Original Investigation

Structural and Predictive Equivalency of the Wisconsin Smoking Withdrawal Scale across Three Racial/Ethnic Groups

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Abstract

Introduction: The Wisconsin Smoking Withdrawal Scale (WSWS) is a valid and reliable scale among non-Latino Whites but has not been validated for use among other racial/ethnic groups despite increasing use with these populations. The current study examined the structural invariance and predictive equivalency of the WSWS across three racial/ethnic groups.

Methods: The WSWS scores of 424 African American, Latino, and White smokers receiving smoking cessation treatment were analyzed in a series of factor analyses and multiple-group analyses. Additionally, hierarchical logistic regression analyses were conducted to determine whether WSWS scores differentially predicted smoking relapse across racial/ethnic groups. These analyses were consistent with a step-down hierarchical regression procedure for examination of test bias.

Results: The 7-factor structure of the WSWS was largely confirmed in the current study, with the exception of the removal of two offending items. Evidence of full invariance across race/ethnicity was found in multiple-group analyses. The WSWS total score and subscales measuring anger, anxiety, concentration, and sadness predicted relapse, whereas the hunger, craving, and sleep subscales did not. None of these scales displayed differential predictive ability across race/ethnicity. The WSWS sleep subscale showed a significant interaction with race/ethnicity such that it was a significant predictor of relapse among Whites but not African Americans or Latinos.

Conclusions: Overall, the WSWS is similar in structure and predictive of relapse across racial/ethnic groups. Caution should be exercised when using the WSWS sleep subscale with African Americans and Latinos.

Introduction

The Wisconsin Smoking Withdrawal Scale (WSWS; [Welsch et al., 1999](#)) was created to address limitations of previous withdrawal measures and as an alternative to proxy measures of negative mood, which capture only some aspects of the smoking withdrawal syndrome. This 28-item self-report measure conforms to a 7-factor structure that represents the diagnostic and associated symptoms of the smoking withdrawal syndrome. [Etter and Hughes \(2006\)](#) and [Welsch et al.](#) also found that alternative structures adequately fit WSWS data, including a 6-factor structure and a 2-tiered structure, respectively. [Welsch et al.](#) and [Etter and Hughes](#) each demonstrated good internal consistency for the WSWS and found observed scores of the craving subscale to be predictive of relapse. [Welsch et al.](#) additionally found that observed scores over time were sensitive to quitting smoking.

The WSWS has become a frequently used measure of withdrawal and in recent years has been increasingly used with racially/ethnically diverse samples (see [Blalock, Robinson, Wetter, Schreindorfer, and Cinciripini, 2008](#); [Businelle et al., 2009](#); [Javitz, Brigham, Lessov-Sclagger, Krasnow, and Swan, 2009](#); [Leventhal et al., 2008](#); [McCarthy et al., 2008](#); [McCarthy, Gloria, and Curtin, 2009](#); [Piper et al., 2008](#)). The increase in research on tobacco use and withdrawal among minority populations is consistent with the call from the U.S. Public Health Service Clinical Practice Guideline for increased attention to minority populations in tobacco research ([Fiore et al., 2000, 2008](#)). However, less attention has been paid to ensuring that psychological measures used in such studies are appropriate for research with diverse populations. For example, the validation sample in the study of [Welsch et al. \(1999\)](#) consisted of 98% White smokers, and no information was given on the racial/ethnic breakdown of the U.S. sample in the study of [Etter and Hughes \(2006\)](#). As such,

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one concern about the popularity of the WSW is that it is increasingly being used with racial/ethnic minority smokers in the absence of data on measurement validity in these populations.

Numerous studies have shown that smoking withdrawal has an important impact on smoking cessation (Allen, Bade, Hatsu-kami, and Center, 2008; Bagot, Heishman, and Moolchan, 2007; Killen and Fortmann, 1997). Given that some minority groups have lower cessation rates compared to non-Hispanic Whites (Centers for Disease Control and Prevention [CDCP], 2002), accurate assessment of withdrawal symptoms among racial/ethnic minority groups is important. Although there is some indication that African Americans may experience more severe craving than Whites (Carter et al., 2010), there is little published research or clinical or theoretical reasons indicating that the smoking withdrawal syndrome is qualitatively different across race/ethnicity. Thus, measures purporting to capture this construct should function similarly across race/ethnicity.

Demonstrating that a measure functions similarly across groups generally involves examination of measurement invariance and tests of predictive equivalence (Millsap, 1997). Invariance in measurement does not ensure equivalent predictive ability; both must be examined empirically to determine whether one can make comparisons on a test across groups (Millsap). Measurement invariance is said to be present when members of different groups with the same status on a construct produce the same score on a measure of that construct (Schmitt and Kuljanin, 2008). Moreover, measurement invariance in a test is necessary in order to make valid and meaningful comparisons between groups on the construct of interest (Borsboom, 2006; Meredith and Teresi, 2006; Schmitt and Kuljanin). Predictive equivalence is said to be present when the observed score on a measure leads to the same prediction on an external outcome variable for members of two different groups with the same score (Lautenschlager and Mendoza, 1986). Established statistical procedures exist for examination of each of these forms of invariance (Lautenschlager and Mendoza; Vandenberg and Lance, 2000).

In the area of smoking, some evidence suggests that African Americans and Latinos have more difficulty quitting than do non-Latino Whites (CDCP, 2002). Thus, it is vitally important to understand whether the determinants of smoking cessation differ across groups in order to better inform treatments among minority populations, and comparability of tests across groups is necessary for making such determinations. Given the growing use of the WSW in smoking cessation research and the lack of validity information among minorities, the current study examined the structure of the WSW for invariance across three racial/ethnic groups: African Americans, Whites, and Latinos. Additionally, WSW observed scale scores were examined for differential prediction of smoking relapse across the three groups.

Methods

Participants

Participants were 424 smokers (African American, $N = 144$, 34%; White $N = 139$, 32.8%; Latino $N = 141$, 33.2%) enrolled in a longitudinal cohort study designed to examine the social

determinants of smoking cessation. Participants were required to be at least 21 years of age, have smoked at least 5 cigarettes/day for the past year, have a home address and functioning telephone number, demonstrate proficiency in English at the sixth grade level or higher, and be motivated to quit smoking in the next 30 days. Potential participants were excluded if the nicotine patch was contraindicated, if they reported use of tobacco products other than cigarettes, or if they reported participation in a smoking cessation program within the past 90 days.

Procedures

Participants were recruited via local print and radio advertisements to take part in a smoking cessation study. They were first screened via telephone and later in person to determine eligibility. Written informed consent was obtained at an in-person screening/orientation. Participant recruitment and flow through the study are detailed elsewhere (Kendzor et al., 2008).

Participants received smoking cessation treatment including 6 weeks of nicotine patch therapy, six brief smoking cessation counseling sessions based on the *Treating Tobacco Use and Dependence Clinical Practice Guideline* (Fiore et al., 2000), and self-help materials. Data for the current study were collected at baseline (prequit), quit day, 1 week postquit, and 2 weeks postquit. Participants were compensated for their time with \$30 gift cards at the completion of each assessment.

Instruments

Demographics

Demographic variables were collected at baseline and included age, gender, self-reported race/ethnicity (African American, White, or Latino), years of education, employment status (employed or not employed), and annual household income ($< \$20,000/\text{year}$ or $\geq \$20,000/\text{year}$).

Tobacco Use

Average number of cigarettes/day was self-reported at baseline and was reported in sample descriptives. Continuous abstinence (i.e., self-report of not smoking "at all") since the quit date was assessed at 1 and 2 weeks postquit day by self-report and confirmed via carbon monoxide reading of < 10 parts per million. Continuous abstinence was particularly useful as an outcome variable in the current study, where the primary outcome variable was short-term abstinence, because it assesses abstinence beginning from the quit date without a grace period. Thus, the relationship between withdrawal and abstinence is not confounded by potential early lapses in abstinence that would be allowed during a grace period.

Wisconsin Smoking Withdrawal Scale

The WSW is a 28-item self-report questionnaire designed to assess different aspects of the smoking withdrawal syndrome (Welsch et al., 1999). The WSW produces a total score as well as scores on seven subscales: anger, anxiety, concentration, craving, hunger, sadness, and sleep. Participants rate each item on a Likert scale from zero (strongly disagree) to four (strongly agree). Welsch et al. reported postquit internal consistency reliabilities (Cronbach's alpha) for two samples. Reliabilities for the total score were 0.91 and 0.90 and ranged from 0.79 to 0.93 for the subscales. Validity information can be found in Etter and

Hughes (2006) and Welsch et al. In the current study, internal consistency reliability of the quit-day scores for the whole sample was 0.91 for the total score and ranged from 0.70 to 0.90 for the subscales.

Data Analysis

Factor Structure and Measurement Invariance

A confirmatory factor analysis was conducted to examine the factor structure of the WSWS. Where the model was problematic, modification indices were examined to identify offending items, which were subsequently removed. The model was tested for fit after each offending item was removed. To examine measurement invariance across the three race/ethnicity groups, multiple-group analyses following the procedure outlined by Vandenberg and Lance (2000) were conducted. This procedure begins with a test of full invariance, which tests the null hypothesis that the variance–covariance matrices of the groups are equal. This is accomplished by testing a multiple-group confirmatory factor analysis (CFA) in which all parameter estimates (i.e., factor loadings, item intercepts, item residual variances and covariances, factor means and variances, and factor covariances) are constrained to be equal across groups. According to Vandenberg and Lance, a poor fit of this model (rejection of the null hypothesis) is indicative of non-invariance, which is identified through a series of nested models representing specific and increasingly strict levels of invariance (including configural, metric, scalar, and strict invariance; for more in-depth explanations of invariance, see Meredith and Teresi, 2006; Schmitt and Kuljanin, 2008; Vandenberg and Lance). Adequate fit (i.e., failure to reject the null hypothesis) of this highly restrictive model is indicative of overall measurement invariance across groups, and no further testing is warranted.

Model fit in all analyses were examined through inspection of a number of fit indices, including the model chi square (χ^2), root mean squared error of approximation (RMSEA), comparative fit index (CFI), Tucker-Lewis index (TLI), and the standardized root mean square residual (SRMR). Where non-nested models were compared, the Akaike information criterion (AIC) and Bayes' information criterion (BIC) were additionally reported. Although there are no strict rules for assessing fit indices, the following values are generally considered favorable (Kline, 2005): RMSEA < 0.08, CFI and TLI > 0.90, SRMR < 0.10. There is no general acceptable value of AIC or BIC; rather, the relative sizes of these indices are compared between models, with the model having the smaller AIC and BIC being favored and a difference of 10 indicating that the model with the lower value is a superior fit compared to the model with the higher value (Kass and Raftery, 1995; Raftery, 1995).

Predictive Equivalence

Logistic regression analyses were conducted consistent with the step-down hierarchical regression procedure for examination of test bias outlined by Lautenschlager and Mendoza (1986). This is a widely accepted procedure used to analyze predictive bias (Oswald, Saad, and Sackett, 2000) and has been used in a number of studies examining bias in psychological measures (Arbisi, Ben-Porath, and McNulty, 2002; Castro, Gordon, Brown, Anestis, and Joiner, 2008; Culhane, Morera, Watson, and Millsap, 2009; Saad and Sackett, 2002; te Nijenhuis, Tolboom, Resing, and Bleichrodt, 2004). All demographics were entered as covariates in step 1, followed by a WSWS subscale in step 2 in order to test

the subscale's unique predictive ability beyond demographic variables (age, education, employment status, gender, and income) and independent of any potential influence of race/ethnicity. The race/ethnicity and its interaction with the WSWS subscale were entered in step 3 in order to examine whether the interaction term provides incremental predictive ability beyond the WSWS subscale alone. In all logistic regression analyses, the outcome variable was coded such that the referent "1" was "not abstinent" (i.e., relapsed). According to Lautenschlager and Mendoza, a significant increase in variance accounted for from step 2 to step 3 and a significant effect of the interaction term may be indicative of bias, as this suggests that the predictive ability of the WSWS is dependent on race.

Results

Participant Characteristics

The three groups were compared on demographic characteristics and average number of cigarettes/day using multivariate analysis of variance and chi squares where applicable. As shown in Table 1, there were significant differences among the racial/ethnic groups on age, education, employment status, gender, income, and average number of cigarettes/day. The three racial ethnic groups ranged from an average roughly 18.5 cigarettes/day to almost 20 cigarettes/day, indicating this was a sample of moderate to heavy smokers (based on classifications by Zhu, Pulvers, Zhuang, and Baezconde-Garbanati, 2007).

Factor Structure

A confirmatory factor analysis was conducted to replicate the structure of the WSWS as reported in Welsch et al. (1999). The initial 28-item, 7-factor model produced an adequate fit (χ^2 [329] = 802.86, p < .0001; RMSEA = 0.06, CFI = 0.92, TLI = 0.91, SRMR = 0.07). Examination of factor loadings and modification indices

Table 1. Participant Characteristics

	Whites	African Americans	Latinos
	Mean (SD)		
Age	42.82 (11.62)	44.76 (9.87)	36.02 (10.19) ^{ab}
Education	13.34 (2.23)	12.84 (1.59) ^a	12.53 (2.06) ^a
Cigarettes/day	23.86 (9.2)	20.61 (11.9) ^a	18.62 (8.22) ^a
	N (%)		
Employment status			
Not employed	64 (46.7)	74 (52.1)	37 (26.6)
Employed	73 (53.3)	68 (47.9)	102 (73.4) ^{ab}
Gender			
Male	61 (43.9)	58 (40.3)	79 (56) ^{ab}
Female	78 (56.1)	86 (59.7)	62 (44)
Income			
<\$20,000	47 (38.5)	76 (57.1) ^a	35 (29.2) ^b
≥\$20,000	75 (61.5)	57 (42.9)	85 (70.8)

Note. Four individuals did not report years of education, six did not report employment status, and 49 did not report income.

^aSignificantly different from Whites.

^bSignificantly different from African Americans.

revealed two potential offending items. The first was item 1, “food is not particularly appealing to me” which loaded on the hunger factor in Welsch et al. but did not load on the hunger scale in the current sample, and was significantly associated with all other subscales. Removal of this item produced a model that adequately fits the data ($\chi^2 [303] = 709.38, p < .0001$; RMSEA = 0.06, CFI = 0.93, TLI = 0.92, SRMR = 0.05), and this 27-item model was a better fit than the initial model as indicated by a smaller AIC (26,205 vs. 26,364) and BIC (26,606 vs. 27,777). The second offending item was item 7, “I have felt upbeat and optimistic” which loaded on the sadness factor in Welsch et al. This item loaded adequately on the sadness subscale but was also strongly associated with three other scales (anger, anxiety, and craving). Removal of this item produced a model that adequately fits the data ($\chi^2 [278] = 611.08, p < .0001$; RMSEA = 0.06, CFI = 0.94, TLI = 0.93, SRMR = 0.04), and the model’s smaller AIC (25,151) and BIC (25,541) indices indicated that this 26-item model was a better model than the previous two models. Table 2 lists standardized and nonstandardized factor loadings for the 26-item measure. This 26-item measure was used in the remaining analyses.

Measurement Invariance

Consistent with the recommendations of Vandenberg and Lance (2000), the structure of the WSWs was first examined for

overall equivalence of measurement (total invariance) across the three racial/ethnic groups. A multiple-group CFA was conducted in which all parameter estimates (i.e., factor loadings, item intercepts, item residual variances and covariances, factor means and variances, and factor covariances) were constrained to equality across the White, African American, and Latino subsamples. This resulted in a model with adequate fit ($\chi^2 [1032] = 1561.51, p < .0001$; RMSEA = 0.064, CFI = 0.91, TLI = 0.91, SRMR = 0.09), suggestive of overall equivalence of measurement across groups.

Predictive Equivalence

Because of the importance of the implications of null findings in these particular analyses (i.e., null findings are evidence against predictive bias), an analysis of the smallest detectable effect size was conducted. The analysis indicated that the smallest detectable effect (in terms of an odds ratio) was 0.67 and 1.48, given a sample of 328 (after removing participants with missing demographic data), an alpha level of 0.05, and power of 0.80.

A step-down hierarchical regression procedure was conducted to examine the predictive ability of each WSWs subscale separately. Quit-date WSWs scores were used to predict relapse at 1 week postquit. There were significant main effects for the

Table 2. Standardized and Unstandardized Factor Loadings for the 26-Item Wisconsin Smoking Withdrawal Scale

Factor	Item	Standardized (SE)	Unstandardized (SE)
Anger	13. Easily angered	0.86 (0.02)	1.04 (0.05)
	15. Bothered banger/frustration/irritability	0.90 (0.01)	1.11 (0.05)
	18. Felt frustrated	0.85 (0.02)	1.0 (0.05)
Anxiety	3. Tense/anxious	0.71 (0.03)	0.85 (0.06)
	6. Impatient	0.75 (0.03)	0.87 (.05)
	8. Worrying	0.78 (0.02)	0.94 (0.05)
	10. Calm ^a	0.64 (0.03)	0.60 (0.05)
Concentration	4. Excellent concentration ^a	0.70 (0.03)	0.75 (0.05)
	23. Hard to pay attention	0.77 (0.03)	0.76 (0.05)
	27. Difficult to think clearly	0.83 (0.02)	0.80 (0.04)
Craving	9. Frequent urges	0.76 (0.03)	0.82 (0.05)
	11. Bothered by desire to smoke	0.75 (0.03)	0.84 (0.05)
	20. Thought about smoking	0.80 (0.03)	0.95 (0.05)
	26. Trouble getting cigarettes off mind	0.78 (0.03)	0.85 (0.05)
Hunger	14. Want to nibble	0.66 (0.04)	0.78 (0.06)
	16. Eating a lot	0.73 (0.03)	0.81 (0.05)
	21. Felt hungry	0.59 (0.04)	0.67 (0.06)
	28. Think about food a lot	0.91 (0.02)	0.97 (0.05)
Sadness	12. Sad/depressed	0.86 (0.02)	1.03 (0.05)
	19. Hopeless/discouraged	0.85 (0.02)	0.96 (0.05)
	24. Happy/content ^a	0.70 (0.03)	0.71 (0.05)
Sleep	2. Restful sleep ^a	0.63 (0.03)	0.77 (0.06)
	5. Awaken frequently	0.71 (0.03)	0.94 (0.06)
	17. Satisfied with sleep ^a	0.86 (0.02)	1.1 (0.05)
	22. Getting enough sleep ^a	0.84 (0.019)	1.03 (0.05)
	25. Sleep is troubled	0.84 (0.02)	1.04 (0.05)

Note. ^aReverse scored.

Table 3. Wisconsin Smoking Withdrawal Scale Quit-Day Scores Predicting Week 1 Continuous carbon monoxide Confirmed Abstinence

Step 2	Omnibus χ^2 of step	<i>p</i> Value of step	R^2_N of step	Adjusted odds ratio	95% <i>CI</i>
Total	11.87	.001	.15	2.03	1.34–3.06
Anger	14.00	.000	.16	1.60	1.24–2.07
Anxiety	6.54	.01	.13	1.45	1.08–1.93
Concentration	10.23	.001	.14	1.66	1.20–2.30
Craving	0.42	.52	.11	1.10	0.83–1.44
Hunger	1.08	.30	.11	1.16	0.87–1.55
Sadness	25.80	.001	.20	2.15	1.56–2.96
Sleep	3.13	.08	.12	1.24	0.97–1.60
Step 3					
Race/ethnicity $\times$ total	2.32	.51	.16	0.81	0.48–1.38
Race/ethnicity $\times$ anger	2.62	.46	.17	1.08	0.80–1.47
Race/ethnicity $\times$ anxiety	1.71	.63	.14	0.96	0.67–1.38
Race/ethnicity $\times$ concentration	1.70	.64	.15	1.00	0.65–1.52
Race/ethnicity $\times$ craving	3.24	.36	.12	1.19	0.85–1.68
Race/ethnicity $\times$ hunger	3.29	.35	.12	0.82	0.57–1.17
Race/ethnicity $\times$ sadness	1.45	.69	.21	0.97	0.64–1.45
Race/ethnicity $\times$ sleep	8.06	.04	.15	0.68	0.49–0.93

Note. Analyses controlled for age, education, employment status, gender, and income in step 1 (not shown). Bold text indicates a significant effect. Each scale was examined in a separate logistic regression analysis.

WSWS total score and the anger, anxiety, concentration, and sadness subscales (Table 3). The craving, hunger, and sleep subscales did not significantly predict relapse. These analyses were repeated using week 2 relapse as the dependent variable, and results were virtually identical. Additionally, because removal of the two offending items affected the sadness, hunger subscales, and WSWS total score, analyses were additionally repeated for these measures using the original 28 WSWS items, and results were virtually identical.

Examination of potential interaction effects between racial/ethnic group and WSWS subscales indicated that there was a significant interaction of race with the sleep subscale (Table 3) in predicting week 1 relapse. This interaction was further investigated by examining the main effect of the sleep subscale in each racial/ethnic group. Results indicated that the sleep subscale significantly predicted relapse for Whites (adjusted odds ratio [AOR] = 1.62, 95% *CI* = 1.07–2.45), but not for African Americans (AOR = 1.40, 95% *CI* = 0.88–2.22) or Latinos (AOR = 0.72, 95% *CI* = 0.43–1.19). However, the sleep by race/ethnicity interaction term was not a significant predictor of week 2 relapse ($p = .09$). Race/ethnicity did not significantly interact with any other WSWS scales in predicting relapse by the week 1 or week 2 time points.

Discussion

The current study found that the 7-factor structure of the WSWS is applicable across the three racial/ethnic groups, and a highly conservative test of measurement invariance indicated that the scale measures withdrawal constructs equivalently across groups. The current study also demonstrated the predictive equivalence of the WSWS with respect to short-term relapse. With the exception of the WSWS sleep subscale, the

interaction of race with WSWS subscales did not provide incremental utility in the prediction of relapse above and beyond the WSWS subscale alone. Overall, the findings indicate that the predictive validity of the WSWS with respect to relapse risk is equivalent across White, African American, and Latino smokers who are attempting to quit.

A confirmatory factor analysis of the 28-item WSWS indicated that the 7-factor structure as found in [Welsch et al. \(1999\)](#) was an adequate fit for the data in the current study. Thus, the original structure of the WSWS was replicated in a large racially/ethnically diverse sample of smokers in treatment, although slight modifications were made based on modification indices. The current study found that model fit in this diverse sample could be improved with the deletion of two poorly specified items: item 1, “food is not particularly appealing to me,” from the hunger subscale and item 7, “I have felt upbeat and optimistic,” from the sadness subscale. Item 1 failed to load on the hypothesized subscale but loaded on all six other subscales. This may indicate that changes in appetite or interest in food may have been a sign of general psychological distress in this sample of treatment-seeking smokers rather than a reflection of the loss of the appetite-suppressant side effect of nicotine. Although item 7 loaded on the sadness subscale, it also loaded on the anxiety, anger, and craving subscales. Given the wording of the item and the fact that it is reverse scored, this item may better tap positive affect in general, which might be expected to relate to a number of negative emotions and craving.

Multiple-group analysis of the modified 26-item WSWS displayed total measurement invariance across African American, White, and Latino smokers in treatment, suggesting several conclusions. First, it supports configural invariance. That is, the same factors and same pattern of factor loadings exist

across racial/ethnic groups. This finding suggests that the WSWs taps the same constructs for all three racial/ethnic groups. Second, results indicate that the factor loadings of each item are equal across racial/ethnic groups (i.e., metric invariance), indicating that each item is equally representative of the factor on which it loads across groups, and thus, the items are interpreted similarly across groups. Third, results support the presence of scalar invariance, in which item intercepts are equal across racial/ethnic groups. This finding indicates that not only do the items share the same metric across groups but also share the same start point or origin. Thus, a given factor score represents the same level of symptom severity across the three racial/ethnic groups. The presence of metric and scalar invariance indicates that factor variances, covariances, and means can be compared across groups. Finally, results suggest that the item residual variances of the WSWs are equal across racial/ethnic groups. This indicates that items are equally precise across groups, and thus, observed scale scores can be compared across groups.

Observed scale scores of the WSWs were also examined for predictive equivalence using short-term (week 1 and week 2) relapse as the criterion. Results demonstrated predictive equivalence of the total WSWs scale and all subscales across racial/ethnic groups with the exception of the sleep subscale. The sleep subscale was predictive of relapse for Whites, but not for African Americans or Latinos. Thus, the current study provides the first evidence that the WSWs sleep subscale predicts relapse differentially across racial/ethnic groups. However, evidence of predictive bias was found only at week 1. Although replication of this finding is needed, a conservative interpretation of this result would be to exercise caution when assessing risk for relapse with this subscale among African Americans and Latinos, as it may not be as useful an indicator of relapse risk compared to other WSWs subscales. However, the subscale is still useful in spite of its limited predictive utility because it appears to characterize sleep disturbance related to withdrawal similarly across all three racial/ethnic groups.

More generally, the current findings provide support for the role of withdrawal in smoking cessation. The findings further indicate that withdrawal is an equally important determinant of smoking cessation across African American, White, and Latino smokers in treatment. Thus, African American, White, and Latino smokers might benefit equally from treatments whose primary function is to reduce withdrawal symptoms. However, the WSWs craving subscale did not significantly predict abstinence in the current sample. Also, we were unable to identify any characteristics of the data that may account for this null finding (i.e., floor or ceiling effects, restricted range of scores, differential relationships between the scale and abstinence across race/ethnicity that may have obscured significant results). However, this null finding should be considered in conjunction with previous research with the WSWs, which has consistently found this subscale to be a useful predictor of relapse (Blalock et al., 2008; McCarthy et al., 2008; Piper et al., 2008).

The current study has several limitations. Because invariance was only examined in these three racial/ethnic groups, the performance of this measure with other groups (e.g., Asian/Asian American and American Indian smokers) is not known. Further, we could not distinguish subgroups of Latino smokers

by important cultural variables such as immigrant status, country of origin, or acculturation status, so it is unknown if bias exists when these variables are taken into account. Although measures of acculturation were not collected for the current sample, reasonable English language proficiency was necessary in order to participate in this study, and English language proficiency has been shown to correlate with greater acculturation among Latinos (Thomson and Hoffman-Goetz, 2009). Additionally, the current Latino sample consisted of moderate to heavy smokers, and some research indicates that smoking behavior (e.g., cigarettes smoked per day) tends to be correlated with greater acculturation (Marín, Pérez-Stable, and Marín, 1989; Palinkas et al., 1993). Thus, it is possible that the current study may be most applicable to relatively acculturated, English-speaking Latinos. Future research would benefit from a demonstration of measurement equivalence of a translated version of the WSWs among Spanish-speaking Latinos, as well as other languages, in order to expand the reach of this instrument and facilitate smoking research with diverse samples more generally.

Predictive equivalence was examined with data collected over a 3-week period that included the quit date, 1 week post quit date, and 2 weeks postquit date, and thus, current findings are limited to short-term relapse. However, given that the vast majority of smokers smoke within a few days of their quit date (Hughes, Keely, and Naud, 2004), it might be particularly important to have a measure that can identify those at risk for relapse early in their attempt to quit. Also, it is possible that the analyses of predictive bias could have been nonsignificant due to low power. However, the effect size estimates conducted for these analyses indicated that the current sample size could detect moderate effects, and the confidence intervals of the resulting analyses are relatively narrow, indicating reasonable precision of effect estimates. Finally, the current study is the first, to our knowledge, to identify the WSWs as an acceptable instrument for assessing the smoking withdrawal syndrome across racial/ethnic groups, but further research in this area is needed.

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Declaration of Interests

The authors declare that, except for income received from the primary employer, no financial support or compensation has been received from any individual or corporate entity over the past three 3 years for research or professional service, and there are not personal financial holdings that could be perceived as constituting a potential conflict of interest, except in the case of Dr. Cinciripini. Dr. Cinciripini has served on the scientific advisory board of Pfizer Pharmaceuticals and has conducted educational talks sponsored by Pfizer on smoking cessation for physicians.

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