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# DETERMINANTS OF OBESITY: RESULTS FROM A LONGITUDINAL STUDY OF ADOLESCENTS AND ADULTS LIVING IN AN URBAN AREA1, ,2

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## Summary

This study examined the relation of cigarette smoking, psychological symptoms (e.g., depressive symptoms, anxiety), physical activity, and body mass index (BMI) separately by sex. The sample consisted of 815 African Americans and Puerto Ricans (324 males, 491 females). The participants were originally 14 years of age and were followed to 32 years of age and gave information on smoking, depressive symptoms, anxiety, physical activity, and BMI. Structural equation modeling showed that for males cigarette smoking in mid/late adolescence was related to cigarette smoking in emerging adulthood and early adulthood. Finally cigarette smoking in early adulthood was negatively related to BMI in adulthood only for male participants. For female participants, cigarette smoking in adolescence was related to psychological symptoms (e.g., depressive symptoms, anxiety) in emerging adulthood and early adulthood. Psychological symptoms in early adulthood predicted physical activity in adulthood, which in turn, was related to BMI. With one exception, all of the standardized coefficients were statistically significant. Implications for preventive interventions are discussed.

Cigarette smoking and obesity are important public health problems. Smoking-related illnesses, such as cardiovascular disease, pulmonary disease, and lung cancer, are major causes of preventable deaths (World Health Organization [WHO], 2012a). According to WHO, over five million people die each year from smoking-related illnesses (WHO, 2012b). Obesity has also been found to be associated with a number of serious illnesses (Mokdad, *et al*., 2003). Findings regarding the relationship between cigarette smoking and obesity are inconclusive. Further clarification is needed regarding the association between cigarette smoking and obesity as measured by body mass index (BMI). Therefore, the present study has two main objectives. The first objective is to examine the relationship between early cigarette smoking and later BMI at different stages of development in a sample of African-American and Puerto Rican participants living in an urban area. Current epidemiological data indicates that there is a relatively high rate of obesity in adults belonging to these racial/ethnic groups in the United States: 45% of Blacks, 37% of Hispanics (i.e., Mexican Americans), and 30% of Whites are obese (Ogden, *et al*., 2006). Consequently, the inclusion of the two minority groups is especially relevant for research on obesity. The second objective is to estimate the associations between psychological symptoms such as depressive symptoms and physical activity, cigarette smoking, and BMI for both sexes.

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Some investigators have reported a negative relation between cigarette smoking and obesity. In a cross-sectional study, Rashad (2006) reported a negative relationship between cigarette smoking and BMI, in which the magnitude of the regression coefficient (range between -1.14 and -1.75) of smoking on BMI differed by ethnic group (Blacks > Whites > Hispanics). In a longitudinal study, Jasuja, *et al.* (2008) also reported a negative relationship between cigarette smoking and BMI using a predominantly White sample (85%). Several investigators using a longitudinal design have found a positive relationship between cigarette smoking and body weight (e.g., Cooper, Klesges, Robinson, & Zbikowski, 2003). However, using a cross-sectional design, other investigators have reported no significant relationship between cigarette smoking and BMI (Strauss & Mir, 2001; Clair, Chiolero, Faeh, Cornuz, Marques-Vidal, Paccaud, *et al*., 2011).

Assuming a positive relationship between cigarette smoking and obesity, one possible intervening factor is psychological symptoms (e.g., depressive symptoms). According to Family Interactional Theory (FIT), cigarette smoking is related to later depressive symptoms, anxiety, interpersonal difficulty, poor coping skills, and low self-esteem (Brook, Brook, Gordon, Whiteman, & Cohen, 1990). A positive association between more frequent smoking and greater depressive symptoms has been reported longitudinally (1.19 < odds ratios < 2.17) (Chaiton, Cohen, O′Loughlin, & Rehm, 2009) as well as cross-sectionally (1.02 < odds ratios < 1.66) (Kiviniemi, Orom, & Giovino, 2010). Indeed, cigarette smoking is correlated with both generalized depressive symptoms and clinical diagnosis of serious psychological distress (Hagman, Delnevo, Hrywna, & Williams, 2002; McClave, Dube, Strine, Kroenke, Caraballo, & Mokdad, 2009). Nevertheless, the association between psychological symptoms (e.g., depressive symptoms, anxiety) and cigarette use during adolescence, emerging adulthood, early adulthood, and adulthood is important for understanding prevention and amelioration programs. That is, this is a crucial period since at age 14 smoking first becomes relatively common and in the early thirties, obesity becomes an important health risk. Depressive symptoms and less physical activity have been reported to predict obesity (Hasler, Pine, Kleinbaum, Gamma, Luckenbaugh, Ajdacic, *et al*., 2005).

Another possible intervening factor between cigarette smoking and obesity is physical activity. Cigarette smoking has also been found to predict less physical activity, in both cross-sectional ($R^2$ = .23) (Dube, Thompson, Homa, & Zack, 2013) and longitudinal studies (1.29 < odds ratios < 1.33; $R^2$ = .10 for males, $R^2$ = .09 for females) (Brook, Schuster, & Zhang, 2004; Duncan & Rees, 2005).

Many, but not all, youngsters who smoke cigarette in adolescence continue to smoke in adulthood (Johnston, O′Malley, Bachman, & Schulenberg, 2011). According to Brody and colleagues (Brody, Mandelkern, & London, 2006), a number of studies have shown that nicotine influences the brain′s reward system, leading to the continuity of cigarette smoking. As noted by Volkow and Wise (2005), the dopamine system may contribute to the rewarding effects of certain drugs.

Similarly, a number of participants who exhibit psychological symptoms (i.e., depressive symptoms, anxiety) in emerging adulthood continue to display these symptoms in adulthood (Jersild, Brook, & Brook, 1978; Caspi & Shiner, 2008). However, there is a sizeable group of individuals, perhaps in part as a result of positive environmental experiences, who do not exhibit this continuity of internal distress. The Children and Adults in the Community Study (Brook, *et al*., 2004) found that cigarette smoking in adolescence was related to psychological symptoms (i.e., depressive symptoms) in later adulthood in a largely White sample.

Several demographic factors are associated with obesity. Females (24%) in comparison to males (18%) have higher rates of obesity in North America and Cuba at ages 30 and 44 years (Haslam & James, 2005). Consequently, the developmental model was estimated separately for the two sexes. Lower socioeconomic status (SES) predicts obesity (Zhang & Wang, 2004). There are also ethnic differences in obesity rates. As noted above, the prevalence of obesity among non-Hispanic Blacks is higher than among Mexican Americans (Ogden, *et al*., 2006). Therefore, SES and ethnicity were controlled in the analysis.

A major advantage of this study is that its design enables examinations of the relations among these relevant factors (e.g., cigarette smoking, psychological symptoms such as depressive symptoms, and physical activity) and BMI. The predictors of BMI were also examined at several major developmental stages, covering a significant portion of the lifespan (i.e., mean ages of 14 to 32 years). (The measure of BMI was only obtained in adulthood). Several pathways between cigarette smoking and BMI were hypothesized.

*Hypothesis 1.* Early cigarette smoking is associated with later cigarette smoking, which, in turn, predicts lower BMI.

*Hypothesis 2.* The relationship between early cigarette smoking and later BMI is mediated by psychological symptoms (i.e., low self control, depressive symptoms, physical depression, anxiety, and interpersonal difficulty) and less physical activity.

*Hypothesis 3.* The pathways to high BMI will be similar for male and female participants. Nevertheless, we will explore sex differences in our model since females as compared to males have higher rates of obesity (Haslam & James, 2005).

## METHOD

### Participants

There were 815 participants (52% African Americans, 48% Puerto Ricans) who participated at Time 5. Of the sample, 40% were males ($n$ = 324) and 60% were females ($n$ = 491). One pregnant participant was removed from the analyses because her BMI might not be valid. Data on the participants were initially collected in 1990 (Time 1; $N$ = 1,332) when the students were attending schools in the East Harlem area of New York City. The questionnaires were completed in the classrooms under the supervision of the research staff in the absence of teachers. The mean age of the participants at the first wave was 14.1 yr. ($SD$ = 1.3). At Time 2 (1994 – 1996, $N$ = 1,190), the National Opinion Research Center located participants and collected the data. The mean age of the participants then was 19.2 yr. ($SD$ = 1.5). At Time 3 (2000 – 2001, $N$ = 662), the Survey Research Center of the University of Michigan collected the data. The mean age of the participants then was 24.4 yr. ($SD$ = 1.3). At Times 4 and 5, the data were collected by our research group. At Time 4 (2004 – 2006, $N$ = 838), the average age of the respondents was 29.2 yr. ($SD$ = 1.4). At Time 5 (2007 – 2010, $N$ = 815), the average age of the participants was 32.3 yr. ($SD$ = 1.3).

The Institutional Review Boards (IRB) of the Mount Sinai School of Medicine and of New York Medical College approved the study′s procedures for data collection in the earlier waves, and the New York University School of Medicine′s IRB approved the study for Times 4 and 5. A Certificate of Confidentiality was obtained from the National Institute on Drug Abuse for Time 1 to Time 4 and from the National Cancer Institute at Time 5. At Times 1 and 2, passive consent procedures were followed with the parents of minors. At each time, informed consent was obtained from all participants. Additional information regarding the study methodology is available from a previous report (Brook, Lee, Finch, & Brown, 2012).

The demographic variables were compared for the 815 adults who participated at Times 1 and 5 with the 517 who participated at Time 1 but not at Time 5. There was no significant difference between the Time 5 non-participants and the Time 5 participants in the proportion of African Americans and Puerto Ricans ($\chi^2 = 0.01$, $p = .9$, $df = 1$). The percentage of males at Time 1 only was 57%, which was significantly higher than the percentage of males participating at time 5, which was 40% ($\chi^2 = 36.2$, $p < .001$, $df = 1$). The scores on cigarette smoking ($\chi^2 = 9.0$, $p = 0.1$, $df = 5$) and depressive symptoms ($\chi^2 = 4.5$, $p = .6$, $df = 6$) for those who participated at Time 1 only were not significantly different from the scores of those who participated at Times 1 and 5. There were no measures of self control, physical depression, anxiety, and interpersonal difficulty at Time 1.

## Measures

The measures used in this study assessed cigarette smoking from adolescence to early adulthood, psychological symptoms from emerging to early adulthood, and both physical activity and BMI during adulthood. The latent variable of cigarette smoking in mid/late adolescence consisted of current smoking at Times 1 and 2 and smoking in the past 5 years at Time 2. The latent variable of cigarette smoking in emerging adulthood consisted of current smoking and smoking in the past 5 years at Time 3. Similarly, the latent variable of cigarette smoking in early adulthood consisted of current smoking and smoking in the past 5 years at Time 4. These specifications enabled us to assess smoking at each time point (current) as well as the interval covering past five years. The latent variable of psychological symptoms in emerging and early adulthood consisted of low self control, depressive symptoms, physical depression, anxiety, and interpersonal difficulty at Times 3 and 4. Further details are presented in Table 1. The Cronbach′s alphas appear in Table 1. Many of the measures have been found to predict drug use, cigarette smoking, psychopathology, and physical functioning (Cohen, Kessler, & Gordon, 1995; Brook & Zhang, 2013). The measure of physical activity assesses the participants′ engagement in physical exercise. This measure predicts obesity (Brook, 2005).

## Analysis

Mplus (Version 6) was used to calculate the measurement model in the entire sample. Structural equation modeling (SEM) then was performed using a multi-group analysis that separated males and females (Muthén, 1998-2004). Following Newcomb and Bentler (1988), the effects of ethnicity and SES were partialed out using SAS (Version 9.3) to compute the partial covariance matrix.

The Comparative Fit Index (CFI), the Root Mean Square Error of Approximation (RMSEA), and the Standardized Root Mean Square Residual (SRMR) were used to assess the fit of the multi-group model. For the CFI, values between 0.90 and 1.0 indicate an adequate fit (Muthén, 1998-2004). Values of the RMSEA and SRMR below 0.10 indicate an adequate fit (Byrne, 1998; Kelloway, 1998; Diamantopoulos & Siguaw, 2000). In order to test for mediation effects (Baron & Kenny, 1986; MacKinnon, Lockwood, Hoffman, West, & Sheets, 2002), the standardized total effects and total indirect effects were calculated using the Model Indirect command in Mplus. The standardized total effect equals the sum of the direct and the indirect effects of each earlier latent variable (estimated in the analysis) on BMI at Time 5. The total indirect effect of a latent construct on BMI is the mediated effect via the intermediate variables that are depicted in the model (see Fig. 1) (Muthén, 1998-2004).

**Missing data—**Sixty-seven percent of the participants provided complete data on each of the 22 variables in the present study. Nine of the variables had data for 90% or more of the

respondents. The structural equation algorithm in Mplus dealt with missing data by using full information maximum likelihood estimation (Muthén, 1998-2004).

## RESULTS

The mean (SD) of SES was 5.8 (2.6) with a range from 1 (lowest level) to 10 (highest level). The tests comparing the percentages or mean differences on the variables by ethnicity and sex appear in Table 2. African American participants smoked fewer cigarettes per day over the past 5 years at times 2, 3, and 4 and fewer cigarettes currently at times 1, 2, and 4 than Puerto Rican participants. African American participants were more likely to belong to a higher socioeconomic status at time 2 than Puerto Rican participants. Puerto Rican participants reported somewhat more physical depression at times 3 and 4, and somewhat more depressive symptoms at time 3 than African American participants.

Females as compared to males reported more extensive physical depression at times 3 and 4 and somewhat more anxiety at times 3 and 4. Female participants also reported greater physical activity at time 5 than male participants. Male participants reported more cigarette use currently and in the past 5 years at time 4 than female participants, but not earlier.

For the measurement model, all factor loadings were significant ($0.43 < \beta < 0.93$, $p < .001$). For the multi-group structural model (controlling for the participants′ ethnicity and SES at Time 2), the fit indices were CFI = 0.92, RMSEA = 0.07, and SRMR = 0.06. This indicated an adequate fit. The standardized coefficients and associated *z*-statistics of the structural model are presented in Fig. 1 for male and female participants separately.

For male participants, cigarette smoking in mid/late adolescence was positively related to cigarette smoking in emerging adulthood ($\beta = 0.63$, $p < .001$), which in turn, was also positively related to cigarette smoking in early adulthood ($\beta = 0.90$,$p < .001$). Cigarette smoking in early adulthood was negatively associated with BMI in adulthood ($\beta = -0.16$, $p < .01$). Cigarette smoking in mid/late adolescence also was associated positively with psychological symptoms in emerging adulthood ($\beta = 0.21$, $p < .01$), which in turn, was positively associated with psychological symptoms in early adulthood ($\beta = 0.66$, $p < .001$). Greater physical activity in adulthood was directly associated with lower BMI in adulthood ($\beta = -0.13$, $p < .05$). Psychological symptoms in early adulthood were not related significantly to physical activity in adulthood.

For female participants, cigarette smoking in mid/late adolescence was related positively to cigarette smoking in emerging adulthood ($\beta = 0.73$, $p < .001$), which in turn, was related positively to cigarette smoking in early adulthood ($\beta = 0.90$, $p < .001$). Cigarette smoking in mid/late adolescence also was associated positively with psychological symptoms in emerging adulthood ($\beta = 0.27$, $p < .001$), which in turn, were associated positively with psychological symptoms in early adulthood ($\beta = 0.68$, $p < .001$). Early adult psychological symptoms were weakly associated with less physical activity in adulthood ($\beta = -0.09$, $p < .10$). Physical activity in adulthood was directly associated with lower BMI in adulthood ($\beta = -0.20$, $p < .001$).

Table 3 contains the estimated standardized total effects. Physical activity in adulthood had a statistically significant total effect for both male ($\beta = -0.13$, $p < .05$) and female ($\beta = -0.20$, $p < .01$) participants. Cigarette smoking in mid/late adolescence ($\beta = -0.09$, $p < .05$), in emerging adulthood ($\beta = -0.14$, $p < .01$), and in early adulthood ($\beta = -0.16$, $p < .05$) had statistically significant total effects only for male participants. There were weak relations for psychological symptoms in emerging adulthood ($\beta = 0.02$, $p < .10$) and in early adulthood ($\beta = 0.02$, $p < .1$) to have a total effect on BMI only for female participants.

## DISCUSSION

The findings provided partial support for the hypotheses. Firstly, more cigarette smoking was associated with lower BMI among male participants. Secondly, the relation of early cigarette smoking in adolescence and later BMI in adulthood was mediated by psychological symptoms and physical activity among female participants.

The findings contribute to the literature in four important ways. Firstly, the analysis reports results covering several important stages of development over a period of 18 years, beginning when the participants were in adolescence and continuing into adulthood. Secondly, this is the first study of the adolescent longitudinal predictors of BMI in adulthood assessed in a sample of urban African Americans and Puerto Ricans separately by sex. Thirdly, the study highlights the interrelationships between cigarette smoking and psychological symptoms in the emerging and early stages of adulthood, which are precursors of later BMI. Fourthly, the relationship between physical activity and BMI in adulthood were investigate using SEM. The use of SEM enabled assessment of the multiple pathways from cigarette smoking in adolescence to BMI in adulthood.

The first hypothesis was supported: there was a direct path between cigarette smoking in early adulthood and lower BMI in adulthood among male participants. The results are in accord with the findings of Bamia and colleagues (Bamia, Trichopoulou, Lenas, & Trichopoulou, 2004) who reported that tobacco smoking was associated with lesser body fat mass and body fat distribution. In the current sample, the greater percentages of smokers in early adulthood among the male participants (current 36%, past 5 years 47%) than among female participants (current 28%, past 5 years 35%) may contribute to the pathway being statistically significant only for male participants. One possible explanation of this difference is that males, as compared to females, may be less concerned about the effect of cigarette smoking on their children because they spend less time with their children.

There was also partial support for Hypothesis 2: the relationship between early cigarette smoking and later BMI was mediated by psychological symptoms (i.e., low self control, depressive symptoms, physical depression, anxiety, and interpersonal difficulty) and less physical activity. Smoking predicted psychological symptoms for both male and female participants. Among female participants, psychological symptoms, in turn, were related to lower physical activity, which, in turn, was associated with greater BMI. Past research suggests that smoking is related to psychiatric disorders including depression and anxiety (Johnson, Rhee, Chase, & Breslau, 2004). Current findings indicate that the pathway from psychological symptoms to physical activity only was statistically significant for female participants. In a related cross-sectional study, Ishii and colleagues (Ishii, Shibata, & Oka, 2011) reported that only women showed clinically significant relationships between depressive symptoms and physical activity (odds ratio = 1.63). Greater prevalence of major depression among females (20%) in contrast to males (11%) (Oakley Browne, Wells, Scott, & McGee, 2006) may contribute to the pathway being statistically significant only for female participants. In Table 3, greater psychological symptoms and physical activity were documented for females.

The continuity of smoking, particularly in adolescence and emerging adulthood, is well documented. According to Social Learning Theory (Bandura, 1986), individuals observe, model, and imitate the behavior of other important individuals in their environment. Thus, if parents smoke, in addition to the adolescents′ best friend and siblings, the risk of smoking will increase because of the cumulative effect of several significant others. A few experimental observational studies (Harakeh, Engels, Baaren, & Scholte, 2007; Harakeh & Vollebergh, 2013) have shown that imitation of peer smoking is an important mechanism in

explaining why adolescents and young adults continue to smoke. Furthermore, small effects over time may have a large cumulative effect. For example, it has been shown that the adolescents′ risk of smoking increases when there are more models of smoking in their environment (Taylor, 2004). In addition to these environmental characteristics, physiological arousal and the addictive property of smoking contribute to the continuity of smoking. As noted in the Introduction, a number of studies have shown that nicotine influences the brain reward system (Brody, *et al*., 2006), leading to the continuity of cigarette smoking. Several investigators (e.g., Merikangas & Conway, 2009) have found evidence for the addictive nature of smoking. Furthermore, symptoms of withdrawal, such as sleep disturbances, difficulties in concentrating, irritation, depression, restlessness, and anxiety, were frequently reported by smokers trying to quit (Hughes, 2007).

There is some continuity in psychological symptoms between emerging adulthood and early adulthood. Individuals who have difficulty in controlling their emotions, who report greater depression and anxiety, and who have difficulty in establishing and maintaining interpersonal relations often exhibit similar characteristics at a later stage of development. While smoking cigarettes may provide immediate relief of some symptoms such as anxiety, it may evoke and/or exacerbate other psychological symptoms. Further research needs to assess the interactions between personal level factors and environmental influences.

Cigarette smoking in adolescence is also shown to have a relationship with psychological symptoms (i.e., low self control, depressive symptoms, physical depression, anxiety, and interpersonal difficulty) in emerging adulthood and in early adulthood. According to FIT, individuals who smoke are often discriminated against increasing the probability that they will experience depressive symptoms and difficulty in interpersonal relations.

Less physical activity was related to greater BMI in the present analysis for both male and female participants, which is consistent with Frank, Anderson, and Schmid (2004). Frank and colleagues (2004) found that the odds of obesity declined by 4.8% for each additional kilometer walked and increased by 6% for each hour spent in a car per day.

## Limitations

The study has several limitations. Firstly, the measure of BMI was based on self-reported height and weight. In general, it has been shown that men, as compared with women, tend to overestimate their height (Gunnell, Berney, Holland, Maynard, Blane, Frankel, *et al*., 2000; Spencer, Appleby, Davey, & Key, 2002). At the same time, females often underestimate their weight (Brener, McManus, & Galuska, 2003). However, the measure of BMI has been used in a number of survey studies (Storey, Forshee, Weaver, & Sansalone, 2003) and found to have adequate reliability and validity. Secondly, the findings of this study are based on African-American and Puerto Rican adults living in an urban area. This may affect the generalizability of the findings to other populations. Thirdly, no genetic measures were included, although there is some genetic evidence for the relationship of smoking and BMI (Freathy, Kazeem, Morris, Johnson, Paternoster, Ebrahim, *et al*., 2011). Future research is needed to identify the underlying mechanisms of similarity in BMI between a sample and their parents, as well as the interaction of genetic and environmental influences.

Despite these limitations, the study has a number of strengths and adds to the literature in several significant ways. Unlike research that focuses on one point in time, variables were assess over 18 years. The prospective nature of the data allowed consideration of the temporal sequencing of variables. As noted earlier, a major contribution of the paper is a set of findings relating earlier predictors of smoking and psychological symptoms with BMI in adulthood.

The findings document the association between cigarette smoking and BMI through three developmental stages. More specifically, the relation of cigarette smoking to BMI was mediated by the participants′ psychological symptoms and physical activity for female participants. This indicates the importance of the assessment, early intervention, and a focus on psychological symptoms for females. This study suggests that early cigarette use is predictive of later psychological symptoms for participants from either sex and decreased BMI in adulthood for male participants. Therefore, prevention programs for obesity need to focus on the prevention of cigarette use from mid/late adolescence to early adulthood for the males. Finally, every effort should be devoted to increasing physical activity in childhood to prevent later obesity in adulthood.

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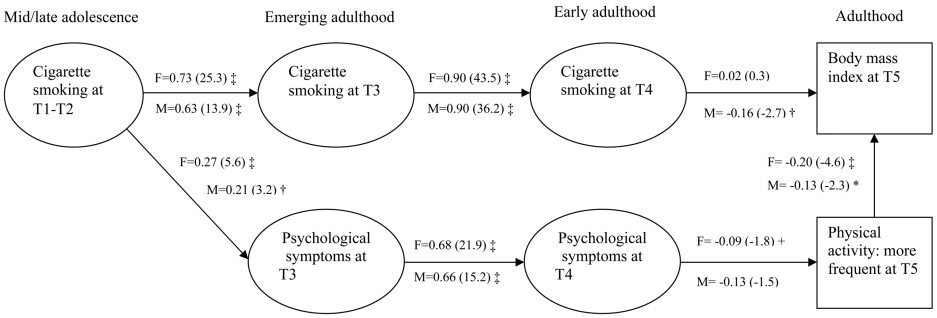


*Note.*—Multi-group CFI=0.92; RMSEA=0.07; SRMR=0.06. Ethnicity and socioeconomic status at T2 were statistically controlled. F=Female; M=Male; T1=Time 1; T2=Time 2; T3=Time 3; T4=Time 4; T5=Time 5. Mean age of respondents at T1 = 14.1 yr.; at T2 = 19.2 yr.; at T3 = 24.4 yr.; at T4 = 29.2 yr.; at T5 = 32.3 yr. Psychological symptoms included low self control, depressive symptoms, physical depression, anxiety, and interpersonal difficulty.
All comparisons were two-tailed. +$p < 0.1$. *$p < .05$. †$p < .01$. ‡$p < .001$.

**Fig 1.**
Standardized coefficients (*z*-statistic) from cigarette smoking, psychological symptoms, and physical activity to body mass index

## TABLE 1

MEASURES

| | Cronbach's alphas and the number of items in parentheses | Sample question | Answer options |
|---|---|---|---|
| *Demographic variables* | | | |
| Sex | NA (1) at T1 | Are you female? | female (1), male (2) |
| Ethnicity | NA (1) at T1 | What is your race? | African American (1), Puerto Rican (2) |
| Parent occupation | NA (1) at T2 | What kind of work does each parent do? The variable is the higher level of the parent occupation. | not working (0), semi-skilled worker (1), skilled worker (2), office worker (3), professional worker (4) |
| Parent education | NA (1) at T2 | How far in school did each parent go? The variable is the higher level of parent education | GED or less (1), some high school (2), completed high school (3), technical school (4), some college (5), completed college (6) |
| Socioeconomic status | NA (1) at T2 | Sum of parent occupation and parent education variables | NA |
| *Cigarette smoking* | | | |
| Current cigarette smoking at T1, T2, T3, and T4 | NA (1) at each time wave | How many cigarettes do you currently smoke? | none (1), a few cigarettes or less a week (2), 1-5 cigarettes a day (3), about half a pack a day (4), about one pack a day (5), more than one pack a day ( 6 ) |
| Past 5 year cigarette smoking at T2, T3, and T4 | NA (1) at each time wave | How many cigarettes did you smoke in the past 5 years? | Same as current cigarette smoking |
| *Psychological symptoms* | | | |
| Low self control (Gough, 1987) | .68 (4) at T3 and .73 (4) at T4 | Do you feel like losing your temper at people? | completely false (1), mostly false (2), mostly true (3), and completely true (4) |
| Depressive symptoms (Derogatis et al., 1974) | .81 (8) at T3 and .74 (5) at T4 | Do you sometimes feel unhappy, sad, or depressed? | not at all (0), a little (1), somewhat (2), quite a bit (3), and extremely (4) |
| Physical depression (Costello et al., 1982) | .75 (6) at T3 and .78 (6) at T4 | Over the last few years, how much were you bothered by loss of appetite? | Same as depressive symptoms |
| Anxiety (Derogatis et al., 1974) | .77 (3) at T3 and .78 (3) at T4 | Over the last few years, how much were you bothered by feeling fearful? | Same as depressive symptoms |
| Interpersonal difficulty (Derogatis et al., 1974) | .76 (4) at T3 and .79 (4) at T4 | Over the last few years, how much were you bothered by feeling easily s annoyed or irritated? | Same as depressive symptoms |
| Physical activity at T5 | NA (1) | How often do you engage in moderate physical activity (i.e., using a vaccum, bowling)? | never (0), seldom (1), sometimes (2) most days (3), nearly every day (4), and every day (5) |
| Log of BMI at T5 (Brook, 2005) | NA (1) | $\mathrm{Ln}\left\{\frac{weight(lb) \times 703}{height^2(inches)}\right\}$ | NA |

*Notes.*– T1: *M* age = 14.1 yr.; T2: *M* age =19.2 yr.; T3: *M* age = 24.4 yr.; T4: *M* age = 29.2 yr.; T5: *M* age = 32.0 yr. BMI was calculated using participants' self reported height and weight. NA = Not applicable.

**TABLE 2**

Summary Statistics and Results of $\chi^2$ or Student *t* Tests Comparing Ethnic Groups and Sexes

| Variables | | AA (n=424) | PR (n=391) | $\chi^2$ or *t* statistic | Female (n=491) | Male (n=324) | $\chi^2$ or *t* statistic |
|---|---|---|---|---|---|---|---|
| **Higher socioeconomic status at T2** | | **13.7%** | **4.7%** | **37.8‡** | **11.1%** | **7.2%** | **0.01** |
| | | *M* *SD* | *M* *SD* | | *M* *SD* | *M* *SD* | |
| Current cigarette smoking at T1-T2 | | 1.3 (0.6) | 1.5 (0.8) | −3.79‡ | 1.4 (0.7) | 1.4 (0.6) | 0.65 |
| Past 5 year cigarette smoking at T2 | | 1.5 (1.0) | 2.0 (1.5) | −6.17‡ | 1.7 (1.2) | 1.8 (1.4) | −1.43 |
| Current cigarette smoking at T3 | | 1.8 (1.2) | 2.0 (1.4) | −1.95 | 1.8 (1.3) | 1.9 (1.3) | −1.09 |
| Past 5 year cigarette smoking at T3 | | 2.0 (1.5) | 2.3 (1.7) | −2.59† | 2.1 (1.5) | 2.2 (1.7) | −0.77 |
| Current cigarette smoking at T4 | | 1.6 (1.2) | 1.9 (1.4) | −2.84† | 1.6 (1.2) | 2.0 (1.4) | −3.25† |
| Past 5 year cigarette smoking at T4 | | 1.9 (1.5) | 2.3 (1.6) | −3.55‡ | 1.9 (1.4) | 2.3 (1.6) | −3.24† |
| Psychological symptoms at T3 | Low self control | 8.3 (2.6) | 8.5 (2.8) | −1.03 | 8.4 (2.7) | 8.4 (2.7) | 0.21 |
| | Depressive symptoms | 4.2 (1.6) | 4.5 (1.7) | −2.14* | 4.5 (1.7) | 4.2 (1.6) | 1.62 |
| | Physical depression | 5.4 (3.9) | 6.1 (4.5) | −2.19* | 6.2 (4.1) | 5.1 (4.2) | 3.53‡ |
| | Anxiety | 2.7 (2.3) | 3.0 (2.6) | −1.32 | 3.0 (2.4) | 2.6 (2.4) | 2.24* |
| | Interpersonal difficulty | 4.3 (2.9) | 4.2 (3.2) | 0.61 | 4.3 (2.8) | 4.1 (3.3) | 1.05 |
| Psychological symptoms at T4 | Low self control | 7.2 (2.5) | 7.5 (2.6) | −1.09 | 7.3 (2.6) | 7.4 (2.6) | −0.16 |
| | Depressive symptoms | 3.9 (1.5) | 4.0 (1.7) | −0.94 | 4.1 (1.6) | 3.9 (1.6) | 1.64 |
| | Physical depression | 5.2 (4.2) | 5.8 (4.6) | −1.97* | 5.8 (4.5) | 4.9 (4.1) | 2.60† |

| Variables | | AA (n=424) | PR (n=391) | $\chi^2$ or *t* statistic | Female (n=491) | Male (n=324) | $\chi^2$ or *t* statistic |
|---|---|---|---|---|---|---|---|
| **Higher socioeconomic status at T2** | | **13.7%** | **4.7%** | **37.8‡** | **11.1%** | **7.2%** | **0.01** |
| | Anxiety | 2.4 (2.5) | 2.7 (2.7) | −1.58 | 2.7 (2.5) | 2.2 (2.6) | 2.48* |
| | Interpersonal difficulty | 3.4 (3.2) | 3.7 (3.5) | −0.97 | 3.7 (3.4) | 3.3 (3.3) | 1.76 |
| Physical activity at T5 | | 3.0 (1.5) | 3.1 (1.5) | −0.91 | 3.2 (1.5) | 2.9 (1.3) | 2.76† |
| BMI at T5 | | 29.2 (7.0) | 29.3 (6.6) | −0.91 | 29.4 (7.3) | 29.2 (5.9) | 0.46 |

*Note*.– AA = African Americans; PR = Puerto Ricans. $\chi^2$ test statistic were used for percentage variables, and *t* test statistic for other variables. Higher socioeconomic status at T2 was assigned a score of 1 if the SES is greater than or equal to 1 standard deviation above the mean; otherwise 0. Answer options for cigarette smoking; none (1), a few cigarettes or less per week (2), 1-5 cigarettes a day (3), about half a pack a day (4), about one pack a day (5), more than one pack a day (6). Answer options for self control and depressive symptoms; completely false (1), mostly false (2), mostly true (3), and completely true (4). Answer options for physical depression, anxiety, and interpersonal difficulty; not at all (0), a little (1), somewhat (2), quite a bit (3), and extremely (4). Answer options for physical activity; never (0), seldom (1), sometimes (2) most days (3), nearly every day (4), and every day (5).

*$p < .05$.

†$p < .01$.

‡$p < .001$.

## TABLE 3

Standardized total effects (z-statistic) of physical activity at T5, cigarette smoking at T4, at T3, and T1-T2, and psychological symptoms at T4 and at T3 on body mass index at T5

| Independent construct | Body mass index at T5 | | | |
|---|---|---|---|---|
| | Females | | Males | |
| | Standardized total effects (z-statistic) | Standardized total indirect effects (z-statistic) | Standardized total effects (z-statistic) | Standardized total indirect effects (z-statistic) |
| Physical activity at T5 | −0.20‡ (−4.46) | NA | −0.13* (−2.34) | NA |
| Cigarette smoking at T4 | 0.02 (0.33) | NA | −0.16† (−2.66) | NA |
| Psychological symptoms at T4 | 0.02+ (1.65) | 0.02+ (1.65) | 0.01 (1.23) | 0.01 (1.23) |
| Cigarette smoking at T3 | 0.01 (0.33) | 0.01 (0.33) | −0.14† (−2.66) | −0.14† (−2.66) |
| Psychological symptoms at T3 | 0.02+ (1.65) | 0.02+ (1.65) | 0.01 (1.22) | 0.01 (1.22) |
| Cigarette smoking at T1-T2 | 0.01 (0.42) | 0.01 (0.42) | −0.09* (−2.55) | −0.09* (−2.55) |

*Note*.–Ethnicity and socioeconomic status were statistically controlled. T1: *M* age = 14.1 yr.; T2: *M* age = 19.2 yr.; T3: *M* age = 24.4 yr.; T4: *M* age = 29.2 yr.; T5: *M* age = 32.3 yr. NA = Not applicable. The dependent variable was ln (Body mass index).

+ $p < 0.1$.

* $p < .05$.

† $p < .01$.

‡ $p < .001$.