



PAPER

Smoking and weight loss attempts in overweight and normal-weight adolescents

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AIM: To explore the relationship between smoking and dieting in a cross-sectional nationally representative sample of young adolescents.

METHODS: Smoking was assessed by serum cotinine concentrations in 1132 adolescents aged 12–18 y enrolled in the NHANES III study. Information on adolescents' weight loss attempts were obtained by questionnaire. Normal weight was defined as a body mass index (BMI) less than the 85th percentile for age and gender. Overweight was defined as a BMI equal to or greater than the 85th percentile for age and gender. Nutritional intake was assessed with a 24 h recall and food frequency questionnaire.

RESULTS: There was a two-fold increase in smoking among normal-weight adolescent girls who reported trying to lose weight (23.7% vs 12.6%, $P < 0.01$). In contrast, prevalence of smoking was similar among overweight adolescent girls who tried to lose weight compared to those who did not (15.8% vs 14.1%, $P = 0.76$). Similar trends were observed in boys. However, overweight boys who were trying to lose weight were less likely to smoke than overweight boys who were not trying to lose weight (9.8% vs 24.5%, $P < 0.05$). There were no differences in body weight, BMI, caloric intake or fat intake among smokers and non-smokers. However, smokers reported eating less fruit and vegetables compared to non-smokers, and were over five times more likely to drink alcohol compared to non-smokers (odds ratio: $\geq 1 \times$ /month, 5.28 (3.82–7.28), $\geq 4 \times$ /month, 5.29 (3.58–7.82).

CONCLUSION: Tobacco use is common among normal weight adolescents trying to lose weight. Tobacco use is also associated with a cluster of other unhealthy dietary practices in adolescents.

International Journal of Obesity (2001) 25, 1381–1385

Keywords: adolescent; smoking; dieting

Introduction

Although it has been suggested that adolescents may use tobacco as a form of weight control, the prevalence of this practice is unknown. Ryan and colleagues have reported that adolescent Irish girls who report recent dieting are over twice as likely to smoke as adolescents who do not report weight loss attempts.¹ In addition, data from Tomeo *et al*² and French *et al*³ also suggest that smoking among girls was associated with almost a two-fold risk of dieting. In fact, the Expert Committee on the Evaluation and Treatment of Childhood Obesity recommends that *smoking cessation* should be one of the cornerstones of treating overweight

children, along with improved parenting skills, reduced caloric intake and increased activity levels.⁴

Previous studies on the relationship between smoking and dieting have relied on self-reported smoking behavior in adolescents. While self-reported smoking behavior is generally considered a reliable measure of actual smoking in adolescents, biases may exist in the data depending on the setting that the information was obtained.^{5,6} In addition, previous studies have also not examined whether smoking was more prevalent among either normal-weight or overweight adolescents who were trying to lose weight or whether nutritional intake was actually different among smokers and non-smokers.

To address the association of dieting and adolescent smoking, data were analyzed from the National Health and Nutrition Examination Survey, cycle III (NHANES III), a nationally representative sample of children and adults. Comprehensive data including weight, height, weight loss attempts, smoking habits, and serum cotinine levels allowed

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Received 20 April 2000; revised 11 January 2001;
accepted 21 January 2001

for analysis of the relationship of smoking to weight loss attempts in overweight and normal-weight adolescents. Data from both 24 h dietary recall and a food frequency questionnaire also allowed for the analysis of the relationship between smoking and nutritional intake among adolescents.

Methods

Sample

The National Health and Nutritional Examination Survey, Cycle III (NHANES III) is the seventh in a series of large national health examination surveys conducted in the United States since the 1960s. The first phase of NHANES III examined a nationally representative sample of children and adults between 1988 and 1991.⁷ The sample included 1331 children aged 12–18. Weights and heights were available on over 99% of the children. Serum cotinine levels were available on 1132 of the adolescents (85% of eligible cohort).

Anthropometrics

Body weight and height were measured according to previously described methods.⁷ Reference body mass index (BMI) percentiles were derived from the first National Health and Nutrition Examination Survey.⁸ This definition is in accordance with recommendations of the Expert Committee on Clinical Guidelines for Overweight in Adolescence⁹ and Expert Committee on Obesity Evaluation and Treatment.⁴ Normal weight was defined as a BMI (kg/m^2) less than the 85th percentile for age and gender; we classified adolescents with a BMI (kg/m^2) greater than the 85th percentile for age and gender as overweight.^{11,12}

Smoking, weight loss attempts and nutritional assessment

Adolescents were asked about frequency of smoking and number of cigarettes smoked per day. In addition, adolescents were also asked whether they had tried to lose weight within the last 12 months. Nutritional intake was assessed using a food frequency questionnaire and 24 h diet recall. The food frequency questionnaire included an assessment of alcohol intake. Previous studies have demonstrated the validity and reliability of reported adolescent alcohol intake.^{10–12} Intake of fat and energy were calculated using the USDA's Survey Nutrient Data Base (SNDB) based on the 24 h dietary recall, which the adolescents provided themselves. Interviews were conducted privately, by trained study staff, and staff performance was monitored routinely.

[†]Serum cotinine levels were not measured in the second phase of NHANES III (1992–1994).

Laboratory testing

Serum cotinine levels were measured using an isotope dilution, liquid chromatography, tandem mass spectrometry method. Cotinine, a long-lasting metabolite of nicotine ($t_{1/2} = 15–20$ h), is considered the most specific and sensitive biological marker of cigarette smoking.¹³ Serum cotinine cut-off levels of 15 ng/ml were used to designate smokers and non-smokers. Previous studies using the NHANES III data have demonstrated a 96% concordance between self-reported smoking status and serum cotinine levels above or below 15 ng/ml.¹⁴

Statistics

For the purposes of this study, 'adolescents' were defined as 12–18-y-old children and 'smokers' were defined as those adolescents with a serum cotinine level of 15 ng/ml or higher. Since the NHANES III study oversampled black people, Hispanic people, and younger adolescents, the data were adjusted to account for unequal selection by using sample weights provided by NHANES III. Differences in proportions were assessed using chi-square. Odds ratios were calculated using logistic regression. Multivariate logistic regression analysis was utilized to assess the independent effects of smoking on nutritional intake after adjusting for age, gender and family income. In order to adjust for complex sample design and clustering effects in the NHANES III sample, statistical significance was assessed using the balanced repeated replication method using the software package WesVarPC (Westat Inc., Rockville, MD).

Results

Overall concordance between self-reported smoking status and serum cotinine levels was 92.7% (Table 1). In particular, 96.5% of adolescents with cotinine levels below 15 ng/ml were self-reported non-smokers while 69.6% of adolescents with serum cotinine levels above 15 ng/ml were self-reported smokers. As a result, sensitivity for self-report was 77% and specificity was 95%. For both boys and girls, prevalence of both self-reported smoking and elevated serum cotinine levels were significantly more common in older adolescents compared to younger adolescents ($P < 0.001$). There was no difference in family income between smokers and non-smokers ($P = 0.95$).

Similar levels of smoking were present in normal-weight and overweight girls (17.0% vs 15.2%, $P = 0.51$). However,

Table 1 Serum cotinine levels and self-reported smoking in 12 to 18-y-old adolescents, NHANES III 1988–1991

Self-report	Cotinine < 15 mg/ml	Cotinine \geq 15 mg/ml
Non-smoker	n = 937	n = 49
Smoker	n = 34	n = 112

Self-report: sensitivity, 77%; specificity, 95%.

normal-weight girls who reported trying to lose weight were over twice as likely to smoke as normal-weight girls who did not try to lose weight (23.7% vs 12.6%, $P < 0.01$; odds ratio: 2.16 (1.26–3.72)). In addition, normal-weight female smokers who attempted to lose weight reported smoking almost twice as many cigarettes per day as normal-weight female smokers who did not try to lose weight (cigarettes/day: 14.1 ± 1.1 vs 8.6 ± 1.2 , $P < 0.001$). In contrast, there was no difference in smoking among overweight girls who tried to lose weight and those who did not (15.8% vs 14.1%, $P = 0.76$).

Similar results were observed in boys. Prevalence of smoking was similar in normal-weight and overweight boys (22.2% vs 19.4%, $P = 0.44$). There was a trend for normal-weight boys attempting weight loss to smoke more often than normal-weight boys who did not attempt to lose weight (35.5% vs 21.6%, $P = 0.11$; odds ratio 2.00 (0.86–4.61)). However, among overweight boys, those who were trying to lose weight were significantly less likely to smoke compared to those who were not trying to lose weight (9.8% vs 24.5%, $P < 0.05$).

Too few smoking adolescents were enrolled to determine whether racial differences existed in patterns of smoking and attempted weight loss. In addition, too few younger adolescents were smokers to determine whether smoking and attempted weight loss was related to age.

After adjusting for age and gender, there were no differences in reported caloric intake ($P = 0.75$) and total fat intake ($P = 0.13$) between adolescent smokers and non-smokers (Table 2). After adjusting for age, there was also no difference in BMI between smokers and non-smokers among either normal weight boys ($P = 0.26$), overweight boys ($P = 0.84$), normal-weight girls ($P = 0.36$), or overweight girls ($P = 0.98$). However, smokers reported significantly lower fruit and vegetable intake per day (Table 2). Adolescents who smoked had substantially lower levels of serum vitamin C and β -carotene compared to non-smokers (vitamin C, 35.9 ± 2.9 vs 47.4 ± 1.6 , $P < 0.001$; β -carotene, 0.19 ± 0.01 vs

0.26 ± 0.01 , $P < 0.001$). In addition, alcohol intake was significantly higher among smokers in both the 24 h dietary recall ($P < 0.001$) and the food frequency record ($P < 0.001$). In fact, adolescent smokers were over five times more likely to report alcohol consumption compared to adolescent non-smokers (odds ratio: $\geq 1 \times$ /month, 5.28 (3.82–7.28); $\geq 4 \times$ /month, 5.29 (3.58–7.82)).

Discussion

This study demonstrates over a two-fold increase in smoking among normal-weight adolescent girls who have tried to lose weight in a large, cross-sectional national cohort. By using objective measures of smoking status, this study has confirmed previous findings showing a similarly increased risk of smoking among girls who report either excessive weight concerns or frequent dieting.^{1–3} In contrast, there was no increased risk of smoking among either overweight girls or overweight boys trying to lose weight. In fact, overweight boys who were trying to lose weight were significantly less likely to smoke than those who were not trying to lose weight. These results imply that normal-weight girls may adopt more pathological methods of weight loss than overweight girls and boys.

Overall dietary intake was worse in adolescents who smoked compared to those who did not. While there were no detectable differences in reported caloric or fat intake among adolescent smokers and non-smokers, smokers ate significantly less fresh fruit and vegetables. Similar findings have been previously reported by Coulson and colleagues.¹⁵ Studies in adults also report less healthy diets in smokers compared to non-smokers. A meta-analysis of over 60 studies in adults examining patterns of nutrient intake in smokers revealed a slight *increase* in total calories and fat among smokers as well as decreased intake of fiber, fruit and vegetables.¹⁶ Adolescent smokers were also more than five times more likely to consume alcohol on a regular basis than non-smokers. In addition, Crisp and colleagues have

Table 2 Dietary intake in smokers and non-smokers, NHANES III 1988–1991

	Non-smokers	Smokers ^a	Difference	Adjusted difference ^b
Reported 24 h intake:				
Energy (kcal)	2338 ± 32	2553 ± 80	215 ± 72**	27 ± 83
Percentage of calories from fat	34.0%	33.3%	0.7%	1.0 ± 0.7
Alcohol (g)	1.12 ± 0.24	13.17 ± 2.62	12.05 ± 2.61***	10.02 ± 2.57***
Food frequency:				
Fruit/day	0.89 ± 0.02	0.47 ± 0.04	– 0.42 ± 0.04***	– 0.38 ± 0.05***
Vegetables/day	1.27 ± 0.04	1.08 ± 0.07	– 0.19 ± 0.06**	– 0.22 ± 0.08**
Alcohol ($\geq 1 \times$ /month)	15.1 ± 1.5%	48.4 ± 3.2%	33.3 ± 3.99%***	24.1 ± 4.2%***
Alcohol ($\geq 4 \times$ /month)	6.9 ± 1.1%	28.3 ± 3.3%	21.4 ± 3.7%***	17.0 ± 3.9%***

Mean ± s.e.

^aSerum cotinine level ≥ 15 ng/ml.

^bDifference adjusted for age, gender, body mass index.

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.

demonstrated more than a seven-fold increase in alcohol consumption among adolescents who smoke.¹⁷ Therefore, this study confirms the clustering of adolescent smoking with adverse health and dietary behaviors which has been previously described.^{18,19}

Previous studies have demonstrated that almost 40% of adolescents believe that smoking can help control their weight.^{20,21} Although the cross-sectional design of the study precludes any definitive conclusions on the relationship between smoking and weight loss, the finding of similar BMI as well as caloric and fat intake in both smokers and non-smokers argues against any major relationship between smoking and appetite suppression. Although there is ample evidence that smoking cessation in adults typically leads to 3–5 kg weight gain, there is no evidence that smoking initiation leads to weight loss.²² Both the Coronary Artery Risk Development in Young Adults Study (CARDIA) and the Nurses Health Study demonstrate similar degrees of weight gain over a 7–8 y period in those who initiated smoking and those who never smoked.^{23,24} Unfortunately, the NHANES III data does not include objective measures of physical activity or energy expenditure which could be influenced by nicotine or other cigarette byproducts.²⁵

The causal mechanism for the association between smoking and dieting among adolescents remains speculative. While it is likely that many adolescents begin smoking in order to lose weight, it is also possible that dieting leads to increased rates of smoking and alcohol use. Krahn and colleagues have hypothesized that the feelings of deprivation associated with dieting may increase the desire for both cigarettes and alcohol.²⁶ In animal models, food deprivation is one of the most powerful stimulants for increased self-administration drugs, alcohol and nicotine.²⁷ In young women, Jones *et al*,²⁸ Hatsukami *et al*²⁹ and Beary *et al*³⁰ have shown that the prevalence of daily alcohol use increases dramatically after the onset of bulimia.

In this study, serum cotinine levels were used as an objective measure of smoking. While previous studies have generally confirmed the reliability of self-reported smoking, many adolescent smokers underestimate the amount of cigarettes they smoke or even deny smoking.⁶ Murray and colleagues have demonstrated that adolescent disclosure of cigarette smoking is also different when adolescents are promised confidentiality but not anonymity compared to when the adolescents are promised both confidentiality and anonymity.⁶ In this study, the results were both confidential and anonymous. Nevertheless, the sensitivity and specificity of self-reported smoking among adolescents was 77% and 95%, respectively, which is comparable to results obtained by other authors using similar methodology.^{31–33}

In summary, the use of the NHANES III data and its inclusion of serum cotinine levels provides the most objective measure of the relationship between smoking and attempted weight loss in adolescence. Normal-weight adolescent girls who are trying to lose weight are particularly likely to smoke. In addition, these results also highlight the

clustering of high-risk health patterns among adolescents—smoking, dieting, alcohol consumption, and poor fruit and vegetable intake. Although many adolescents believe that smoking will decrease their weight, this study demonstrates similar BMI, caloric intake and fat intake among smokers.

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