Association of Smoking Status, Weight Change, and Incident Metabolic Syndrome in Men: A 3-Year Follow-Up Study

BYUNG JIN KIM, MD, PHD
BUM SOO KIM, MD, PHD
KI CHUL SUNG, MD, PHD
JIN HO KANG, MD, PHD
MAN HO LEE, MD, PHD
JUNG RO PARK, MD, PHD

OBJECTIVE — We investigated the incidence of the metabolic syndrome and assessed the effect of smoking status and weight change on incident metabolic syndrome.

RESEARCH DESIGN AND METHODS — This study included 4,542 men without metabolic syndrome at baseline who were followed for an average of 3 years. Subjects were divided into four categories according to smoking status at baseline and at the 3-year follow-up.

RESULTS — The overall incidence of metabolic syndrome was 10.6%: 8.0% in nonsmokers, 7.1% in new smokers, 17.1% in ex-smokers, and 13.9% in sustained smokers ($P < 0.001$). In a multivariate regression model, ex-smokers had significantly increased odds for incident metabolic syndrome with a mean 1.45 (95% CI 1.06–1.98) compared with sustained smokers. This was no longer significant after including weight change.

CONCLUSIONS — Smoking cessation within 3 years may be a higher risk factor for incident metabolic syndrome than sustained smoking, indicating that weight control in ex-smokers is critical to attenuate the additional risk for incident metabolic syndrome.

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As the number of smokers who quit cigarette smoking is increasing, recent research has focused on the impact of prior smoking on cardiometabolic disorders. Several epidemiological studies have reported that smoking cessation is associated with an increased prevalence of the metabolic syndrome (1,2) compared with that of nonsmokers. However, the studies were cross-sectional and could not exactly evaluate the effects of smoking status on the risk of incident metabolic syndrome. The aim of the present study was to investigate the 3-year incidence of metabolic syndrome in men who did not have metabolic syndrome at baseline and to assess the effect of smoking status and weight change on the risk of incident metabolic syndrome.

RESEARCH DESIGN AND METHODS

— A total of 5,407 men, who were inhabitants of either Seoul or Kyung-gi province, visited Kangbuk Samsung Hospital for health examinations in 2002 and 2005. Among them, 4,542 participants with a median age of 42 years who did not have metabolic syndrome in 2002 (baseline visit) were enrolled for this study, and the average follow-up period was 2.9 years. Medical and medication history, smoking status (current, ex-, or nonsmoker), alcohol drinking (≥3 times per week), and physical activity (≥3 times per week) were assessed using the same standard questionnaires in 2002 and 2005. Metabolic syndrome was defined using the World Health Organization–West Pacific Region guidelines (3). Subjects were divided into four categories according to smoking status at baseline and follow-up: nonsmokers, who never smoked at baseline or follow-up; new smokers, who never smoked at baseline but were currently smoking at follow-up; ex-smokers, who smoked at baseline but quit smoking by follow-up; sustained smokers, who smoked continuously at baseline and follow-up. Weight change was categorized as weight loss (loss of ≥2 kg), stable (loss or gain of ≤2 kg), or weight gain (gain of ≥2 kg).

Data are expressed as means ± SD for continuous variables and percentages for categorical variables. Multivariate logistic regression analysis models were used to investigate whether there was an independent association between smoking status and the risk of incident metabolic syndrome. Statistical tests were two-tailed, and $P < 0.05$ was considered statistically significant. All statistical analyses were conducted using SPSS for Windows, version 11.5 (SPSS, Chicago, IL). This research protocol was approved by the ethics committee of Kangbuk Samsung Hospital.

RESULTS

— The overall incidence of new metabolic syndrome was 10.6% (482 of 4,542 individuals); the incidence of metabolic syndrome was 8.0% in nonsmokers, 7.1% in new smokers, 17.1% in ex-smokers, and 13.9% in sustained smokers ($P < 0.001$). The overall mean ± SD weight change was 0.53 ± 2.89 kg; the weight change within each group was 0.31 ± 2.81 kg in nonsmokers, −0.32 ± 3.06 kg in new smokers, 1.56 ± 3.12 kg in ex-smokers, and 0.73 ± 2.82 kg in sustained smokers ($P < 0.001$).

The results of multivariate logistic regression analyses for the association between smoking status and incident metabolic syndrome are shown in Table 1. In a logistic regression analysis model adjusting for age, baseline weight, alcohol consumption, exercise, and baseline number of metabolic syndrome components, the sustained smokers and ex-smokers predicted significant increased odds for incident metabolic syndrome of a mean 1.68 (95% CI 1.33–2.12) and 2.43 (1.80–3.29), respectively, compared with the nonsmokers. In sustained

From the Division of Cardiology, Department of Internal Medicine, Kangbuk Samsung Hospital, Sungkyunkwan University School of Medicine, Seoul, South Korea.
Corresponding author: Byung Jin Kim, bjjake.kim@samsung.com.
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Table 1—*Multivariate logistic regression analyses of the association between smoking status and incident metabolic syndrome*

	MetS(+) vs. MetS(−)	Model 1		Model 2		Model 3	
	n	OR (95% CI)	*P*	OR (95% CI)	*P*	OR (95% CI)	*P*
Nonsmokers	202/2,326		1		1		1
New smokers	16/210	0.76 (0.43–1.33)	0.336	0.73 (0.41–1.30)	0.286	0.85 (0.48–1.51)	0.576
Ex-smokers	85/411	2.43 (1.80–3.29)	<0.001	2.65 (1.93–3.64)	<0.001	1.87 (1.37–2.56)	<0.001
Sustained smokers	179/1,113	1.68 (1.33–2.12)	<0.001	1.84 (1.44–2.35)	<0.001	1.54 (1.21–1.95)	0.001
Amount of smoking							
<10 cigarettes/day	31/230	1.45 (0.94–2.25)	0.093	1.59 (1.01–2.52)	0.047	1.31 (0.84–2.05)	0.242
10–19 cigarettes/day	113/726	1.67 (1.27–2.18)	<0.001	1.82 (1.37–2.41)	<0.001	1.53 (1.15–2.02)	0.003
≥20 cigarettes/day	35/157	2.16 (1.39–3.37)	<0.001	2.37 (1.48–3.79)	<0.001	1.90 (1.21–3.00)	0.006
Duration of smoking							
<10 years	19/158	1.31 (0.76–2.26)	0.332	1.39 (0.79–2.45)	0.255	1.38 (0.79–2.39)	0.258
10–19 years	89/565	1.61 (1.20–2.17)	<0.001	1.70 (1.25–2.32)	0.001	1.48 (1.09–2.02)	0.012
>20 years	71/390	1.93 (1.39–2.67)	<0.001	2.23 (1.58–3.14)	<0.001	1.66 (1.18–2.33)	0.004

The reference category is nonsmokers. Weight change was expressed as a continuous variable in kilograms. Model 1 was adjusted for age, baseline weight, lifestyle status (alcohol and exercise), and the number of components of the metabolic syndrome. Model 2 was adjusted for model 1 and other risk factors including LDL cholesterol, high sensitivity C-reactive protein, uric acid, and homeostasis model assessment of insulin resistance. Model 3 was adjusted for model 1 and weight change. MetS, metabolic syndrome.

smokers, the odds for incident metabolic syndrome increased with the daily number and duration of cigarettes smoked when the nonsmokers were used as a reference.

Furthermore, the ex-smokers had significantly increased odds of incident metabolic syndrome compared with the sustained smokers in models 1 and 2 (OR 1.45 [95% CI 1.06–1.98] and 1.44 [1.04–2.00], respectively). In contrast, this was no longer significant in model 3, which includes weight change (1.22 [0.89–1.68]).

Multivariate stratified analyses based on the three categories of weight change showed that in the stable weight and weight gain groups, ex-smoking was an independent risk factor for incident metabolic syndrome compared with never-smoking (2.31 [1.41–3.78] and 2.09 [1.29–3.38], respectively, for model 2). However, in the weight loss group, ex-smoking was no longer significant.

CONCLUSIONS — In this 3-year follow-up study, the ex-smokers and sustained smokers had higher risk of incident metabolic syndrome, independent of multiple covariates, compared with the nonsmokers. The ex-smokers showed a higher risk of incident metabolic syndrome than the sustained smokers when using the multivariate regression models excluding weight change, but this finding was no longer significant after including weight changes.

Several studies have reported that chronic smoking is associated with insulin resistance and the prevalence of the metabolic syndrome (4,5). The results from the present study are consistent with results from previous epidemiologic studies (1,6). However, the previous studies were cross-sectional and could not determine the exact cause-and-effect relationship between cigarette smoking and the incidence of the metabolic syndrome.

Numerous cross-sectional studies have reported that cigarette smoking is negatively associated with body weight and BMI (7–10). However, several prospective studies (11–13) have reported conflicting results regarding weight change in relation to smoking cessation in women. In the present study, sustained smokers showed more weight gain than nonsmokers. This result may be because sustained smokers were less physically active and the majority of them had already smoked for a long period of time at baseline.

Smoking cessation is known to be associated with weight gain and metabolic syndrome (1,2,10). In the present study, ex-smokers experienced significant weight gain and incident metabolic syndrome, consistent with previous studies. Furthermore, our results showed that the ex-smokers were at an even higher risk for incident metabolic syndrome than the sustained smokers, independent of potential covariates excluding weight change. However, this result was no longer statistically significant when including weight change. This result emphasizes the importance of weight control in ex-smokers for reducing the incidence of the metabolic syndrome.

In conclusion, either sustained smoking or smoking cessation in a 3-year period is a risk factor for incident metabolic syndrome in men, independent of weight change, compared with nonsmoking men. In addition, smoking cessation within 3 years may be a higher risk factor for incident metabolic syndrome than sustained smoking. The present study indicates that weight control, especially in men who stop smoking, is critical to attenuate the additional risk for incident metabolic syndrome.

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