Association of smoking status, weight change, and incident metabolic syndrome in men: A 3-year follow-up study

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Objective: We investigated the incidence of MetS and assessed the effect of smoking status and weight change on incident MetS.

Research Design and Methods: This study included 4542 men without MetS at baseline who were followed-up for an average of 3-year. Subjects were divided into four categories according to their smoking status at baseline and at the 3-year follow-up.

Results: The overall incidence of MetS was 10.6%; 8.0% in non-smokers, 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 significant increased odds for incident MetS of 1.45 (95% CI 1.06 to 1.98), as 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 MetS than sustained smoking, indicating that weight control in ex-smokers is critical to attenuate the additional risk for incident MetS.
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 metabolic syndrome (MetS), as compared to nonsmokers. However, the studies were cross-sectional and could not exactly evaluate the effects of smoking status on the risk of incident MetS.

The aim of the present study was to investigate the 3-year incidence of MetS in men who did not have MetS at baseline and to assess the effect of smoking status and weight change on the risk of incident MetS.

RESEARCH DESIGN AND METHODS

A total of 5407 men, who were inhabitants of either Seoul or Kyung-gi province, visited Kangbuk Samsung Hospital for their health examinations in 2002 and 2005. Among them, 4542 participants with a median age of 42 years who did not have MetS in 2002 (baseline visit) were enrolled for this study and their average follow-up period was 2.9 years. Medical and medication history, smoking status (current-/ex-/non-smoker), alcohol drinking (≥ 3 times per week), physical activity (≥ 3 times per week) were assessed using the same standard questionnaires in 2002 and 2005. MetS was defined using the World Health Organization-West Pacific Region guidelines. Subjects were divided into four categories according to their smoking status at baseline and follow-up; non-smokers, 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 (< -2 kg), stable (-2 kg to 2 kg), or weight gain (> 2 kg).

Data are expressed as mean ± SD or median and interquartile range for continuous variables, and percentages for categorical variables. Multivariate logistic regression models were used to investigate if there was an independent association between smoking status and the risk of incident MetS. 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, Inc., Chicago, Illinois). This research protocol was approved by the Ethical Committee of Kangbuk Samsung Hospital.

RESULTS

The overall incidence of new MetS was 10.6% (482 of 4542 individuals); the incidence of MetS was 8.0% in non-smokers, 7.1% in new-smokers, 17.1% in ex-smokers, and 13.9% in sustained-smokers (p<0.001). The overall mean weight change (standard deviation [SD]) was 0.53 kg (2.89 kg); the mean weight change (SD) within each group was 0.31 kg (2.81 kg) in non-smokers, -0.32 kg (3.06 kg) in new-smokers, 1.56 kg (3.12 kg) in ex-smokers, and 0.73 kg (2.82 kg) in sustained-smokers group (p<0.001).

The results of multivariate logistic regression analyses for the association between smoking status and incident MetS are shown in Table 1. In a logistic regression model adjusting for age, baseline weight, alcohol consumption, exercise, and baseline number of MetS components, the sustained-smokers and ex-smokers predicted significant increased odds for incident MetS of 1.68 (95% CI 1.33 to 2.12) and 2.43 (95% CI 1.80 to 3.29), respectively, as compared with the non-smokers. In the sustained-smokers group, the odds for incident MetS increased with the daily number and duration of cigarettes smoked when the non-smokers were used as a reference.

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

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 MetS, compared to never-smoking (OR 2.31, 95% CI 1.41 to...
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3.78; OR 2.09, 95% CI 1.29 to 3.38 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 MetS, independent of multiple covariates, as compared to the non-smokers. The ex-smokers showed a higher risk of incident MetS 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 MetS. The results from the present study are consistent with results from previous epidemiologic studies. However, the previous studies were cross-sectional and could not determine the exact cause-and-effect relationship between cigarette smoking and the incidence of MetS.

Numerous cross-sectional studies have reported that cigarette smoking is negatively associated with body weight and BMI. However, several prospective studies 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 non-smokers. 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 MetS. In the present study, ex-smokers experienced significant weight gain and incident MetS, consistent with previous studies. Furthermore, our results showed that the ex-smokers were at an even higher risk for incident MetS 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 MetS.

In conclusion, either sustained smoking or smoking cessation in a 3-year period is a risk factor for incident MetS in men, independent of weight change, as compared to non-smoking. In addition, smoking cessation within 3 years may be a higher risk factor for incident MetS 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 MetS.

**Disclosures:** None
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Table 1: Multivariate logistic regression analyses of the association between smoking status and incident metabolic syndrome (MetS).

| Smoking Status | MetS(+) / MetS(-) | Model 1 | Model 2 | Model 3 |
|----------------|-------------------|---------|---------|---------|
| Non-smokers    | 202/2326          | 1       | 1       | 1       |
| New-smokers    | 16/210            | 0.76 (0.43-1.33) | 0.73 (0.41-1.30) | 0.85 (0.48-1.51) |
| Ex-smokers     | 85/411            | 2.43 (1.80-3.29) | 2.65 (1.93-3.64) | 1.87 (1.37-2.56) |
| Sustained-smokers | 179/1113   | 1.68 (1.33-2.12) | 1.84 (1.44-2.35) | 1.54 (1.21-1.95) |

Amount of smoking
- <10 (cigarette per day) | 31/230 | 1.45 (0.94-2.25) | 1.59 (1.01-2.52) | 1.31 (0.84-2.05) |
- 10-19 | 113/726 | 1.67 (1.27-2.18) | 1.82 (1.37-2.41) | 1.53 (1.15-2.02) |
- ≥ 20 | 35/157 | 2.16 (1.39-3.37) | 2.37 (1.48-3.79) | 1.90 (1.21-3.00) |

Duration of Smoking
- <10 years | 19/158 | 1.31 (0.76-2.26) | 1.39 (0.79-2.45) | 1.38 (0.79-2.39) |
- 10-19 years | 89/565 | 1.61 (1.20-2.17) | 1.70 (1.25-2.32) | 1.48 (1.09-2.02) |
- >20 years | 71/390 | 1.93 (1.39-2.67) | 2.23 (1.58-3.14) | 1.66 (1.18-2.33) |

Values are odds ratio (95% confidence interval).
The reference category is non-smokers.
Weight change were 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 MetS.
Model 2 was adjusted for model 1 and other risk factors including low density lipoprotein-cholesterol, high sensitivity-C reactive protein, uric acid, and homeostatic model assessment-insulin resistance.
Model 3 was adjusted for model 1 and weight change.