**Need for Systematic Efforts to Modify Health-Related Behaviors After Acute Myocardial Infarction in Korea**

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**Background:** Modification of health-related behaviors may improve clinical outcomes after acute myocardial infarction (AMI), but the need for systematic efforts to modify such behaviors and the estimated effect have not been investigated, especially in Asian populations. The aim of the study was to investigate changes in smoking and physical activity after AMI and their associations with death and recurrent revascularization.

**Methods and Results:** Using the Korean National Insurance Health Service database, we included 13,452 patients with AMI in 2011, who were stable until 1.5 years on average after onset. Patients were grouped according to their smoking status and physical activity before and after AMI. After AMI, 44.6% of smokers continued smoking and only 11.0% of inactive patients increased their physical activity to a sufficient level. The 'smoker/smoker' group and 'non-smoker/smoker' group showed higher mortality (hazard ratio (HR): 1.566, 95% confidence interval (CI): 1.192–2.035; HR: 1.785, 95% CI: 1.061–2.815, respectively). On the other hand, the 'active/active' group and 'inactive/active' group showed less mortality (HR: 0.625, 95% CI: 0.460–0.832; HR: 0.681, 95% CI: 0.438–1.009, respectively) and the 'inactive/active' group showed less recurrent revascularization (HR: 0.761, 95% CI: 0.599–0.952).

**Conclusions:** Smoking cessation and maintaining sufficient physical activity after AMI remain challenging for many Korean patients, and are associated with higher rates of mortality and recurrent revascularization. Systematic nationwide efforts such as cardiac rehabilitation (CR) to change health-related behaviors after AMI are required in Korea.

**Key Words:** Mortality; Myocardial infarction; Myocardial revascularization; Physical activity; Smoking

**A**cute myocardial infarction (AMI) is a major cause of mortality and morbidity worldwide. In Korea, the incidence of AMI has doubled from 1997 to 2007. Smoking and lack of exercise are potentially modifiable risk factors for AMI. However, the smoking rate in Korean men is the highest among OECD countries, and Korean patients with coronary artery disease engaged in less physical activity than is usual in North America or Western Europe.

Patients with AMI rarely change their health-related behaviors, such as smoking and physical activity, towards better behaviors. Exercise-based cardiac rehabilitation (CR) is strongly recommended after AMI for secondary prevention to modify the potential risk factors after percutaneous coronary intervention (PCI) or coronary artery bypass graft (CABG). However, the CR program is used much less in Asian countries than in Western countries, and most of the evidence for the benefits of CR has been provided by studies of Western patients. The size of the Korean population that needs behavioral modification, such as provided by a CR program, may differ because of cultural or ethnic differences. Therefore, there is a need to investigate the nationwide evidence for possible benefits from behavioral modification in Korea.

The objective of this study was to investigate, using Korean National Health Insurance Service Data, how many patients with AMI undergoing PCI or CABG change their health-related behaviors, specifically, smoking and physical activity, in the real world, not in a controlled situation such as clinical trials. In addition, we investigated the effect of changes in health-related behaviors on mortality and recurrent revascularization rates, which may provide indirect evidence for the effectiveness of behavioral modification in Korea.

**Data Sources**
Approximately 97% of the Korean population is covered by the Korean National Health Insurance Service (NHIS).
Patients’ demographic data, medical claim records, diagnoses confirmed by the International Classification of Diseases, 10th revision, Clinical Modification (ICD-10-CM) codes and mortality data are collected in the Korean NHIS database. In addition, the Korean NHIS provides a regular health check-up program every 2 years for Koreans, which includes measurement of height, weight and blood pressure, blood count and chemistry, and a self-administered questionnaire about past medical history, family history, and health-related behaviors (smoking, diet, and physical activity).

**Study Cohort**

This study was based on Korean NHIS data from January 1, 2009, to December 31, 2015. Patients who were hospitalized for AMI, which was defined using the ICD-10-CM codes (I1210-I1213, I2140, I2141, I2148, I2149, I21), and who underwent PCI or CABG defined by the presence of each claim code (PCI: M6551, M6552, M6561, M6563, M6564, M6571 and M6572; CABG: O1641, O1642, O1647, OA641, OA642 and OA647) during the index admission from January 1, 2011 to December 31, 2011 were screened. Of these, patients who participated in the regular health check-up both before and after AMI and were aged 40–80 years were included in the study. Because the average time from AMI to health check-up was approximately 1.5 years, patients who were unstable or died within this period were excluded. Patients with a history of previous ischemic heart disease or congestive heart failure were also excluded based on the questionnaire from the regular health check-up before AMI. The final study population consisted of 13,452 subjects (Figure 1), and the retrospective cohort including data on demographics, health check-up, intervention for AMI (PCI or CABG), health-related behaviors (smoking and physical activity), mortality, and revascularization was constructed (Figure 2). This study was approved by the Institutional Review Board of Seoul National University Bundang Hospital, South Korea. Data in the Korean NHIS were fully anonymized for analyses. Informed consent was waived and not specifically obtained from participants.
Health-Related Behaviors

Assessment of health-related behaviors was done by self-reported questionnaire included in the regular health check-up. Subjects who smoked ≥5 packs (i.e., 100 cigarettes) during their life time and were currently smoking were defined as ‘smoker’; otherwise they were defined as ‘non-smoker’. Because the questionnaire was administered in 2 different periods (before and after AMI), the subjects were divided into 4 groups: ‘smoker/smoker’, ‘smoker/non-smoker’, ‘non-smoker/smoker’, and ‘non-smoker/non-smoker’.

Physical activity was defined by the specific questionnaire format written in Korean. The questionnaire consisted of 3 questions:

1. How many days did you do vigorous physical activities (such as running, aerobics, fast bicycling or mountain climbing) more than 20 min during the last 7 days?
2. How many days did you do moderate physical activities (such as fast walking, doubles tennis or bicycling at a regular pace) more than 30 min during the last 7 days?
3. How many days did you walk more than 30 min during the last 7 days?

According to the questionnaire response, the intensity of physical activity was divided into ‘vigorou’, ‘moderate’, ‘low’, and ‘sedentary’ (Figure S1). Subjects with vigorous or moderate physical activity were considered ‘active’ while those with low or sedentary physical activity were considered ‘inactive’. As with smoking, subjects were divided into 4 groups according to physical activity: ‘active/active’, ‘active/inactive’, ‘inactive/active’ and ‘inactive/inactive’.

Mortality and Recurrent Revascularization

Information on all-cause death and recurrent revascularization was obtained from the Korean NHIS database until December 31, 2015. Mortality was defined as death from any cause during the follow-up period after AMI. Recurrent revascularization was defined as the number of patients who underwent another PCI or CABG during the follow-up, using the claim code for PCI or CABG.

Covariate Data

Demographic data including age, sex, region of residence and health insurance information were collected. Region of residence was divided into rural or city. Rural residence was considered to be an area with a population <50,000 of residence was divided into rural or city. Rural residence, n (%) 6,541 (48.6)

Table 1. Baseline Characteristics of the Study Population (n=13,452)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Age, years, mean±SE</th>
<th>Male, n (%)</th>
<th>Type of intervention, n (%)</th>
<th>PCI</th>
<th>CABG</th>
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<tbody>
<tr>
<td></td>
<td>62.8±9.0</td>
<td>9,723 (72.3)</td>
<td>13,252 (95.8)</td>
<td>579 (4.2)</td>
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<td>Length of hospital stay, days, mean±SD</td>
<td>5.40±4.13</td>
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<td>Days from first health check-up to AMI, mean±SD</td>
<td>555±231</td>
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<td>Days from AMI to second health check-up, mean±SD</td>
<td>524±223</td>
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<td>Rural residence, n (%)</td>
<td>6,541 (48.6)</td>
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<td>Medical aid recipient, n (%)</td>
<td>52 (0.4)</td>
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<td>Health insurance premium (KRW), n (%)</td>
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<td>1st quantile</td>
<td>2,279 (17.5)</td>
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<td>2nd quantile</td>
<td>2,175 (16.7)</td>
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<td>3rd quantile</td>
<td>3,290 (25.3)</td>
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<td>4th quantile</td>
<td>5,271 (40.5)</td>
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<td>Past medical history, n (%)</td>
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<td></td>
<td></td>
<td></td>
<td>Hypertension</td>
<td>5,887 (35.5)</td>
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<td></td>
<td>Diabetes</td>
<td>3,211 (29.3)</td>
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<td>Dyslipidemia</td>
<td>1,004 (9.2)</td>
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<td>Family history, n (%)</td>
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<td>Stroke</td>
<td>1,135 (8.4)</td>
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<td>Heart disease</td>
<td>552 (4.1)</td>
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<td>CCI (before AMI), n (%)</td>
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<td>0</td>
<td>1,523 (11.2)</td>
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<td>1</td>
<td>2,711 (19.8)</td>
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<td>2</td>
<td>2,892 (21.2)</td>
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<td>3 or more</td>
<td>6,538 (47.8)</td>
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<td>LDL &lt;70mg/dL after AMI, n (%)</td>
<td>5,548 (41.6)</td>
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<td>BP &lt;140/90mmHg after AMI, n (%)</td>
<td>2,937 (21.8)</td>
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<td>Fasting plasma glucose &lt;110mg/dL after AMI, n (%)</td>
<td>8,663 (64.4)</td>
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<td>BMI (kg/m²) after AMI, n (%)</td>
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<td>&lt;18.5</td>
<td>175 (1.3)</td>
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<td>18.5–24.9</td>
<td>7,304 (54.3)</td>
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<td>&gt;24.9</td>
<td>5,968 (44.4)</td>
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<td>Waist circumference after AMI, n (%)</td>
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<td>&lt;40 inches (men), &lt;35 inches (women)</td>
<td>12,397 (92.2)</td>
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</table>

AMI, acute myocardial infarction; BMI, body mass index; BP, blood pressure; CABG, coronary artery bypass graft; CCI, Charlson comorbidity index; KRW, The Korean Republic Won; LDL, low-density lipoprotein; PCI, percutaneous coronary intervention; SD, standard deviation; SE, standard error.

A Charlson comorbidity index (CCI) was used to evaluate baseline comorbidities using ICD-10-CM codes as suggested by Quan et al. It is a weighted scoring system in which comorbid conditions are assigned a number from 1 to 6 based on the relative risk of 1-year death from the condition. The CCI of the study cohort was measured before the index admission date of AMI and categorized into 4 groups: 0, 1, 2, and ≥3. The length of hospital stay during the index admission period was calculated and dichotomized (≥5 days in the PCI-treated group and ≥16 days in the CABG-treated group) to indirectly adjust AMI severity.
smoker/smoker' group had the highest all-cause mortality rate (Figure 4A). In the Cox model after adjustment for significant variables, the 'smoker/smoker' and 'non-smoker/smoker' groups showed a 55% and 77% increased risk, respectively, for all causes of death compared with the 'non-smoker/non-smoker' group (Table 2). But there were no significant differences between the 4 groups with regard to recurrent revascularization. For physical activity, the 'inactive/inactive' group had the highest mortality followed by the 'active/inactive' group (Figure 4B). After adjustment, the 'active/active' group showed 37% less risk for all-cause death than the 'inactive/inactive' group (Table 2). The 'inactive/active' group showed a trend of 32% mortality reduction compared with the 'inactive/inactive' group. In addition, the 'inactive/active' group showed 24% less risk for revascularization than did the 'inactive/inactive' group. Patients who quit smoking and increased their physical activity showed trends of lower mortality compared with those who started sufficient physical activity only or those who sustained their bad health-related behaviors (P for trend=0.014) (Figure 4C). Adjusted hazard ratios for 'smoker/non-smoker and inactive/active', 'smoker/non-smoker and inactive/inactive', and 'smoker/smoker and inactive/active' compared with 'smoker/smoker and inactive/inactive' were 0.776 (0.269–1.768), 0.798 (0.544–1.165), and 0.914 (0.317–2.080), respectively.

When stratifying the patients further according to the intensity of physical activity after AMI, more intense physical activity was associated with higher survival (Figure 4D). Adjusted hazard ratios with 95% confidence intervals for each of the 'vigorous', 'moderate' and 'low' physical activity groups after AMI compared with the 'sedentary' group were 0.575 (0.423–0.766), 0.787 (0.494–1.189), and 0.784 (0.622–0.981), respectively.

**Discussion**

This study showed that a substantial number of patients...
Behavioral Changes After AMI

This result is consistent with other studies, even though the experience of AMI provides a motivation for smoking cessation. Therefore, systemic efforts are needed to encourage smoking cessation and prevent new smoking, such as a CR program, which is more effective than individual smoking cessation counseling. Smoking cessation after AMI reduced mortality by 30% in our study with a follow-up period of approximately 53 months after AMI, which implies that the effect of smoking cessation may appear in a relatively short time. In a report by the US Surgeon General, the risk of AMI was reduced by half within 1 year of smoking cessation and normalized to that of never-smokers in 5–15 years.

The importance of physical activity in primary and secondary prevention of cardiovascular disease is emerging. Physical activity lowers the resting heart rate and systolic blood pressure, thereby decreasing myocardial oxygen demands. Regular physical activity also improves myocardial perfusion by improving endothelial function, and reduces platelet adhesion and aggregation via antioxidant and anti-inflammatory effects. Likewise, moderate to vigorous physical activity was associated with lower mortality and recurrent revascularization after AMI in this study. Moreover, a dose–response association between

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**Figure 4.** Kaplan-Meier curves for mortality according to smoking (A), physical activity (B), both smoking and physical activity (C), and intensity of physical activity after acute myocardial infarction (D). S/N & I/A: smoking/non-smoking and inactive/active; S/N & I/I: smoking/non-smoking and inactive/inactive; S/S & I/A: smoking/smoking and inactive/active; S/S & I/I: smoking/smoking & inactive/inactive.

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continued smoking and only a small percentage of patients started exercising sufficiently after AMI in Korea (Figure 3). These changes in health-related behaviors were associated with all-cause death and recurrent revascularization. Subjects who continued smoking had 55% higher risk of death than those who did not smoke at all, and those who started smoking after AMI had 77% higher risk of death (Table 2). In contrast, physical activity after AMI showed protective effects. Patients who maintained enough physical activity had a 37% reduction in mortality; those who increased physical activity showed a trend of 24% reduction in mortality and a 24% reduction in recurrent revascularization. The results were apparent after accounting for multiple confounders, including age, sex, past medical history, CCI, length of hospital stay, and categorized health check-up data associated with the cardiovascular event.

It is well known that smoking is an important risk factor for AMI, and cessation of smoking reduces disease risk. In the INTERHEART study, the risk of AMI increased by 5.6% with every single cigarette. Similarly, the ‘smoker/smoker’ and ‘non-smoker/smoker’ groups in our study showed higher mortality after AMI. However, among patients with AMI who smoked, only half quit smoking.
physical activity and death after AMI was observed such that patients with more intense physical activity had a lower incidence of death. Interestingly, a significant reduction in recurrent revascularization was found only in patients who started sufficient physical activity after AMI (Table 2). Although the observed difference might be caused by chance, one possible explanation is that the response to physical activity may differ according to individual characteristics. Several studies have shown that genetic polymorphism influences changes in heart rate or blood pressure in response to physical activity. However, individual differences in the effect of physical activity on the occlusion of the coronary artery have not been investigated as in the case of smoking, so further research is needed.

The strength of our study is that the Korean national data we used are representative for AMI patients who underwent PCI or CABG, and detailed information about past medical history, residence, health insurance, and laboratory tests could be obtained from the regular health check-up data, which was used as the covariates for analyses.

**Study Limitations**

First, subjects who did not participate in the regular health check-up before or after AMI were excluded, which may increase the risk of selection bias. One possibility for exclusion was a no-show for the health check-up because of severe physical or cognitive disabilities. Although an alternative CR model has yet to be developed and provided, patients with severe physical or cognitive disabilities may not be the best candidates for active standard CR. Another possibility for exclusion is that patients with AMI died before the health check-up, which could explain why the 1-year mortality in our study cohort was as low as 0.7%, lower than in the Korean Acute Myocardial Infarction Registry of 30-day survivors after AMI (1.2%). However, those patients who died within 1 year after AMI may benefit less from CR, in terms of reductions in mortality and recurrent revascularization.

Second, the diagnosis of AMI was based on medical claim codes. In a previous study, the diagnostic accuracy of AMI with ICD codes was >70%. To increase the reliability of diagnosis, we narrowed the diagnosis of AMI by combining claim codes for PCI or CABG with the codes for AMI in the same index admission period.

Third, there were confounding factors that were not adjusted for in this study, such as medication, severity of AMI (e.g., extent of infarction, function of left ventricle, and overall functional status) and psychological factors. We tried to adjust for compliance with the secondary prevention guideline for AMI using the health check-up results (e.g., blood pressure, BMI, waist circumference <40 inches (men) or <30 inches (women), BMI 18.5–24.9/kg/m²). We also adjusted for comorbidities before AMI and the length of hospital stay to indirectly reflect the severity of AMI were also adjusted.

Finally, health-related behaviors were evaluated simply by self-reporting questionnaire. Self-reported data is known to be more prone to bias, which overestimates physical activity compared with more objective measures such as accelerometers. The prevalence of physical inactivity was high among the patients with AMI in this study, and it might be higher, considering the overestimation bias of self-reporting questionnaires.

**Conclusions**

Among patients with AMI in Korea, only half quit smoking and many fewer increased their physical activity after AMI. Smoking was associated with higher mortality, and physical activity was associated with lower mortality and revascularization rates. Thus, systematic nationwide efforts for behavioral modification after AMI are required to reduce the mortality and revascularization rates in Korea.

**Acknowledgments**

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**Disclosures**

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**Name of Grant**

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References


Supplementary Files

Supplementary File 1

Figure S1. Physical activity categorization.

Please find supplementary file(s): http://dx.doi.org/10.1253/circj.CJ-17-1405