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A study of the psychometric and predictive properties of the Fagerström Test for Nicotine Dependence in a population of young smokers

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This study examined the psychometric properties of the Fagerström Test for Nicotine Dependence (FTND) in a population ($N = 7998$) of young smokers entering US Air Force Basic Military Training (BMT). An exploratory factor analysis suggested that the FTND is comprised of two factors. The first factor, labeled *Smoking Pattern*, included items assessing the number of cigarettes smoked per day, time to first cigarette, difficulty refraining from smoking, and smoking when ill. The second factor, labeled *Morning Smoking*, consisted of two items measuring whether one smokes more in the morning and whether one would rather give up the first cigarette of the day or all others. The *Smoking Pattern* factor proved to have adequate internal consistency, impressive criterion-related validity, and was strongly related to smoking cessation 1 year following BMT. In contrast, the *Morning Smoking* factor demonstrated questionable psychometric properties and was not supported by a confirmatory factor analysis.

Introduction

The Fagerström Tolerance Questionnaire (FTQ) was developed in 1978 to provide a self-report measure of nicotine dependence (Fagerström, 1978). Although the FTQ was found to be associated with several biochemical markers of nicotine dependence and was widely used in smoking research (Fagerström & Schneider, 1989), it suffered from significant psychometric problems (Pomerleau, Majchrazak, & Pomerleau, 1989). For instance, the FTQ demonstrated unacceptable internal consistency (Lichtenstein & Mermelstein, 1986; Pomerleau, Pomerleau, Majchrzak, Kloska, & Malakuti, 1990; Pomerleau, Carton, Lutzke, Flessland, & Pomerleau, 1994; Swan, Ward, & Jack, 1991) and correlations between individual items and criterion variables were often larger than correlations between the FTQ total scale and the same criterion variables (Lichtenstein & Mermelstein, 1986; Pomerleau *et al.*, 1990). Furthermore, although the FTQ was designed to be a unidimensional measure of nicotine dependence (Fagerström & Schneider, 1989), factor analytic studies revealed a multifactorial structure (Lichtenstein & Mermelstein, 1986; Swan *et al.*, 1991).

In response to the questionable psychometric properties of the FTQ, Heatherton and colleagues developed the Fagerström Test for Nicotine Dependence (FTND), a revision of the FTQ (Heatherton, Kozlowski, Frecker, & Fagerström, 1991). The FTND consists of six of the original FTQ items with revised scoring for two items. The FTND was found to have improved internal consistency (i.e., $\alpha = 0.61$; Heatherton *et al.*, 1991) compared to the FTQ, although it remains below levels required for research instruments (i.e., $\alpha = 0.70$; Nunally & Bernstein, 1994). Subsequent studies have confirmed that the FTND is psychometrically superior to the FTQ, however, the improvements reported are modest (Kozlowski, Porter, Orleans, Pope, & Heatherton, 1994; Payne, Smith, McCracken, McSherry, & Antony, 1994; Pomerleau *et al.*, 1994).

An additional problem with the extant literature on the psychometric properties of the FTND is that pre-

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vious studies have typically been based on small, clinic-based, convenience samples. For example, the FTND was originally developed using a sample of 254 smokers who responded to a sign soliciting volunteers in the Ontario Science Centre (e.g., Heatherton *et al.*, 1991). In a subsequent study of the FTND, Payne and colleagues (Payne *et al.*, 1994) used a clinic sample of 117 smokers enrolled in a Department of Veterans Affairs Medical Center Smoking Cessation Clinic. Pomerleau and colleagues examined the reliability of the FTND in a sample of 60 smokers who were participating in research in their lab (Pomerleau *et al.*, 1994). In the largest study to date, Kozlowski and colleagues examined the predictive validity of the FTND in a sample of 2809 smokers undergoing treatment (Kozlowski *et al.*, 1994). Given the widespread use of the FTND in smoking research, additional psychometric research using populations of smokers in non-clinic settings is needed.

Finally, previous research regarding the psychometric properties of the FTND has been based on mature, adult smokers. For instance, the mean age of smokers in the original FTND study by Heatherton and colleagues was 33.5 years (Heatherton *et al.*, 1991). Virtually no reliability or validity data for the FTND exists for adolescents and young adults, a population of increasing interest to smoking researchers. One exception is a study by Prokhorov and colleagues (Prokhorov, Pallonen, Fava, Ding, & Niaura, 1996) which found that, using a modified version of the FTQ, a non-random sample of 110 teenage smokers had lower nicotine dependence scores than a sample of 173 adult smokers. Unfortunately, this study does not provide psychometric data for the FTND based on a diverse population of young smokers. Recent epidemiological studies indicate that reductions in the prevalence of smoking among young adults plateaued at the beginning of the decade (Nelson, Giovino, Shopland, Mowery, Mills, & Eriksen, 1995), and the prevalence is currently *increasing* (CDC, 1996, 1998). Thus, evidence that the FTND provides a reliable and valid measure of nicotine dependence would be of great interest to researchers studying young smokers.

This study examines the psychometric properties of the FTND in a large, diverse population of young smokers entering the United States Air Force (USAF). This study is unique in that all smokers entering USAF Basic Military Training (BMT) during a 1-year period completed a variety of smoking history measures, providing a rich data set in which to examine the reliability and validity of the FTND in young smokers. Further, this study prospectively examined the relationship between responses on the FTND and smoking status 1 year following BMT.

Methods

Participants

From the population ($N = 32,144$) of individuals who entered the USAF from August 1995 to August 1996, 24.9% ($N = 7998$) reported smoking regularly up to BMT. A strictly monitored tobacco ban is part of BMT, therefore, all smokers were required to be abstinent during the 6 weeks of BMT. Average age of the smokers was 19.7 (standard deviation, SD = 2.1, range = 17–35). Among trainees who smoked, 24.3% were female. Individuals from minority ethnic backgrounds constituted 16.2% of the smokers (4.9% African-American; 4.9% Hispanic-American, 2.6% Asian-American, 4.0% other). Smokers were well represented with individuals from low and moderate income backgrounds, as evidenced by 22% reporting lower than a $20,000 total household income (i.e., income of household where recruit lived in year prior to BMT) and another 48.2% reporting a family income between $20,000 and $50,000. Education level was categorized as "some high school or less but not a diploma, certificate, or GED" (0.3% of the participants); "high school diploma or GED" (67.5%); "some college or other non-military technical school training" (29.0%); "2-year college degree" (2.1%); "4-year college degree" (0.9%); "graduate work but no advanced degree" (0.1%); or "advanced degree" (0%). In terms of smoking history, 2.87% of participants reported smoking less than 10 cigarettes, 46.5% smoked 11–20 cigarettes, 19.5% smoked 21–30 cigarettes, and 5.2% smoked 31 or more cigarettes each day. The average number of years the participants reported smoking was 4.1 years (SD = 2.9).

Assessment procedures

In the first week of BMT, trainees completed the baseline assessment questionnaire. Administration was in a group setting in 'flights' of approximately 50 individuals. Instructions were read and participants completed all items using a scanable questionnaire. Questions were answered and all questionnaires were checked for thoroughness prior to the flight departing. Obtaining follow-up data regarding the participants' smoking status was challenging because they were stationed around the world. Participants were located via the military World Wide Locator by the Air Force Survey Branch, an organization dedicated to conducting Air Force-approved surveys. Once addresses were obtained for the study participants, they were mailed a project follow-up survey. Those not responding to the follow-up survey were contacted by phone. Those unavailable for the follow-up assessment included individuals who completed BMT but did not enter the Air Force (e.g., National Guard or Air Force reserve members), those who completed BMT but dropped out of the Air Force by the 1-year follow-up, persons who were deceased, and those who were "unreachable" (e.g., on covert assignments, in remote locations such as Bosnia and accessible only by secured radio communication). A total of 5228 smokers were contacted at the 1-year follow-up and were included in this study. This represents 65% of all baseline smokers or 96% of available smokers. Smokers who were assessed at the 1-year follow-up were similar to smokers not assessed in terms

Table 1. FTND item distributions and corrected item-total correlations with total scale

Item	Response format	Points	Per cent endorsing	Mean	SD	Kurtosis	Skewness	Item-total correlations
1. How soon after you wake up do you smoke?	Within 5 min	3	19.6	1.49	1.08	−0.15	−1.28	0.61
	6–30 min	2	36.6					
	31–60 min	1	17.2					
	After 60 min	0	26.5					
2. Do you find it difficult to refrain from smoking in places where it is forbidden, e.g., in church, at the library, in cinema, etc.?	Yes	1	21.6	0.23	0.41	1.38	−0.09	0.32
	No	0	78.4					
3. Which cigarette would you hate most to give up?	The first one in the morning	1	28.9	0.29	0.45	0.93	−1.13	0.26
	All others	0	71.1					
4. How many cigarettes/day do you smoke?	10 or less	0	28.7	1.01	.83	.52	−0.27	0.52
	11–20	1	46.5					
	21–30	2	19.5					
	31 or more	3	5.3					
5. Do you smoke more frequently during the first hours after waking than during the rest of the day?	Yes	1	14.4	0.14	0.35	2.03	2.12	0.31
	No	0	85.6					
6. Do you smoke if you are so ill that you are in bed most of the day?	Yes	1	39.6	0.40	0.49	0.43	−1.82	0.51
	No	0	60.4					

Note: $N = 7998$.

of their FTND scores (mean FTND for smokers assessed at follow-up = 3.4, SD = 2.4; mean FTND for smokers not assessed at follow-up = 3.9, SD = 2.5, and the average number of years participants had smoked; mean years smoked for those assessed at follow-up = 4.1, SD = 2.8; mean years smoked for smokers not assessed at follow-up = 4.3, SD = 3.0).

Measure

A 53-item questionnaire was developed for use in this study. This instrument collects information from four general domains. First, basic demographics were measured, including gender, ethnic status, age, education, and household income. Second, history of tobacco use was assessed. Embedded in this part of the questionnaire was the FTND (Heatherton *et al.*, 1991). Third, questions thought to be associated with smoking onset/relapse were asked (e.g., the percentage of friends who smoked, perceived social attractiveness of smoking, smoking for weight control). Finally, other health risk factors were measured, such as alcohol and smokeless tobacco use. All questionnaires were then scanned into a computer using an NCS Opscan 5 model #25 scanner. Due to numerous quality control checks and the fact that the questionnaire was given as part of BMT, adherence was extremely high with virtually no missing data. A 6-week test–retest reliability was performed on all items used in this study using a randomly selected subgroup of trainees ($n = 7080$). Considering the long lag between assessments and unusually stressful circumstances (i.e., military basic training), the measure demonstrated good reliability. The median test-retest reliability coefficient was 0.83 (range = 0.60 to 1.00). At the 12-month follow-up, a brief survey asked participants to report their smoking status.

Because of the very large sample size and limited available assessment time, self-reports of smoking were obtained. Self-reports of smoking, even in intervention studies, generally are highly valid, with agreement rates to biochemical indices averaging well over 90% (Velicer, Prochaska, Rossi, & Snow, 1992). Self-reports of smoking are particularly valid in large surveys. Further, research has demonstrated that if confidentiality is assured, participants accurately report smoking status (Williams, Eng, Botvin, Hill, & Wynder, 1979). Therefore, given the large scale nature of this study and the fact that confidentiality was strongly stressed during the assessment, the validity of the smoking data is expected to be high.

Results

Item analysis

Table 1 presents descriptive data for the FTND items. Significantly large kurtosis and skewness values (i.e., >2.0) were found for item 5, "Do you smoke more frequently during the first hours after waking than during the rest of the day?" Most (85%) of smokers indicated that they did not smoke more in the first hours of the day. Interestingly, item 1, "How soon after you wake up do you smoke?", demonstrated the largest item-total correlation. Item 1 has consistently been found to be among the strongest of the FTND items in terms of its psychometric properties (e.g., Heatherton *et al.*, 1991).

In terms of the FTND total scale scores, a mean ($\bar{X}$) of 3.6 and an SD of 2.4 was found for the entire distribution of scores (males $\bar{X} = 3.7$, SD = 2.4; females $\bar{X} = 3.2$, SD = 2.3), suggesting that these young smokers generally reported low to moderate nicotine dependence. When FTND total scores are categorized into levels of nicotine dependence (Jarvik & Henningfield, 1993), 36.1% of smokers reported very low, 28.4% low, 13.1% moderate, 16.7% high, and 5.7% very high nicotine dependence. These findings are consistent with the nicotine dependence levels recently found in a study that used the FTQ in a sample of high-risk adolescent smokers (Prokhorov *et al.*, 1996).

Factor analysis of the FTND

For the factor analysis of the FTND, the population of smokers was divided into two samples, with counterbalanced selection in terms of time of entry into BMT. Preliminary diagnostics and initial factor analysis were based on data from the first group ($n = 4042$). Next, the factor model suggested by the initial factor solution was subjected to a confirmatory factor analysis (Bollen, 1989) using the second group ($n = 3956$). Confirmatory factor modeling was conducted using EQS (Bentler & Wu, 1993).

Preliminary diagnostics. The factorability of the FTND covariance matrix was examined using Diziuban and Shirkey's (1974) tests. The overall Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.73, which places it in the moderate range. The Bartlett's Test of Sphericity was significant ($p < 0.001$) and the determinant of the matrix was in the acceptable range. Thus, the FTND covariance matrix appeared acceptable for factor analysis.

Exploratory factor analysis. Consistent with previous studies of the factor structure of the Fagerström questionnaires, a principal components analysis with varimax rotation was conducted without limitation on the number of factors extracted. The criterion for item inclusion was a factor loading of 0.30 or more (Floyd & Widaman, 1995). Items with loadings on other factors were interpreted as belonging to the factor on which they had the highest loading. Cattell's scree test and examination of the percentage of total and common variance accounted for suggested that a two factor solution was adequate to explain the variation in the FTND in this population (Floyd & Widaman, 1995). Table 2 presents the FTND factors and item loadings. Factor 1 was labeled *Smoking Pattern* and consisted of FTND items 1, 2, 4, and 6. The mean Factor 1 sub-scale score was 3.1 (SD = 2.1) for the entire sample of smokers. Factor 2 was labeled *Morning Smoking* and consisted of items 3 and 5. The mean Factor 2 sub-scale score was 0.43 (SD = 0.64) for all smokers. Given that Factor 2 consists of only two items, its ability to represent a unique factor is questionable (Kim & Mueller, 1978, p. 63). The correlation between Factor 1 and the FTND total scale was nearly unity ($r = 0.97$) while the correlation between Factor 2 and total scale was moderate ($r = 0.55$).

As can be seen in Table 2, Item 1 ("How soon after you wake up do you smoke?) demonstrated significant commonality with both the *Smoking Pattern* and *Morning Smoking* factors. Given the label used for the *Morning Smoking* factor, including Item 1 on this scale would appear reasonable. However, given the larger commonality between Item 1 and the *Smoking Pattern* factor, Item 1 was assigned to the *Smoking Pattern* factor for this study.

Confirmatory factor analysis. The two-factor model suggested by the exploratory factor analysis (EFA) was tested with a confirmatory factor analysis (CFA) model. This model produced a Bentler–Bonett normed fit index of 0.82, suggesting that the two-factor model did not provide an adequate fit with the data. Diagnostics indicated statistical problems with the items comprising factor 2 of the exploratory factor analysis (items 3 and 5). Thus, these two items were excluded from the covariance matrix and a one-factor model was tested. This one-factor model produced a Bentler–Bonett normed fit index of 0.98 (χ^2 (2) = 61.1, $p < 0.001$), suggesting an excellent fit with the data. Item loadings produced by the one-factor CFA model are presented in Table 2. Therefore, the *Smoking Pattern* factor was validated by both the EFA and CFA models while the *Morning Smoking* factor was not consistently supported.

Internal consistency

In terms of internal consistency, an alpha of 0.67 was found for the FTND total scale, which just fails to meet minimum standards suggested for research instruments (Nunally & Bernstein, 1994). Factor 1 from the exploratory factor analysis demonstrated adequate internal consistency ($\alpha = 0.70$) while Factor 2 had very poor internal consistency ($\alpha = 0.40$). However, given that coefficient alpha is dependent on the number of items on a scale, the poor internal consistency of Factor 2 is not surprising (Cortina, 1993).

Table 2. FTND factors and item loadings

	Exploratory factor analysis sample 1 ($n = 4042$)		Confirmatory factor analysis sample 2 ($n = 3956$)
FTND Item	Factor 1	Factor 2	Factor 1
Smoking Pattern			
Item 1	0.677	0.427	0.713
Item 2	0.627	−0.099	0.447
Item 4	0.756	0.124	0.674
Item 6	0.739	0.139	0.637
Morning Smoking			
Item 3	0.040	0.791	—
Item 5	0.107	0.731	—

Table 3. Criterion-related validity of the FTND

Factor	*n*	FTND Total scale			Factor 1 (*Smoking Pattern*)			Factor 2 (*Morning Smoking*)		
		Mean	SD	*p*	Mean	SD	*p*	Mean	SD	*p*
Smoking intentions after BMT				<0.001			<0.001			0.100
I plan on staying quit	2386	3.05	2.33		2.63	2.03		0.42	0.64	
I am thinking about staying quit	4069	3.53	2.35		3.10	2.08		0.43	0.63	
I do not plan to stay quit	1446	4.46	2.42		4.00	2.14		0.46	0.66	
Successful 24-h quit				<0.001			<0.001			<0.001
Yes	3048	2.93	2.23		2.56	1.98		0.37	0.60	
No	4947	4.56	2.34		4.03	2.04		0.53	0.69	
Cigarette brand				<0.001			<0.001			<0.001
Regular	3969	4.01	2.45		3.51	2.16		0.50	0.67	
Light	3566	3.15	2.27		2.78	2.01		0.37	0.60	
Ultra Light	161	2.67	2.35		2.30	2.03		0.36	0.61	
No usual brand	299	2.68	2.31		2.33	2.04		0.35	0.57	
Years of smoking				<0.001			<0.001			<0.001
0–2	2219	2.61	2.24		2.26	1.97		0.35	0.58	
2.01–3.5	1781	3.50	2.23		3.05	1.97		0.45	0.64	
3.51–6.0	2102	3.91	2.37		3.45	2.08		0.47	0.65	
>6.0	1893	4.29	2.43		3.81	2.14		0.48	0.68	

Note: BMT = Basic Military Training. Years of smoking categories based on quartiles of the population distribution.

FTND criterion-related validity analyses

Relationships between two indicators of smoking intentions, cessation intentions and history of a successful 24-h quit attempt in the previous year, and the FTND total scale scores and factors are presented in Table 3. The FTND total scale, $F(2, 7992) = 163.2$, $p < 0.001$, and *Smoking Pattern* factor, $F(2, 7992) = 197.7$, $p < 0.001$ were significantly related to the participants' prediction of whether they would resume smoking following BMT. Specifically, intentions to quit smoking following BMT were associated with significantly lower FTND total scale scores and *Smoking Pattern* scores. Alternatively, the *Morning Smoking* factor from the exploratory factor analysis was not related to smoking plans. The data can also be expressed in terms of the standardized mean difference of nicotine dependence scores between smokers who did not wish to remain quit versus smokers who were planning to remain quit. These analyses suggested that the FTND total scale ($d = 0.60$) and the *Smoking Pattern* factor ($d = 0.66$) produced effect sizes of moderate magnitude, while the *Morning Smoking* factor produced a small effect size ($d = 0.06$) based on Cohen's (1992) criteria.

In terms of a history of a successful 24-h quit attempt, mean scores on the FTND total scale, $F(1, 7993) = 973.2$, $p < 0.001$, *Smoking Pattern* factor, $F(1, 7993) = 1016.4$, $p < 0.001$, and the *Morning Smoking* factor, $F(1, 7993) = 123.6$, $p < 0.001$, were significantly different for smokers who had and had not experienced a quit attempt. As expected, those who had experienced a successful quit attempt had significantly smaller nicotine dependence scores on all three measures. However, standardizing outcomes in terms of standardized mean difference scores (*d*) demonstrated that the magnitude of the difference between those who did and did not have a history of a successful quit attempts was large for both the FTND total scale ($d = 0.71$) and *Smoking Pattern* factor ($d = 0.73$), while it was small for the *Morning Smoking* factor ($d = 0.24$).

Two indicators of smoking exposure, cigarette brand and years of smoking are also presented in Table 3. In terms of cigarette brands, FTND total scale scores, $F(3, 7991) = 105.4$, $p < 0.001$, the *Smoking Pattern* factor, $F(3, 7991) = 101.8$, $p < 0.001$ and the *Morning Smoking* factor, $F(3, 7991) = 25.7$, $p < 0.001$ significantly differed among smokers with different brand preferences. That is, smokers of regular brand cigarettes had higher nicotine dependence scores while those who preferred light, ultra-light, or had no usual brand had lower dependence scores. The data can also be expressed in terms of the standardized mean difference of nicotine dependence scores between smokers of regular cigarettes versus other brands. These analyses suggested that the FTND total scale ($d = 0.39$) and the *Smoking Pattern* factor ($d = 0.37$) produced effect sizes of moderate magnitude, while the *Morning Smoking* factor produced a small effect size ($d = 0.20$).

Finally, nicotine dependence scores for smokers divided into quartiles of the number of years of smoking are presented in Table 3. Again, the FTND total scale score, $F(3, 7991) = 203.7$, $p < 0.001$, *Smoking Pattern* factor, $F(3, 7991) = 223.7$, $p < 0.001$, and *Morning Smoking* factor, $F(3, 7991) = 17.2$, $p < 0.001$, significantly differed among the various years of smoking categories. Specifically, as the number of years of smoking increased, the nicotine dependence scores also increased. Alternatively, if years of smoking is analyzed as a continuous variable and correlated with the nicotine dependence scores, the FTND total scale ($r = 0.25$, $p < 0.001$) and *Smoking Pattern* factor ($r = 0.27$, $p < 0.001$) demonstrate modest relationships while the *Morning Smoking* factor produces a small correlation ($r = 0.07$, $p < 0.001$).

Table 4. Predictive validity of the FTND: smoking cessation at 1-year follow-up

		FTND Total scale		Factor 1 (*Smoking Pattern*)		Factor 2 (*Morning Smoking*)	
Group	*n*	OR	95% CI	OR	95% CI	OR	95% CI
All Smokers	5228	0.85	0.82–0.88	0.83	0.80–0.86	0.82	0.73–0.93
Males	3948	0.86	0.83–0.89	0.84	0.81–0.88	0.84	0.73–0.96
Females	1280	0.83	0.78–0.89	0.80	0.75–0.86	0.82	0.65–1.03
Euro-Americans	4361	0.85	0.82–0.88	0.83	0.80–0.87	0.79	0.69–0.90
African-Americans	230	0.82	0.70–0.95	0.74	0.61–0.90	0.98	0.64–1.51
Hispanic-Americans	296	0.88	0.78–1.00	0.85	0.73–0.98	1.04	0.68–1.63

Note: OR = Odds Ratio; CI = Confidence Interval. Smoking cessation coded 0 = smoking, 1 = quit. Smoking cessation based on 7-day point prevalence.

Reliability of recall

A 6-week "reliability of recall" analysis was conducted with a randomly selected sample of smokers ($n = 1714$). The second assessment was conducted between 1 and 3 days prior to the troops' graduation from BMT. This reliability analysis is unique in that the participants were tobacco free during the 6-week period due to the BMT tobacco ban. Participants were asked to complete the FTND based on their smoking patterns prior to BMT. Thus, this reliability analysis assesses the ability of subjects to recall smoking patterns following a 6-week period of abstinence. Such data may be informative for studies using the FTND in a retrospective fashion. Analysis of the FTND total score suggested that smokers were able to recall their smoking patterns prior to BMT in a manner highly consistent with their report during week one of BMT ($r = 0.87$, $p < 0.001$). In terms of the two FTND factors, the *Smoking Pattern* sub-scale ($r = 0.87$, $p < 0.001$) evidenced better reliability than the *Morning Smoking* factor ($r = 0.64$, $p < 0.001$).

Predictive validity

At the 1-year follow-up, 17.7% ($n = 925$) of the participants reported quitting smoking. This cessation rate is likely due in part to the 6-week smoking ban during BMT and a series of smoking cessation initiatives supported by the Air Force. Table 4 provides data on the predictive validity of the FTND stratified by gender and the three largest ethnic groups (i.e., Euro-Americans, African-Americans, and Hispanic-Americans). Other ethnic groups provided samples too small to develop reliable predictive models and therefore were not included in the analyses based on ethnicity. The FTND total score was significantly related to smoking cessation at the 1-year follow-up assessment for the entire population of smokers. Specifically, for each unit increase in FTND scores, subjects were 18% less likely to have quit smoking at follow-up. The *Smoking Pattern* factor demonstrated nearly identical predictive ability to the FTND total score. The *Morning Smoking* factor also demonstrated significant predictive ability, however, as can be seen by the wide confidence intervals which resulted from this sub-scale, provided a less reliable point estimate of the odds of quitting. Both the FTND total score and the *Smoking Pattern* sub-scale demonstrated good predictive validity for both males and females and Euro-Americans and Hispanic-Americans. The *Morning Smoking* sub-scale, in contrast, was not significantly related to smoking cessation for females, African-Americans, or Hispanic-Americans. In fact, only the *Smoking Pattern* sub-scale was significantly related to smoking cessation in Hispanic-Americans.

Discussion

This investigation examined the psychometric properties of the FTND in a population ($N = 7998$) of young smokers entering the USAF. Contrary to the original report on the FTND (Heatherton *et al.*, 1991), an exploratory factor analysis (EFA) suggested that the FTND is multidimensional in this sample and consists of two factors, *Smoking Pattern* (Items 1, 2, 4, and 6) and *Morning Smoking* (Items 3 and 5). This factor structure is similar to that found by Payne and colleagues (Payne *et al.*, 1994) in a sample ($n = 117$) of smokers enrolled in a Veteran's Affairs Medical Center Smoking Cessation Clinic. Moreover, a confirmatory factor analysis (CFA) model suggested that a one-factor model consisting of the items from the *Smoking Pattern* factor from the EFA provided an excellent fit with the data. Thus, the unidimensional structure of the six-item FTND suggested by the measure's authors (Heatherton *et al.*, 1991) has failed to be replicated in subsequent studies using heterogeneous groups of smokers.

The two items comprising the *Morning Smoking* factor of the EFA (i.e., items 3 and 5 of the FTND) demonstrated questionable psychometric utility in this study. First, the validity of this factor was not supported by the CFA. Moreover, most psychometricians agree that two items do not provide an adequate sample for assessing a construct (Anastasi, 1988; Floyd & Widaman, 1995). The internal consistency of Factor 2 was very poor and inadequate for a research instrument ($\alpha = 0.40$), likely due to coefficient alpha's dependence on item number (Cortina, 1993). Further, the criterion-related validity analyses of the *Morning Smoking* factor were mixed, suggesting that this factor has questionable utility as a measure of nicotine dependence. Finally, the

Morning Smoking factor yielded inconsistent relationship to smoking cessation. For females, African-Americans, and Hispanic-Americans the *Morning Smoking* factor was not related to quitting.

Given the problems associated with the *Morning Smoking* factor, we suggest that researchers might use the items comprising the *Smoking Pattern* factor as a measure of nicotine dependence. Using the *Smoking Pattern* factor in studies of young smokers might offer several advantages. First, using the items contained on the *Smoking Pattern* factor would result in little loss of information, given that the correlation between this factor and the FTND total scale was almost unity. Second, these items would provide the only measure of nicotine dependence based on the Fagerström scales in the published literature which demonstrates adequate internal consistency ($\alpha = 0.70$). Third, the *Smoking Pattern* factor received strong support from the CFA. Fourth, the *Smoking Pattern* factor demonstrated criterion-related validity that was compelling and comparable to that of the FTND total scale. Fifth, the *Smoking Pattern* factor was consistently and strongly related to smoking cessation. Finally, Lichtenstein and Mermelstein (1986) have noted that two items from the FTQ, which are now items 1 and 4 on the FTND, were more closely related to measures of nicotine dependence and withdrawal than the remaining FTQ items. These authors have suggested that tobacco researchers use these two items only, calling their sum the Heaviness of Smoking (HIS) scale. The *Smoking Pattern* factor contains the two HIS items, plus has the advantage of additional information and strong reliability and validity. Items addressing morning smoking may increase in importance as one becomes an older, more chronic smoker with concomitant increases in tolerance and withdrawal symptoms, factors with less consistent relevance to young smokers.

Although this study provides the first population-based examination of the FTND among young smokers, several limitations should be noted. First, the FTND may perform differently when used with young, less addicted smokers than with more mature smokers in cessation clinics. Specifically, relationships found between the FTND and factors such as smoking intentions, history of quit attempts, and actual cessation should be considered tentative and likely not representative of more highly-dependent smokers. Second, this population of young smokers is unique in that all participants were employed, possessed at least a high school diploma, and had volunteered for military service. Further, this population was over-represented with individuals from ethnic minority backgrounds relative to national census data. Therefore, whether the results found in this study generalize to other populations of young smokers remains to be demonstrated.

Third, the poor performance of the two items comprising the *Morning Smoking* factor could be due to the peculiarities of this population of smokers. For example, whether an individual smokes more in the morning hours than later in the day may depend as much on environmental circumstances as nicotine dependence. Most of these young smokers recently graduated from high school, institutions that usually do not allow smoking during the day. Also, parental prohibitions against smoking may be easier to enforce during the morning hours as opposed to after school when many young smokers may be unsupervised. Fourth, the FTND assessment occurred during a period where the subjects had been abstinent from tobacco use for 2–3 days. Although the FTND asks smokers to report reasonably objective information about long-term smoking patterns, the fact that these smokers were in withdrawal may have influenced the participants' responses to the items. However, a reliability of recall analysis suggested that participants reported their smoking patterns in a consistent manner. Finally, given that this study was based on a large, population survey, biochemical measures of smoking exposure and dependence were not obtained. Future studies should examine the criterion-related validity of the FTND for young smokers using biochemical measures.

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