Socioeconomic Status, Race, and Body Mass Index: The Mediating Role of Physical Activity and Sedentary Behaviors during Adolescence

Margaret D. Hanson, MA and Edith Chen, PhD

Department of Psychology, University of British Columbia

Objective To assess how sociodemographic and activity behaviors contribute to adolescent body mass index (BMI). **Methods** One hundred and thirteen adolescents ($M = 17$ years; 42% Caucasian, 56% African American) were assessed on BMI. Teens reported activity levels and caregivers reported socioeconomic status (SES). **Results** Adolescents from lower SES backgrounds, and from minority groups, had higher BMI ($r = -.26$, $p < .01$ and $t(110) = -3.01$, $p < .01$). Formal statistical mediation tests revealed that sedentary behaviors significantly mediated the association between SES and BMI ($Z = 2.31$, $p < .05$), whereas physical activity significantly mediated the race–BMI association ($Z = 2.32$, $p < .05$). **Conclusions** Interventions targeting teen BMI could benefit by aiming to decrease sedentary behavior in low SES teens and increase physical activity in teens from minority groups.

Key words   adolescence; BMI; physical activity; sedentary behaviors; sociodemographics.

Obesity rates are rising in all states, races, age groups, and for both men and women. In 2000, over 15% of children in the United States between the ages of 6 and 19 were overweight, and the largest rate increases have been observed in older adolescents and young adults (Freedman, Srinivasan, Valdez, Williamson, & Berenson, 1997; Mokdad, Serdula, Dietz, Marks, & Koplan, 1999). Despite the increasing public awareness of the detrimental health effects of being overweight, the number of obese adolescents has tripled since 1980 (Puska, Nishida, & Porter, 2003). Given the costs of obesity, research on the factors contributing to weight gain is critical in order to both identify those at greatest risk and develop interventions to curb obesity earlier in life.

In this study, we will first consider two sociodemographic factors: socioeconomic status (SES) and race, and their relation to obesity. Second, we will examine possible mediating pathways between sociodemographic factors and overweight during adolescence. SES is frequently studied in relation to obesity. Researchers have found that, in adults, low SES is consistently related to higher body mass index (BMI) in adult women (Garn, Bailey, Cole, & Higgins, 1977; Jeffery & French, 1996;

Matthews, Kelsey, Meilahn, Kuller, & Wing, 1989; Millar & Wigle, 1986; Oken, Hartz, Giefer, & Rimm, 1977; Rimm & Rimm, 1974; Sobal & Stunkard, 1989; Wardle et al., 2004) and somewhat consistently related to higher BMI in adult men (Garn et al., 1977; Millar & Wigle, 1986). In children, the relationship between SES and BMI is less clear (da Veiga, da Cunha, & Sichieri, 2004; Garn, Hopkins, & Ryan, 1981; Hernandez et al., 1999). Some studies report that family SES is inversely associated with child adiposity (Bergstrom, Hernell, & Persson, 1996; Boulton, Cockington, Hamilton-Craig, Magarey, & Mazumdar, 1995; Friedstad, Pirkis, Biehl, & Irwin, 2003; Gliksman, Dwyer, & Wlodarczyk, 1990; Zuckerman et al., 1989), whereas others have reported that SES is not associated with childhood overweight but may impact rates later on in adolescence (Jones, Nesheim, & Habicht, 1985; Leino et al., 1996; Parsons, Power, Logan, & Summerbell, 1999; Power, Manor, & Matthews, 2003). Adolescence, therefore, may be a "critical period" for the heightened risk of overweight (Dietz, 1994).

Race is another demographic characteristic associated with overweight. Black children (Crawford, Story,

Wang, Ritchie, & Sabry, 2001; Gidding, Bao, Srinivasan, & Berenson, 1995; Goodman, McEwen, Huang, Dolan, & Adler, 2005; Walter & Hofman, 1987) and adults (Flegal, Carroll, Ogden, & Johnson, 2002; Kumanyika, 1987; Lavie, Kuruvanka, Milani, Prasad, & Ventura, 2004; Mokdad et al., 1999; Okosun, Tedders, Choi, & Dever, 2000; Winkleby, Kraemer, Ahn, & Varady, 1998) often display higher BMI than other races. Black females may be particularly at risk of becoming overweight (Crawford et al., 2001; Diez-Roux, Nieto, Tyroler, Crum, & Szkla, 1995) and show the largest rate increases in recent years (Morrison, James, Sprecher, Khoury, & Daniels, 1999). Obesity rates have also increased in other minority groups (Mokdad et al., 2005; WHO Expert Consultation, 2004). Our first aim in the present study is to test relationships of SES and race separately with BMI in adolescents. Although SES and race overlap with one another, some researchers have argued that race is not just a confounding variable in SES relationships (and vice versa) (Kaufman, Cooper, & McGee, 1997; Williams, 1999) and thus that controlling for one variable in tests with the other can take away from the meaning of such analyses.

There are many potential pathways through which sociodemographic variables may impact overweight in youth. One important pathway may be physical activity. Previous research has shown associations between low SES and low physical activity (Bradley, McMurray, Harrell, & Deng, 2000; Gordon-Larsen, McMurray, & Popkin, 2000; Millar & Wigle, 1986; Pate & et al., 1995; Sallis, Zakarian, Hovell, & Hofstetter, 1996; Tunistra, Groothoff, Van Den Heuvel, & Post, 1998; Zakarian, Hovell, Hofstetter, Sallis, & Keating, 1994). Reasons for inadequate activity levels in youth may include poor neighborhood safety (Burdette & Whitaker, 2004; Molnar, Gortmaker, Bull, & Buka, 2004), the lack of school supervision and physical activity equipment (Sallis et al., 2001), and low enrollment in organized sports (Cauley, Donfield, LaPorte, & Warhaftig, 1991; Duncan, Duncan, Strycker, & Chaumeton, 2002; Sallis et al., 1996; Tunistra et al., 1998). These factors may help explain low levels of physical activity in youth from lower SES backgrounds.

Racial differences in physical activity have also been reported in past research (Bradley et al., 2000; Lowry, Kahn, Collins, & Kolbe, 2003; Pate et al., 1995; Sallis, Prochaska, & Taylor, 2000; Winkleby et al., 1998). Differences may be especially large for females. For example, in a study by Lowry et al. (2003), White females report more activity in a 7-day physical activity recall than Black females, and a greater proportion of Black

females reported no daily physical activity than White females (Bungum, Pate, Dowda, & Vincent, 1999). Differences in activity patterns between Black and White males are not as consistent (Pate, Heath, Dowda, & Trost, 1996).

In addition to physical activity, sedentary behaviors may play an important role in the association between sociodemographic factors and overweight in adolescence. Traditionally, individuals who are less physically active are considered more sedentary, and vice versa. However, it is possible that these two types of behaviors reflect dimensions of energy expenditure that are separate. For example, it is possible for adolescents to engage in high levels of physical activity (e.g., swimming regularly) while also spending large amounts of time being sedentary (e.g., playing video games or watching television many hours a day). In support of this notion, previous research has documented weak or null associations between physical activity and sedentary behaviors (Brodersen, Steptoe, Williamson, & Wardle, 2005; Robinson et al., 1993; Sallis et al., 1993). In adults, physical activity did not significantly explain the association between SES and weight (Ball & Crawford, 2005; Jeffery & French, 1996), and Wardle and colleagues suggested that this may be because other types of behaviors, such as sedentary behaviors (e.g., television viewing), are important in predicting overweight (Wardle et al., 2004).

The goal of this research is to better understand the mechanisms through which sociodemographic variables come to be associated with BMI in adolescents. The first aim of this study is to test the associations between SES/race and BMI. We hypothesize that low SES and minority teens will have higher BMI than high SES and White teens. Our second aim is to test (1) whether physical activity/sedentary behaviors are associated with SES/race and (2) whether they mediate the associations between SES/race and BMI. On the basis of our previous findings, we hypothesize that low SES and minority teens will be less physically active and more sedentary than high SES or White teens and that these behaviors will partially explain the associations between SES/race and BMI.

Methods
Participants

One hundred thirteen participants from a public high school in the St. Louis, Missouri area were recruited via flyers and school announcements. Ages of participants ranged from 16 to 19 years, with an average age of 16.85 years. The student body was racially diverse, consisting

of about 25% Black and a range of socioeconomic groups. The Washington University IRB approved the study protocol, and parents and adolescents signed consent/assent forms. The final sample of adolescents was 61% female, and 42% Caucasian, 56% Black, and 2% other. We sought a high participation rate from minority students by explicitly encouraging participation from these groups in announcements and flyers. These students were part of a larger study on psychophysiological consequences of acute stressors. Only students who were medically healthy and not taking medications that would influence the cardiovascular system were included in the study. One family declined to provide SES information and was therefore excluded from participation.

Given the small percentage of "other" participants ($n = 3$), Black and "Other" students were combined into one group representing minorities in the sample. For simplicity, this group will be referred to as "minority."

Procedures

Adolescents and a parent came to the lab and signed consent/assent forms. Adolescents were weighed and measured by the experimenter. The experimenter then left the room and the adolescent completed pen-and-paper questionnaires pertaining to their physical activity and sedentary behaviors. In a separate room, parents completed a survey on their family income and family savings, as well as the education and occupational status of the parent(s).

Measures

SES

SES scores were based on yearly family income and family assets (i.e., stocks, bonds, and savings accounts), as well as parents' educational and occupational status. Hollingshead's Four Factor Index of Social Status (Hollingshead, 1975) was used to code parents' occupation and education. A total SES score was computed by standardizing and summing family income, assets, and parental occupation and education. Higher scores indicated higher total SES.

BMI

Using a physician's balance beam scale and standard height rod to measure height and weight (Model 402S, Precision Weighing Balances, 2004), BMI was computed for each adolescent (BMI = kg/m^2). For children and adolescents, the National Center for Health Statistics presents BMI by age and sex, using Z-scores. These age- and sex-adjusted Z-scores were used as the dependent variable in this study.

Questions on physical activity and sedentary behaviors were drawn from a larger measure used in a national cohort study of child health, administered via questionnaire. In a previous research, this measure was significantly related to physical fitness, defined by mile-run completion times ($\rho = -.37$) (Aaron et al., 1993), and demonstrated acceptable test–retest reliability ($r = .55$). In this study, we chose to analyze physical activity and sedentary behavior items separately, because of mounting evidence that these behaviors may be different dimensions of energy expenditure, rather than two ends of the same continuum.

Physical Activity

Physical activity scores were determined by the number of times in the past 14 days on which adolescents engaged in 20 min of hard physical activity (e.g., playing basketball, and jogging) and 20 min of light physical activity (e.g., playing baseball and walking) (Aaron et al., 1993). These items assessed adolescents' leisure-time physical activity. The two items were standardized and summed to form a total physical activity variable, which demonstrated good internal consistency ($\alpha = .74$).

Sedentary Behavior

Teens' sedentary behavior scores were based on the number of hours they spend watching television or playing video games per day (Aaron et al., 1993).

Analysis Plan

Our analytic approach tested whether associations in our sample were consistent with a mediational explanation in which lower SES students as well as students from minority groups were more likely to engage in sedentary behaviors and lower levels of physical activity, and in turn have higher BMI. In our analyses, we transformed raw BMI values to Z-scores using the formula provided by the Centers for Disease Control (Kuczmarski et al., 2002). This was done because the meaning of BMI varies depending on a child's age and gender, and thus the Z-score represents age- and gender-normed values. Z-scores were used for all analyses below. We then tested, using independent samples' t tests, whether gender and race differences existed across activity variables and BMI. We tested, using bivariate correlations, whether SES or age was linearly associated with activity variables and BMI. Correlations were used because SES and age represent continuous variables, whereas gender and race were categorical variables.

More specifically, our first set of analyses tested our hypothesis that sociodemographic variables would be associated with BMI. Thus we tested whether SES and race were significantly associated with BMI.

Second, we tested whether sociodemographic variables were associated with our proposed mediators. Thus we tested whether SES or race were associated with the activity variables. Because physical activity levels have been found to vary by gender, we included gender in these regression equations; thus SES, gender, and the SES by gender interaction were included as predictors of activity variables (and parallel analyses were conducted for race). Centering procedures were used for interaction analyses, in accordance with recommendations by Aiken and West (West, Aiken, & Krull, 1996).

Finally, we tested whether physical activity/sedentary behaviors mediated the relation between SES/race and BMI by conducting formal tests of statistical mediation. For these analyses, we used MacKinnon's distribution of products test of statistical mediation, which is a variant of the Sobel test. MacKinnon has argued that the traditional Sobel test has low power because the path coefficients are often not normally distributed. MacKinnon has run computer simulations to demonstrate that using a variant on this test would produce more accurate results. To test whether the indirect effect, $\alpha\beta = 0$, we use one of the recommended tests, MacKinnon's distribution of products formula: $(\alpha/\sigma_\alpha)*(\beta/\sigma_\beta)$, where α represents the relation between the IV and mediator, β represents the relation between the mediator and DV adjusted for the IV, and σ represents each respective standard error (MacKinnon, Lockwood, Hoffman, West, & Sheets, 2002). This statistic tests the significance of the indirect pathway (IV → mediator → DV), with $Z > 2.18$ indicating a statistically significant pathway. MacKinnon et al. (1998), conducted extensive simulations in order to determine the critical values for statistical tests of mediation based on empirical sampling distributions, given that these product of coefficients tests are often not normally distributed. These critical value tables can be found at http://www.public.asu.edu/~davidpm/ripl/methods.htm. For the distribution of products test, this critical value is 2.18, instead of the traditional 1.96. Given the cross-sectional nature of this study, the mediation analyses cannot conclude whether associations between SES/race, activity, and BMI operate in a causal fashion. However, analyses provide a preliminary indication of whether SES/race relate to physical activity/sedentary behaviors and BMI in a manner consistent with a mediational hypothesis, which would support our theory of pathways through which sociodemographic variables come to be linked to overweight in adolescents.

Results

Sample Characteristics

Family income ranged from $3,240 to $550,000; 14.2% of families had an annual income of $0–24,999, 51.3 % had an annual income between $25,000 and $74,999, 24.8% had between $75,000 and $149,000, and 13.3% had an annual income over $150,000. Family assets ranged from $0 through $500,000. In all, 51.3% of families reported having between $0 and $4,999 in savings, 13.3% had between $5,000 and $19,000 saved, 21.2% had between $20,000 and 99,999 saved, and 13.3% had over $100,000 in savings. Hollingshead Social Status scores ranged from 19 to 66, with a median score of 47. The SES characteristics of our sample were similar to the characteristics of the school district where the sample was drawn. In the school district, median family income was in the $50,000–74,999 range, 50% of adults had a college degree or higher, and 80% of families owned homes (based on 2000 U.S. Census data). In our sample, average family income was in the $50,000–74,999 range, 61% of parents had a college degree or higher, and 87% of families owned homes.

Teens reported engaging in 20 min of "hard" physical activity 3–5 times, and 20 min of "light" physical activity 6–8 times, over 14 days. For sedentary behaviors, teens watched 2–3 hours of television or video games per day. The correlation between physical activity and sedentary behaviors was $r = -.15$, ($p = .11$), indicating that although these two behaviors are negatively associated, they are not simply two ends of the same construct.

Unadjusted BMIs ranged from 17.18 to 42.43, with a mean of 24.80. In all, 63.7% of the sample was within the normal BMI-to-age range, 15.1% had BMIs that are considered to be "at-risk" for becoming overweight, and 20.4% had BMIs in the overweight range. BMI Z-scores for the total sample ranged from –2.26 to 2.87 (see Table 1).

Testing Predictors of BMI

We first tested the associations between demographic variables (i.e., SES, race, age, and gender) and BMI. Pearson's correlations revealed that SES ($r = -.26$, $p < .01$), but not age ($r = -.11$, n.s.), was significantly associated with BMI, such that lower SES teens had higher BMIs. Independent samples t tests revealed that racial groups significantly differed in BMI, $t(110) = 3.01$, $p < .01$, $\beta = .28$, $p < .01$. Minority teens had significantly higher BMI ($M = 26.22$, $SD = 5.90$) than White teens ($M = 22.90$, $SD = 4.55$). No significant differences in BMI were found by gender, $t(110) = 1.40$, n.s., $\beta = .13$, n.s. The mean and

Table I. Descriptive Statistics on Study Variables

Variable	Min	Max	Mean	SD
SES				
Income	3,240.00	550,000.00	(54,500.00)	67,367.00
Assets	0.00	500,000.00	(3650.00)	68,138.00
Parent's education	10.5	20.5	15.21	6.07
Parent's occupation	8.0	62.5	39.57	8.97
Physical activity				
20 min hard/week[a]	1	5	3.36	1.38
20 min light/week[a]	1	5	3.66	1.24
Sedentary behavior				
TV/video hours[b]	15		3.29	1.05
Overweight				
BMI (unadjusted)	17.15	42.43	24.80	5.60

Note. SES, socioeconomic status; BMI, body mass index. Although Z-scores were used in all analyses of BMI, unadjusted values are presented here as they are more easily interpretable.

Values presented in parentheses are median values due to skewed distributions.

[a]Response options ranged from 1 to 5. A score of 3 indicates that teens were physically active 3–5 times over the previous 14 days.

[b]Response options ranged from 1 to 5. Teens reporting a score of 3 watch television or play video games for an average of 2–3 hr per day.

standard deviations of BMI for males and females were 24.26 (5.49) and 25.15 (5.68), respectively.

Associations of Race/SES with Physical Activity and Sedentary Behaviors

We next tested associations of sociodemographic variables with activity variables. As described in the *Analysis Plan* section, gender was included in these regression equations because activity levels vary by gender. Values presented below represent standardized betas. For SES, results showed a main effect of SES predicting physical activity ($\beta = .67$, $p < .05$) but no significant interaction of SES × gender ($\beta = -.43$, n.s.). Teens from lower SES families reported less physical activity than teens from higher SES families.

With respect to sedentary behaviors, again, results showed a main effect of SES ($\beta = -.24$, $p < .05$) but no significant interaction ($\beta = -.20$, n.s.). Lower SES teens reported more time spent in sedentary behaviors than higher SES teens.

For race, we found a main effect of race predicting physical activity, $F(1, 112) = 9.36$, $p < .01$, but no significant interaction of race × gender, $F(1, 112) = .01$, n.s. The main effect of race revealed that Whites reported greater amounts of physical activity than minorities.

For sedentary behaviors, the race × gender interaction term was statistically significant, $F(1, 112) = 10.16$, $p < .01$. Within-group analyses revealed that race significantly predicted sedentary behaviors in females, $F(1, 68) =$ 34.35, $p < .001$, but not in males, $F(1, 43) = .14$, n.s. Minority females reported spending more time in sedentary behaviors than White females.

Testing the Mediation Models

Next we tested the role of physical activity/sedentary behaviors as mediators of the relationship between SES/race and BMI by conducting formal tests of statistical mediation using MacKinnon's distribution of products test. Values below represent unstandardized betas for each step in the pathway (with standardized betas depicted in the figures). Results revealed a statistically significant pathway between SES and BMI via sedentary behaviors ($Z = 2.31$, $p < .05$). This statistic indicates the overall significance of the indirect path from low SES to high levels of sedentary behaviors ($\beta = -.16$, $SE = .06$, $p < .05$) and from high sedentary behaviors to high BMI ($\beta = .15$, $SE = .09$, $p = .12$). SES alone accounted for 7.0% of the variance in BMI. When sedentary behaviors were partialled out, SES accounted for 5.7% of the variance in BMI, representing a decrease of 18.6% (see Fig. 1).

In contrast, physical activity did not significantly mediate the path from SES to BMI ($Z = 1.96$, n.s.).

With respect to race, statistical mediation testing revealed a significant pathway between race and BMI via physical activity ($Z = 2.32$, $p < .05$); that is, overall the indirect pathway from being from a minority group to engaging in less physical activity ($\beta = -1.10$, $SE = .33$, $p < .01$), and in turn from less physical activity to higher BMI ($\beta = -.08$, $SE = .06$, $p = .13$), was statistically significant. Race alone accounted for 7.5% of the variance in BMI. When physical activity was partialled out, race accounted for 5.9% of the variance in BMI, representing a decrease of 21.3% (see Fig. 2).

Total sample (N = 113)

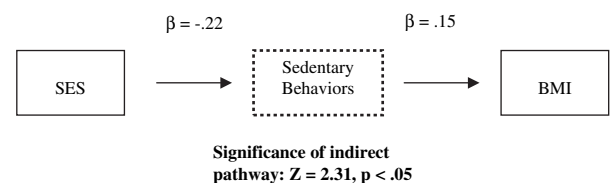*Sedentary Behaviors as a Mediator between SES and BMI*

β = -.22   β = .15

SES → Sedentary Behaviors → BMI

Significance of indirect pathway: Z = 2.31, p < .05

Figure 1. Relationship between socioeconomic status (SES) and body mass index (BMI) operates through sedentary behaviors. Standardized coefficients are presented for each step in this pathway.

Total sample (N = 113)

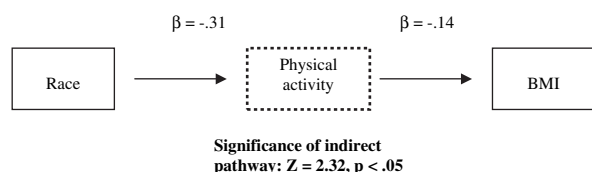*Physical activity as a Mediator between Race and BMI*

β = -.31   β = -.14

Race → Physical activity → BMI

**Significance of indirect
pathway: Z = 2.32, p < .05**

Figure 2. Relationship between race and body mass index (BMI) operates through physical activity. Standardized coefficients are presented for each step in this pathway.

In contrast, sedentary behaviors were not found to significantly mediate the relationship between race and BMI among females (Z = 0.32, n.s.). Note that mediation in this case was tested only in females because race differences in sedentary behaviors were found only in females, as reported above.

Discussion

Consistent with previous research, both SES and race were significantly associated with BMI. Teens from low SES and minority groups had higher BMI than high SES or White teens. Age and gender, however, were not significantly associated with BMI in this sample.

The magnitude of these associations is similar to, or slightly larger than, those from other studies. For example, Lee and Cubbin (2002), Kimm et al. (2005), and Springer, Kelder, and Hoelscher (2006) found that minority adolescents engaged in significantly less physical activity than Caucasian adolescents (β = .39 and .11, respectively, as compared with our result of β = .31). Lee and Cubbin (2002) also reported that low SES teens were less physically active than high SES teens (β = −.10, as compared with β = −.22 from our study). Springer et al. (2006) found that sedentary behavior was significantly associated with higher BMI (β = .12, as compared with our result of β = .15); however, the relation between physical activity and BMI was not significant (β = −.01), an effect size smaller than the β = −.14 reported in our results.

In our mediation tests, two main findings emerged. First, sedentary behavior significantly mediated the SES–BMI association, such that lower SES teens reported more sedentary behavior than higher SES teens, and sedentary behavior formed an indirect pathway between lower SES and higher BMI. Although the relationship

between SES and BMI was small, almost 20% of it could be explained by greater amounts of sedentary behaviors in low SES teens. We should note that the path from low SES to sedentary behaviors was statistically significant, whereas the path from sedentary behavior to BMI was weaker. This finding indicates that, although sedentary behaviors play a significant role in the SES–BMI association, there are likely other factors that directly impact BMI, such as poor diet, impaired sleep, and substance use.

Second, physical activity significantly mediated the race–BMI association, such that being from a minority group was associated with less physical activity, and lack of physical activity formed an indirect pathway between race and BMI. Although the relationship between race and BMI was small, ~20% of it could be explained by the lack of physical activity in minority teens. Similar to the SES–BMI pattern, we found that the path from minority status to physical activity was statistically significant; however, the path from physical activity to BMI was weaker, suggesting once again that while physical activity helps explain the relation between minority status and BMI, physical activity is likely to be just one of many factors contributing to BMI in teens.

The finding that sedentary behavior mediates the SES–BMI association adds to previous findings reported in adult samples that physical activity may not be sufficient to account for the association between income and BMI (Jeffery & French, 1996). Because physical activity and sedentary behaviors were not significantly correlated, this suggests two distinct pathways from low SES to high BMI and from minority status to high BMI. The SES–BMI relationship may be mediated by sedentary behaviors in part because of the characteristics of low SES neighborhoods. For example, neighborhoods may be more dangerous, requiring more time spent inside. In addition, low SES caregivers may rely on sedentary activities, such as television watching, to provide a safe and inexpensive means of supervision (Gordon-Larsen et al., 2004).

We also found that physical activity significantly mediated the race–BMI association. These results may be because of cultural beliefs about the benefits of leisure-time physical activity and the importance of adhering to national physical activity guidelines. The lack of availability of activities often preferred by certain ethnic groups, such as dance classes, could partially account for the lower reported physical activity in minority teens.

Although results from this study provide an important step forward in our understanding of the factors

that place adolescents at risk of becoming overweight, the research is not without limitations. First, SES and race had stronger relationships with physical activity/ sedentary behaviors than these behaviors had with BMI, raising the possibility that our health behaviors were imperfectly measured. For example, information on activity was gathered via self-report, and the test–retest reliability of the measure was relatively low ($r = .55$). Future research should employ more accurate and reliable ways of monitoring activity, such as through the use of pedometers. Second, BMI was measured as an indicator of adiposity. Although studies have shown that BMI and adiposity are associated, BMI may not be as reliable a measure in children as it is in adults (Troiano & Flegal, 1998). In the future, additional characteristics of adiposity should be measured, such as waist circumference and hip-to-waist ratio. As well, we did not measure teens' pubertal stage and therefore cannot adjust for maturation, nor did we query for teens' dietary intake, which may be significantly linked to SES, race, and BMI. Third, data were gathered from a convenience sample, and the sample size was small. As well, this was a predominantly biracial sample, yet previous research has found that adolescents from many racial groups are also at risk of overweight, including Asians and Hispanics (Mokdad et al., 2005; WHO Expert Consultation, 2004). Data, therefore, may not be representative of groups of teens from other racial groups or areas of the United States.

Finally, this was a cross-sectional study, so it is unclear whether physical activity and sedentary behaviors result in overweight, or whether overweight drives behavioral profiles. Longitudinal studies would allow us to track physical activity, sedentary behaviors, and BMI over time in order to better assess directionality. Nonetheless, the present study's findings are consistent with a mediational explanation in which low SES environments may encourage sedentary behaviors, which in turn promotes higher BMI, as well as with a mediational explanation in which being a member of a minority group may be associated with less engagement in physical activity behaviors, which also promote higher BMI.

Despite these limitations, results from this study contribute to our understanding of the role of physical activity/sedentary behaviors in BMI among adolescents. A greater comprehension of the behavioral pathways linking SES, race, and BMI in adolescence is necessary in order to inform health promotion interventions earlier in life. Interventions aimed at targeting teen overweight may benefit from aiming to increase physical activity in minorities and decrease sedentary behaviors in low SES teens. Changes in behavior could improve the quality of adolescent health and could potentially have long-term ramifications for adult health.

References

Aaron, D. J., Kriska, A. M., Dearwater, S. R., Anderson, R. L., Olsen, T. L., Cauley, J. A., et al. (1993). The epidemiology of leisure physical activity in an adolescent population. *Medicine and Science in Sports and Exercise*, *25*, 847–853.

Ball, K., & Crawford, D. (2005). Socioeconomic status and weight change in adults: A review. *Social Science and Medicine*, *60*, 1987–2010.

Bergstrom, E., Hernell, O., & Persson, L. A. (1996). Cardiovascular risk indicators cluster in girls from families of low socio-economic status. *Acta Paediatrica*, *85*, 1083–1090.

Boulton, T. J. C., Cockington, R. A., Hamilton-Craig, I., Magarey, A. M., & Mazumdar, J. (1995). A profile of heart disease risk factors and their relation to parents' education, fathers' occupation and family history of heart disease in 843 South Australian families: The Adelaide Children's WHO Collaborative Study. *Journal of Pediatric and Child Health*, *31*, 200–206.

Bradley, C. B., McMurray, R. G., Harrell, J. S., & Deng, S. (2000). Changes in common activities of 3rd through 10th graders: The CHIC study. *Medicine and Science in Sports and Exercise*, 2071–2078.

Brodersen, N. H., Steptoe, A., Williamson, S., & Wardle, J. (2005). Sociodemographic, developmental, environmental, and psychological correlates of physical activity and sedentary behavior at age 11–12. *Annals of Behavioral Medicine*, *29*, 2–11.

Bungum, T., Pate, R., Dowda, M., & Vincent, M. (1999). Correlates of physical activity among African-American and Caucasian female adolescents. *American Journal of Health Behavior*, *23*, 25–32.

Burdette, H. L., & Whitaker, R. C. (2004). Neighborhood playgrounds, fast food restaurants, and crime: Relationships to overweight in low-income preschool children. *Preventive Medicine*, *38*, 57–63.

Cauley, J. A., Donfield, S. M., LaPorte, R. E., & Warhaftig, N. E. (1991). Physical activity by socioeconomic status in population based cohorts. *Medicine and Science in Sports and Exercise*, *23*, 343–351.

Crawford, P. B., Story, M., Wang, M. C., Ritchie, L. D., & Sabry, Z. I. (2001). Childhood and adolescent obesity: Ethnic issues in the epidemiology of childhood obesity. *Pediatric Clinics of North America*, *48*, 855–878.

da Veiga, G. V., da Cunha, A. S., & Sichieri, R. (2004). Trends in overweight among adolescents living in the poorest and richest regions of Brazil. *American Journal of Public Health*, *94*, 1544–1548.

Dietz, W. H. (1994). Critical periods in childhood for the development of obesity. *American Journal of Clinical Nutrition*, *59*, 955–959.

Diez-Roux, A. V., Nieto, F. J., Tyroler, H. A., Crum, L. D., & Szkla, M. (1995). Social inequalities and atherosclerosis. The Atheroscelrosis Risk in Communities Study. *American Journal of Epidemiology*, *141*, 960–973.

Duncan, S. C., Duncan, T. E., Strycker, L. A., & Chaumeton, N. R. (2002). Relations between youth antisocial and prosocial activities. *Journal of Behavioral Medicine*, *25*, 425–438

Flegal, K. M., Carroll, M. D., Ogden, C. L., & Johnson, C. L. (2002). Prevalence and trends in obesity among US adults, 1999–2000. *Journal of the American Medical Association*, *288*, 1723–1727.

Freedman, D. S., Srinivasan, S. R., Valdez, R. A., Williamson, D. F., & Berenson, G. S. (1997). Secular increases in relative weight and adiposity among children over two decades: The Bogalusa Heart Study. *Pediatrics*, *99*, 420–426.

Friedstad, C., Pirkis, J., Biehl, M., & Irwin, C. E. (2003). Socioeconomic patterning of smoking, sedentary lifestyle, and overweight status among adolescents in Norway and the United States. *Journal of Adolescent Health*, *33*, 275–278.

Garn, S. M., Bailey, S. M., Cole, P. E., & Higgins, I. T. T. (1977). Level of education, level of income, and level of fatness in adults. *American Journal of Clinical Nutrition*, *30*, 721–725.

Garn, S. M., Hopkins, P. J., & Ryan, A. S. (1981). Differential fatness gain of low income boys and girls. *American Journal of Clinical Nutrition*, *34*, 1465–1468.

Gidding, S. S., Bao, W., Srinivasan, S. R., & Berenson, G. S. (1995). Effects of secular trends in obesity on coronary risk factors in children: The Bogalusa Heart Study. *Journal of Pediatrics*, *127*, 868–874.

Gliksman, M. D., Dwyer, T., & Wlodarczyk, J. (1990). Differences in modifiable cardiovascular disease risk factors in Australian schoolchildren: The results of a nationwide survey. *Preventive Medicine*, *19*, 291–304.

Goodman, E., McEwen, B. S., Huang, B., Dolan, L. M., & Adler, N. E. (2005). Social inequalities in biomarkers of cardiovascular risk in adolescence. *Psychosomatic Medicine*, *67*, 9–15.

Gordon-Larsen, P., Griffiths, P., Bentley, M. E., Ward, D. S., Kelsey, K., Shields, K., et al. (2004). Barriers to physical activity: Qualitative data on caregiver-daughter perceptions and practices. *American Journal of Preventive Medicine*, *27*, 218–223.

Gordon-Larsen, P., McMurray, R. G., & Popkin, B. M. (2000). Determinants of adolescent physical activity and inactivity patterns. *Pediatrics*, *105*, 1327–1328.

Hernandez, B., Gortmaker, S. L., Colditz, G. A., Peterson, K. E., Laird, N. M., & Parra-Cabrera, S. (1999). Association of obesity with physical activity, television programs and other forms of video viewing among children in Mexico City. *International Journal of Obesity*, *23*, 845–854.

Hollingshead, A. B. (1975). *Four factor index of social status*. New Haven: Department of Sociology, Yale University.

Jeffery, R. W., & French, S. A. (1996). Socioeconomic status and weight control practices among 20-to-45-year-old women. *American Journal of Public Health*, *86*, 1005–1010.

Jones, D. Y., Nesheim, M. C., & Habicht, J. P. (1985). Influences of child growth associated with poverty in the 1970s: An examination of HANES I and HANES II, cross-sectional US national surveys. *American Journal of Clinical Nutrition*, *42*, 714–724.

Kaufman, J. S., Cooper, R. S., & McGee, D. L. (1997). Socioeconomic status and health in Blacks and Whites: The problem of residual confounding and the resiliency of race. *Epidemiology*, *8*, 621–628.

Kimm, S. Y., Glynn, N. W., Obarzanek, E., Kriska, A. M., Daniels, S. R., Barton, B. A., et al. (2005). Relation between the changes in physical activity and body-mass index during adolescence: a multicentre longitudinal study. *Lancet*, *366*, 23–29.

Kuczmarski, R. J., Ogden, C. L., Guo, S. S., Grummer-Strawn, L.M., Flegal, K.M., & Mei, Z. (2002). CDC growth charts for the United States: Methods and development. *Vital Health Statistics*, *11*.

Kumanyika, S. (1987). Obesity in Black women. *Epidemiologic Reviews*, 9, 31–50.

Lavie, C. J., Kuruvanka, T., Milani, R. V., Prasad, A., & Ventura, H. O. (2004). Exercise capacity in adult African-Americans referred for exercise stress testing: Is fitness affected by race? *Chest*, 126, 1962–1968.

Lee, R. E., & Cubbin, C. (2002). Neighborhood context and youth cardiovascular health behaviors. *American Journal of Public Health*, 92, 428–436.

Leino, M., Porkka, K. V. K., Raitakari, O. T., Laitinen, S., Taimela, S., & Viikari, J. S. (1996). Influence of parental occupation on coronary heart disease risk factors in children. The cardiovascular risk in Young Finns Study. *International Journal of Epidemiology*, 25, 1189–1195.

Lowry, R., Kahn, L., Collins, J. L., & Kolbe, L. J. (2003). The effect of socioeconomic status on chronic disease risk behavior among US adolescents. *Journal of the American Medical Association*, 42, 494–499.

MacKinnon, D. P., Lockwood, C., & Hoffman, J. (1998, June). A new method to test for mediation. Paper presented at the annual meeting of the Society for Prevention Research, Park City, UT.

MacKinnon, D. P., Lockwood, C. M., Hoffman, J. M., West, S. G., & Sheets, V. (2002). A comparison of methods to test mediation and other intervening variable effects. *Psychological Methods*, 7, 83–104.

Matthews, K. A., Kelsey, K., Meilahn, E. N., Kuller, L. H., & Wing, R. R. (1989). Educational attainment and behavioral and biologic risk factors for coronary heart disease in middle-aged women. *American Journal of Epidemiology*, 129, 1132–1144.

Millar, W. J., & Wigle, D. T. (1986). Socioeconomic disparities in risk factors for cardiovascular disease. *Canadian Medical Association Journal*, 134, 127–132.

Mokdad, A. H., Ford, E. S., Bowman, B. A., Dietz, W. H., Vinivor, F., Bales, V. S., et al. (2005). Prevalence of obesity, diabetes, and obesity-related health risk factors, 2001. *Journal of the American Medical Association*, 289, 76–79.

Mokdad, A. H., Serdula, M. K., Dietz, W. H., Marks, J. S., & Koplan, J. P. (1999). The spread of the obesity epidemic in the United States, 1991–1998. *Journal of the American Medical Association*, 282, 1519–1522.

Molnar, B. E., Gortmaker, S. L., Bull, F. C., & Buka, S. L. (2004). Unsafe to play? Neighborhood disorder and lack of safety predict reduced physical activity among urban children and adolescents. *American Journal of Health Promotion*, 18, 378–386.

Morrison, J. A., James, F. W., Sprecher, D. L., Khoury, P. R., & Daniels, S. R. (1999). Sex and race differences in cardiovascular disease risk factor changes in schoolchildren, 1975–1990: The Princeton School Study. *American Journal of Public Health*, 89, 1708–1714.

Oken, B., Hartz, A., Giefer, E., & Rimm, A. A. (1977). Relation between socioeconomic status and obesity changes in 9046 women. *Preventive Medicine*, 6, 447–453.

Okosun, I. S., Tedders, S. H., Choi, S., & Dever, G. E. A. (2000). Abdominal adiposity values associated with established body mass indexes in white, black, and Hispanic Americans. A study from the Third National Health and Nutrition Examination Survey. *International Journal of Obesity*, 24, 1279–1285.

Parsons, T. J., Power, C., Logan, S., & Summerbell, C. D. (1999). Childhood predictors of adult obesity: A systematic review. *International Journal of Obesity*, 23, S1–S107.

Pate, R., Heath, G. W., Dowda, M., & Trost, S. G. (1996). Associations between physical activity and other health behaviors in a representative sample of US adolescents. *American Journal of Public Health*, 86, 1577–1581.

Pate, R. R., Pratt, M., Blair, S. N., Haskell, W. L., Macera, C. A., Bouchard, C., et al. (1995). Physical activity and public health: a recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. *Journal of the American Medical Association*, 273.

Power, C., Manor, O., & Matthews, S. (2003). Child to adult socioeconomic conditions and obesity in a national cohort. *International Journal of Obesity*, 27, 1081–1086.

Puska, P., Nishida, C., & Porter, D. (2003). Global strategy on diet, physical activity, and health. *World Health Organization*, 1–2.

Rimm, I. J., & Rimm, A. A. (1974). Association between socioeconomic status and obesity in 59,556 women. *Preventive Medicine*, 3, 543–572.

Robinson, T. N., Hammer, L. D., Killen, J. D., Kraemer, H. C., Wilson, D. M., Hayward, C., et al. (1993). Does television viewing increase obesity and reduce physical activity? Cross-sectional and longitudinal analyses among adolescent girls. *Pediatrics*, 273–280.

Sallis, J. F., Conway, T. L., Prochaska, J. J., McKenzie, T. L., Marshall, S. J., & Brown, M. (2001). The association of school environments with youth physical activity. *American Journal of Public Health*, 91, 618–620.

Sallis, J. F., Nader, P. R., Broyles, S. R., Berry, C. C., Elder, J. P., McKenzie, T. L., et al. (1993). Correlates of physical activity at home in Mexican-American and Anglo-American preschool children. *Health Psychology*, 390–398.

Sallis, J. F., Prochaska, J. J., & Taylor, W. C. (2000). A review of correlates of physical activity of children and adolescents. *Medicine and Science in Sports and Exercise*, *32*, 963–975.

Sallis, J. F., Zakarian, J. M., Hovell, M. F., & Hofstetter, R. (1996). Ethnic, Socioeconomic, and Sex Differences in Physical Activity Among Adolescents. *Journal of Clinical Epidemiology*, *49*, 125–134.

Sobal, J., & Stunkard, A. J. (1989). Socioeconomic status and obesity: A review of the literature. *Psychological Bulletin*, *105*, 260–275.

Springer, A. E., Kelder, S. H., & Hoelscher, D. M. (2006). Social support, physical activity and sedentary behavior among 6th-grade girls: a cross-sectional study. *International Journal of Behavioral Nutrition and Physical Activity*, *3*, 1–9.

Troiano, R. P., & Flegal, K. M. (1998). Overweight children and adolescents: Description, epidemiology, and demographics. *Pediatrics*, *101*, 497–504.

Tunistra, J., Groothoff, J. W., Van Den Heuvel, W., & Post, D. (1998). Socio-economic differences in health risk behavior in adolescence: Do they exist? *Social Science and Medicine*, *47*, 67–74.

Walter, H. J., & Hofman, A. (1987). Socioeconomic status, ethnic origin, and risk factors for coronary heart disease in children. *American Heart Journal*, *113*, 812–818.

Wardle, J., Robb, K. A., Johnson, F., Griffith, J., Brunner, E., Power, C., et al. (2004). Socioeconomic variation in attitudes to eating and weight in female adolescents. *Health Psychology*, *23*, 275–282.

West, S. G., Aiken, L. S., & Krull, J. L. (1996). Experimental personality designs: Analyzing categorical by continuous variable interactions. *Journal of Personality*, *64*, 1–48.

WHO Expert Consultation (2004). Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *Lancet*, *363*, 157–163.

Williams, D. R. (1999). Race, SES, and health: The added effects of racism and discrimination. *Ann N Y Acad Sci*, *896*, 173–189.

Winkleby, M. A., Kraemer, H. C., Ahn, D. K., & Varady, A. N. (1998). Ethnic and socioeconomic differences in cardiovascular disease risk factors. *Journal of the American Medical Association*, *280*, 356–362.

Zakarian, J. M., Hovell, M. F., Hofstetter, R., Sallis, J. F., & Keating, K. J. (1994). Correlates of vigorous exercise in a predominantly low SES and minority high school population. *Preventive Medicine*, *23*, 314–321.

Zuckerman, A. E., Olevsky-Peleg, E., Bush, P. J., Horowitz, C., Davidson, F. R., Brown, D. G., et al. (1989). Cardiovascular risk factors among Black schoolchildren: Comparisons among four Know Your Body studies. *Preventive Medicine*, *18*, 113–132.