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

by

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Abstract

Purpose: The aim of this study was to assess socio-demographic (SES and race) and behavioral factors (physical activity and sedentary behaviors) contributing to adolescent obesity.

Methods: 113 adolescents (M=17 years; 42% Caucasian, 56% African-American) were assessed on body mass index (BMI). They reported their physical activity and sedentary behaviors. Caregivers provided information on socioeconomic status (SES).

Results: Adolescents from lower SES backgrounds and who belonged to minority groups had higher BMI ($r = -.30$, $p < .01$ and $t(110) = 3.41$, $p < .01$ respectively). Formal statistical mediation tests revealed that sedentary behaviors significantly mediated the association between SES and BMI ($Z = 3.79$, $p < .05$). In contrast, physical activity scores significantly mediated the association between race and BMI ($Z = 6.01$, $p < .05$). Gender was also found to moderate relationships, such that physical activity was a more robust mediator among boys, whereas sedentary behavior was a more robust mediator among girls.

Conclusions: Results from this study could help clarify the role of physical activity versus sedentary behaviors on adolescent BMI. Interventions aimed at targeting teen obesity could benefit by aiming to increase physical activity in minorities and decreasing sedentary behaviors in low SES teens.

Keywords: Socioeconomic status, race, body mass index, physical activity, sedentary behaviors, adolescence

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Obesity rates are rising in all states, races, age groups, and for both men and women. In 2000, over 15% of children in the US between 6 and 19 were obese ($\geq$ 95th percentile of body mass index distribution), and the largest rate increases have been observed in older adolescents and young adults(1, 2). Obesity is considered a significant risk factor in diseases including type II diabetes, hypertension, and heart disease(3). An estimated 8 to 30 years of life may be lost in young adults who are severely obese(4). Obesity-related health care treatment costs are also mounting, making up 9.1% of total health care expenses, amounting to roughly $92.6 billion in the United States in 2003. Despite the increasing public awareness of the detrimental health effects of being overweight, the number of obese adolescents has tripled since 1980(5). Given the costs of obesity, both at the individual and societal level, 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.

Socioeconomic status (SES) is one factor frequently studied in relation to obesity. Researchers have found that, in adults, low socioeconomic status is consistently related to higher body mass index (BMI) in adult women(6-13), and somewhat consistently related to higher BMI in adult men(11, 13). In children, the relationship between SES and BMI is less clear(14-16). Some studies report that family SES is inversely associated with child and adolescent adiposity (17-21), while others have reported that SES is not associated with childhood obesity but may impact obesity rates later on in adolescence and adulthood(22-25). Adolescence may be a "critical period" for the emergence of obesity(26), and past studies have found that the biggest increases in obesity rates in recent years have been in 19 to 24-year-olds(1, 16).

Race is another demographic characteristics associated with obesity. Black children(3, 27-29), and adults(2, 30-34) often display higher BMI scores than other races/ethnicities. Black females may be particularly at risk of becoming obese(28, 35) and show the largest obesity rate increases in recent years(36). The relation between race and SES is complex, however, due to the confounding effects of SES; minorities are often over-represented in low SES segments of the population. Some research reports that the association between race and BMI differs across SES brackets and between genders (37), while other studies found that, even after controlling for SES, racial differences remain (38). The first aim of this study is to test in a sample of older adolescents the associations between the sociodemographic variables of SES and race and obesity.

Second, we aim to test the reasons why these sociodemographic variables may be associated with BMI. Although obesity can be understood as an imbalance between energy input and output, many factors can contribute to this imbalance, including both biology and behaviors. Psychosocial factors can impact behaviors that lead to weight gain, and yet their impact on childhood obesity is not well understood(8). One important pathway may relate to adolescents' energy expenditure, for example, the physical activities in which an adolescent engages. In a study by Yin and colleagues(39), for example, they found that physical activity buffered the effects of personal stress on adiposity in a sample of adolescents. Physical activity may, therefore, also buffer the effects of SES, which could be considered a measure of chronic stress, on BMI.

Previous research has shown associations between low SES and low physical activity(11, 40-44). Reasons for inadequate activity levels in youth may include poor neighborhood safety(45, 46), the lack of school supervision and exercise equipment(47), and low enrollment in organized sports(41, 42, 48, 49).

Racial differences in physical activity have also been reported in past research(33, 43, 50, 51). Differences may be especially large for females. For example, in a study by Lowry and colleagues(50), White females report more activity in a 7-day physical activity recall than Black females. In addition, non-Hispanic blacks were the ethnic group least likely to meet public health recommendations of 30 minutes of daily moderate physical activity (40), and a greater proportion of Black females reported *no* daily physical activity than White females(52). The declines in physical activity during adolescence occur across races but are greatest in Black, as compared to White, females (53).

It should be noted that, in adults, physical activity did not significantly explain the association between SES and weight(6, 54). Wardle and colleagues suggested that this may be because other types of behaviors, such as sedentary behaviors (e.g., TV viewing), may be more important in predicting obesity(8). Young people are spending more and more of their leisure time watching television and playing video games. For each hour of TV watched per day, a child increases their obesity risk by 2%(55, 56). Thus, some researchers have suggested that it may be sedentary behaviors, more so than physical activity, that best explain the association between SES and BMI(8) and are the most appropriate target for intervention (49). In adolescents, research shows an inverse association between parental education and sedentary behaviors (17, 50) (e.g., playing video games or watching television many hours a day). Minority teens also report greater amounts of sedentary behaviors as compared to Caucasian adolescents (40, 50).

Physical activity and sedentary behaviors may therefore act as potentially distinct constructs with differing impacts on obesity. Traditionally, individuals who are less physically active are typically 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, in a study by Gorden-Larsen and colleagues(40), they found that males reported the highest levels of both activity and sedentary behaviors. Therefore, individuals may engage in high levels of physical activity (e.g., swimming regularly) while also engaging in high levels of sedentary behaviors (e.g., playing video games or watching television many hours a day).

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 in a sample of older adolescents. We hypothesize that low SES and Black teens will have higher BMI scores than high SES and White teens. Our second aim is to measure the amounts of physical activity and sedentary behaviors that teens are getting and test 1) whether they are associated with the demographic variables of SES and race, and 2) whether they mediate the associations between SES and race, and BMI. Based on previous findings, we hypothesize that low SES and Black 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 low SES, being Black, and having higher BMI scores.

Method

Participants

113 participants were recruited from a public high school in the St. Louis, Missouri area. The student body was racially diverse, consisting of about 25% African Americans, and a range of socio-economic groups (21% of students were eligible for the federal free lunch program).

Students learned of the study via flyers and school announcements. The Washington University IRB approved the study protocol. Parents and adolescents came to the lab and signed consent/assent forms. Ages of participants ranged from 16-19, with an average age of 16.85. The final sample of adolescents was 61% female, and 42% Caucasian, 56% African-American, and 2% other. Given the small percentage of 'other' participants, African-American and Other students were combined into one group representing minorities in the sample.

The characteristics of the families attending this high school included a median family income in the $50,000-74,999 range, and 50% of parents with a college degree or higher (based on 2000 U.S. census data for the district whether the high school is located). Our sample was similar, in having an average family income in the $50,000-74,999 range, and 44% of parents with a college degree or higher.

Materials

Socioeconomic Status (SES). To obtain SES data, parents/guardians provided information on SES measures, including yearly family income and family savings, as well as parents' educational and occupational status. Hollingshead's Four Factor Index of Social Status(57) was used to code parents' occupation and education.

A total SES score was computed by standardizing and summing family income, family savings, and parental occupation and education. Higher scores indicated higher total SES.

Body Mass Index (BMI). Adolescents were weighed and measured during their laboratory visit using a physician's balance beam scale (Model 402S, Precision Weighing Balances, 2004). Body mass index was then computed for each child (BMI = kg/m^2). For a 17-year-old male from the US, a BMI score less than 17.5, or the 5^{th} percentile, would be considered underweight and above 28, or in the 95th percentile would be considered overweight. For females, a score of 17.5 would be considered underweight and above 29.5 overweight.

Physical Activity. Adolescents reported the number of times in the past 14 days on which they engaged in 20 minutes of hard exercise (e.g., playing basketball, jogging, fast bicycling), 20 minutes of light exercise (e.g., playing baseball, walking, slow bicycling), and the total number of team or individual activities participated in over the previous year. The three items were standardized and summed to form a total physical activity variable representing a physically active lifestyle(58).

Sedentary Behavior. Teens reported the amount of time they spend in sedentary behaviors by responding to the item, "During a normal week, how many hours a day do you watch television and videos, or play computer or video games before and after school?" (58).

Results

Sample Characteristics

Teens reported having engaged in 20 minutes of 'hard' exercise an average of 3 to 5 times over 14 days, and 20 minutes of 'light' exercise 6 to 8 times over 14 days. This is significantly less exercise behavior than reported in previous studies, when teens engaged in 3 or more episodes of activity *per week* (59). Adolescents in the current study also reported participating in 1 team or individual sport over the previous 12 months. For sedentary behaviors, teens watched an average of 2 to 3 hours of TV or video games per day (see Table 1). The correlation between the total physical activity score and sedentary behaviors was $r = -.19$, $p < .05$, indicating that although these two behaviors are associated, they are not simply two ends of the same construct. Independent samples t-tests revealed that, consistent with previous studies, males engaged in significantly more physical activity than females ($t\ (111) = 2.93$, $p < .01$), but there were no significant gender differences in reports of sedentary behaviors (t (111) = .16, *n.s.*). Independent samples t-tests also showed that Whites reported more physical activity than Blacks/others (t (110) = 3.74, $p < .001$) and Blacks/others reported more sedentary behavior than Whites (t (110) = 4.32, $p < .001$). BMI scores for the total sample ranged from 17.18 to 42.43, with a mean of 24.8. A total of 15.9% of females in the sample had BMI scores equal to or greater that 29.5, or above the 95^{th} percentile, and are therefore considered obese. For males, 15.9% had BMI scores equal to or greater than 28, also meeting criteria for obesity.

The socioeconomic characteristics of the sample are presented in Table 1. Family income ranged from $3,240 to 550,000; savings ranged from $0 through 500,000. Parents reported completing a median of 15.5 years of school. Hollingshead Social Status scores ranged from 19 to 66, with a median of 47.

Testing Predictors of BMI

We first tested the associations between demographic variables and body mass index. These demographic variables included SES, race (White vs. Black/Other), age, and gender. For continuous variables, Pearson's correlations revealed that SES (r = -.30, $p < .01$), but not age (r = -.02, *n.s.*), was significantly associated with BMI, such that lower SES teens had higher BMI scores. Independent samples t-tests were computed to test whether differences in BMI existed between the categorical variables of gender and race. Only race was significantly associated with BMI (t (110) = 3.41, $p < .001$). These analyses show that teens from minority groups (i.e., a race other than White) had significantly higher BMI scores than Caucasian teens.

Associations of Race/SES with Physical Activity and Sedentary Behaviors

Because SES and race were significantly associated with BMI, we next tested potential pathways explaining this association. To do this, we first tested the associations of SES and race with our potential pathways of physical activity and sedentary behaviors. Because physical activity levels have been found to vary by gender, we also included tests of interactions between SES/race and gender in the equations.

For SES analyses, we performed a regression analysis predicting sedentary behaviors/physical activity from SES, gender, and the SES x gender interaction term. For sedentary behaviors, results showed a main effect of SES ($\beta = -.24, p < .05$) but no significant interaction ($\beta = -.42$, *n.s.*). Across the whole sample, lower SES teens reported more time spent in sedentary behaviors than higher SES teens.

We then ran a regression analysis predicting teen's report of physical activity from SES, gender, and the SES x gender term entered simultaneously. In this case, the SES x gender interaction significantly predicted physical activity ($\beta = -.80, p < .05$). To understand the nature of this interaction, we examined results for each gender separately. Results showed that SES significantly predicted physical activity in males ($\beta = .45, p < .01$) but not females ($\beta = .06$, *n.s.*). High SES males reported more physical activity than low SES males, but in females, physical activity did not differ significantly by SES.

For race analyses, we conducted a univariate analysis of variance predicting physical activity/sedentary behaviors from race, gender, and the race x gender interaction term entered simultaneously (given that in this case, all variables were categorical). We found a main effect for race predicting physical activity ($F(1, 112) = 10.95, p < .01$), but no significant race x gender interaction ($F(1, 112) = .59$, *n.s.*). The main effect of race revealed that across the whole sample, Whites reported greater amounts of physical activity than Blacks/Others.

For sedentary behaviors, we also performed a univariate analysis of variance of race, gender, and race x gender entered simultaneously. The race x 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.*). Black/Other females reported spending more time doing sedentary behaviors than White females.

Testing the Mediation Models

Next we tested the role of physical activity and sedentary behaviors as mediators of the relationship between SES/race and BMI. To do this, we conducted formal tests of statistical mediation using MacKinnon's distribution of products test(60). Given the cross-sectional nature of this study, the mediational analyses cannot conclude whether associations between sociodemographic factors, activity, and BMI operate in a causal fashion. However, analyses provide a preliminary indication of whether sociodeomgraphic factors relate to physical activity/sedentary behaviors and BMI in a manner that is consistent with a mediational hypothesis (i.e., of physical activity/sedentary behaviors being a significant part of the causal path between sociodemographic factors and BMI in adolescence).

Earlier we found that SES significantly predicted sedentary behaviors across the whole sample. Thus, we tested whether sedentary behaviors mediated the association between SES and BMI. Results revealed a statistically significant relationship ($Z = 3.79, p < .05$), indicating that the indirect path from low SES to high levels of sedentary behaviors, and in turn from high sedentary behaviors to high BMI was statistically significant (see Figure 1).

Second, we found that SES predicted physical activity in males only, and thus we tested physical activity as a mediator between SES and BMI in males. Physical activity was found to significantly mediate the path from SES to BMI ($Z = 5.97, p < .05$), indicating that physical activity served as a significant indirect pathway explaining SES differences in BMI among males (see Figure 1).

With respect to race, we found that across the whole sample, race was significantly associated with physical activity. Thus, we next tested the role of physical activity as a mediator in the race-BMI relationship. Results showed that physical activity significantly mediated the association ($Z = 6.01, p < .05$); that is, physical activity served as a significant indirect pathway explaining race differences in BMI across the whole sample (see Figure 2).

Finally, based on the finding that race significantly predicted time spent in sedentary behaviors in females only, we tested sedentary behaviors as a mediator in the race-BMI relation among females. Sedentary behaviors were found to significantly mediate the relationship between SES and BMI among females ($Z = 4.93, p < .05$) (see Figure 2).

Discussion

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

In our mediation tests of physical activity and sedentary behaviors linking SES, race, and BMI, two main findings emerged. First, physical activity significantly mediated the race-BMI association across the whole sample. Blacks/Others had lower levels of physical activity than Whites. In turn, lower physical activity was associated with higher BMI in the whole sample. These results may be due to different cultural beliefs about the benefits of exercise and sport participation and the importance of adhering to national physical activity guidelines. Alternatively, the *types* of physical activities that teens engage in have been shown to vary by race in previous research(41). The lack of availability of certain types of activities, such as dance classes, could result in the lower levels of physical activity found in minority teens. Finally, previous research supports the notion that, at least in female adolescents, the psychosocial factors that influence physical activity differ across races. In a study by Bungum and colleagues (52), family support and enjoyment of the specific activity predicted exercise levels in Black girls, whereas self-efficacy and school sport participation predicted exercise in White girls. Teens of different races in this study, therefore, may have had different motivations for exercise, and further research is needed to test the motivating factors behind activity in different races.

The second finding is that sedentary behaviors mediated the SES-BMI association across the sample. This finding adds to previous research reporting that physical activity does *not* reduce the magnitude of the association between income and BMI in adults (6), and that the psychological stress suffered by members of lower social classes may effect sedentary behaviors (39). The SES-BMI relation may be mediated by sedentary behaviors more so than physical activity because, for low SES teens, other extracurricular activities, such as music lessons or soccer practices, may require a level of family involvement and expense not possible for low SES parents who often work multiple jobs. Instead, low teens' leisure time may be filled with activities that require less planning and organization, such as television and video games. The neighborhoods of low SES teens may also be more dangerous, requiring teens to spend more time inside and resulting in greater amounts of sedentary behavior. In addition, low SES caregivers may prefer that their children spend time in sedentary pursuits, such as TV watching, because it provides safe and inexpensive supervision (61).

We also found that gender moderated some of the associations of sociodemographic variables with adolescent BMI. For males, we found that physical activity was a more robust predictor of BMI, in that physical activity mediated associations of SES with BMI in boys, but not girls. In a study of middle school boys, McKenzie and colleagues observed that boys spent more of their leisure time (e.g., lunch break) pursuing moderate to vigorous activities than girls (48). Thus physical activity may be a more important component of boys' daily lives, and as such, may play a more important role in the relationship between SES and BMI.

In contrast, among girls, sedentary behaviors were a more robust predictor of BMI, in that sedentary behaviors mediated associations of race with BMI in girls, but not boys. Females' behavior may be driven more by social relationships, family support, and interacting with others than males' behavior (49). Girls who are part of underrepresented groups, such as minority girls, may be less connected to everyday social activities, and as a result, may spend more time engaging in solitary sedentary behaviors such as watching television. Long hours spent in front of the television could then lead to weight gain and higher BMI scores.

Although results from this study provide an important step forward in our understanding of the characteristics and behaviors contributing to adolescent obesity, the research is not without limitations. First, information on physical activity and sedentary behaviors was gathered via self-report. With the many messages pertaining to exercise and fitness that exist at school and in the media, teens who attend to these messages may be more likely to over-report the amount of exercise in which they engage. Future research that employs more accurate ways of monitoring activity levels, such as through the use of pedometers, would eliminate the possibility of these potential confounds. Also, past research suggests that parental physical activity and support influences youth physical activity(62). In the future, it would be useful to measure the relation of parents' physical activity on the relation between SES, race, and physical activity/sedentary behaviors.

Second, BMI was measured as an indicator of obesity and adiposity. While studies have shown that BMI and adiposity are associated, BMI may not be as reliable a measure in children as it is in adults (63). In the future, additional characteristics of obesity should be measured, such as waist circumference and hip-to-waist ratio. Third, future studies should consider other potential mediators, such as diet, genetics, and psychological characteristics. Fourth, our sample size was small, and data may not be representative of groups of teens from other areas of the United States. Also, by studying groups with a broader range of ethnicities, more could be learned about the different cultural factors that impact obesity in adolescents.

Finally, this was a cross-sectional study, so it is unclear whether physical activity and sedentary behaviors shape obesity rates, or whether obesity drives behavioral profiles. For example, males with a high BMI may find physical activity more difficult and less rewarding than males whose body composition is within the normal range, resulting in less physical activity in males with higher BMI scores. For females, those with high BMI scores may be stigmatized and excluded from social and extracurricular activities, leading them to fill their time watching television. Longitudinal studies would allow us to track physical activity, sedentary behaviors, and BMI over time in order to better assess directionality.

Despite these limitations, results from this study contribute to our understanding of the role of physical activity/sedentary behaviors in BMI scores among adolescents. A greater comprehension of the behavioral pathways linking socioeconomic status, race, and body mass index in children and adolescents is necessary in order to inform health promotion interventions earlier in life. For example, interventions aimed at targeting teen obesity may benefit from aiming to increase physical activity in minorities and to 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.

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Table 1. Descriptive statistics on study variables

Variable	Min	Max	Median	SD
SES				
Income	3,240.00	550,000.00	54,500.00	67,367.00
Savings	0.00	500,000.00	3650.00	68,138.00
Parent's Education	10.5	20.5	15.5	6.07
Hollingshead	19	66	47.0	12.54
Physical Activity				
20min hard/week[a]	1	5	3	1.38
20min light/week[a]	1	5	4	1.24
Sports Participation[b]	1	5	3	1.34
Sedentary Behavior				
TV/Video Hours[c]	1	5	3	1.05
Obesity				
BMI	17.15	42.43	23.6	5.60

Note. SES = Socioeconomic status. BMI =Body Mass Index.

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

[b] Response options ranged from 1 to 5. A score of 3 indicates that teens reported participating on one sports team in the past year.

[c] Response options ranged from 1 to 5. Teens reporting a score of three watch an average of 2 to 3 hours of television or video games per day.

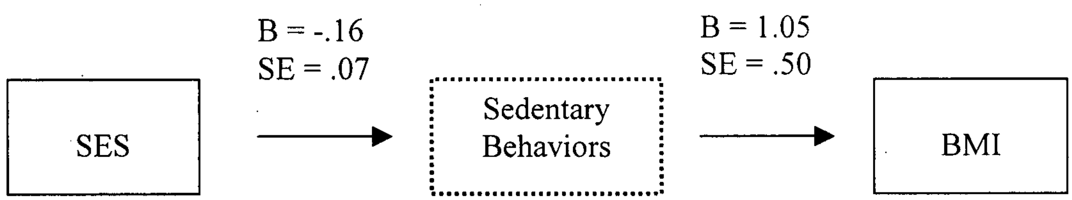
Figure 1. Results revealed that sedentary behaviors served as a significant indirect pathway explaining SES differences in BMI. Among males, the indirect path from low SES to low levels of physical activity, and in turn, from low physical activity to high BMI was also statistically significant.

Figure 2. Physical activity served as a significant indirect pathway explaining race differences in BMI. Sedentary behaviors were found to significantly mediate the relationship between SES and BMI among females only.

Figure 1.

Total sample (N = 113)

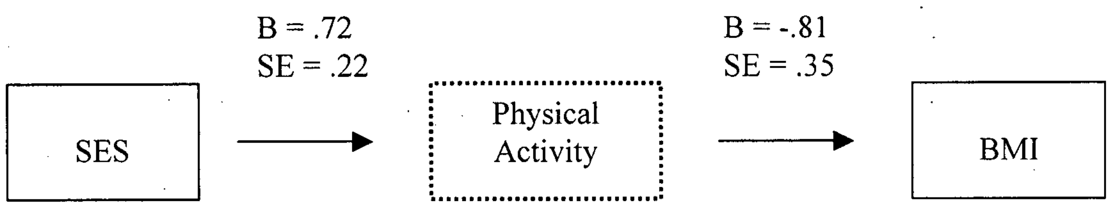
Sedentary Behaviors as a Mediator between SES and BMI



Significance of indirect pathway: Z = 3.79, p < .05

Males Only (N = 44)

Physical Activity as a Mediator between SES and BMI

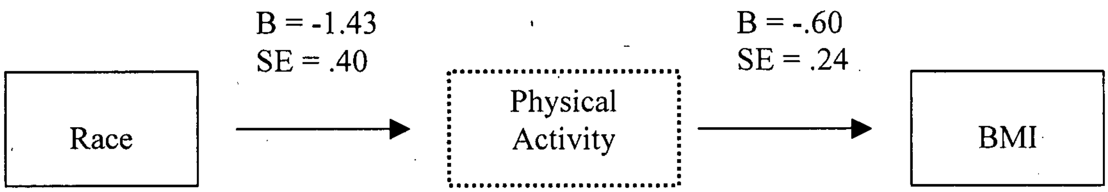


Significance of indirect pathway: Z = 5.97, p < .05

Figure 2.

Total sample (N = 113)

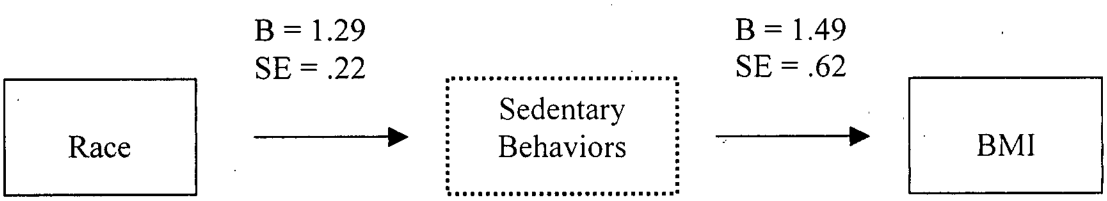
Physical Activity as a Mediator between Race and BMI



Significance of indirect pathway: Z = 6.01, p < .05

Females only (N = 69)

Sedentary Behaviors between Race and BMI



Significance of indirect pathway: Z = 4.93, p < .05