

Association Between Smoking Cessation and Obstructive Spirometry Pattern: A Cross-sectional Study

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Abstract

Smoking cessation aids in restoring lung function. However, whether long-term cessation can fully restore lung function has not been studied thoroughly, especially in Asian countries. This study aimed to evaluate the association between smoking cessation status and obstructive spirometry pattern among Koreans aged 40–79 years. In total, 6,298 men and 8,088 women aged 40–79 years from the Korea National Health and Nutrition Examination Survey (2015–2019) were analyzed for smoking cessation status, including the duration after quitting. Current-smokers showed a higher likelihood of having an obstructive spirometry pattern than never-smokers among both men (odds ratio [OR]: 3.15, 95% confidence interval [CI]: 2.32–4.29) and women (OR: 2.60, 95% CI: 1.59–4.23). In men, the effect tended to decrease with longer duration after cessation, but male ex-smokers who had quit smoking ≥ 20 years ago still showed a higher likelihood of having an obstructive spirometry pattern than male never-smokers (OR: 1.40, 95% CI: 1.05–1.89). In female ex-smokers, there was no significant association with the obstructive spirometry pattern, compared to that in female never-smokers. This study emphasizes the benefits of smoking cessation, possibility of long-lasting harm to lung function due to tobacco smoking, and importance of smoking prevention.

Introduction

Chronic obstructive pulmonary lung disease (COPD) is a progressive life-threatening lung disease and a major public health problem worldwide [1]. Globally, 251 million cases of COPD are reported, and it accounts for approximately 5% of all deaths [2].

The primary causative factor of COPD is tobacco smoking. Studies have revealed that 15–50% of elderly smokers eventually develop COPD, and 40–70% of COPD cases are attributed to tobacco smoking [3–6].

Usually, lung function reaches its maximal capacity at the age of 20–25 years and thereafter declines gradually with aging [7,8]. Smoking accelerates this age-related decline in lung function and eventually results in chronic airway obstruction [8,9]. Particularly, greater smoking volume, or adolescent-onset smoking, is known to be associated with a high risk of lung function impairment and COPD [10–12].

The accelerated decline in lung function could be alleviated by the cessation of smoking [11]. Three to five years after smoking cessation, the age-related FEV₁ decline almost halved in ex-smokers compared to that in current smokers [12,13]. More recent studies have explored whether long-term smoking cessation could completely normalize lung function, and if so, how long it will take for full restoration. A meta-analysis reported that the FEV₁ decline in ex-smokers did not differ from that in never-smokers [14]. In contrast, the lung function of ex-smokers did not normalize even decades after smoking cessation in a prospective cohort study conducted in the US population [15]. Moreover, it remains unclear whether the lung function of high-risk smokers, such as heavy smokers or adolescent-onset smokers, can recover to the level observed in other ex-smokers after long-term cessation. The impact of smoking cessation on lung function recovery has been well described in Western countries, while there are only few studies, conducted using reliable measuring instruments, focusing on long-term cessation in the Asian population.

Therefore, this study aimed to investigate the relationship between smoking cessation status, including the duration after cessation, and obstructive spirometry pattern among Korean adults aged 40–79 years, using a nationally representative survey. We also performed an additional analysis to investigate whether the cumulative smoking exposure or adolescent-onset smoking affected the association between lung function and smoking cessation status among male participants. Lastly, to minimize age differences across categories of smoking cessation status, separate analyses were performed after dividing the study participants into 10-year age groups.

Results

Of 6,298 men and 8,088 women, 1,326 (21.1%) and 467 (5.8%) showed an obstructive spirometry pattern, respectively. Among men, 1,111 (17.6%) were never-smokers; 2,001 (31.8%) were current-smokers; and 1,007 (16.0%), 493 (7.8%), 528 (8.4%), 477 (7.6%), and 681 (10.8%) were ex-smokers with ≥ 20 , 15–20, 10–15, 5–10, and < 5 years of cessation, respectively. Among women, 7,379 (91.2%) were never-smokers; 344 (4.3%) were current-smokers; and 123 (1.5%), 42 (0.5%), 74 (0.9%), 37 (0.5%), and 89 (1.1%) were ex-smokers with ≥ 20 , 15–20, 10–15, 5–10, and < 5 years of cessation, respectively (Table 1).

Current-smokers showed a higher likelihood of having an obstructive spirometry pattern than never-smokers among both men (odds ratio [OR]: 3.15, 95% confidence interval [CI]: 2.32–4.29) and women (OR: 2.60, 95% CI: 1.59–4.23). Male ex-smokers were more likely to have an obstructive spirometry pattern than male never-smokers; the risk tended to decrease with a longer duration of smoking cessation: the ORs were 1.93 (95% CI: 1.32–2.84), 2.66 (95% CI: 1.84–3.87), 1.48 (95% CI: 1.00–2.18), 1.18 (95% CI: 0.82–1.68), and 1.40 (95% CI: 1.05–1.89) in male ex-smokers with < 5 , 5–10, 10–15, 15–20, and ≥ 20 years of cessation, respectively. Female ex-smokers showed no significant association with the obstructive spirometry pattern, when compared to female never-smokers (Table 2).

Compared to male never-smokers, male current-smokers who had started smoking before and after the age of 15 years showed ORs of 4.55 (95% CI: 2.08–9.94) and 3.16 (95% CI: 2.32–4.30), respectively, for the obstructive spirometry pattern. Male ex-smokers who had started smoking before and after the age of 15 years and had quit smoking ≥ 20 years ago showed ORs of 1.30 (95% CI: 0.49–3.45) and 1.41 (95% CI: 1.05–1.90), respectively, for the obstructive spirometry pattern (comparison group: male never-smokers) (Figure 1).

The ORs for the obstructive spirometry pattern were 2.67 (95% CI: 1.90–3.76), 4.41 (95% CI: 3.10–6.27), and 5.01 (95% CI: 3.73–6.74) in male current-smokers with < 20 , 20–30, and ≥ 30 pack-years of smoking, respectively (comparison group: male never-smokers). Compared to male never-smokers, male ex-smokers with ≥ 20 years of cessation and < 20 , 20–30, and ≥ 30 pack-years of smoking showed ORs of 1.53 (95% CI: 1.12–2.09), 1.41 (95% CI: 0.84–2.36), and 1.66 (95% CI: 1.01–2.72) for the obstructive spirometry pattern, respectively (Figure 2).

Among men, the relationship between smoking cessation status and obstructive spirometry pattern was generally similar across age groups, except in the 40–49 years age group. Men aged 40–49 years did not show any significant association between smoking cessation status and obstructive spirometry pattern (Table 3)

Discussion

In this cross-sectional study, we evaluated the association between smoking cessation status, considering the duration after smoking cessation, and obstructive spirometry pattern among Korean adults aged 40–79 years. Our findings suggested that a longer duration of smoking cessation was related to a decreasing tendency in the likelihood of having an obstructive spirometry pattern among men. However, despite ≥ 20 years after smoking cessation, male ex-smokers still showed a higher likelihood of having the obstructive spirometry pattern than male never-smokers. Analyses after stratification by age groups, which reduced the potential difference in age distribution across smoking cessation status categories, showed a tendency similar to that observed in the main analysis. In women, the number of ex-smokers with the obstructive spirometry pattern was not sufficient to perform analyses.

Since our study was cross-sectional design, the partial restoration of lung function observed can be explained in two ways. First, although the rate of lung function decline normalized, the decrease in maximal lung function due to smoking was not fully restored. Second, acceleration of the age-related decline in lung function due to smoking could not be fully normalized even after long-term cessation. Our results are consistent with recent cohort study that although smoking cessation has a benefit in terms of lung function, lung injury from smoking could persist for decades after smoking cessation [15].

Tobacco smoking is related to pathophysiologic abnormalities of the lung, including inflammation [16-18], immune dysfunction and increased susceptibility to infection [19-21], mucus hypersecretion [22,23], genetic abnormalities [24,25], and airway remodeling [26-28]. Although such lung abnormalities can improve with smoking cessation, there is evidence for sustained pathophysiological abnormalities in ex-smokers [16,18]. Lung injuries during the active smoking period, such as irreversible emphysematous change, may also contribute to persistent lung function impairment.

Findings regarding heavy smokers or adolescent-onset smokers are also notable. In male current-smokers, greater cumulative smoking exposure and adolescent-onset smoking showed relatively higher effect sizes (represented as ORs) for the obstructive spirometry pattern than their counterparts. However, among male ex-smokers with a smoking cessation duration of ≥ 20 years, participants showed similar effect sizes for the obstructive spirometry pattern across categories of cumulative smoking exposure and age at smoking onset. Therefore, long-term smoking cessation may be more beneficial for high-risk smokers than for low-risk smokers, in terms of recovering lung function. These findings reinforce prior research that heavy smokers benefited from smoking cessation more than did light smokers, in the first year after cessation [12].

This study has several limitations. First, the number of years of smoking cessation and cumulative smoking exposure were indirectly calculated without considering intermittent smoking history. Although self-reported smoking history is known to be highly reliable, the gap between the actual and estimated smoking history may have affected our results (Vartiainen, 2002 #14). Second, Korean women are likely to underreport their history of smoking owing to social unacceptance. Therefore, the number of female smokers was lower than expected in this study, and the results may have been distorted. Third, with the cross-sectional design, we could not estimate individuals' age-related decline in lung function. Instead, the likelihood of having an obstructive spirometry pattern was used to evaluate the lung function of participants. Thus, our results should be cautiously interpreted, when compared to the findings of similar studies. Further long-term prospective study, including accurate smoking history of women participants, is needed to evaluate impacts of smoking cessation on age-related decline in lung functions in Koreans.

Despite these limitations, this study has a major strength: this study was based on one of the most representative health statistics of the Korean population and a reliable measurement of lung function.

In conclusion, our study showed that a longer duration of smoking cessation was linked to a decreasing tendency in the likelihood of having an obstructive spirometry pattern among men. Our findings suggest that tobacco smoking causes long-lasting harm to lung function and indicates the importance of the prevention and cessation of smoking, particularly in high-risk male smokers.

Methods

Ethical considerations

The Korea National Health and Nutrition Examination Survey (KNHANES) is conducted by the Korean government, and the data are anonymized and released to the public for research. In this study, further approval from the institutional review board was not required, based on Article 15.2 of the Bioethics and Safety Act in Korea.

Study subjects and data sources

This was a cross-sectional study. The study data were collected during 2015–2019 from the KNHANES VI, VII, and VIII. The KNHANES is a cross-sectional, nationally representative survey that assesses the health, risk factors for health, and nutritional status of Koreans; it is conducted annually by the Korea Centers for Disease Control and Prevention. Details on the design and contents of the KNHANES are available on the KNHANES webpage (<https://knhanes.kdca.go.kr/knhanes/eng/index.do>).

The study included participants aged 40–79 years, which is the target population of the spirometry test in the KNHANES. Participants with asthma, with unreadable spirometry results, or who were unable to undergo the test were excluded from the study. Those who had incomplete or missing data were also excluded. The final study population included 6,298 men and 8,088 women.

Exposure and outcomes

Participants were classified as never-smokers, ex-smokers, or current-smokers according to their self-reported smoking status. Ex-smokers were subdivided into five categories according to the duration after smoking cessation: < 5 years, 5–10 years, 10–15 years, 15–20 years, and ≥ 20 years.

The obstructive spirometry pattern was defined as an FEV₁/FVC < 0.7 [29,30]. Spirometry was performed at least two times by trained technicians, and the largest value was reported. The study included only interpretable and reproducible spirometry results. The quality of the spirometry test was managed by the Korean Academy of Tuberculosis and Respiratory Diseases.

Covariates

All data were stratified by sex. The covariates were pack-years of smoking (< 20 years, 20–30 years, > 30 years), age (continuous variable), education level (middle school or below, high school, college or above), household income (quartile of household income according to the 2015–2019 KNHANES survey), occupation (white collar, pink collar, blue collar, none or homemaker), area of residence (capital, metropolitan, rural), high-risk drinking (yes, no), aerobic physical activity (active, inactive), and height (continuous variable).

Statistical analyses

Chi-square tests were performed to determine differences in general characteristics between participants with and without an obstructive spirometry pattern. Multiple logistic regression analysis was performed to calculate ORs with 95% CIs for evaluating the relationship between smoking cessation status and obstructive spirometry pattern. All statistical analyses were performed using SAS software (version 9.4, SAS Institute, Cary, NC, USA).

Declarations

Data availability

The datasets generated during and/or analysed during the current study are available in the KNHANES webpage (Korean), [https://knhanes.kdca.go.kr/knhanes/sub03/sub03_02_05.do].

Acknowledgements

Author contributions (names must be given as initials)

J.B.A was involved in the study conceptualization and design. Y.J.Y., M.S.L., and K.W.J. contributed to data analysis and interpretation. E.-C.P. and K.H. supervised the study and revised the manuscript for important intellectual content. All authors have reviewed and approved the final manuscript.

Competing interests

The authors declare no competing interests.

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Tables

Table 1. General characteristics of the study population

Variables	Obstructive spirometry pattern ^a											
	Men						<i>P-value</i>	Women				
	Total		Yes		No			Total		Yes		No
	N	%	N	%	N	%		N	%	N	%	N
Total	6,298	100.0	1,326	21.1	4,972	78.9		8,088	100.0	467	5.8	7,621
Smoking cessation status (years of cessation)	<.0001											
Never-smoker	1,111	17.6	149	13.4	962	86.6		7,379	91.2	410	5.6	6,969
Ex-smoker (≥ 20)	1,007	16.0	251	24.9	756	75.1		123	1.5	7	5.7	116
Ex-smoker (15–20)	493	7.8	91	18.5	402	81.5		42	0.5	1	2.4	41
Ex-smoker (10–15)	528	8.4	103	19.5	425	80.5		74	0.9	5	6.8	69
Ex-smoker (5–10)	477	7.6	122	25.6	355	74.4		37	0.5	3	8.1	34
Ex-smoker (< 5)	681	10.8	142	20.9	539	79.1		89	1.1	6	6.7	83
Current smoker	2,001	31.8	468	23.4	1,533	76.6		344	4.3	35	10.2	309
Cumulative smoking exposure (pack-years)	<.0001											
< 20	3,600	57.2	565	15.7	3,035	84.3		7,997	98.9	454	5.7	7,543
20–30	1,141	18.1	240	21.0	901	79.0		54	0.7	6	11.1	48
> 30	1,557	24.7	521	33.5	1,036	66.5		37	0.5	7	18.9	30
Age (years), mean, SD	57.5	10.7	65.1	9.1	55.4	10.2	<.0001	57.3	10.5	64.9	9.4	56.7
Education level	<.0001											
Middle school or below	1,828	29.0	606	33.2	1,222	66.8		3,306	40.9	302	9.1	3,004
High school	2,091	33.2	409	19.6	1,682	80.4		2,722	33.7	113	4.2	2,609
College or above	2,379	37.8	311	13.1	2,068	86.9		2,060	25.5	52	2.5	2,008
Household income	<.0001											
Low	978	15.5	338	34.6	640	65.4		1,619	20.0	175	10.8	1,444
Mid-low	1,557	24.7	400	25.7	1,157	74.3		2,024	25.0	124	6.1	1,900
Mid-high	1,718	27.3	295	17.2	1,423	82.8		2,103	26.0	93	4.4	2,010
High	2,045	32.5	293	14.3	1,752	85.7		2,342	29.0	75	3.2	2,267
Occupation^b	<.0001											
White collar	1,726	27.4	183	10.6	1,543	89.4		1,340	16.6	24	1.8	1,316
Pink collar	574	9.1	87	15.2	487	84.8		1,416	17.5	66	4.7	1,350
Blue collar	2,535	40.3	534	21.1	2,001	78.9		1,588	19.6	117	7.4	1,471
None/homemaker	1,463	23.2	522	35.7	941	64.3		3,744	46.3	260	6.9	3,484
Residential area	<.0001											
Capital	2,601	41.3	425	16.3	2,176	83.7		3,407	42.1	150	4.4	3,257
Metropolitan	1,754	27.9	431	24.6	1,323	75.4		2,246	27.8	145	6.5	2,101
Rural	1,943	30.9	470	24.2	1,473	75.8		2,435	30.1	172	7.1	2,263
High-risk drinking	0.0011											
No	5,021	79.7	1,100	21.9	3,921	78.1		7,775	96.1	449	5.8	7,326
Yes	1,277	20.3	226	17.7	1,051	82.3		313	3.9	18	5.8	295
Aerobic physical activity	0.3103											
Active	2,849	45.2	583	20.5	2,266	79.5		3,272	40.5	171	5.2	3,101

Inactive	3,449	54.8	743	21.5	2,706	78.5		4,816	59.5	296	6.1	4,520
Height (cm), mean, SD	169.2	6.2	168.1	6.3	169.5	6.1	<.0001	156.5	5.9	155.5	6.3	156.5

^aObstructive spirometry pattern was defined as an FEV₁/FVC < 0.7

^bBased on the International Standard Classification Occupations codes

SD, standard deviation

Table 2. Association between smoking cessation status and obstructive spirometry pattern

Variables	Obstructive spirometry pattern ^a				
	Men			Women	
	OR	95% CI		OR	95% CI
Smoking cessation status (years of cessation)					
Never-smoker	1.00			1.00	
Ex-smoker (≥ 20.0)	1.40	(1.05	1.89)	1.08	(0.44 2.67)
Ex-smoker (15–20)	1.18	(0.82	1.68)	1.79	(0.21 15.02)
Ex-smoker (10–15)	1.48	(1.00	2.18)	1.43	(0.48 4.24)
Ex-smoker (5–10)	2.66	(1.84	3.87)	1.62	(0.44 5.98)
Ex-smoker (< 5)	1.93	(1.32	2.84)	1.32	(0.47 3.69)
Current smoker	3.15	(2.32	4.29)	2.60	(1.59 4.23)
Cumulative smoking exposure (pack-years)					
< 20	1.00			1.00	
20–30	1.28	(1.02	1.62)	1.20	(0.42 3.43)
> 30	1.47	(1.20	1.80)	1.00	(0.35 2.85)
Age (years)	1.12	(1.10	1.13)	1.09	(1.08 1.11)
Education level					
Middle school or less	1.00			1.00	
High school	0.84	(0.69	1.02)	1.01	(0.77 1.34)
College or over	0.82	(0.64	1.05)	0.98	(0.66 1.45)
Household income					
Low	1.00			1.00	
Mid-low	1.08	(0.86	1.37)	0.92	(0.70 1.21)
Mid-high	0.90	(0.70	1.15)	0.83	(0.60 1.16)
High	0.91	(0.69	1.21)	0.76	(0.53 1.09)
Occupation^b					
White collar	1.00			1.00	
Pink collar	1.12	(0.79	1.58)	1.41	(0.80 2.48)
Blue collar	1.12	(0.86	1.46)	1.33	(0.75 2.36)
None/homemaker	1.11	(0.85	1.45)	1.21	(0.71 2.04)
Residential area					
Capital area	1.00			1.00	
Metropolitan area	1.40	(1.15	1.70)	1.52	(1.13 2.05)
Rural	1.39	(1.14	1.69)	1.50	(1.13 1.99)
High-risk drinking					
No	1.00			1.00	
Yes	0.96	(0.78	1.18)	1.25	(0.68 2.30)
Aerobic physical activity					
Active	1.00			1.00	
Inactive	0.80	(0.69	0.92)	1.06	(0.85 1.32)
Height (cm)	1.04	(1.03	1.06)	1.05	(1.03 1.07)

Table 2. Association between smoking cessation status and obstructive spirometry pattern

Variables	Obstructive spirometry pattern ^a			
	Men		Women	
	OR	95% CI	OR	95% CI

^aObstructive spirometry pattern was defined as an FEV₁/FVC < 0.7

^bBased on the International Standard Classification Occupations codes

OR, odds ratio; CI, confidence interval

Table 3. Association between smoking cessation status and obstructive spirometry pattern according to age group

Variables	Age (years)	Never-smoker	Obstructive spirometry pattern ^a							
			Ex-smoker (cessation years)							
			≥ 20		15–20		10–15		5–10	
OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	
Men	40–49	1.00	0.74 (0.18 3.01)	0.50 (0.11 2.32)	0.34 (0.08 1.40)	1.17 (0.42 3.31)				
	50–59	1.00	1.75 (0.84 3.64)	1.08 (0.47 2.47)	1.69 (0.75 3.81)	2.16 (0.93 4.97)				
	60–69	1.00	1.46 (0.92 2.33)	1.70 (1.02 2.83)	1.70 (0.94 3.05)	3.35 (1.89 5.84)				
	70–79	1.00	1.64 (1.03 2.60)	1.15 (0.60 2.19)	1.83 (0.93 3.62)	4.34 (2.03 9.31)				
Women	40–49	1.00	3.12 (0.75 12.91)	4.73 (0.86 25.99)	3.33 (0.63 17.74)	-				
	50–59	1.00	0.30 (0.04 2.30)	-	1.69 (0.18 15.81)	-				
	60–69	1.00	-	-	0.85 (0.16 4.38)	-				
	70–79	1.00	1.08 (0.25 4.73)	-	-	6.90 (1.15 41.44)				

^aObstructive spirometry pattern was defined as an FEV₁/FVC < 0.7.

OR, odds ratio; CI, confidence interval

Figures

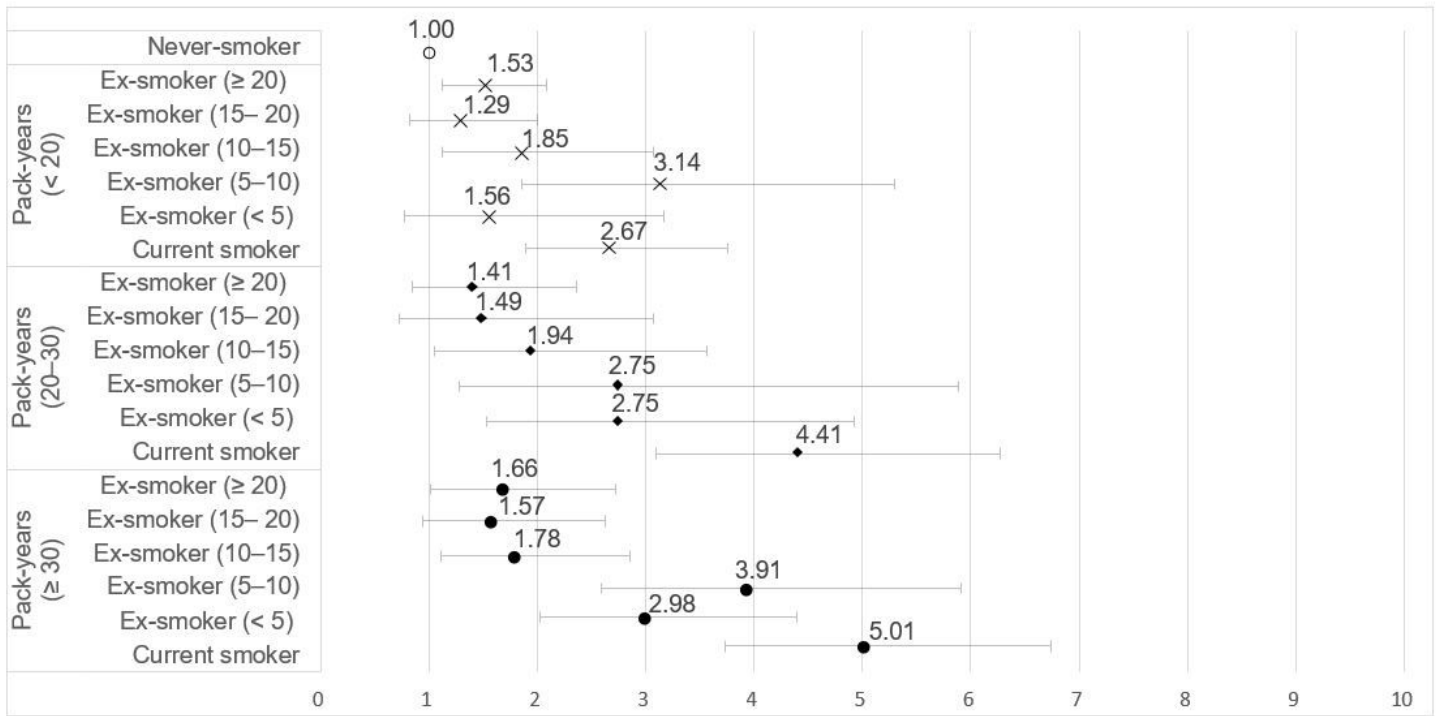


Figure 1

Association between smoking cessation status and obstructive spirometry pattern according to the cumulative smoking exposure in men

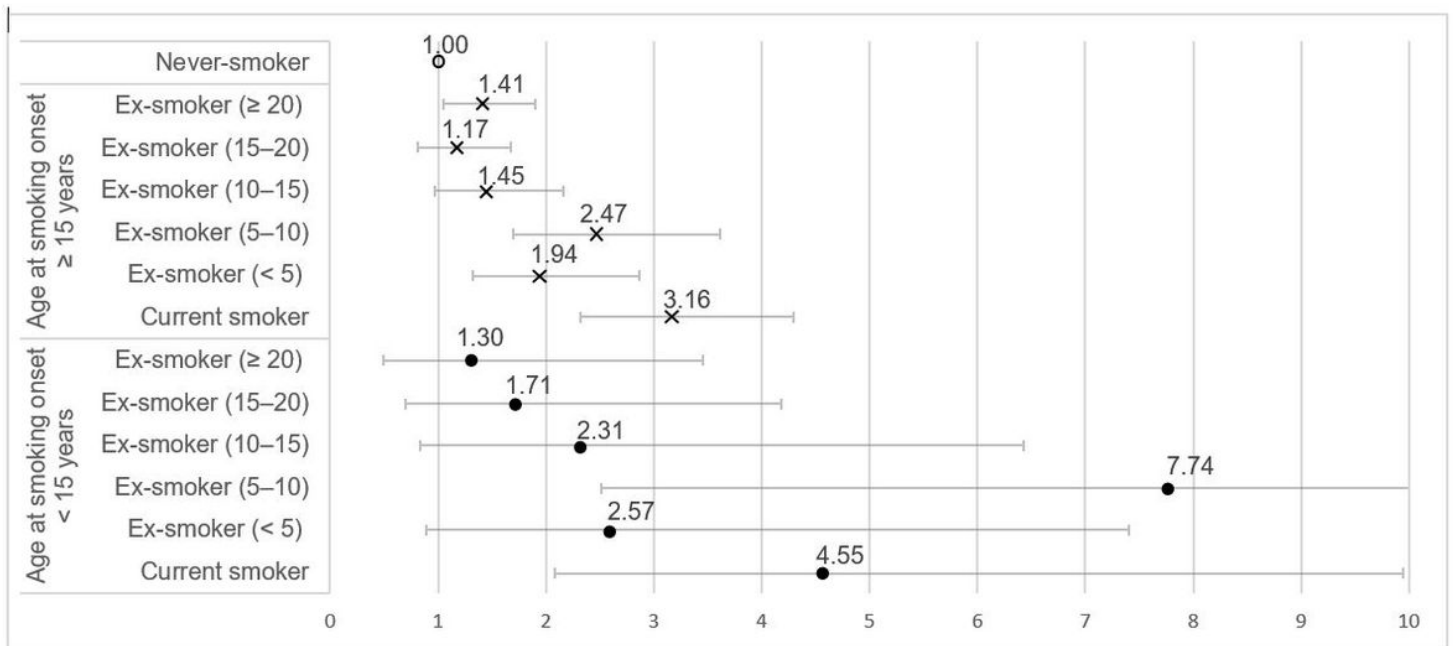


Figure 2

Association between smoking cessation status and obstructive spirometry pattern according to the age at smoking onset in men