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A prospective evaluation of the relationships between smoking dosage and body mass index in an adolescent, biracial cohort

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Abstract

Although there is clearly an inverse relationship between smoking and body weight, recent studies suggest that weight attenuation via smoking is slow and may take decades to accrue. This investigation prospectively evaluated the relationships between smoking dosage (or lack thereof) and relative weight change in 1697 adolescents followed over 4 years. A 4 (smoking groups: 0, 1, 2, or 3 or more years of smoking exposure)×2 (ethnicity: Caucasian or African American)×2 (gender: male or female) analysis of variance (ANOVA) was performed to assess weight gain attenuation associated with increasing exposure to smoking. The overall results revealed a significant three-way interaction between smoking dosage, gender, and ethnicity. Specifically, smoking initiation was associated with an *increase* in body mass index (BMI) for 2 years after initiation. For those youth smoking 3 or more years, body weights were almost identical compared to never-smokers. No significant reductions in body weight were observed in any gender or ethnic group for up to 3 years after smoking initiation. It is concluded that smoking initiation is not associated with adolescent body weight change for at least a 3-year period.

Keywords: Smoking; Youth; Weight gain; Body mass index

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1. Introduction

It is well established that cigarette smoking is the single most preventable cause of disease in the United States (United States Department of Health and Human Services [U.S. DHHS], 1990). Indeed, it has also been determined that, although the negative health consequences associated with smoking and the health benefits of quitting smoking are widely known, approximately 26% of all adults in the United States continue to smoke (U.S. DHHS, 1990). Moreover, recent smoking prevalence estimates suggest that prevalence is *increasing* in youth (Centers for Disease Control [CDC], 1996). In fact, it is estimated that one-third of all high school students smoke (U.S. DHHS, 1994).

One of many important reasons that individuals begin to smoke (particularly adolescents and women) is the perception that smoking helps control body weight (French & Jeffery, 1995). In one study, the best predictor of experimental versus regular smoking was the use of tobacco for weight control purposes (Robinson, Klesges, Zbikowski, & Glaser, 1997). In fact, 40% of seventh grade students in another study believed that smoking had weight control benefits, and 12% of regular smokers at that age level reported using smoking specifically for the purpose of weight control (Klesges, Elliott, & Robinson, 1997). White females in this study scored highest on the dietary restraint measures and endorsed the benefits of smoking on weight control more than any other subgroup surveyed.

In the only prospective study to date examining the effects of weight concerns on risk for smoking onset, after adjustment for grade, relative obesity, and socioeconomic status, females who reported having tried to lose weight in the past year, having two or more eating disorder symptoms, or having constant thoughts about their weight were twice as likely to initiate smoking as those who did not report these dieting concerns (French, Perry, Leon, & Fulkerson, 1994). In this study, none of the dieting behaviors or weight concerns were significantly related to smoking initiation in males; however, some studies have found that similar weight concerns are associated with smoking onset in boys (Klesges, Elliott, et al., 1997; Tucker, 1983).

Though the perception that smoking controls body weight appears to be very common, what evidence is there that a relationship actually exists between smoking and body weight? Clearly, there is evidence that after many years of smoking, there is a 5–10-lb weight difference in which aging smokers weigh less than older nonsmokers (Klesges, Meyers, Klesges, & LaVasque, 1989), and those who quit smoking experience a weight gain of a similar magnitude over the short-term (Klesges, Winders, et al., 1997; U.S. DHHS, 1988). However, the extant prospective data, typically conducted with older subjects, generally do not support the belief that smoking *initiation* has a dramatic, or even a minimal impact on body weight, within 4 to 8 years. For example, in a 2-year study of those who either initiated smoking at what appears an atypically older age and those who remained nonsmokers (mean age of 38 at baseline), there was no significant difference in body weight between those who initiated smoking and those who remained nonsmokers (French, Jeffery, et al., 1994). Similarly negative findings were reported for females in the Nurses Health Study who were followed for 8 years (Colditz et al., 1992).

In contrast, in another study, significant weight differences were found between initiators and never-smokers among a cohort of 38–60-year-old females who were followed for approximately 6 years (Lissner, Bengtsson, Lapidus, & Bjorkelund, 1992). However, all of the above investigations were conducted with older people, in which smoking initiation is highly unusual. Thus, it is possible that these findings have limited generalizability to younger individuals who are most likely to initiate smoking (U.S. DHHS, 1994) and who are more likely to perceive weight control benefits of smoking initiation, compared to adults (French & Jeffery, 1995; Robinson et al., 1997). In addition, there appear to be age-related effects of the role of smoking on body weight, in which significant differences exist between body weights of smokers and nonsmokers in older individuals, but no such differences are found among younger counterparts (Klesges et al., 1989).

Data assessing the relationship between smoking and body weight in adolescent samples are sparse. Only three studies have assessed the relationship between smoking status/initiation and body weight among adolescents or young adults. Two of these studies are limited by their cross-sectional nature, and the sole prospective study (Klesges, Ward, et al., 1998) was conducted within an age range (18–30) in which smoking initiation is relatively uncommon. Klesges, Robinson, and Zbikowski (1998) investigated the smoking status and body weight relationship cross-sectionally utilizing the same baseline data used here. In this biracial sample of seventh grade students, smoking was *positively* related to body mass index (BMI, weight in kilograms per square meter of height), in that with increasing amounts of smoking, BMI also increased. Another cross-sectional study evaluated this relationship, and results indicated that smoking had no relationship to body weight in females and a very small effect of body weight reduction in males, less than 1 kg (Klesges, Zbikowski, et al., 1998).

In the only prospective investigation of the relationship between smoking, smoking initiation, and body weight in young subjects to date (ages 18–30 years), Klesges, Ward, et al. (1998) assessed the impact of smoking initiation and cessation on body weight change in a biracial, population-based, cohort study, and results indicated that initiators did not lose weight, and, in fact, most gained as much weight as never-smokers. This investigation concluded that there was no weight control benefit, at least over a 7-year period, among Black females, White males, and White females, the latter group most likely to smoke for the purpose of controlling body weight. Taken together, these studies indicate that the immediate weight control "benefits" of beginning to smoke are small and may take years and perhaps decades for a difference to accrue. However, no prospective study of smoking initiation in those most at risk for smoking onset, adolescents, has been conducted.

Clearly, prospective studies with large sample sizes, with adequate gender and ethnic diversity, and with adolescents, the group most at risk for smoking onset, are needed to further assess the important relationships between smoking and body weight in younger smokers and nonsmokers. Thus, the purpose of the investigation is to evaluate the relationship between BMI and smoking dosage or lack thereof prospectively, in a large, biracial cohort of both adolescent smokers and nonsmokers.

2. Method

2.1. Overview

All seventh graders in a mid-South urban public school system were invited to participate in this survey. This school system is among the 20 largest in the nation, and approximately 80% of the student body are African American. Administrative support for the project was excellent, with all of the 39 eligible schools agreeing to participate. Initially, 8946 seventh graders were approached to take part in the study, and, of these, 78% (n=6967) completed the survey in the first year. Only 3% (n=289) of the children initially refused to complete the survey. A parental notification procedure was used, in which a letter was mailed to their home. This letter, signed by the school superintendent, informed parents of the study and invited them to call the project if they had questions or did not want their child surveyed. At baseline, parental support was strong as well, with only 2% (n=164) of the children withdrawn from the study because of parental refusal or our inability to notify the parents of the research project. Another 16% (n=1405) of the students were not surveyed due to absenteeism or problems with survey administration. Participants were reassessed at 2-, 3-, and 4-year follow-ups.

Attrition over the course of a prospective study in a low-income, urban area represents a significant challenge. Despite this typical problem, we obtained data using aggressive, focused tracking and retention strategies in the second year from 81% of the participants, in the third year follow-up from 72%, and in the fourth year from 67%, with 51% of the cohort having complete data in all 4 years. During the second year of the study, 5% (n=350) of the children refused to complete the survey, while 19% (n=1331) of the students were not surveyed due to absenteeism, problems with survey administration, or the inability to locate them. In the third year, 7% (n=520) of the students refused to complete the survey, and 28% (n=1925) were not surveyed due to absenteeism, problems with survey administration, or the inability to locate them. Finally, in the fourth year, 9% (n=628) of the children refused to complete the survey, while 33% (n=2317) were not surveyed due to absenteeism, problems with survey administration, or the inability to locate them. While this attrition rate is less than optimal, it is noteworthy that similar projects with urban youth have experienced much larger annualized cohort loss (Epstein, Botvin, & Diaz, 1998; Farrel & Danish, 1993; Siddiqui, Hedeker, Flay, & Hu, 1996; Wills, 1986). In fact, this study's annualized cohort loss of 11.4% is lower than both the average annualized cohort loss for similar studies with urban populations (24.4%) as well as studies with less urban populations (14.6%). Comparisons were made between participants included in the current study versus those not included (those lost to attrition and those not meeting study criteria). Analyses revealed participants who remained in the current study were more likely to be female (OR=2.33), Caucasian (OR=1.79), and nonsmokers (OR=.27) than those lost to follow-up. Additionally, no differences were found between those included and those not included on baseline BMI. Due to the differential attrition, results presented need to be interpreted with caution due to potential limitations on generalizability.

2.2. Design

The current design is a correlational investigation of the relationship between smoking and body weight changes. Independent variables included smoking dosage (if any), gender, and ethnicity. The dependent variable was BMI change over time (see below).

2.3. Subjects

This sample was comprised of students who entered the seventh grade in the fall of 1993 and participated in a longitudinal study of the determinants of smoking. Selection criteria for the current study were conservative, as missing smoking, height, and weight data could not be accurately determined. Subjects were included only if they participated in all annual surveys and provided data on their smoking status at each of the assessment periods, as well as height and weight during years of and prior to reported smoking exposure. Participants who reported quitting smoking prior to or during the 4 years of the study were also excluded from analyses. The sample consisted of 1697 responders who met the above criteria. These participants were 81% Black, 19% White, 34% male, and 66% female.

2.4. Procedure

Trained school coordinators (i.e., teachers or counselors) who were appointed by the school principals managed the research activities within each school, including the distribution and collection of surveys. Manuals, specifically developed for survey administration, contained a verbatim script to assist teachers in providing instructions to the students. These instructions specified that this was a smoking and health questionnaire and that participation was voluntary. Teachers administered surveys to these students at baseline and at the 2-, 3-, and 4-year follow-up assessments.

2.5. Measures

On the basis of previous research, a survey assessing a variety of factors thought to be related to smoking onset was constructed. This questionnaire was both approved by the school system for level of reading appropriateness and piloted on a group of sixth graders to ensure its readability.

At each assessment, students responded to both demographic questions and psychosocial questions related to smoking onset in various domains. These domains included: modeling influences on smoking onset (i.e., family and peer models), the perceived peer smoking prevalence rate, the instrumental value of smoking (i.e., whether or not it looks "cool" or "mature"), rebelliousness, perceptions of academic success and social support, and the perceived availability of cigarettes (Robinson & Klesges, 1997). For the purposes of this study, responses to ethnicity, gender, height, weight, and smoking status were identified.

Students' self-reports of cigarette use were obtained each year for 4 years. Although biochemical verification of smoking status is considered important in some intervention studies, such measures are not practical with large samples (Velicer, Prochaska, Rossi, & Snow, 1992) and typically not used for survey research (U.S. DHHS, 1994). Self-reported data are considered sufficiently valid in such large-scale studies (Velicer et al., 1992) and in instances in which recall is restricted to 1 year (Stanton & Silva, 1993), as is the case in the current study. Moreover, the thrust of the research findings suggests that the best predictor of accurate reporting among adolescents is whether or not they are assured confidentiality (Murray & Perry, 1987). For this reason, we instituted a number of procedures to reassure students that their privacy would be protected and maintained. For example, teachers were instructed not to assist students once the survey administration had begun, and students sealed their surveys in large, unmarked envelopes that were placed in a sealed box prominently marked "confidential."

Students on the survey were asked each year to choose from the following options which is true: "I have never smoked, not even a puff," "I have smoked a cigarette or a few cigarettes just to try, but I have not smoked in the past month," "I no longer smoke, but in the past I was a regular smoker (at least one cigarette per week)," "I smoke, but less than one cigarette per month," "I smoke, but less than one cigarette per week," "I smoke from one to six cigarettes per week, " or "I smoke at least one cigarette per day." Based on their reports, participants were categorized on the basis of number of years of smoking dosage during the 4 years of the study. Smoking dosage in the current study is defined as reporting smoking at least one cigarette per month without reporting quitting smoking prior to or during the study period. Although this criterion is not the ideal measure of current smoking, it was used here primarily for two reasons. First, during the first year of the study, participants were in seventh grade, an age at which heavier levels of smoking are unusual, and this criteria was used throughout the other 3 years of the study for the sake of consistency. Second, this study's sample is heavily Black, and it is well documented (U.S. DHHS, 1994) that African American youth both smoke fewer cigarettes and are less likely to smoke than their Caucasian counterparts, so a broad criterion better encapsulates this entire population. The four smoking dosage categories constituted: (1) 0 year of smoking dosage, (2) 1 year of smoking dosage, (3) 2 years of smoking dosage, and (4) 3 or more years of smoking dosage, indicating years of reported smoking.

At baseline and each of the following years, BMI (kg weight/m^2 height) was calculated for each student based on self-reported height and weight. Although within this population there may be a tendency toward underestimating weight and overestimating height (Crawley & Portides, 1995), group means reported for weight and height are considered valid measures of actual weight and height for adolescents in large-scale epidemiological studies (Troy et al., 1995). Based on previously established cutoff points for outliers (Klesges, Robinson, et al., 1998), before calculating BMI for each student, height and weight distributions were examined, and outliers beyond the upper and lower 0.5% for height and the upper and lower 1% for weight were eliminated from further analysis.

3. Results

3.1. Approach to analyses

There are at least two appropriate methods of analysis of these data. The first would be a repeated-measures approach. Although the major advantage of this approach is that it typically is well suited for longitudinal data of this type, it would not likely be the best approach to these data for two reasons. First, such an approach would require that every participant included in the analyses have all 4 years of height and weight data in addition to the already strict criteria of having all 4 years of smoking data. This would further reduce the number of subjects in the study, thus reducing power to detect a relationship between smoking and body weight. Second, a repeated-measures approach would not allow the appraisal of body weight based solely on smoking dosage. For example, a subject who was a nonsmoker for 3 years of the study and a smoker in the last year of the study would be considered a smoker, and the analyses would fail to reflect the effects of dosage on body weight (years of smoking exposure), the central aim of the study.

An alternative approach to analyzing these data is an analysis of variance (ANOVA) using an annualized BMI surrounding the particular years of smoking. The major advantage of this approach is that, unlike the repeated-measures approach, it allows us to model the unusual pattern of adolescent smoking in a consistent way, providing the greatest likelihood that a relationship between smoking and body weight will be revealed, if there is one. Thus, in our effort to find any association between smoking and body weight, we opted to use the ANOVA approach using annualized BMI change scores. It should be noted that the results were similar, regardless of the analytic approach, except that in the repeated-measures approach, approximately 10% fewer subjects were available.

BMI change was calculated for each student. Afterward, that BMI change score was converted into an annualized change score to ensure consistent comparisons. To clarify, students with 1 year of smoking dosage simply had a BMI change score based on the difference between BMI from the year before reported smoking and the year of reported smoking. Students with two consecutive years smoking dosage had BMI change calculated based on the 2-year difference in BMI the year before smoking initiation and the year of smoking exposure. Then, that change was divided by two to result in an annualized BMI change score. For those students who smoked two nonconsecutive years during the study, one of two approaches was taken. In the first case, if students smoked during the first year of the study and another nonconsecutive year (either Year 3 or 4), annualized BMI change was calculated by taking the 1 year difference between the latter year of reported smoking and the year prior to that year. In the second case, if students reported smoking Years 2 and 4, annualized BMI change was calculated in half of the cases using the difference between Years 2 and 1 BMIs, while in the other half of the cases the change score was based on the difference between Years 4 and 3 BMIs. This approach was used in order not to introduce a systematic bias into selection of BMI used for annualization. Finally, students with no smoking dosage or 3 or more years smoking dosage had BMI change calculated by the difference between Years 1 and 4 BMIs, and then that score was divided by four to constitute

an annualized BMI change score. In rare instances (n=43), we had to eliminate cases in which baseline smokers had 2 or fewer years of smoking dosage because an accurate baseline BMI could not be determined.

In order to analyze the current data, it was necessary to determine, not only the number of subjects that constitute each smoking dosage group, but also the gender and ethnic make-up of each group. As cell sizes were adequate for analyses, we performed a 4 (smoking dosage groups: 0, 1, 2, and 3 or more years smoking)×2 (ethnicity: Black and White)×2 (gender: female and male) ANOVA with annualized BMI change as the dependent variable. Post hoc tests were conducted on significant interactions to ascertain the meaning of such interactions.

3.2. Descriptive analyses

Of the 1697 students in the study, average height and weight, respectively, at baseline were 63.5 in. and 119.8 lb. Average BMI in Year 1 was 20.9, while in Year 4, mean BMI significantly increased to 22.95 (P<.0001). Of the 1697 students in the study, 10.1% (n=171) had some level of smoking exposure over the course of 4 years. Table 1 summarizes all baseline descriptive analyses according to years of smoking.

As can be seen in Table 1, as the number of years of smoking increases, the percentage of minorities in the sample decreases. This is consistent with the literature that suggests that Black smoking initiation occurs later, with onset frequently in adulthood (Robinson et al., 1997). At baseline, those that subsequently had 3 or more years of smoking had similar BMIs than those with subsequently 0 year of smoking.

3.3. Primary analyses

The results of this study are presented as illustrated in Fig. 1. The overall effects revealed a significant three-way interaction between smoking dosage, gender, and ethnicity (F=11.04, df=3,1682, P=.0001). Overall, those youth that began smoking *increased* their relative body weight for 2 years after initiation of smoking. The weight gain is particularly prominent for White females, who significantly increased their BMI 1.369 units (S.D.=5.888, P<.001) in the year following smoking initiation. Black males following 2 years of smoking had a significantly increased BMI of 1.505 units (S.D.=2.367; P<.001) relative to those Blacks with

Table 1
Baseline descriptive analyses

Variable	0 year of smoking (n=1526)	1 year of smoking (n=94)	2 years of smoking (n=38)	3 or more years of smoking (n=39)
% Male	33	46	39	31
% Minority	83	69	47	38
Height (in.)	63.46 (S.D.=3.92)	62.90 (S.D.=3.63)	64.39 (S.D.=3.18)	63.97 (S.D.=3.94)
Weight (lb)	119.44 (S.D.=27.13)	123.33 (S.D.=30.28)	123.45 (S.D.=31.48)	121.26 (S.D.=37.71)
BMI	20.89 (S.D.=4.16)	21.86 (S.D.=4.60)	20.89 (S.D.=4.33)	20.58 (S.D.=4.03)

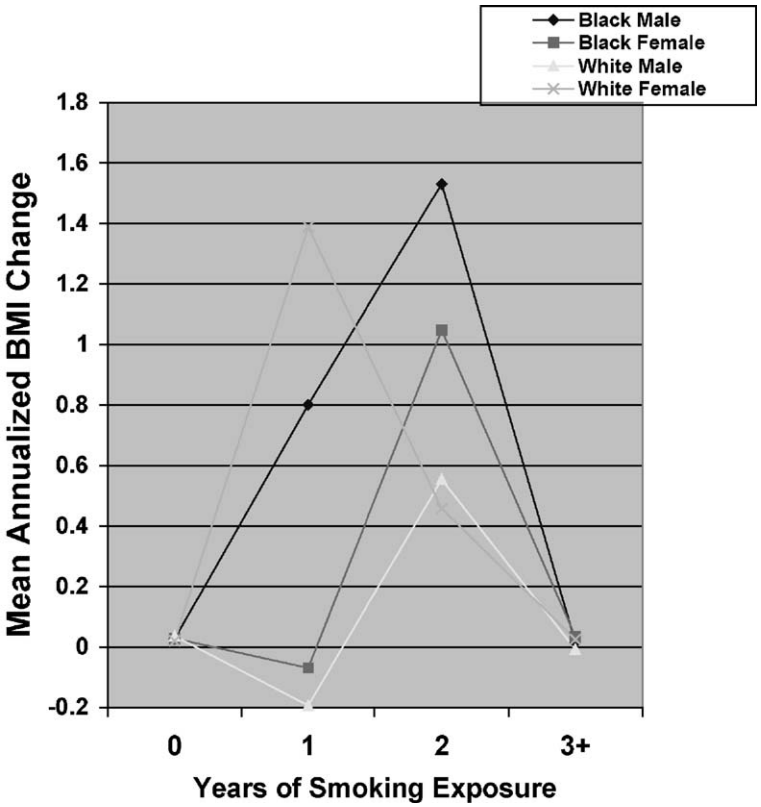

Fig. 1. Primary analyses (three-way interaction).

0 year of smoking. Both White males and Black females with 1 year of smoking had slight reductions in BMI in the first year (mean decrease of 0.228 and 0.097 for White males and Black females, respectively), but these differences were not statistically significant. Those with 2 years smoking had a much higher BMI relative to like groups with 0 year of smoking (mean increase of 0.519 for White males and 1.02 for Black females), yet only the latter difference (Black females) was statistically significant (P=.002). In all four ethnic and gender groups, those with 3 or more years of smoking had BMIs virtually identical to those with 0 year of smoking.

4. Discussion

Consistent with previous research (Klesges, Robinson, et al., 1998), these results indicate that smoking, even after 3 or more years, is not associated with significant reductions in BMI in adolescents, the group most likely to initiate smoking, as well as the group most likely to do so for the purpose of reducing weight. In fact, up to 2 years of smoking in the current analysis is associated with weight increases, in which weight gain is most pronounced for

White females after 1 year of smoking and Black males and females after 2 years of smoking. Three or more years of smoking are associated with no observed effect on body weight relative to never smoking.

Despite the 4-year follow-up, no groups showed significant weight attenuation effects (i.e., weight loss) associated with smoking. The finding that minimal or no weight attenuation is found in groups beginning to smoke is consistent with three other studies in the literature. Klesges, Robinson, et al. (1998) in their cross-sectional study of teen smoking and body weight found that smokers were actually heavier than nonsmokers by a small yet significant margin. Klesges, Ward, et al. (1998) examined the smoking and body weight relationship with a 1-year follow-up and presented results that smoking had minimal impact on relative weight. Lastly, Klesges, Zbikowski, et al. (1998) explored the effects of smoking on body weight in a large sample and found no impact of smoking on body weight, except in White males, who experienced a minimal weight attenuation effect of smoking (less than 1 kg). Future research should continue to explore this relationship using large samples representative of both beginning smokers and nonsmokers in an attempt to scrutinize any minimal impact smoking initiation has on relative body weight, perhaps extending the length of the follow-up period to assess at what point smokers' weights significantly differ from weights of nonsmokers.

Interesting is the finding that, after initiation of smoking, BMIs actually *increased*, particularly for White females after 1 year of smoking and Black males and females after 2 years of smoking. This finding is consistent with some cross-sectional studies in adolescence that suggest smokers have higher BMIs than never-smokers (Klesges, Robinson, et al., 1998). However, this is the first study to demonstrate such a result longitudinally. Several plausible reasons for this finding exist. First, it is possible that those adolescents who are already experiencing accelerated weight gain are the most likely to initiate smoking, believing that smoking is an effective means of weight control. A second possible explanation is that adolescents who begin to smoke feel there is less need to practice dietary restraint, again reflecting the belief that smoking controls body weight. Finally, it is plausible that smoking onset in adolescence is associated with the onset of other negative lifestyle factors, like the consumption of alcohol or foods higher in fat content, resulting in weight gain concurrent with smoking initiation. Future research should continue to explore the relationship between adolescent smoking and body weight using measures of weight control beliefs, dietary restraint, eating habits, and other lifestyle factors.

Although there are many positive features of this study, including a large representative biracial cohort over a 4-year period, there are some noteworthy limitations as well. First, as is true in many longitudinal studies, significant attrition occurred that limits the generalizability of the results of this study. Second, because of the school system used, ethnic comparisons were limited to only Blacks and Whites, impeding generalizability of the results in other ethnic groups. Future studies should replicate this investigation and include other ethnicities in the sample. Third, because risk factors for smoking onset comprise the focus of the overall project from which this study is taken, some ideal measures for this study were not included in the survey and therefore were not included as covariates in these analyses. For example, other variables that influence BMI especially in youth, such as diet, exercise, growth, and

development were not included in the survey or this study. Future studies of smoking onset and body weight should measure and include these variables in the analyses. Fourth, because youth smoking is episodic in nature, Black adolescents (81% of this sample) smoke less and are less likely to smoke, and few students in the current study reported daily or weekly smoking, smoking status was based on a monthly criteria that may increase the heterogeneity of smoking groups in terms of exposure to cigarettes. Future studies should attempt to more rigorously measure cigarette intake by quantifying specific numbers of cigarettes smoked in a certain time period. Additionally, the likely most problematic limitation in this study is that both smoking status and height/weight were self-reported; however, measurement of any of these variables would be costly and difficult, given such a large sample size, and self-reported height and weight is considered valid in large surveys, even in adolescents (Troy et al., 1995). Also, although there may be a tendency for adolescents to underestimate weight and overestimate height (Crawley & Portides, 1995), there is no reason to believe that a systematic bias exists in the relationship between smoking status and body weight. Nevertheless, future studies could use samples representative of both smokers and non-smokers and use measurements of height and weight, as well as biochemical verification of smoking status.

In summary, 3 or more years of smoking in adolescence are associated with no observed weight differences relative to never smoking. Moreover, cigarette smoking is associated with increases in relative weight, especially in Black males and females with 2 years of smoking and White females with 1 year of smoking. It is particularly intriguing that White females experienced one of the larger increases in BMI, as this group is the most likely to believe and use smoking for the purpose of weight control. For these reasons, intervention strategies aimed at correcting the potential ‘‘myths’’ about smoking and weight control should be included as a vital component in bolstering adolescent smoking prevention.

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