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Attention-Deficit/Hyperactivity Disorder (ADHD) Confounds Nicotine Withdrawal Self-Report in Adolescent Smokers

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Abstract

Objective—Individuals with ADHD are more likely than those without ADHD to initiate smoking and develop nicotine dependence. Recent research indicates that adults with ADHD experience more severe nicotine withdrawal symptoms than those without ADHD. However, little is known about nicotine withdrawal in adolescent smokers with history of ADHD.

Methods—Among a sample of 134 nicotine-dependent adolescents entering a smoking cessation research study, participants completed the Minnesota Nicotine Withdrawal Scale (MNWS) and lifetime diagnostic assessment for ADHD during the baseline visit. Responses on individual items and MNWS total score were compared between participants with and without history of ADHD. Additionally, correlations between MNWS responses and current ADHD symptoms were investigated among participants with history of ADHD.

Results—Forty-eight participants (36%) met lifetime ADHD criteria. Adolescent smokers with history of ADHD scored significantly higher on MNWS than those without history of ADHD. Among participants with history of ADHD, responses on the MNWS difficulty concentrating, restlessness/impatience, and anxiety/nervousness items each correlated positively with several current ADHD symptoms.

Conclusion—Treatment-seeking adolescent smokers with history of ADHD are more likely to endorse nicotine withdrawal symptoms than those without history of ADHD. However, it does not appear that the symptoms reported in this sample represent a valid “withdrawal syndrome,” particularly because these smokers had not yet formally attempted to quit. Rather, the data likely reflect common features between ADHD and nicotine withdrawal. Smoking research, particularly

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Declaration of Interest

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among adolescents in whom ADHD is so common, should carefully consider the complex issue of comorbid ADHD and nicotine dependence.

Keywords

Nicotine; Tobacco; Smoking; Withdrawal; ADHD; Adolescent

Introduction

Smoking initiation typically occurs in adolescence. In the United States, the average age of first cigarette use is 16.9 years, while 19% of 16–17 year olds and 33% of 18–20 year olds have smoked in the last month (1). Recent research indicates that adolescents may be more vulnerable than adults to developing nicotine dependence upon smoking initiation (2–5).

Among adolescents, those with Attention-Deficit/Hyperactivity Disorder (ADHD) may be at particularly high risk for nicotine dependence. Individuals with ADHD become regular smokers at an earlier age, and are about twice as likely to develop nicotine dependence when compared with their non-ADHD counterparts (6,7). Genetic, neurobiological, behavioral, environmental, and psychopathological mechanisms have been proposed to account for shared vulnerability to ADHD and nicotine dependence (8,9).

Of additional concern is that individuals with ADHD may have more difficulty quitting smoking (10,11). It has been suggested that smokers with ADHD may be “self-medicating” with nicotine to reduce ADHD symptoms (12,13). Withdrawal from nicotine may therefore be complicated by re-emergence of ADHD symptoms. Among adult smokers, those with ADHD demonstrate more severe irritability, difficulty concentrating, and decreased response inhibition, compared with those without ADHD, upon withdrawal from nicotine (14–15). Complicating this issue is that there may be significant overlap between symptoms of ADHD and nicotine withdrawal, including difficulty concentrating and restlessness/impatience. While increasing attention has focused on adolescent nicotine withdrawal (16–22), notably absent from the literature are studies examining ADHD and nicotine withdrawal in adolescent smokers.

The purpose of the present analysis was to examine the relationship between lifetime diagnosis of ADHD and self-reported nicotine withdrawal symptoms within a group of treatment-seeking adolescent smokers. Data came from a larger randomized clinical trial (N=134), which examined placebo-controlled bupropion +/- contingency management (2x2 design) for adolescent smoking cessation (results forthcoming).

Methods

Participant Eligibility and Recruitment

The parent treatment study required adolescents to a) be 12 to 21 years old, b) smoke at least 5 cigarettes per day, c) have baseline urine cotinine > 100 ng/mL, d) be non-pregnant and use birth control to avoid pregnancy, e) lack current substance abuse/dependence aside from nicotine, f) have no history of serious psychiatric or medical illness, g) have no suicide attempts in the past year or suicidal ideation in the past month, and h) not be taking current pharmacotherapy for smoking cessation treatment.

Recruitment occurred primarily through local secondary schools, colleges, universities, and community media advertisements. If an initial telephone screen suggested potential eligibility, participants were scheduled for an informed consent and baseline assessment visit. Parental consent was obtained for all adolescents below age 18.

Assessments

Several measures were collected at the baseline assessment visit. Only those measures relevant to the current analysis are presented below.

ADHD—The Childhood Symptoms Scale (23), a validated, DSM-IV-based instrument, combined with confirmatory clinical interview, was used to determine lifetime history of ADHD (as part of diagnostic assessment). Among participants determined to have a positive history of ADHD, the ADHD-Rating Scale (ADHD-RS) (24) was additionally used to evaluate self-reported current ADHD symptoms (as part of baseline symptom evaluation). The ADHD-RS is comprised of 18 individual items (nine each reflecting inattention and hyperactivity/impulsivity), each rated on a 4-point scale (never or rarely=0, sometimes=1, often=2, very often=3). Thus, the total possible range for the ADHD-RS is 0–54 (0–27 for each of inattention and hyperactivity subscales).

Nicotine Withdrawal—Participants provided self-report of nicotine withdrawal symptoms using the Minnesota Nicotine Withdrawal Scale (MNWS) (25). The MNWS is comprised of eight individual items, each rated on a 5-point scale (none=0, slight=1, mild=2, moderate=3, severe=4). Thus, the total possible range for the MNWS is 0–32. The MNWS items are based on the seven DSM-IV symptoms of nicotine withdrawal, with an added craving item.

Other Baseline Assessments—On the basis that the relationship between ADHD status and withdrawal might be confounded by other variables, we also ascertained basic demographic and smoking history data, and assessed craving (Questionnaire of Smoking Urges—Brief (QSU-B) (26)) and nicotine dependence (Fagerström Test for Nicotine Dependence (FTND) (27) and the Hooked on Nicotine Checklist (HONC) (28)).

Data Analysis

Descriptive statistics were used to characterize demographic variables and other variables of interest. Differences in continuous variables were assessed using a Two Sided Wilcoxon Rank Sum Test. Differences in categorical variables were assessed using a Two Sided Fisher Exact Test. The following variables were considered as adjustment variables in all adjusted regression models: a) age, b) age the participant became a regular smoker, and c) years of regular smoking. These variables were sufficiently collinear to allow age (most associated with ADHD status) to represent the construct in all regression models.

For all statistical comparisons between participants with and without history of ADHD, individual MNWS responses were dichotomized in two ways: a) 0 (absent) versus ≥ 1 (present) and b) < 3 versus ≥ 3 (high level). The first approach was used to detect the presence versus absence of withdrawal symptoms, and the latter was used to detect a higher (i.e., more clinically significant) symptom severity. To test the hypothesis that participants with history of ADHD endorse greater baseline withdrawal symptoms than those without history of ADHD, logistic regression models were used to determine the association between ADHD status and response to each item on the MNWS while controlling for age at study entry.

To evaluate potential overlap between symptoms of ADHD and nicotine withdrawal among participants with history of ADHD, correlations between ADHD-RS and MNWS (total scores and individual item scores) were tested using Spearman's Rho.

All statistical analyses were performed using SAS v.9.1.3 (SAS Institute, Cary, NC).

Results

Sample Characteristics

Upon enrolling in an adolescent smoking cessation study, 134 participants (78 males and 56 females) were assessed for history of ADHD. Characteristics of participants with ($n = 48$) and without ($n = 86$) history of ADHD are shown in Table 1. Participants with history of ADHD were significantly younger (mean age: 17.6 versus 18.9), initiated smoking at an earlier age (14 versus 15), and scored significantly higher on MNWS (10.9 versus 6.3) than those without history of ADHD.

Relationship Between Lifetime ADHD Status and Withdrawal

The univariate analysis of ADHD status association with MNWS individual item scores was initially performed without control for possible covariates (see **Data Analysis**). Participants with history of ADHD had significantly higher odds of endorsing *depressed mood*, *difficulty concentrating*, *restlessness/impatience*, and *increased appetite* on MNWS.

When the analysis was adjusted for possible covariates, there was some diminution of the effect of ADHD status on MNWS individual item scores as measured by the odds ratio and the overall level of significance. No items gained further significance, but the *depressed mood* item lost statistical significance. Participants with history of ADHD were more likely to endorse (score ≥ 1 ; see Table 2) *difficulty concentrating*, *restlessness/impatience*, and *increased appetite* than those without history of ADHD. Additionally, participants with history of ADHD, relative to those without, were more likely to endorse high-level (score ≥ 3) *insomnia* ($p = 0.045$; OR = 3.0; 95% CI = 1.0–8.6), *anxiety/nervousness* ($p = 0.039$; OR = 2.9; 95% CI = 1.1–8.2), *difficulty concentrating* ($p = 0.014$, OR = 4.8; 95% CI = 1.4–16.7), *restlessness/impatience* ($p = 0.004$; OR = 4.9; 95% CI = 1.6–14.8), and *increased appetite* ($p = 0.002$; OR = 9.6; 95% CI = 2.3–39.8).

Relationship Between ADHD Symptoms and Withdrawal Symptoms—Adolescent Smokers with History of ADHD

Participants with history of ADHD (i.e., either past or current) completed the ADHD-RS to self-report current ADHD symptoms. Among these 48 participants, MNWS total score did not correlate significantly with number of total symptoms endorsed on ADHD-RS (Rho = 0.194; $p = \text{NS}$), ADHD-RS total score (Rho = 0.199; $p = \text{NS}$), ADHD-RS inattentive score (Rho = 0.205; $p = \text{NS}$), or ADHD-RS hyperactive/impulsive score (Rho = 0.131; $p = \text{NS}$). However, several individual MNWS and ADHD-RS items correlated significantly, as illustrated in Table 3. The MNWS *difficulty concentrating*, *restlessness/impatience*, and *anxiety/nervousness* items demonstrated significant positive correlation with many ADHD-RS items. Specifically, the MNWS *difficulty concentrating* item correlated highly with the ADHD-RS total score and individual items *fails to give close attention to details or makes careless mistakes in schoolwork*, *has difficulty sustaining attention in tasks or play activities*, *has difficulty playing or engaging in leisure activities quietly*, *talks excessively*, and *loses things necessary for tasks or activities*.

Discussion

Despite the prevalence of ADHD and nicotine dependence in adolescents, little work to date has explored symptom associations between these disorders in this age group. Past research in adults has revealed that individuals with ADHD may have a more difficult time quitting smoking (10,11,29). Worsened severity of nicotine withdrawal symptoms may contribute to this difficulty (14,15). The present study sought to determine if lifetime diagnosis with

ADHD in treatment-seeking adolescent smokers was associated with heightened report of nicotine withdrawal symptoms.

The prevalence of lifetime ADHD in the sample is notable, with 36% meeting diagnostic criteria, despite no specific recruitment efforts targeting individuals with ADHD. Approximately 3–10% of adolescents have ADHD (30), and it has been estimated that nicotine dependence is twice as common in individuals with ADHD (6). Even with this elevated risk, the present sample represents a remarkable proportion of adolescent smokers with history of ADHD. This finding underscores the potential for interactions between ADHD and nicotine dependence (31), and the need for clinicians and researchers to assess for ADHD among treatment-seeking adolescent smokers.

Interestingly, adolescent smokers with history of ADHD, relative to those without, reported significant elevation in nicotine withdrawal symptoms on MNWS. This was at the baseline assessment visit, prior to any attempts to quit. There are several potential explanations for this finding. The first and most likely explanation is that symptoms endorsed on MNWS, particularly during non-abstinence, may not reflect actual withdrawal phenomena. They may instead reflect significant overlap between ADHD symptoms and items of the MNWS (e.g., difficulty with concentration, restlessness/impatience). It may be that such symptoms are present at higher levels across all adolescents with history of ADHD, regardless of nicotine use. This explanation is supported by the significant correlation between individual ADHD-RS and MNWS item scores summarized in Table 3. While nicotine withdrawal symptoms have been reported in adolescents (16,17,19,20), some studies have questioned their severity and clinical relevance, particularly among lighter smokers (18,21,22). Prokhorov and colleagues hypothesized that some “withdrawal symptoms” might instead be natural developmental characteristics of adolescents (18). The present findings may support this interpretation, but suggest that this hypothesized overlap might be particularly attributable to adolescents exhibiting symptoms of ADHD.

Another potential explanation for the present findings is that adolescent smokers with history of ADHD may be more acutely prone to nicotine withdrawal symptoms, even within a relatively short span of time since last cigarette. Significant neurobiological interactions between ADHD and nicotine dependence have been observed, providing a possible rationale for such a finding (9). However, the finding that ADHD status did not predict cigarette craving, a hallmark of nicotine withdrawal, argues against this explanation.

A third potential explanation is that adolescent smokers with history of ADHD may be more likely to “over-endorse” a variety of non-specific symptoms, perhaps owing to impulsivity and inattention to detail when completing self-report measures. This explanation appears unlikely, though, considering that participants with and without history of ADHD scored similarly on several other self-report measures at the baseline visit.

Regardless of the underlying explanation, the present results suggest the need for caution when interpreting reports of nicotine withdrawal symptoms in adolescents with history of ADHD. It may be necessary to develop an assessment measure for nicotine withdrawal that is not confounded by the ADHD status of smokers. At minimum, clinicians and researchers are urged to consider the symptomatic overlap between ADHD and nicotine withdrawal symptoms when treating co-morbid patients.

The present study contains limitations that may temper interpretation of the findings. Most notably, the parent study was not designed specifically to parse associations between ADHD and nicotine withdrawal. As such, the present analysis depended on the serendipitous finding that a significant minority of participants had a history of ADHD; thus, power limitations are noteworthy. Another consideration is that the time since last cigarette was not

standardized during the baseline visit. Participants may have been in varying states of acute nicotine deprivation, though all were non-abstinent at the time of assessment. Additionally, the present study relied on self-report of current symptoms of ADHD and nicotine withdrawal, and would have benefited from corroborative objective report/observation. Future studies should prospectively assess ADHD and nicotine withdrawal symptoms in adolescent smokers with and without history of ADHD in a controlled observation environment across a variety of smoking behavior states (e.g., non-abstinence, acute deprivation, chronic abstinence).

Conclusions

Adolescent smokers with history of ADHD, compared to those without history of ADHD, endorse heightened levels of nicotine withdrawal symptoms on self-report, even under non-abstinent conditions. While the underlying explanation for this finding remains unclear, the present results reveal significant overlap between ADHD and nicotine withdrawal symptoms, suggesting the need for caution in the interpretation of self-reported nicotine withdrawal symptoms among adolescent smokers with history of ADHD.

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References

1. Substance Abuse and Mental Health Services Administration, Office of Applied Studies. Results from the 2007 National Survey on Drug Use and Health: National Findings. Rockville, MD: 2008 [Accessed April 11, 2009]. (NSDUH Series H-34, DHHS Publication No. SMA 08-4343) Available online at: <http://oas.samhsa.gov/NSDUH/2k7NSDUH/2k7results.cfm#Ch4>
2. DiFranza JR, Rigotti NA, McNeil A, et al. Initial symptoms of nicotine dependence in adolescents. *Tobacco Control* 2000;9:313–319. [PubMed: 10982576]
3. DiFranza JR, Wellman RJ. A sensitization-homeostasis model of nicotine craving, withdrawal, and tolerance: Integrating the clinical and basic science literature. *Nicotine Tob Res* 2005;7:9–26. [PubMed: 15804674]
4. Kandel DB, Hu MC, Griesler PC, Schaffran C. On the development of nicotine dependence in adolescence. *Drug Alcohol Depend* 2007;91:26–39. [PubMed: 17553635]
5. O'Loughlin J, DiFranza J, Tyndale RF, et al. Nicotine dependence symptoms are associated with smoking frequency in adolescents. *Am J Prev Med* 2003;25:219–225. [PubMed: 14507528]
6. Lambert NM, Hartsough CS. Prospective study of tobacco smoking and substance dependencies among samples of ADHD and non-ADHD participants. *J Learn Disabil* 1998;31:533–544. [PubMed: 9813951]
7. Milberger S, Biederman J, Faraone SV, Chen L, Jones J. ADHD is associated with early initiation of cigarette smoking in children and adolescents. *J Amer Acad Child Adolesc Psychiatry* 1997;36:37–44. [PubMed: 9000779]
8. Laucht M, Hohm E, Esser G, Schmidt MH, Becker K. Association between ADHD and smoking in adolescence: shared genetic, environmental, and psychopathological factors. *J Neural Transm* 2007;114:1097–1104. [PubMed: 17406960]
9. McClernon FJ, Kollins SH. ADHD and smoking: from genes to brain to behavior. *Ann N Y Acad Sci* 2008;1141:131–147. [PubMed: 18991955]
10. Humfleet GL, Prochaska JJ, Mengis M, et al. Preliminary evidence of the association between the history of childhood attention-deficit/hyperactivity disorder and smoking treatment failure. *Nicotine Tob Res* 2005;7:453–460. [PubMed: 16085513]
11. Pomerleau CS, Downey KK, Stelson FW, Pomerleau CS. Cigarette smoking in adult patients diagnosed with attention deficit hyperactivity disorder. *J Subst Abuse* 1995;7:373–378. [PubMed: 8749796]

12. Gehricke JG, Whalen CK, Jamner LD, Wigal TL, Steinhoff K. The reinforcing effects of nicotine and stimulant medication in the everyday lives of adult smokers with ADHD: A preliminary examination. *Nicotine Tob Res* 2006;8:37–47. [PubMed: 16497598]
13. Lerman C, Audrain J, Tercyak K, et al. Attention-Deficit Hyperactivity Disorder (ADHD) symptoms and smoking patterns among participants in a smoking-cessation program. *Nicotine Tob Res* 2001;3:353–359. [PubMed: 11694203]
14. McClernon FJ, Kollins SH, Lutz AM, et al. Effects of smoking abstinence on adult smokers with and without attention deficit hyperactivity disorder: results of a preliminary study. *Psychopharmacology (Berl)* 2008;197:95–105. [PubMed: 18038223]
15. Pomerleau CS, Downey KK, Snedecor SM, Mehninger AM, Marks JL, Pomerleau OF. Smoking patterns and abstinence effects in smokers with no ADHD, childhood ADHD, and adult ADHD symptomatology. *Addict Behav* 2003;28:1149–1157. [PubMed: 12834657]
16. Killen JD, Ammerman S, Rojas N, Varady J, Haydel F, Robinson TN. Do adolescent smokers experience withdrawal effects when deprived of nicotine? *Exp Clin Psychopharmacol* 2001;9:176–182. [PubMed: 11518093]
17. McNeill AD, West RJ, Jarvis M, et al. Cigarette withdrawal symptoms in adolescent smokers. *Psychopharmacology (Berl)* 1986;4:533–536. [PubMed: 3101108]
18. Prokhorov AV, Hudmon KS, Cinciripini PM, Marani S. “Withdrawal symptoms” in adolescents: a comparison of former smokers and never-smokers. *Nicotine Tob Res* 2005;7:909–913. [PubMed: 16298726]
19. Prokhorov AV, Hudmon KS, de Moor CA, Kelder SH, Conroy JL, Ordway N. Nicotine dependence, withdrawal symptoms, and adolescents’ readiness to quit smoking. *Nicotine Tob Res* 2001;3:151–155. [PubMed: 11403729]
20. Rojas NL, Killen JD, Haydel KF, Robinson TN. Nicotine dependence among adolescent smokers. *Arch Pediatr Adolesc Med* 1998;152:151–156. [PubMed: 9491041]
21. Rubinstein ML, Benowitz NL, Auerback GM, Moscicki AB. Withdrawal in adolescent light smokers following 24-hour abstinence. *Nicotine Tob Res* 2009;11:185–189. [PubMed: 19246428]
22. Smith AE, Cavallo DA, McFetridge A, Liss T, Krishnan-Sarin S. Preliminary examination of tobacco withdrawal in adolescent smokers during smoking cessation treatment. *Nicotine Tob Res* 2008;10:1253–1259. [PubMed: 18629736]
23. Barkley, RA.; Murphy, KR.; Fischer, M. ADHD in adults: What the science says. New York, NY: Guilford Publications; 2006.
24. DuPaul, GJ.; Power, TJ.; Anastopoulos, AD.; Reid, R. ADHD Rating Scale–IV: Checklists, Norms, and Clinical Interpretation. Bethlehem, PA: Guilford Publications; 1998.
25. Hughes JR, Hatsukami DK. Signs and symptoms of tobacco withdrawal. *Arch Gen Psychiatry* 1986;43:289–294. [PubMed: 3954551]
26. Cox LS, Tiffany ST, Christen AG. Evaluation of the brief questionnaire of smoking urges (QSU-brief) in laboratory and clinical settings. *Nicotine Tob Res* 2001;3:7–16. [PubMed: 11260806]
27. Heatherton TF, Kozlowski LT, Frecker RC, Fagerstrom KO. The Fagerstrom Test for Nicotine Dependence: A revision of the Fagerstrom Tolerance Questionnaire. *Br J Addict* 1991;86:1119–1127. [PubMed: 1932883]
28. DiFranza JR, Savageau JA, Fletcher K, et al. Measuring the loss of autonomy over nicotine use in adolescents: The DANDY (Development and Assessment of Nicotine Dependence in Youths) study. *Arch Pediatr Adolesc Med* 2002;156:397–403. [PubMed: 11929376]
29. Upadhyaya HP. Do patients with ADHD have a harder time quitting cigarettes? *J Am Acad Child Adolesc Psychiatry* 2006;45:891. [PubMed: 16865030]
30. Faraone SV, Sergeant J, Gillberg C, Biederman J. The worldwide prevalence of ADHD: is it an American condition? *World Psychiatry* 2003;2:104–113. [PubMed: 16946911]
31. Upadhyaya HP, Carpenter MJ. Is Attention Deficit Hyperactivity Disorder (ADHD) severity associated with tobacco, alcohol and other drug use among college students? *Am J Addict* 2008;17:195–198. [PubMed: 18463996]

Table 1

Baseline comparison of participants with and without history of ADHD

	No History of ADHD (n=86)	SE	History of ADHD (n=48)	SE	p-value
% Male*	57.0		60.4		0.719
Age	18.9	1.8	17.6	1.8	<0.001
Age Became Regular Smoker	15.0	2.2	14.0	2.4	0.013
Cigarettes per Day	13.7	7.4	13.6	7.8	0.889
Number of Quit Attempts	2.6	2.0	3.2	3.9	0.747
Years of Regular Smoking	4.0	2.1	4.1	2.3	0.836
FTND	3.9	2.2	4.7	2.3	0.058
HONC	7.2	2.4	7.9	2.1	0.149
QSU-B Factor 1	26.0	6.9	25.4	7.4	0.692
Factor 2	14.8	6.6	17.2	6.7	0.044
MNWS	6.3	4.8	10.9	6.5	<0.001

Two sided Wilcoxon Rank Sum p-values, unless otherwise noted

* Two Sided Fisher Exact test of equality

p-values assessed for significance at $\alpha \leq 0.05/10 = 0.005$

FTND = Fagerström Test for Nicotine Dependence

HONC = Hooked on Nicotine Checklist

QSU-B = Questionnaire of Smoking Urges—Brief

MNWS = Minnesota Nicotine Withdrawal Scale

Baseline Minnesota Nicotine Withdrawal Scale (MNWS) individual item scores (dichotomized, 0 versus ≥ 1) by ADHD history status, controlling for age

Table 2

Item	History of ADHD	Item score = 0		Item score ≥ 1		p-value	Odds Ratio
		n	%	n	%		
Depressed Mood	No	69	81.2	16	18.8	0.147	1.9 (0.8–4.4)
	Yes	30	62.5	18	37.5		
Insomnia	No	52	60.5	34	39.5	0.201	1.6 (0.8–3.5)
	Yes	21	43.7	27	56.3		
Irritable, Frustrated, Angry	No	55	64.0	31	36.0	0.165	1.7 (0.8–3.7)
	Yes	23	47.9	25	52.1		
Anxious, Nervous	No	45	52.3	41	47.7	0.192	1.7 (0.8–3.6)
	Yes	19	39.6	29	60.4		
Difficulty Concentrating	No	59	68.6	27	31.4	0.009	2.8 (1.3–6.2)
	Yes	18	37.5	30	62.5		
Restless, Impatient	No	54	62.8	32	37.2	0.004	3.2 (1.4–7.0)
	Yes	16	33.3	32	66.7		
Increased Appetite	No	69	80.2	17	19.8	0.016	2.8 (1.2–6.6)
	Yes	29	60.4	19	39.6		
Desire, Craving to Smoke	No	4	4.7	82	95.4	0.483	0.6 (0.1–2.5)
	Yes	5	10.4	43	89.6		

All *p*-values are unadjusted Fisher Exact values

Odds Ratio values are considered asymptotically significant at $\alpha = 0.05$

MNWS items are rated on a 5-point scale (none=0, slight=1, mild=2, moderate=3, severe=4)

Table 3

Rank correlations (Spearman's Rho) between individual ADHD Rating Scale (ADHD-RS) and Minnesota Nicotine Withdrawal Scale (MNWS) item scores among participants with history of ADHD

Items	Nicotine Withdrawal (MNWS) Individual Items										MNWS Total Score
	depressed mood	insomnia	irritable, frustrated, angry	anxious, nervous	difficulty concentrating	restless, impatient	increased appetite	smoke craving to	desire, craving to	smoke	
Fails to give close attention to details or makes careless mistakes in schoolwork	0.138	-0.046	0.325*	0.204	0.498[†]	0.498[†]	0.186	0.253		0.398*	
Fidgets with hands or feet or squirms in seat	0.101	0.083	-0.102	0.110	0.322*	0.199	-0.156	-0.210		0.034	
Has difficulty sustaining attention in tasks or play activities	0.296	-0.068	0.093	0.108	0.433[†]	0.148	0.087	0.145		0.230	
Leaves seat in classroom or in other situations in which remaining seated is expected	0.159	-0.024	0.022	-0.156	0.251	0.196	-0.019	0.102		0.071	
Does not seem to listen when spoken to directly	0.229	-0.212	0.037	-0.127	-0.001	-0.049	-0.159	-0.099		-0.093	
Runs about or climbs excessively in situations in which it is inappropriate ⁺	0.077	0.287	-0.006	0.143	0.330*	0.383[†]	0.118	0.123		0.290	
Does not follow through on instructions and fails to finish work	0.241	0.074	-0.115	0.182	0.311	0.226	0.095	0.034		0.213	
Has difficulty playing or engaging in leisure activities quietly	0.186	0.005	0.011	0.089	0.430[†]	0.194	0.164	0.083		0.230	
Has difficulty organizing tasks and activities	0.051	-0.153	-0.213	-0.168	0.151	0.076	0.041	0.326*		0.015	
Is "on the go" or acts as if "driven by a motor"	-0.176	0.204	-0.152	-0.124	0.257	0.157	0.043	0.060		0.080	

ADHD (ADHD-RS) Individual Items

Items	Nicotine Withdrawal (MNWS) Individual Items										MNWS Total Score
	depressed mood	insomnia	irritable, frustrated, angry	anxious, nervous	difficultly concentrating	restless, impatient	increased appetite	smoke desire, craving to	smoke		
Avoids tasks (e.g., schoolwork, homework) that require sustained mental effort	0.242	0.167	0.074	0.496 [†]	0.331 [*]	0.397 [*]	0.133	0.214		0.372 [*]	
Talks excessively	0.031	0.020	0.068	0.161	0.425 [†]	0.335 [*]	0.075	0.069		0.190	
Asks things necessary for tasks or activities	0.162	-0.019	0.009	0.101	0.413 [†]	0.198	0.212	-0.046		0.209	
Starts out answers before questions have been completed	-0.098	0.015	0.093	0.084	0.110	0.392 [*]	0.045	0.004		0.175	
Is easily distracted	0.065	-0.124	-0.113	0.098	0.317 [*]	0.081	-0.154	-0.054		-0.010	
Has difficulty awaiting turn	0.033	-0.148	-0.067	-0.089	0.223	0.260	-0.078	0.177		0.061	
Is forgetful in daily activities	0.093	-0.056	0.0116	0.339 [*]	0.334 [*]	0.290	0.059	-0.001		0.260	
Interrupts or intrudes on others	0.046	-0.254	0.170	-0.001	0.380 [*]	0.344 [*]	0.151	0.089		0.186	
ADHD-RS Total Score	0.108	0.108	-0.006	0.113	0.400 [†]	0.283	0.001	0.285			

* $p < 0.05$

[†] $p < 0.01$