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Predictors of Smoking Cessation Among College Students in a Pragmatic Randomized Controlled Trial

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Abstract

An effective strategy to quit smoking should consider demographic aspects, smoking-related characteristics and psychological factors. This study examined potential predictors of smoking cessation in Spanish college students. A total of 255 college student smokers (18–24 years old), recruited to a cessation trial (Spain, 2013–2014), comprised an observational cohort. The main outcome was biochemically verified (urine cotinine) abstinence at the 6-month follow-up. Baseline potential predictors included socio-demographic, smoking-related and psychological variables (Fagerström Test for Nicotine Dependence (FTND), expired monoxide level (CO), intention to quit, previous quit attempts, participation in previous multicomponent programmes and confidence in quitting). Logistic regression models were used to identify potential predictors, the area under the ROC curve (AUC) was used to discriminate the capacity of the predictors and the Hosmer–Lemeshow goodness-of-fit test was used to assess model calibration. After 6 months of follow-up, variables related to high nicotine dependence, FTND and expired CO levels were associated with lower odds of quitting smoking (OR = 0.69 [95% CI 0.54–0.89] and 0.84 [0.77–0.92], respectively). Furthermore, being prepared to change (OR = 3.98 [1.49–10.64], $p = 0.006$) and being confident to quit (OR = 4.73 [2.12–10.55], $p < 0.001$) were also potential predictors of smoking cessation. The model that combined all these variables had the best predictive validity (AUC = 0.84 [0.78–0.91], $p = 0.693$) and showed good predictive capacity ($\chi^2 = 10.36$, $p = 0.241$). Findings highlight that, in this population of college student smokers, having a lower level of nicotine dependence, being prepared to quit and having the confidence in the ability to quit were associated with smoking cessation, and these factors had good predictive capacity.

Keywords Fagerström · Stage of change · Expired carbon monoxide · Self-efficacy · College student · Predictors · Smoking cessation

Introduction

In Spain, approximately 26% of the young adult population is enrolled in universities (Ministry of Education, Culture and Sport 2016). Cigarette smoking among Spanish college students is a matter of particular concern because of the high smoking prevalence (34.9%) (Varela-Mato et al. 2012), which is almost 11 points higher than among young adults not attending college (23.9%) (Spanish Observatory of Drugs and Addictions 2015). Moreover, the prevalence of nondaily smoking increases from 15 to 39.1% between the ages of 14 and 18 years (Spanish Observatory of Drugs and Addictions 2016). Finally, nicotine dependence is of particular concern because it is considered a youth-onset disorder (US Department of Health and Human Services 2012; Walker and Loprinzi 2014), and the mean age at onset in Spain is 14 years.

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The period of university study is critical for the initiation and consolidation of smoking (Bernat et al. 2012; Brown 2013). It is estimated that 30% of university smokers will have difficulty quitting, and they will remain addicted to nicotine for decades (Centers for Disease Control and Prevention 2014). Thus, helping college students quit tobacco is an important public health goal (Pardavila-Belio et al. 2015, 2019). To provide effective support for smoking cessation, it is relevant to identify which characteristics are associated with an increased probability of smoking cessation.

We already know the main predictors to quit smoking among young adults, including a low nicotine dependence, previous quit attempts, having social support to stop (Diemert et al. 2013; Walker and Loprinzi 2014), being confidence in quitting (perceived self-efficacy) (Diemert et al. 2013; US Department of Health and Human Services 2012) and the intention to quit (Haddad and Petro-Nustas 2006). However, there is no solid evidence to prove whether these aspects are similar in college students. Several studies (Hayes and Plowfield 2007; Tavolacci et al. 2013) have shown that in college students, as against noncollege students, the tobacco is used as a means of controlling stress and/or anxiety, in periods of increased intellectual demand as examinations, leading to an increase in cigarette consumption/day. This could be explained because the students believe that tobacco helps them for relaxation and concentration (Tavolacci et al. 2013), making this a reason to continue smoking (Hayes and Plowfiled, 2007). Additionally, there are other differential characteristics of the college community which influence negatively to smoking cessation such as living in a residence hall or in an apartment with other students, with no ban on smoking (Klein et al. 2013; US Department of Health and Human Services 2012). Considering the peculiarities of college students, we suggest the possibility that smoking cessation predictors may differ in comparison with other young adults.

Good measures to predict smoking cessation in college students could help health professionals personalize interventions and increase cessation rates. Cigarette-dependent measures (Bolger et al. 2010; Pardavila-Belio et al. 2015; Riaz et al. 2016) have been shown to be valid for predicting smoking cessation in young people, adults and pregnant smokers (Peña et al. 2016; Riaz et al. 2016; US Department of Health and Human Services 2012; Vangeli et al. 2011), but little is known about their validity for predicting smoking cessation in college students. In addition, studies rarely include perceived self-efficacy and the intention to change, measured by the stage change model, although this model is commonly used in daily practice (Cahill et al. 2010; Hummel et al. 2018). Moreover, a statistically significant association of some of these factors with smoking cessation is not adequate for risk prediction. Furthermore, there is no strong evidence about the capacity of these measures to discriminate those who will probably quit from those who will not quit (Pencina et al. 2008). The area under the receiver operating characteristic (ROC) curve (AUC) is frequently used to capture the discrimination capacity of risk prediction models.

In this study, we first aimed to explore the association between demographic variables and smoking-related variables to assess potential predictors of smoking cessation in college students. Second, we compared the discriminatory ability of different risk prediction models combining FTND, expired CO level, stages of change model, and perceived self-efficacy to predict smoking cessation, adjusting for age, sex, and randomization group.

Materials and Methods

Design and Participants

This study was based on a secondary analysis of data from a pragmatic randomized trial assessing a smoking cessation intervention in Spanish college students (NCT03448900) (Pardavila-Belio et al. 2015, 2019). Briefly, participants were randomized to the intervention group ($N = 133$), which received a multicomponent intervention. The first session consisted in a face-to-face 50-min motivational interview (MI) (Miller and Rollnick 2008) addressed by a nurse, and when this was finished, the nurse invited students to read the self-help material available on the college Moodle platform. This online self-help material was focused on (1) decisions, (2) moods, (3) social life, (4) smoking health effects and (5) quitting (available in the on-line version of Pardavila-Belio et al. 2015). The follow-up programme was scheduled according to the MI date. In order to provide them social support and to prevent relapses, the following follow-up plan was carried out: (1) e-mail 15 days before the MI, (2) group therapy 2 months after the MI (60 min), (3) a second follow-up visit 4 months after the MI (20 min) and (4) a final evaluation (15 min), conducted after 6 months. The control group ($N = 122$) received brief advice (5–10 min) and a self-help pamphlet. The full details of the intervention and the control condition are reported elsewhere (Pardavila-Belio et al. 2015, 2019).

In the current study, data from college smokers were analysed using a prospective design. College smokers were recruited from a university in the north of Spain between September 2013 and February 2014. The strategy used to recruit candidates for the study is described in the original trial paper (Pardavila-Belio et al. 2015). According to the inclusion criteria, participants were aged 18–24 years, were university undergraduate or master's students and had smoked an average of at least one cigarette a week within the last 6 months (Pardavila-Belio et al. 2015, 2019). All undergraduate or master's students ($n = 8{,}050$) were invited to participate in the study because a register of current smokers does not exist. A

total of 359 students agreed. Among them, 2 did not meet the inclusion criteria because they did not smoke, 4 refused to participate and 98 were unavailable for contact. A total of 255 students (age range 18–24 years) met the inclusion criteria. Of the 255 subjects enrolled in the trial, 225 (88.2%) completed the 6 months of follow-up, and 30 were lost to follow-up: 19 in the intervention group and 11 in the control group. A total of 40 (15.7%) participants reported that they had stopped smoking. Two of them refused to undergo biochemical validation, and the other two falsely reported smoking cessation. Finally, 36 (14.1%) participants were classified as abstinent.

Predictive Measures

The following demographic, psychological and smoking characteristics, available at baseline, were considered for assessment as potential predictors of smoking cessation: age, sex, area of study, area of residence, number of cigarettes smoked per day, years of smoking, nicotine dependence, expired monoxide (CO) level, intention to quit smoking, previous quit attempts, participation in a previous multicomponent programme to stop smoking and perceived self-efficacy (confidence in quitting). Additionally, the randomization group (brief advice versus multicomponent programme) was considered as a potential predictor variable (Pardavila-Belio et al. 2015).

The Fagerström Test for Nicotine Dependence (FTND) was used to measure physical nicotine dependence at baseline. We used a validated Spanish translation (Becoña and Vázquez 1998). This 6-item scale ranges from 0 to 10 points, with scores < 4 indicating minimum physical dependence, scores of 4–7 indicating moderate physical dependence and scores > 7 indicating maximum physical dependence (Heatherson et al. 1991).

The expired CO level was measured with a Bedfont Micro^{+} Smokerlyzer® device using standardized techniques. The monitor provides a score for the degree of smoking compared with normative data. Nonsmokers have CO levels of 0–6 ppm; borderline smokers, 7–9 ppm; low addicted, 10–15 ppm; moderately addicted, 16–25 ppm; heavily addicted, 26–35 ppm; and very heavily addicted, < 36 ppm (Bedfont 2017).

The intention to quit smoking was measured using Prochaska's stage of change model (Prochaska and DiClemente 1983). The students' stage of change was determined using two questions: (1) 'Did you quit smoking?' The two possible answers are 'yes' and 'no' and (2) 'If you make the decision to stop smoking definitely, when would you consider quitting?' There were four possible answers: 'not within the next 6 months', 'yes, in the next 6 months', 'yes, in the next 30 days' and 'I cannot pinpoint the exact time'. According to their responses, the students were classified as follows: precontemplation (a period in which smokers were not considering quitting smoking (at least not within the next 6 months)), contemplation (period in which smokers were seriously thinking about quitting smoking within the next 6 months) and preparation (period when smokers were seriously thinking about quitting smoking within the next month and had also tried to quit smoking during the past year) (Pardavila-Belio et al. 2015, 2019). The action (period ranging from 0 to 6 months after smokers had made the overt change to stop smoking) and maintenance (period beginning 6 months after the action had started) stages were not included because all participants were current smokers at the beginning of the study.

Perceived self-efficacy was measured with the following question: 'If you decided to quit smoking completely for two weeks, how sure are you that you would succeed?' There were two possible answers: yes or no.

All predictor variables were measured at baseline in face-to-face meetings with a trained nurse in smoking cessation interventions, using a standardized paper questionnaire.

Outcome Measures

The main outcome was smoking cessation after 6 months of follow-up. This outcome was first self-reported by the participants in an interview with one member of the research team, and biochemical validation was performed for those who self-reported at least 7 days of abstinence. We used a urine cotinine analysis, and we defined current smokers as those with cotinine values of 500 ng/ml or higher (Bize et al. 2012).

Statistical Analysis

Continuous variables are described as the mean (standard deviation (SD)), and categorical variables are described as percentages (*n*, %). We performed univariate logistic regression to assess the association between potential predictors and smoking cessation (yes/no). Among the smoking-related variables, we included baseline cigarette dependence variables (FTND, number of cigarettes per day, CO level), the stages of change model (Prochaska's model) and perceived self-efficacy to quit As baseline socio-demographic factors, we included age, sex, area of study and type of residence.

We also applied multivariable logistic regression models. In the first model, we adjusted for years of smoking and mean number of cigarettes as potential predictors and age, sex and randomization group as potential confounders. Afterwards, we performed additional analyses by adding other potential predictors one by one, including the stages of change model, perceived self-efficacy to quit and cigarette dependence variables (FTND, CO level). Finally, we performed a multivariable model with all these variables.

In addition we conducted multivariable logistic regression analyses stratified by the randomization group (multicomponent intervention or brief advice). In these models, we adjusted for the main predictors of smoking cessation (daily cigarettes, years of smoking, FTND score, expired CO, stage of change and perceived self-efficacy), age and sex. We used the likelihood ratio test to assess the statistical significance of interaction between the randomization group and the stage of change, FTND score, expired CO level and perceived self-efficacy. For this we compared a logistic regression model with the multiplicative term between the randomization group and these predictors (stage of change, FTND score, expired CO level or perceived self-efficacy) and another logistic regression model without the multiplicative term.

Discrimination was evaluated using the area under receiver operating characteristics (ROC) curve (AUC) and 95% confidence interval for the multivariable logistic regression models. We also assessed calibration by comparing the observed versus predicted probabilities of smoking cessation derived from the deciles of predicted risk obtained by the Hosmer–Lemeshow goodness-of-fit test (χ^2) (Hosmer and Lemeshow 2000).

The data were analysed on an intention-on-treat basis, assuming that the subjects who did not complete the trial had not stopped smoking (West et al. 2005).

STATA (version 12) software was used to perform the statistical analysis.

Results

Participants' Characteristics

The baseline characteristics of the participants are shown in Table 1. Of a total of 255 volunteers, 158 (62%) were women, and the mean age was 20 years. The participants were mostly light smokers, smoking a mean of nine cigarettes per day, and according to both the FTND and the expired CO level, the students had on average a mild addiction to nicotine. Most of the participants were in the passive stages of change (precontemplation and contemplation). Although 73.7% of the subjects had made a previous attempt to quit smoking, only 12.9% had received a health professional's brief advice to quit, and 2.4% had participated in a smoking cessation programme.

Table 1 Baseline characteristics of the student smokers

Variables	($N = 255$)
Demographic characteristics	
Age, mean (SD)	20.3 (1.7)
Sex, *n* (%)	
Male	97 (38.0)
Female	158 (62.0)
Area of study, *n* (%)	
Health sciences	111 (43.5)
Social sciences	108 (42.4)
Technological sciences	36 (14.2)
Residence, *n* (%)	
With parent	67 (26.3)
Residence hall	82 (32.2)
House/apartment	106 (41.6)
Smoking-related characteristics	
Daily cigarettes, mean (SD)	9.2 (5.7)
Years of smoking, mean (SD)	5.7 (2.3)
FTND*, mean (SD)	2.2 (1.8)
Expired carbon monoxide level (CO), mean (SD)	9.6 (6.2)
Stage of change (Prochaska's model), *n* (%)	
Precontemplation	87 (34.1)
Contemplation	89 (34.9)
Preparation	79 (31.0)
Previous attempts to quit, *n* (%)	
No	67 (26.3)
Yes	188 (73.7)
Previous brief advice, *n* (%)	
No	222 (87.1)
Yes	33 (12.9)
Previous multicomponent programme, *n* (%)	
No	249 (97.7)
Yes	6 (2.4)
Perceived self-efficacy, *n* (%)	
No	143 (56.1)
Yes	112 (43.9)
Randomization group, *n* (%)	
Control (brief advice)	122 (47.8)
Intervention (multicomponent programme)	133 (52.2)

**FTND* Fagerström Test for Nicotine Dependence*

Potential Predictors of Smoking Abstinence

After 6 months of follow-up, 36 of 255 (14%) participants in the study stopped smoking (verified with by cotinine analysis). Table 2 shows the association between potential predictors and smoking cessation in univariate logistic regression models. A statistically significant association was found for five variables. Variables related to high nicotine dependence, FTND and expired CO levels were associated with lower odds of quitting smoking (OR = 0.69 [95% CI 0.54–0.89] and 0.84 [0.77–0.92], respectively). Additionally, two psychological variables, perceived self-efficacy and the intention to quit (being in the preparation stage of the stages of change model), were associated with a higher odds of smoking cessation (OR = 4.73 [2.12–10.55] and 3.98 [1.49–10.64], respectively. Furthermore, the multicomponent programme intervention

Table 2 Association between socio-demographic and smoking-related variables associated with smoking abstinence (N = 255)

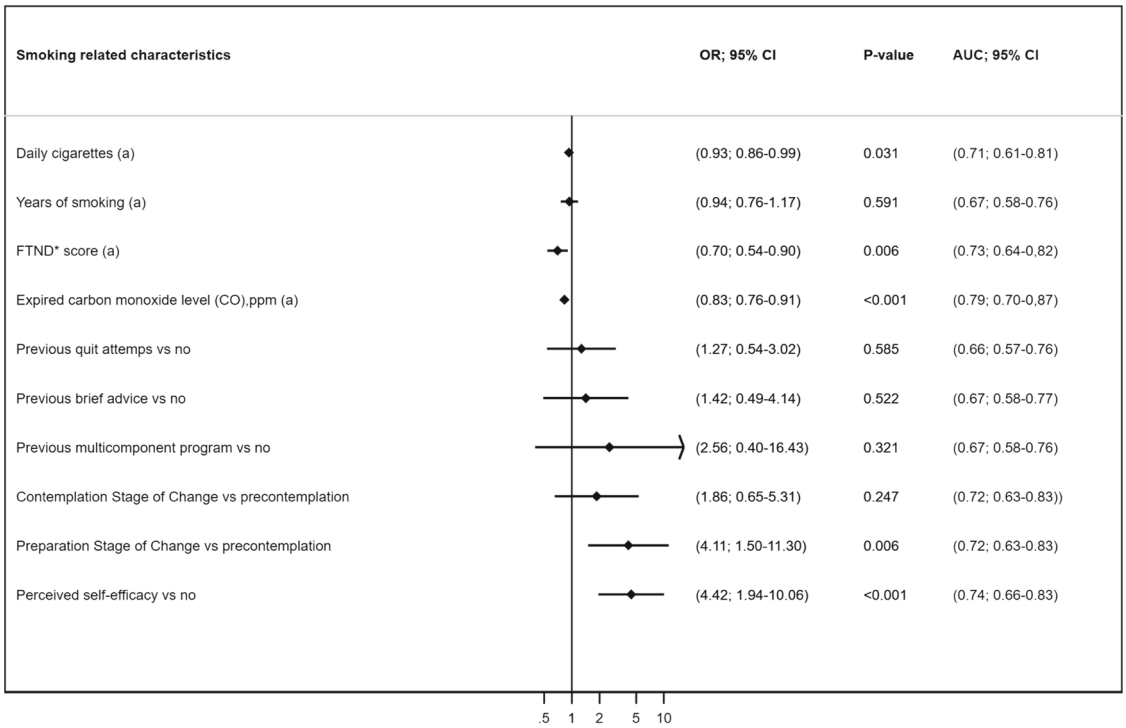
Variables	Quitters (*n*)	Nonquitters (*n*)	OR (95% CI)	*p* values
Demographic characteristics				
Age (years)			1.01 (0.82, 1.24)	0.928
Sex				
Male	15	82	1 (Ref)	
Female	21	131	0.84 (0.41, 1.72)	0.629
Area of study				
Health sciences	17	94	1 (Ref)	
Social sciences	13	95	1.11 (0.40, 3.06)	0.846
Technological sciences	6	30	0.76 (0.35, 1.64)	0.481
Residence				
With parents	12	55	1 (Ref)	
Residence hall	8	74	0.50 (0.19, 1.29)	0.152
House/apartment	16	90	0.81 (0.36, 1.85)	0.625
Smoking-related characteristics				
Daily cigarettes, number per day			0.93 (0.87, 1.00)	0.057
Years of smoking			0.99 (0.85, 1.15)	0.853
FTND* score (units)			0.69 (0.54, 0.89)	0.004
Expired carbon monoxide level (CO)[a] (ppm)			0.84 (0.77, 0.92)	< 0.001
Previous attempts to quit				
No	8	59	1 (Ref)	
Yes	28	160	1.29 (0.56, 2.99)	0.552
Previous brief advice				
No	31	191	1 (Ref)	
Yes	5	28	1.10 (0.39, 3.06)	0.855
Previous multicomponent programme				
No	34	215	1 (Ref)	
Yes	2	4	3.16 (0.56, 17.93)	0.194
Stage of change (Prochaska's model)				
Precontemplation	6	81	1 (Ref)	
Contemplation	12	77	2.10 (0.75, 5.88)	0.156
Preparation	18	61	3.98 (1.49, 10.64)	0.006
Perceived self-efficacy				
No	9	134	1 (Ref)	
Yes	27	85	4.73 (2.12, 10.55)	< 0.001
Randomization group				
Brief advise	8	114	1 (Ref)	
Multicomponent programme	28	105	3.80 (1.66, 8.71)	0.002

**FTND* Fagerström Test for Nicotine Dependence

[a] The odd ratios reflect the effect of a per-unit change in the independent variable on the smoking cessation outcome

was significantly associated with higher odds of smoking abstinence (OR = 3.80 [1.66–8.71], $p = 0.002$). Similar results were found after adjusting for age, sex and randomization group (Fig. 1).

Figure 1 shows that the highest AUC value was found in the model that included perceived self-efficacy (AUC = 0.74). The discriminatory ability increased progressively with the number of predictors included in the regression model (Table 3). The highest AUC value was found for the fully adjusted model, which included age, sex, randomization group, FTND, expired CO level, stages of change model and perceived self-efficacy (0.84 [0.78–0.91]). Suppl. Figure 1 shows the calibration of this model (observed versus predicted probabilities of



Adjusted for age, sex, and randomization group. * FTND (Fagerström Test for Nicotine Dependence). a. The odd ratios reflect the effect of a per-unit change in an independent variable on the smoking cessation outcome.

Fig. 1 Multivariable logistic regression model analyses of smoking-related characteristics associated with smoking cessation ($N = 255$)

smoking cessation) across deciles of predicted risk. The Hosmer–Lemeshow χ^2 did not reach statistical significance, indicating adequate goodness of fit.

Table 4 shows the association between the main potential predictors and smoking cessation in multivariable logistic regression models stratified by randomization group. A statistically significant association with smoking cessation was found for CO levels, perceived self-efficacy and intention to quit only in participants receiving the multicomponent intervention. The expired CO levels variable were associated with lower odds of quitting smoking (OR = 0.83 [95% CI 0.72–0.96]), and the perceived self-efficacy to quit and the intention to quit (being in the preparation stage of the stages of change model) were associated with a higher odds of smoking cessation (OR = 4.73 [95% CI 1.44–15.55] and 5.49 [95% CI 1.97–15.27], respectively). We did not find statistically significant interactions between randomization group with nicotine dependence measures (FTND score and expired CO level) or perceived self-efficacy of smoking cessation. Nevertheless, we found a significant interaction between stages of changes

Table 3 Measures of discrimination and calibration comparing different multivariable adjusted models for predicting smoking cessation

Model	Hosmer–Lemeshow		Receiver operating characteristics	
	χ^2	*p* value	AUC (95% CI)	*p* for difference
Years of smoking and number of cigarettes	6.67	0.573	0.76 (0.67–0.85)	Reference
+ FTND*	3.68	0.885	0.79 (0.72–0.86)	0.259
+ Expired carbon monoxide level (CO)	7.44	0.491	0.80 (0.72–0.88)	0.160
+ Stages of change (Prochaska's model)	9.33	0.315	0.77 (0.68–0.87)	0.490
+Perceived self-efficacy	13.41	0.099	0.77 (0.68–0.86)	0.561
+ FTND* and stages of change (Prochaska's model)	8.96	0.346	0.80 (0.73–0.89)	0.090
+ FTND*, stages of change (Prochaska's model), and perceived self-efficacy	9.71	0.286	0.82 (0.74–0.89)	0.048
+ FTND*, expired carbon monoxide level, stages of change, and perceived self-efficacy	10.36	0.241	0.84 (0.78–0.91)	0.008

Adjusted for age, sex, and randomization group

**FTND* Fagerström Test of Nicotine Dependence

Table 4 Stratified analysis by intervention group (multicomponent intervention group compared versus brief advice) showing the association between principal predictors with smoking cessation

Variables	Multivariable OR (95% CI)	*p* values
Multicomponent intervention (n = 133)		
Daily cigarettes[a]	0.97 (0.72, 1.31)	0.827
Years of smoking[a]	0.98 (0.87, 1.10)	0.688
FTND[a] score	1.18 (0.74, 1.89)	0.482
Expired carbon monoxide level (CO)[a]	0.83 (0.72, 0.96)	0.012
Stage of change (Prochaska's model)		
Precontemplation or contemplation	1 (Ref)	
Preparation stage of change	5.49 (1.97, 15.27)	0.001
Perceived self-efficacy		
No	1 (Ref)	
Yes	4.73 (1.44, 15.55)	0.011
Brief advice (n = 122)		
Daily cigarettes[a]	1.14 (0.94, 1.38)	0.183
Years of smoking[a]	0.90 (0.53, 1.51)	0.682
FTND*[a] score	0.80 (0.41, 1.57)	0.523
Expired carbon monoxide level (CO)[a]	0.83 (0.67, 1.02)	0.079
Stage of change (Prochaska's model)		
Preparation stage of change	1 (Ref)	
Precontemplation or contemplation	0.49 (0.08, 2.97)	0.441
Perceived self-efficacy		
No	1 (Ref)	
Yes	2.13 (0.41, 11.02)	0.367

Adjusted for age, and sex

**FTND* Fagerström Test for Nicotine Dependence

[a] The odd ratios reflect the effect of a per-unit change in the independent variable on the smoking cessation outcome

and randomization group (p = 0.008). Figure 2 shows the joint analysis between the randomization group and the stages of changes. Using those participants in the control group (brief advice) and in precontemplation or contemplation stage as reference group, we found that college students who were prepared to change and received the multicomponent intervention had the highest probability of quitting smoking (odds ratio 8.20 [95% CI 2.51–26.77]).

Discussion

In this population of college student smokers, we found that both smoking dependence and psychological factors are significantly associated with smoking cessation. Self-confidence in quitting had the highest discrimination ability after adjusting for age, sex and randomization group. Moreover, the model that combined all the potential predictors, including FTND, expired CO level, stage of change and perceived self-efficacy, had the best discrimination ability (an AUC of 84%).

The association of a lower level of nicotine dependence, measured by FTND and expired CO, with smoking abstinence is consistent with other studies of youths (Cengelli et al. 2012; US Department of Health and Human Services 2012) and adults (Hyland et al. 2004; McPherson et al. 2014; Peña et al. 2016; Vangeli et al. 2011). In other words, the higher the Fageströn test score (score from 0 to 7) and the higher the CO level of expired air (measured in pp.mm.) is associated with less success in smoking cessation. Furthermore, the AUC values showed that both predictors had adequate discrimination ability (79% for the FTND and 80% for expired CO level).

The results of our study show an association between preparedness to quit (thinking about stopping smoking in the next month) and smoking cessation. These results are similar to those of the Haddad and Petro-Nustas (2006) study with Jordanian University students. The use of the stages of the change model as a measure of intention to quit smoking has been criticized by several authors (Cahill et al. 2010; Riemsma et al. 2003; West 2005). One of the principal problems of this approach is that classifying individuals assumes that they make coherent and stable plans (West 2005). However, we found that this predictor had an AUC of 77% for discriminating between quitters and nonquitters after a 6-month follow-up.

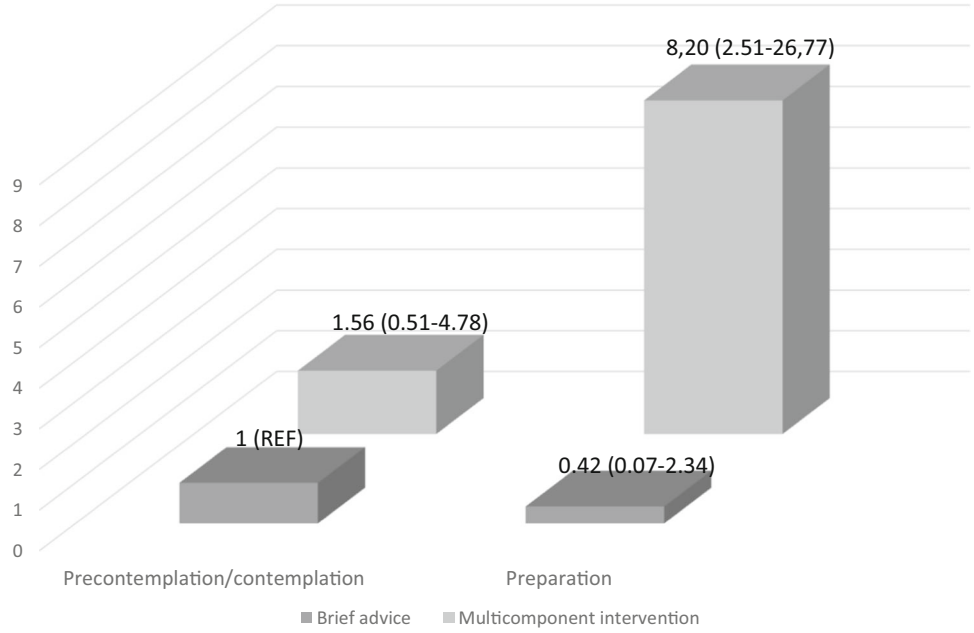


Fig. 2 Multivariable adjusted odds ratio (95% CI) for smoking cessation according by stage of change stratified by multicomponent intervention or brief advice

Adjusted for daily cigarettes, years of smoking, Fageström Test for Nicotine Dependence score, expired carbon monoxide level, perceived self-efficacy, age, and sex.

Similar to previous studies, we found that the perceived self-efficacy for quitting was associated with successfully quitting in college students (Diemert et al. 2013; Piper 2015). In addition, this measure had a good predictive capacity (77%). Because this was a good predictor, it may be useful to promote strategies for increasing self-confidence in smoking cessation programmes with college student smokers.

We found that the model with all potential predictors had the best discrimination ability according to the AUC values (84%). This model included both the FTND and the expired CO level with the stages of change and the perceived self-efficacy. When comparing this model with a model without the expired CO level, we found a small difference between the AUCs (2%). Considering the cost associated with measuring expired CO, measurements of just FTND and the psychological aspects related to quitting smoking could be used to predict the potential success of a smoking cessation programme among college student smokers.

One aspect to take into account is the modification of the effect by the intervention programme on the association between the initial stages of change of the participants and the odds of tobacco cessation. We observed that being in the multicomponent intervention group had a synergistic effect in combination with being determined for smoking cessation. According to these results, special efforts should be made to determine how ready students are prepared to quit smoking during the implementation of an intervention for smoking cessation. In this regard, motivational interview (MI) is based on the theoretical stages of change, which help the health professional to determine how ready a student is prepared to quit (Pardavila-Belio et al. 2019) and to improve the progress through these stages (Borland et al. 2013; Pardavila-Belio et al. 2019). The higher the number of participants who move for precontemplantion or contemplation stages to determination for change, the higher the probability of success for smoking cessation.

Implications for Smoking Cessation Interventions Tailored Toward College Students

Our results indicate that interventions tailored toward college students should take into account the main predictors of smoking cessation: nicotine dependence, intention to quit and perceived self-efficacy.

Regarding nicotine dependence, cravings and the negative effects of nicotine deprivation are associated with relapse in undergraduates who are heavy smokers (Piper 2015; Piñeiro et al. 2014; Van Zundert et al. 2012). In addition, withdrawal can influence smokers' cognitive processes, causing them to tire of quitting (Piper 2015).

Bandura (1998) suggested that high self-efficacy at the preparation stage contributes to taking action and maintaining the corresponding behaviour. Based on this assumption and our results, we propose the use of MI for the following reasons: (1) MI is based on the theoretical stages of change and can help health professionals

improve smokers' progress through these stages (Borland et al. 2013; Pardavila-Belio et al. 2019), and (2) the literature suggests that MI strategies, such as feedback, emphasize personal responsibility and that an empathetic counselling style increases undergraduates' self-efficacy for quitting (Bolger et al. 2010; Pardavila-Belio et al. 2019).

Therefore, we suggest that the interventions to support college students in quitting smoking should have three phases: (1) a face-to-face MI (Toljamo et al. 2012), (2) optional nicotine replacement therapy (NRT) to manage nicotine withdrawal (Van Zundert et al. 2012) in those students with a high level of nicotine dependence and (3) a follow-up support programme to maintain abstinence and prevent relapses. In addition, we recommend that these interventions be conducted within the university's own health services to facilitate access to these programmes for students.

Strengths and Weaknesses

This study is the first to include both association measures in the statistical analysis, along with the calibration (goodness-of-fit analysis) and discrimination ability (AUC). Both calibration and discrimination are essential factors for determining the clinical validity and clinical utility of an intervention programme for smoking cessation (Altman et al. 2009; Kraft et al. 2009; Real et al. 2016). Our study is also the first to employ data from a clinical trial of college students that is biochemically validated with urine cotinine measurements, a method for verifying self-reported abstinence. The use of this indicator is especially important when testing associations with factors that influence smoking cessation (Riaz et al. 2016). Furthermore, an intention-to-treat approach was applied, assuming that students who did not attend the evaluation session had not stopped smoking.

Power analysis was not calculated concretely for this study as it was based on a secondary analysis of a clinical trial that focused on evaluating the effectiveness of a multicomponent intervention aimed at helping college students to quit smoking. Thus, the sample size of this study was relatively small, and we could only detect relatively strong predictive relationships. Nevertheless, our results are consistent with much larger studies of college students or young adult populations. Although this research considered a broad range of variables that could be related to quitting, there are other factors that could also be good predictors of smoking cessation. Finally, although we assessed the participants' smoking status at the 6-month follow-up, we suggest that future research should include longer-term quitters (12 months), which may provide greater insight into the predictors of smoking cessation.

Conclusion

The findings of this study show that lower levels of dependence, being prepared and having confidence to quit, are associated with smoking cessation, with very similar predictive capacity. Moreover, this study suggests that when considering the cost-effectiveness of interventions in clinical settings, omitting expired CO level measurements will not substantially impact the capacity to predict potential barriers for smoking cessation in a college student population. Our findings could be used to design successful smoking cessation interventions targeted toward undergraduates, although to confirm our results, additional studies are needed, including studies to determine additional long-term predictors of smoking abstinence among college students.

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Compliance with Ethical Standards

Informed consent was obtained from all students before starting the face-to-face interview. Ethical approval was sought and granted by the University of Navarra Research Ethics Committee (reference number 055/2013).

Conflict of Interest The authors declare that they have no conflict of interest.

Statement of Human Rights All procedures performed in this study in were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments.

Statement of the Welfare of Animals This article does not contain any studies with animals performed by any of the authors.

Informed Consent Informed consent was obtained from all individual participants included in the study.

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