



Self-efficacy and sex influences on the relationship between tobacco dependence and long-term abstinence: a moderated mediation approach

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Abstract

Tobacco dependence and abstinence self-efficacy are interrelated, and both are relevant variables for quitting smoking. Previous literature suggests that sex may also be a key factor in this relationship. This study aims to examine the relationship between tobacco dependence, self-efficacy and 12-months abstinence, and to explore the role of sex in this relationship. A total sample of 288 adult treatment-seeking daily smokers ($M_{age}=45.8$, $SD=10.63$; 62.5% females) was used. Participants were enrolled in a cognitive-behavioral smoking cessation treatment and were followed during a one-year period. We found a negative correlation between baseline tobacco dependence and smoking self-efficacy at the end of the intervention. Mediation analysis showed a significant indirect effect of tobacco dependence on quitting smoking via self-efficacy ($B=-0.162$, $SE=0.053$, 95% BootCI [-0.287, -0.082]). We also found that sex significantly moderated the relationship between baseline tobacco dependence and self-efficacy at the end of the intervention. This result indicates that the indirect effect of tobacco dependence on quitting success through smoking self-efficacy was significant for females ($B=-0.239$, $SE=0.069$, 95% BootCI [-0.402, -0.131]), but not for males. Self-efficacy has key role in the association between tobacco dependence and long-term abstinence, being particularly relevant for females. These findings contribute to understanding the role of tobacco dependence on abstinence, which is a well-known barrier to smoking cessation, and have several clinical implications as focusing on post-treatment self-efficacy in those with higher dependence could be relevant to improving the effectiveness of interventions to quit.

Keywords Tobacco dependence · Self-efficacy · Sex · 12-months quitting success · Cognitive-behavioral intervention

Introduction

Smoking remains the leading preventable cause of morbidity and mortality worldwide (Dai et al., 2022). Although effective smoking cessation interventions exist (Marshall et al., 2023; Patnode et al., 2021), it is necessary to continue investigating smoking-related variables and psychological constructs that could influence treatment outcomes to better adapt to the needs of treatment-seeking smokers and improve abstinence outcomes. Among the variables most studied due to their relationship with smoking cessation success are tobacco dependence and self-efficacy. Tobacco use disorder, defined as a problematic pattern of tobacco use leading to clinically significant impairment or distress (American Psychiatric Association, 2022), is a complex construct that involves physiological, psychological, social, and behavioral features (Fagerstrom, 2012). Higher tobacco dependence is associated with a lower likelihood of

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quitting smoking and experiencing more difficulties achieving and maintaining abstinence (Martínez-Vispo et al., 2023; McCarthy et al., 2015; Spears et al., 2017).

Self-efficacy is defined as beliefs about one's ability to achieve a given accomplishment (Bandura, 1997). Two perspectives have been considered regarding smoking-related self-efficacy: self-efficacy for abstaining from smoking in different situations and self-efficacy in performing the tasks necessary to maintain abstinence (Brandon et al., 2004). It is the former, the self-efficacy in remaining abstinent in different situations, which has received more attention (Wang et al., 2017).

Self-efficacy has been considered as a behavioral process that may play an important role in the relationship between tobacco dependence and tobacco cessation (Cinciripini et al., 2003; Li et al., 2015). In this vein, a higher abstinence-related self-efficacy has been associated with a higher likelihood of quitting and maintaining long-term abstinence (Baishya et al., 2022; Cooley et al., 2012; Martinez et al., 2010). Tobacco dependence and self-efficacy are also inter-related (Brandon et al., 2004), with self-efficacy playing a determinant role in the loss of control, which is a characteristic aspect of tobacco dependence. Moreover, a high number of cigarettes smoked (a feature of tobacco dependence) is related to lower self-efficacy. More specifically, Yang et al. (2011) note that self-efficacy in quitting smoking decreases as the score on the Fagerström Test for Cigarette Dependence (FTCD) increases (Fagerström, 2012). Therefore, they recommend targeting self-efficacy in smoking cessation treatments to address dependence and facilitate the cessation process.

Another variable that has been related to tobacco dependence and self-efficacy is sex, although the results have not always been conclusive (Poggiolini, 2019; Smith et al., 2016). For instance, in some studies, being male is associated with greater dependence (Sim et al., 2021), but others, such as Komiyama et al. (2018), find no sex differences in tobacco dependence severity, although male smoke more cigarettes per day than female.

Regarding abstinence self-efficacy differences according to sex, the results are also diverse. Studies such as those conducted by Martínez et al. (2010) and Poggiolini (2019) found no differences between male and female, while others concluded that female have lower self-efficacy than male (Etter et al., 2002; Stockton et al., 2000). A possible explanation is that female have more negative expectations towards the withdrawal syndrome they may have when quitting smoking and the weight gain that may occur, which leads them to have lower self-efficacy when quitting smoking (Waters et al., 2018).

Based on the abovementioned literature, the aim of this study is to examine in greater depth the relationship between

tobacco dependence and post-treatment self-efficacy concerning long-term abstinence success, given the relevance that both variables have on smoking behavior. In addition, we also intend to explore whether sex (referred to primarily as biological factors; Kaufman et al., 2023) influences this relationship, as inconsistent findings on sex differences highlight a gap in understanding how these variables interact. More specifically, we aim to investigate the subsequent research question: Is there a relationship between baseline tobacco dependence, self-efficacy at the end of the smoking cessation intervention, and 12-months quitting success?

We hypothesize that:

- Tobacco dependence has a negative indirect effect on 12-months quitting success via low smoking self-efficacy.
- Sex moderates the relationship between tobacco dependence and smoking self-efficacy in relation to 12-month abstinence.

Methods

Participants

The sample included 288 treatment-seeking daily adult smokers (62.5% female; Mean age=45.80, SD=10.63 years) recruited from the community to participate in a smoking cessation randomized controlled trial (conducted in Spain), based on a cognitive-behavioral intervention with an App as an adjunct to the intervention (clinicaltrials.gov#NCT04765813). Individuals were eligible if they were 18 years old or older, wished to participate in the smoking cessation treatment, provided written informed consent, smoked at least six cigarettes per day, had a valid e-mail address, and had a smartphone with an Internet connection (Android or iOS). Exclusion criteria were: having a diagnosis of severe mental disorder (bipolar disorder and/or psychotic disorder); having a substance use disorder other than tobacco use disorder (alcohol, cannabis, stimulants, hallucinogens and/or opioids); having participated in the same or similar treatment over the previous year or having received pharmacological treatment to quit smoking over the previous year; presence of a high life-risk pathology (i.e., recent myocardial infarction); and/or using tobacco products other than cigarettes.

Regarding the sample characteristics, 52.1% had university studies, 45.1% were married or living with a partner and 68.1% were currently working. The mean of cigarettes smoked per day was 18.63 (SD=8.95), and 38.2% had high tobacco dependence (score ≥ 6 in the Fagerström Test for Cigarette Dependence).

Procedure

The current study is based on the secondary analysis from the abovementioned randomized controlled trial (López-Durán et al., 2025). A more detailed description of the study procedures can be found in López-Durán et al. (2022). Participants from the general population of Spain were recruited through advertisements, word of mouth, and referrals from the services of the healthcare system. All participants provided written informed consent before entering the study and then they were assessed. Subsequently, those who met the inclusion and exclusion criteria were randomized (1:1 ratio) to the experimental and control group according to a computer-generated randomization list. The study was approved by the Ethics in Research Committee of the University of Santiago de Compostela.

Measures

Assessments were conducted at pre-treatment for sociodemographic and tobacco dependence variables (before the beginning of treatment sessions) and at post-treatment for smoking self-efficacy (during the last treatment session conducted after eight weeks), and 12-months abstinence outcomes. The outcome variable was quitting success at 12-months follow-up, defined as 7-days point prevalence self-reported abstinence at one year after the last treatment session (Piper et al., 2020), which implies that individuals report abstaining from tobacco for a continuous period of 7 days at this follow-up.

Sociodemographic and smoking-related variables

The Smoking Habit Questionnaire (Becona, 1994) was used to gather information on sociodemographic variables (e.g., “Sex: Male or Female”; “What is your age?”; “What is your current marital status? Single, Married/living with a partner, Divorced, Widowed, Other”; “What is the highest level of education you have completed?”) and tobacco use (e.g., number of cigarettes smoked per day, use of tobacco products other than cigarettes, quit attempts).

Tobacco dependence

The Fagerström Test of Cigarette Dependence (FTCD) (Heatherton et al., 1991; Spanish version Becona & Vázquez, 1998) was used. This instrument contains six items, of which two items are scored on a 4-point scale, and four on a 2-point scale (see Supplementary Material). The total score is calculated as a sum of the scores for all six items, ranging between 0 and 10, with higher scores indicating greater tobacco dependence. (e.g., “which cigarette would you hate to give up?”; “how many cigarettes per day do you smoke?”). In the present sample, Cronbach alpha was .60.

Self-efficacy

We used the Smoking Self-Efficacy Scale short form (SSE) (Velicer et al., 1990), which comprises nine items that assess the participant’s confidence in resisting temptations to smoke in specific situations (e.g., “when I feel I need a lift,” “when things are not going my way, and I am frustrated,” “while talking and relaxing over coffee”; see Supplementary Material for the complete questionnaire). The total score is calculated as a sum of the nine items, with higher scores indicating higher self-efficacy. Regarding psychometric properties, Cronbach alpha was .86 in the present sample.

Data analytic strategy

Descriptive data and frequency analyses of the studied variables were conducted and are reported as means with standard deviations or frequencies with the corresponding percentages (Table 1). Correlations among study variables and differences according to sex (Student’s *t* and chi-square tests) were also examined.

We used the PROCESS macro V4.1. (Hayes & Little, 2018) for SPSS (version 27.0; IBM Corp., Armonk, New York, USA) to examine mediation and moderated mediation models. A simple mediation model was performed to determine whether tobacco dependence (independent

Table 1 Descriptive data of the total sample (N=288)

	Mean (SD) % (N)	1	2	3	4	5
1. Age	45.8 (10.63)	–				
2. Sex (female)	62.5 (180)	.128*	–			
3. Education (University)	52.1 (150)	.075	.133*	–		
4. FTCD	4.82 (2.10)	.107	-.003	-.104	–	
5. SSE	29.31 (7.8)	.015	-.118	.021	-.255***	–
6. 12-months 7-days PPA	39.9 (115)	-.021	.101	.072	-.125*	.219***

FTCD=Fagerström Test for Cigarette Dependence; PPA=Point Prevalence Abstinence; SSE=Smoking Self-efficacy

p*<.05. *p*<.01. ****p*<.001

variable= X) had an indirect effect on quitting success at 12-month follow-up (dependent variable= Y ; coded as 1=abstinent, 0=smoking) through self-efficacy assessed at the end of the intervention (mediator variable= M). This analysis also allows obtaining the direct effect of tobacco dependence and self-efficacy on 12-month abstinence. Firstly, the simple mediation model (Model 4) was conducted unadjusted and adjusted by covariates (sex, age, education level, treatment condition). Then, a moderated mediation analysis using Model 7 was conducted, testing the role of sex in moderating the hypothesized mediation effect (coded as 0=male; 1=female). Bootstrap re-sampling techniques were performed (with 10,000 re-samples), and a 95% bias-corrected confidence interval (BootCI) was used to evaluate indirect effects (Preacher & Hayes, 2008). Results are significant if the CIs do not include zero. The significance of moderated mediation was tested with Hayes' index of moderated mediation (Hayes, 2018).

Results

Descriptive results

Of the total sample, 52.1% had university studies, 45.1% were married or living with a partner and 68.1% were currently working. The mean of cigarettes smoked per day was 18.63 (SD=8.95), and 38.2% had high tobacco dependence (score ≥ 6 in the Fagerström Test for Cigarette Dependence). Additional descriptive data of study variables and the bivariate correlations are presented in Table 1.

Results on the relationship between tobacco dependence, self-efficacy and 12-month abstinence showed that tobacco dependence was negatively related to smoking self-efficacy at the end of the intervention ($r=-.255$, $p \leq .001$) and to quitting success ($r=-.125$, $p=.035$). Moreover, smoking self-efficacy at the end of the intervention correlated positively with 12-months quitting success ($r=.219$, $p \leq .001$). No significant differences were found between males and females on tobacco dependence ($t=0.051$, $p=.960$), self-efficacy ($t=1.866$, $p=.063$), or long-term quitting success ($\chi^2=2.912$, $p=.088$).

Mediation models

The results for the simple mediation models (unadjusted and adjusted by sex, age, and education) are presented in Table 2. The analysis showed that the direct effect of tobacco dependence on 12-month abstinence was significant in both unadjusted ($B=-0.951$, $SE=0.23$, 95% BootCI [-1.404, -0.497]) and adjusted models ($B=-0.973$, $SE=0.23$, 95% BootCI [-1.413, -0.516]). We also found a significant direct

effect of self-efficacy on 12-month abstinence in both unadjusted ($B=0.052$, $SE=0.02$, 95% BootCI [0.170, 0.087]) and adjusted models ($B=0.051$, $SE=0.02$, 95% BootCI [0.150, 0.087]). Regarding the mediation effects, in both unadjusted and adjusted models, tobacco dependence at baseline had a negative indirect effect on quitting success via self-efficacy ($B=-0.050$, $SE=0.02$, 95% BootCI [-0.103, -0.014]) as the 95% CI of the point estimate did not cross zero, meaning that a higher baseline tobacco dependence was associated with lower self-efficacy at the end of the intervention, which was related to lower odds of long-term quitting success.

Moderated mediation models

This model shows that the direct effect (c' path) of tobacco dependence after controlling for smoking self-efficacy (M), sex (W), and the interaction of smoking self-efficacy and sex ($X*W$) was nonsignificant (Table 3). A significant interactive effect of tobacco dependence and sex on smoking self-efficacy was found (Table 3). The index of moderated mediation, a test indicating the equivalence of an indirect effect across different levels of a moderator, was significant ($\omega=-0.062$, $SE=0.031$, 95% CI [-0.130, -0.011]), providing evidence of moderation in the link between tobacco dependence and smoking self-efficacy (Fig. 1). This result indicates that the indirect effect of tobacco dependence on quitting success through smoking self-efficacy was dependent on sex (for males; $B=-0.018$, $SE=0.022$, 95% BootCI [-0.069, 0.015]; and for females ($B=-0.079$, $SE=0.030$, 95% BootCI [-0.146, -0.028]).

Discussion

The present study aimed to examine the relationship between tobacco dependence and post-treatment self-efficacy concerning abstinence after 12 months of receiving a cognitive-behavioral intervention to quit smoking. Moreover, we explored the possible moderation of sex in such a relationship.

Relationship between baseline tobacco dependence, self-efficacy at the end of the smoking cessation intervention, and 12-months quitting success

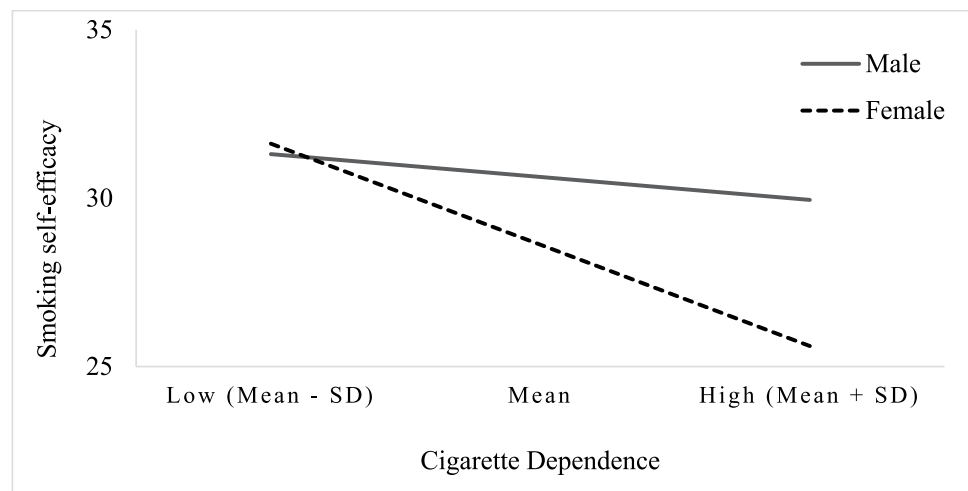
Data showed that greater tobacco dependence was associated with lower smoking self-efficacy at the end of the intervention and was negatively correlated with quitting success at 12 months. We also found that smoking self-efficacy at the end of the intervention was positively associated with 12-month quitting success. These findings are consistent

Table 2 Simple mediation models unadjusted and adjusted by covariates

Unadjusted Model		Post-treatment self-efficacy (M)						12-months PPA (Y)					
Variables	Path	Coeffi- cient	Boot SE	p	Boot LLCI	Boot ULCI	Path	Coefficient	Boot SE	p	Boot LLCI	Boot ULCI	
FTCD (X)	a ₁	-0.951	0.230	<.001	-1.404	-0.497	c'	-0.113	0.066	.087	-0.242	0.016	
SSE (M)	-	-	-	-	-	-	b ₁	0.052	0.018	.004	0.170	0.087	
<i>R</i> ² = .065, <i>F</i> = 17.063, <i>p</i> < .001													
Indirect		Coeffi- cient	Boot SE		Boot LLCI	Boot ULCI		Nagelkerke = 0.079, Model LL 15.086; <i>p</i> < .001					
FTCD → SSE → Abstinence		-0.049	.022		-0.099	-0.014							
Adjusted Model													
Variables	Path	Coeffi- cient	Boot SE	p	Boot LLCI	Boot ULCI	Path	Coefficient	Boot SE	p	Boot LLCI	Boot ULCI	
FTCD (X)	a ₁	-0.973	0.232	<.001	-1.413	-0.516	c'	-0.105	0.067	.119	-0.238	0.027	
SSE (M)	-	-	-	-	-	-	b ₁	0.051	0.018	.005	0.015	0.087	
Sex		-2.012	1.016	.048	-4.019	-0.016		0.619	0.285	.029	-1.177	-0.061	
Age		0.035	0.046	.450	-0.055	0.125		-0.009	0.013	.447	-0.035	0.015	
Education		0.287	0.674	.671	-1.707	2.123		0.369	0.356	.043	0.020	1.416	
Treatment Condition		-0.566	0.964	.557	-1.615	1.041		0.177	0.195	.058	-0.013	0.750	
<i>R</i> ² = .084, <i>F</i> = 4.418, <i>p</i> < .001													
Indirect		Coeffi- cient	Boot SE		Boot LLCI	Boot ULCI		Nagelkerke = 0.125 Model LL 24.224; <i>p</i> < .001					
FTCD → SSE → Abstinence		-0.050	.023		-0.103	-0.014							

FTCD = Fagerström Test for Cigarette Dependence; PPA = Point Prevalence Abstinence; SSE = Smoking Self-efficacy; SE = Standard Error; LLCI = Lower Limit Confidence Interval; ULCI = Upper Limit Confidence Interval

Fig. 1 Moderation of the effect of cigarette dependence on self-efficacy by sex



suggest that this indirect effect was significant only for females. Despite the fact that no significant differences were found between males and females in the study variables (tobacco dependence, self-efficacy, and long-term abstinence), our data indicate that self-efficacy may play a key role in smoking cessation in females with higher tobacco dependence. These findings are consistent with previous studies finding no sex differences in tobacco dependence (Komiyama et al., 2018) or quitting self-efficacy (Poggiolini, 2019), but they add to the previous literature on how tobacco dependence and self-efficacy are related to long term quitting success. To continue analyzing the impact of sex on the smoking cessation process is warranted to fully understand which variables are associated with quitting success. A possible explanation of this finding is that females may have more negative expectations related to withdrawal symptoms. As higher levels of tobacco dependence are associated with higher withdrawal severity, females with higher tobacco dependence severity could have less self-efficacy related to their capacity to cope with the withdrawal syndrome, which could reduce the likelihood of achieving abstinence (Waters et al., 2018). Waters et al. specifically point out that female's negative expectations of withdrawal arise because they are more prone to have more severe mood-related symptoms than male in initial abstinence, which would affect their self-efficacy to quit. In this line, Komiyama et al. (2018) note that there is a significant relationship between depression and tobacco dependence in female that is not found in men. This pattern of results justifies the need of analyzing the factors implied in long-term abstinence considering sex.

Limitations

The present study's findings should be considered in light of the following limitations. Abstinence data was only

self-reported due to the online nature of the intervention, and no biochemical verification was obtained. Nevertheless, self-reported smoking status is considered a satisfactory tool when a study is conducted in healthy individuals, and biochemical confirmation is not feasible (Benowitz et al., 2020; Pell et al., 2008). Moreover, the sample comprised Spanish treatment-seeking smokers, thereby constraining the generalizability of the findings to the general population of smokers.

Implications and future recommendation

The current study has relevant implications for clinical practice and research, highlighting the need to consider sex differences in the smoking cessation process. The percentage of females using smoking cessation services is higher than that of males (Jayakumar et al., 2020; Martínez-Vispo et al., 2023), underscoring the need for a gender-based approach when studying the quitting process, particularly in clinical settings. Efforts have been made in research for developing and testing gender-specific interventions (Bottorff et al., 2016; C. B. Hayes et al., 2022; Melamed et al., 2024); however, more studies are needed as most of these studies are pilot or preliminary research.

In addition, further research is warranted to analyze the relationship of tobacco dependence and quitting self-efficacy with other smoking-related variables, such as past quitting attempts (McCarthy et al., 2015) or treatment adherence according to sex (Gajos et al., 2023). In this vein, recent findings of Gajos et al. suggest that greater quitting self-efficacy is associated with higher adherence to nicotine replacement treatment among females but not males. This could also be of interest in psychological smoking cessation interventions. Finally, further research examining the role of these variables in smoking relapse is needed. As McCarthy et al. highlight, smoking cessation treatments should increase

self-efficacy to improve quitting success rates but also to prevent overconfidence, which could heighten relapse risk. This research will contribute to developing more effective strategies to quit smoking.

Conclusion

The current study showed that self-efficacy mediated the association between tobacco dependence and long-term quitting success, implying that greater dependence was linked to lower success through reduced self-efficacy. This aligns with prior research emphasizing self-efficacy as a key variable for understanding the connection between dependence and quitting success. Moreover, we found that the indirect impact of tobacco dependence on 12-months abstinence through self-efficacy varied according to sex, being significant only for females, which implies the need for gender-specific approaches in smoking cessation interventions. This has additional clinical implications as our results suggest that to improve long-term abstinence in those smokers with higher tobacco dependence targeting post-treatment self-efficacy could be relevant and, especially, for females. For instance, incorporating content to boost self-efficacy through the follow-up period (i.e., text messages, telephone calls) can help reduce the risk of relapse after quitting. Finally, research is necessary to understand the connection between tobacco dependence and self-efficacy in other smoking-related processes, including relapse. This could lead to the development of more effective smoking cessation strategies.

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Authors contributions Ana López-Durán: Conceptualization, Methodology, Writing – original draft, Visualization, Funding acquisition, Project administration, Resources, Supervision. Carmela Martínez-Vispo: Conceptualization, Methodology, Data curation, Formal analysis, Writing – original draft. Daniel Suárez-Castro: Conceptualization, Investigation, Writing – review & editing. María Barroso-Hurtado: Conceptualization, Investigation, Writing – review & editing. M. Carmen Míguez: Conceptualization, Writing – review & editing. Elisardo Becoña: Conceptualization, Methodology, Writing – review & editing, Funding acquisition, Project administration, Resources, Supervision.

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Data availability The data underlying this article will be shared on reasonable request to the corresponding author.

Declarations

Compliance with Ethical Standards The study was approved by the Ethics in Research Committee of the University of Santiago

de Compostela. All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000. Informed consent was obtained from all patients for being included in the study. The authors declare no conflict of interest.

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