.001 | |
| | | | | | | | | |
| **Hispanics** | | | | | | | | |
| Overweight or Obese, W2 | -0.298 | (0.290) | -0.473 | (0.441) | 0.120 | (0.292) | 0.624 | (0.559) |
| Observations | 1204 | | 1204 | | 1200 | | 1200 | |
| R-squared | 0.026 | | 0.032 | | 0.038 | | -0.091 | |
| Overid test (p-value) | 0.521 | | 0.203 | | 0.150 | | 0.606 | |
| F-statistic (first stage) | 4.943 | | 4.943 | | 3.027 | | 3.027 | |
| IV F-test p-value | 0.002 | | 0.002 | | 0.029 | | 0.029 | |

Note: Add Health W1 and W2 data. See text for the sample restrictions. Robust standard errors in parentheses. Instruments for weight status include mother's obesity status, individual's birth weight and whether the individual was breast fed. Significance level: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.