Nicotine Dependence Among Adolescent Smokers

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Objectives: To assess nicotine dependence among adolescents to determine whether quitting smoking is associated with the emergence of nicotine withdrawal symptoms and craving, and to identify the factors associated with these symptoms.

Design: Cross-sectional survey.

Participants: We studied 2197 10th-grade students in 6 San Jose, Calif, high schools.

Main Outcome Measures: Smoking status; history of quitting smoking; Modified Fagerstrom Tolerance Questionnaire (mFTQ) scores; subjective nicotine withdrawal symptoms from the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition; Center for Epidemiologic Studies Depression Scale (CES-D); and saliva cotinine levels.

Results: Of the 485 participants who reported having smoked during the past 30 days, 249 reported previous attempts to quit smoking. Among the participants who had attempted to quit, the self-reported frequencies of subjective withdrawal symptoms were a strong need to smoke (45.4%), nervous and tense (31.8%), restless (29.4%), irritable (28.7%), hungry (25.3%), unable to concentrate (21.7%), miserable and sad (15.3%), and trouble sleeping (12.8%). The total number of withdrawal symptoms was correlated with the mFTQ score (Spearman $r=0.51; P<.001$). In a stepwise linear regression analysis, the mFTQ score and the CES-D score accounted for approximately 35% of the variance in total number of withdrawal symptoms ($R^2=0.35; P<.001$). Males smoked significantly more and had significantly higher mFTQ scores than did females, while female smokers had significantly higher CES-D scores than did their male counterparts.

Conclusions: Considerable levels of nicotine dependence were present among adolescent smokers. Use of mFTQ scores; withdrawal symptoms including nicotine craving; CES-D scores; and saliva cotinine levels may be helpful in designing cessation programs targeted to nicotine-dependent adolescents.


Editor’s Note: With all of the other problems associated with just getting through adolescence, teenagers certainly do not need to add nicotine withdrawal symptoms. Now how do we get that message to preteens?

Catherine D. DeAngelis, MD

The ranks of adolescent smokers are growing. In 1995, about 63.5% of high school seniors reported having smoked, and 34% reported smoking cigarettes during the previous 30 days. Daily smoking prevalence was reported as 10%, 18%, and 22% in grades 8, 10, and 12, respectively. These rates would be higher if high school dropouts were included in study samples. Even more disconcerting is evidence indicating that the percentage of 8th and 10th graders who report having smoked during the past 30 days increased almost 50% from 1991 to 1995. Estimates derived from this recent finding indicate that about 5 million persons aged 0 to 17 years in 1995 will die prematurely of a smoking-related illness.

In response, researchers are revisiting basic questions about the factors that influence smoking among adolescents. In general, social and environmental factors, such as peer and parental smoking and tobacco advertising, are probably the most important variables affecting smoking onset. Indeed, research on the social factors that mediate smoking onset has provided the primary conceptual framework on which state-of-the-art smoking prevention programs are based. However, the effects of smoking prevention programs tend to be short-lived. Thus, it is surprising that comparatively little attention has been given to the factors that maintain smoking or affect the transition from experimental smoking to regular use. In particular, the possible influence of nico-
PARTICIPANTS AND METHODS

PARTICIPANTS

During May 1996, 10th graders (N=2246) enrolled in 6 northern California high schools were asked to complete a survey designed to detect the presence of physical characteristics and behaviors related to the risk for coronary heart disease. Because of their limited English proficiency, 49 participants were excluded from the study, resulting in 2197 total participants. The study included slightly more males (52.4%) than females (47.6%). The ethnic grouping of participants was as follows: Hispanic, 35.7%; Asian (including Cambodian, Vietnamese, Chinese, Japanese, and Thai), 32.5%; white, 17.1%; black, 5.8%; Native American, 0.9%; multiethnic, 4.9%; and other, 3.1%. The percentage of students with at least 1 parent who had completed at least some college was 50% (80% responded to this item).

PROCEDURES

Assessments were conducted during regular classroom periods by trained staff during 2 days in each of the 6 schools. Passive parental consent was used. Parents were informed in advance by mail and given the opportunity to withdraw their child from participation at any time, without prejudice. Students were given the opportunity to decline participation at the time of assessments. School personnel did not participate in any part of the data collection. Confidentiality was maintained by using unique identification numbers. Each survey contained 2 cover sheets, the first with a label printed with the student’s name and the second with a label containing only the identification number. Students were instructed to remove the cover sheet that included their name once they received the survey, so only the cover sheet that included nothing but the identification number remained. The study was approved by the Stanford University School of Medicine (Palo Alto, Calif) Committee for the Protection of Human Subjects in Research.

MEASURES

Smoking Prevalence

Participants reported the number of cigarettes they had smoked during the last 30 days according to the following categories: none, only 1 puff, part or all of 1 cigarette, 2 to 4 cigarettes, 5 to 20 cigarettes, and more than 1 pack.

History of Attempts to Quit Smoking

Participants were asked whether they had “ever tried stopping smoking for good.” Answers were recorded as yes or no, and all who responded yes were then queried about withdrawal symptoms.

Modified Fagerstrom Tolerance Questionnaire

The Fagerstrom Tolerance Questionnaire was developed to help researchers and clinicians categorize smokers according to their degree of nicotine dependence. In general, nicotine dependence can be characterized as the compulsive use of cigarettes to achieve pleasurable effects and to avoid withdrawal symptoms. We modified the Fagerstrom Tolerance Questionnaire (mFTQ) by rescaling the items to provide more response choices and by analyzing daily cigarette consumption separately. The 5 questions included in our modification refer to the following aspects of cigarette consumption patterns:

1. Difficulty refraining from smoking where it is forbidden;

2. Tierce co-occur more frequently than would be expected by chance.

3. In addition, in this sample, more females than males reported smoking to relieve withdrawal symptoms. In a study of 77 adolescent smokers conducted in the context of a youth detention center, Dozois and colleagues found that 42% reported relatively high levels of nicotine dependence on a standardized measurement, and almost 80% reported nicotine cravings associated with previous attempts to quit.

We do not know the extent to which nicotine dependence may exert control over the smoking behavior of adolescents. Therefore, we conducted a study with the following objectives: (1) to assess nicotine dependence among adolescents by using a state-of-the-art self-report measure of nicotine dependence (the modified Fagerstrom Tolerance Questionnaire [mFTQ]), (2) to determine whether quitting smoking is associated with the emergence of nicotine withdrawal symptoms and craving, and (3) to identify the factors associated with these symptoms.

To accomplish these objectives, we studied the relationship among the total number of reported nicotine withdrawal symptoms, the level of nicotine dependence, the symptoms of depression, and body weight in a sample of 249 adolescent smokers who reported previous attempts to quit smoking. Our interest in the symptoms of depression stems from the increasing body of work suggesting that smoking and major depression or psychological distress co-occur more frequently than would be expected by chance. Potential sex differences in nicotine depen-
2. Smoking more in the morning;
3. Smoking when bedridden because of illness;
4. Depth of inhalation;
5. Time after awakening before smoking the first cigarette.

Possible scores on our version of the FTQ range from 5 to 25. Good test-retest reliability has been established in previous research. Test-retest correlations for the 5 questions were 0.78, 0.71, 0.83, 0.79, and 0.90, respectively. We previously documented the validity of this measure among adult smokers by demonstrating that it predicted craving during an 8-week period. The magnitude of the relationship was comparable to that reported for several biochemical indices of tobacco smoke intake. Test-retest reliability ($r=0.68$) for the total mFTQ score was established previously by our research team for a sample of adolescent smokers.

Subjective Withdrawal Symptoms Index

Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition\(^2\) (DSM-IV)--derived ratings of subjective withdrawal symptoms included the question “How did you feel when you stopped smoking?” Yes-no response options were given for the following affective states: miserable and sad, trouble sleeping, more irritable, nervous and tense, unable to concentrate, restless, craving, and hungry. A total of 8 possible withdrawal symptoms were summed for each participant to yield a withdrawal symptoms index. In this index, we included an assessment of craving, defined as a strong need to smoke, despite the fact that craving, as a component of tobacco dependence, is not included in the DSM-IV.\(^2\) We have found that immediate postcessation craving is a useful predictor of smoking relapse in adults.\(^2\)\(^1\) In addition, many tobacco researchers view craving as one of the most important features of nicotine withdrawal.\(^2\)\(^1\)\(^2\)

Symptoms of Depression

We used the 20-item Center for Epidemiologic Studies Depression Scale (CES-D) to measure the symptoms of depression. The scale, which was developed for use in studies of the epidemiology of the symptoms of depression in the general population, has high internal consistency.\(^2\)\(^3\) The CES-D has been used in numerous epidemiologic studies of adolescent depression. Possible CES-D scores range from 0 to 60, with higher scores indicating more symptoms of depression.

Saliva Cotinine Level

The level of cotinine, a metabolite of nicotine, was measured to serve as a potential index of nicotine dependence. Saliva samples were collected by having participants hold a dental roll in their mouth until it was saturated.\(^2\)\(^6\) Cotinine concentrations were measured according to the method of Jacob et al.\(^2\)\(^7\) The half-life of cotinine as measured in saliva is approximately 16 hours.\(^2\)\(^8\)

Body Mass Index

Body mass index is generally considered the preferred index of relative body weight as a reflection of adiposity.\(^2\)\(^9\) The body mass index was computed by dividing the weight in kilograms by the height in meters squared. The standing height was measured to the nearest millimeter by using a portable direct reading stadiometer. Body weight was determined to the nearest 0.1 kg by using digital scales. Participants removed shoes, jackets, and heavy clothing before they were measured.

Among the 249 smokers who reported a previous attempt to quit smoking, 94% to 96% responded to the items about nicotine withdrawal. The group of 249 who had attempted to quit smoking constitutes our study sample.

Characteristics of the study sample are given in Table 1. National data show comparable 30-day smoking rates for 10th graders.\(^1\) Within our sample, males smoked significantly more during the past 30 days than did females (41.1% of the males vs 23.2% of females smoked more than a pack of cigarettes; $\chi^2(3) = 11.79$ [n = 249], $P = .008$).

**RESULTS**

**SMOKING PREVALENCE**

Of the 2197 10th graders surveyed, 2053 (93.4%) answered the questions about cigarette use during the past 30 days. Of the 2053 participants, 485 reported having smoked at least part or all of 1 cigarette during this period. Of the 485 smokers, 249 (51.3%) reported a previous attempt to quit smoking for good, 221 reported not having attempted to quit smoking, 10 participants were excluded from the analysis because of inconsistent responses on smoking questions, and 5 did not respond.
The reported rates of nicotine withdrawal symptoms are given in the following tabulation:

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Percentage Reporting*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Craving</td>
<td>45.4</td>
</tr>
<tr>
<td>Nervous and tense</td>
<td>31.8</td>
</tr>
<tr>
<td>Restless</td>
<td>29.4</td>
</tr>
<tr>
<td>More irritable</td>
<td>28.7</td>
</tr>
<tr>
<td>Hungry</td>
<td>25.3</td>
</tr>
<tr>
<td>Unable to concentrate</td>
<td>21.7</td>
</tr>
<tr>
<td>Miserable and sad</td>
<td>15.3</td>
</tr>
<tr>
<td>Trouble sleeping</td>
<td>12.8</td>
</tr>
</tbody>
</table>

*The maximum possible sample size was 249. Sample sizes changed for each variable because of missing data. The range was 235 to 238.

Of the 249 participants, 34.9% reported more than 2 symptoms, and 30.5% reported no withdrawal symptoms during previous attempts to quit smoking. Craving was the most frequently reported symptom, while trouble sleeping was the least frequently reported symptom. No significant differences were found in the mean number of withdrawal symptoms or in the frequency of specific withdrawal symptoms between males and females.

Those who reported experiencing strong cravings during a previous quit attempt had significantly higher mFTQ scores ($t_{213}$ = −6.6, $P < .001$), higher scores on the CES-D ($t_{227}$ = −2.2, $P = .03$), and higher saliva cotinine levels ($t_{207}$ = −2.6, $P = .01$).

**FACTORS ASSOCIATED WITH NICOTINE WITHDRAWAL SYMPTOMS**

To identify factors associated with nicotine withdrawal, we conducted a stepwise multiple regression analysis with

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**Table 1. Smoking Prevalence Among Male and Female Adolescents Who Attempted to Quit Smoking**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Males (n=141)</th>
<th>Females (n=108)</th>
<th>Total (N=249)</th>
</tr>
</thead>
<tbody>
<tr>
<td>mFTQ score; range, 5-25†</td>
<td>10.94 (4.09)</td>
<td>9.54 (3.65)</td>
<td>10.35 (3.96)</td>
</tr>
<tr>
<td>Withdrawal symptoms index; range, 0-8</td>
<td>2.01 (2.20)</td>
<td>2.07 (2.11)</td>
<td>2.04 (2.16)</td>
</tr>
<tr>
<td>Body mass index</td>
<td>23.21 (4.60)</td>
<td>23.32 (4.42)</td>
<td>23.26 (4.51)</td>
</tr>
<tr>
<td>CES-D score; range, 0-60‡</td>
<td>20.66 (11.72)</td>
<td>25.56 (11.73)</td>
<td>22.78 (11.95)</td>
</tr>
<tr>
<td>Saliva cotinine level§</td>
<td>27.42 ng/mL (65.71)</td>
<td>20.11 ng/mL (51.91)</td>
<td>24.32 ng/mL (60.23)</td>
</tr>
<tr>
<td>No. (%) of cigarettes smoked during last 30 d†</td>
<td>18 (12.8)</td>
<td>26 (24.1)</td>
<td>44 (17.7)</td>
</tr>
<tr>
<td>Part or all of 1</td>
<td>34 (24.1)</td>
<td>25 (23.1)</td>
<td>59 (23.7)</td>
</tr>
<tr>
<td>2 to 4</td>
<td>31 (22.0)</td>
<td>32 (29.6)</td>
<td>63 (25.3)</td>
</tr>
<tr>
<td>5 to 20</td>
<td>58 (41.1)</td>
<td>25 (23.1)</td>
<td>83 (33.3)</td>
</tr>
<tr>
<td>More than 20</td>
<td>44 (31.3)</td>
<td>26 (24.1)</td>
<td>70 (28.7)</td>
</tr>
</tbody>
</table>

†P < .01, females vs males.
‡P < .001, smokers who attempted to quit vs nonsmokers.
§Males, n=125; females, n=92; and total, N=217.

**Table 2. Spearman Correlations, P Values, and Sample Sizes Among Variables for Adolescents Who Attempted to Quit Smoking (N=249)**

<table>
<thead>
<tr>
<th>Variable</th>
<th>BMI</th>
<th>CES-D</th>
<th>mFTQ</th>
<th>No. of Cigarettes Smoked During Last 30 d</th>
<th>Saliva Cotinine Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Withdrawal symptoms index</td>
<td>−0.03</td>
<td>0.21</td>
<td>0.51</td>
<td>0.36</td>
<td>0.15</td>
</tr>
<tr>
<td>r</td>
<td>.61</td>
<td>.01</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.03</td>
</tr>
<tr>
<td>n</td>
<td>238</td>
<td>233</td>
<td>221</td>
<td>244</td>
<td>213</td>
</tr>
<tr>
<td>BMI</td>
<td>r</td>
<td>0.11</td>
<td>0.2</td>
<td>0.01</td>
<td>−0.07</td>
</tr>
<tr>
<td>r</td>
<td>.09</td>
<td>.11</td>
<td>.96</td>
<td>.30</td>
<td></td>
</tr>
<tr>
<td>n</td>
<td>234</td>
<td>221</td>
<td>243</td>
<td>212</td>
<td></td>
</tr>
<tr>
<td>CES-D</td>
<td>r</td>
<td>.01</td>
<td>−0.05</td>
<td>−0.16</td>
<td>−0.16</td>
</tr>
<tr>
<td>r</td>
<td>.93</td>
<td>.1</td>
<td>.41</td>
<td>.02</td>
<td></td>
</tr>
<tr>
<td>n</td>
<td>219</td>
<td>240</td>
<td>210</td>
<td></td>
<td></td>
</tr>
<tr>
<td>mFTQ</td>
<td>r</td>
<td>.58</td>
<td>.31</td>
<td>.01</td>
<td>.01</td>
</tr>
<tr>
<td>r</td>
<td>.58</td>
<td>.41</td>
<td>.19</td>
<td>.16</td>
<td></td>
</tr>
<tr>
<td>n</td>
<td>226</td>
<td>196</td>
<td>217</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of cigarettes smoked during last 30 d</td>
<td>r</td>
<td></td>
<td></td>
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<td>&lt;.001</td>
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<td></td>
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<tr>
<td>n</td>
<td>217</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* BMI indicates body mass index; CES-D, Center for Epidemiologic Studies Depression Scale; mFTQ, modified Fagerstrom Tolerance Questionnaire; and ellipses, not applicable.
the variables listed in Table 1 as independent factors and the withdrawal symptoms index as the dependent variable. Only the mFTQ and CES-D scores met the standard for statistical significance ($P < .05$), together accounting for approximately 35% of the variance in total withdrawal symptoms ($R^2 = 0.35; P < .001$). The mFTQ scores alone accounted for approximately 31% ($R^2 = 0.31; P < .001$) of the variance in nicotine withdrawal symptoms.

The Figure depicts the relationship between mFTQ scores and nicotine withdrawal. The mean withdrawal symptoms index values increased with each successive quartile of mFTQ scores.

**COMMENT**

Nicotine dependence and withdrawal symptoms were present among adolescent smokers by 16 years of age. The mFTQ scores and symptoms of depression accounted for approximately 35% of the variance in the withdrawal symptoms index. This finding helps to validate self-reported measures of nicotine dependence among adolescent smokers. In addition, despite previous reports by other investigators, we found no significant differences between males and females in the reporting of specific withdrawal symptoms.

Our results indicate that adolescent smokers, like their adult counterparts, report a range of withdrawal symptoms associated with quitting. However, the relative likelihood to experience a specific withdrawal symptom may be different between adults and adolescents.8,10,30 Findings from our study and other research suggest that craving is usually reported more frequently than other symptoms and is often the symptom most closely related to failed smoking cessation.8,10,22,25 For these reasons, despite its absence in the DSM-IV,25 we included craving in the withdrawal symptoms index.

Despite the controversial nature of craving, it was clearly a frequent result of quitting among adolescents in our sample (45.4%). In addition, craving was significantly associated with greater cotinine levels, symptoms of depression, and mFTQ scores. The prevalence of other symptoms may vary widely among different samples according to age and smoking levels, but craving is consistently reported as the most frequent withdrawal symptom among adolescents.8,10,12,31 On the whole, the evidence from this study suggests that nicotine dependence among adolescents exists as a measurable psychophysiologic construct and a highly subjective but meaningful affect that includes strong motivational desires to smoke.

Given the markedly higher rates of smoking among adult samples, we cannot adequately compare mean mFTQ scores between adult samples and this group of adolescents. Nevertheless, the mean mFTQ score for the heaviest adolescent smokers in our study was 12.6. This compares with a mean mFTQ score of 14.9 reported for adults who smoked 20 or more cigarettes a day.31 While the overall dependence level may be difficult to compare between adults and adolescents, specific dependence phenomena embedded in the mFTQ score may differ between these groups.30 Differential access to cigarettes and opportunities for cigarette smoking may have a role in the different profiles of nicotine dependence between adults and adolescents.

In adults, body weight tends to correlate with the number of cigarettes smoked,32-34 and higher-dose smokers tend to gain more weight during attempts to quit.35 In contrast, in our sample of adolescent smokers, body fatness was not associated with nicotine dependence. However, the cross-sectional nature of our design limits the conclusions that can be drawn about the association between weight and smoking in adolescents. Clearly, prospective studies of this relationship are required.

Although conventional wisdom implicates weight gain as an important factor in smoking relapse, the existing data tell a different story. For example, Perkins36 concluded from a review of the literature that little direct evidence favors such a relationship. He noted that most adult smokers do not report the following: (1) a relationship between smoking and weight, (2) the use of smoking to control weight, (3) a concern about weight gain after smoking cessation, or (4) a previous relapse caused by weight gain during smoking cessation.

Evidence is increasing that smoking and depression covary more than would be expected by chance.13-15 Our finding that CES-D scores were significantly associated with the number of reported withdrawal symptoms among adolescents adds to this database. Overall, mean CES-D scores among adolescent smokers who attempted to quit were higher than the mean scores of nonsmokers in the sample. The significantly higher level of depression symptoms among female smokers who attempted to quit warrants further investigation.

While substantial levels of nicotine dependence and withdrawal symptoms were reported in our sample of adolescents, more refinement of the diagnostic criteria is needed. prospectively designed studies that clarify the nature of nicotine withdrawal and craving among young smokers may improve smoking cessation programs for adolescents. In our sample, the significant association of saliva cotinine levels with all other variables except the body mass index strengthens the validity of our findings but does not support temporal relationships between other smoking variables and cotinine levels, owing to the cross-sectional design of the study.

Studies of adult smoking cessation programs show
significantly lower rates of maintained abstinence from smoking among those with higher baseline levels of dependence and withdrawal. To date, only 1 cessation trial involving nicotine replacement has been reported for adolescent smokers. That trial showed only a slight reduction in withdrawal symptoms with the use of a nicotine patch for 8 weeks, and only 1 of 22 adolescent smokers remained abstinent after 6 months of the trial. The small reduction in withdrawal symptoms may have contributed to the low level of maintained smoking abstinence at the end point of the study. Combined with our data and the data from others, these results demonstrate that highly nicotine-dependent adolescent smokers may require better preparation before challenging the difficulty of smoking cessation.

Although our results are limited by the cross-sectional design of the study, we found that a measure of nicotine dependence was strongly correlated with withdrawal symptoms in adolescent smokers and at least suggested a higher susceptibility to withdrawal symptoms and a higher rate of failure to quit smoking. While cigarette consumption levels are typically used to indicate the level of dependence, the mFQT score and specific withdrawal symptoms may be more sensitive and specific to nicotine-related dependence phenomena among adolescent smokers. More common use of these measures may help future smoking cessation programs to identify adolescent smokers who are likely to fail at attempts to quit smoking and to place them in more aggressive treatment regimens.

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