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Validation of Risk Prediction Models for Atherosclerotic Cardiovascular Disease in a Prospective Korean Community-Based Cohort

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Background: To investigate the performance of the 2013 American College of Cardiology/American Heart Association Pooled Cohort Equations (PCE) in a large, prospective, community-based cohort in Korea and to compare it with that of the Framingham Global Cardiovascular Disease Risk Score (FRS-CVD) and the Korean Risk Prediction Model (KRPM).
Methods: In the Korean Genome and Epidemiology Study (KOGES)-Ansan and Ansung study, we evaluated calibration and discrimination of the PCE for non-Hispanic whites (PCE-WH) and for African Americans (PCE-AA) and compared their predictive abilities with the FRS-CVD and the KRPM.
Results: The present study included 7,932 individuals (3,778 men and 4,154 women). The PCE-WH and PCE-AA moderately overestimated the risk of atherosclerotic cardiovascular disease (ASCVD) for men (6% and 13%, respectively) but underestimated the risk for women (−49% and −25%, respectively). The FRS-CVD overestimated ASCVD risk for men (91%) but provided a good risk prediction for women (3%). The KRPM underestimated ASCVD risk for men (−31%) and women (−31%). All the risk prediction models showed good discrimination in both men (C-statistic 0.730 to 0.735) and women (C-statistic 0.726 to 0.732). Recalibration of the PCE using data from the KOGES-Ansan and Ansung study substantially improved the predictive accuracy in men.
Conclusion: In the KOGES-Ansan and Ansung study, the PCE overestimated ASCVD risk for men and underestimated the risk for women. The PCE-WH and the FRS-CVD provided an accurate prediction of ASCVD in men and women, respectively.

Keywords: Atherosclerosis; Calibration; Cardiovascular diseases; Cohort studies; Epidemiology; Primary prevention; Risk assessment; Risk factors

INTRODUCTION

Atherosclerotic cardiovascular disease (ASCVD) is a leading cause of death worldwide accounting for one-third of all deaths per year [1]. The development and progression of atherosclerosis is influenced by cardiovascular risk factors, such as age, sex, smoking, physical inactivity, obesity, diabetes mellitus (DM), hypertension, dyslipidemia, and systemic inflammation [2].

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Cardiovascular disease (CVD) including coronary heart disease (CHD) and ischemic stroke are largely preventable by the control of modifiable risk factors [3]. In addition, the benefits from CVD risk reduction are greater in individuals with a higher baseline risk [4]. Therefore, risk prediction and stratification of ASCVD through the clustering of cardiovascular risk factors is a useful strategy for determining preventive interventions.

In 2013, the American College of Cardiology (ACC) and the American Heart Association (AHA) developed the Pooled Cohort Equations (PCE), sex- and race-specific equations to predict 10-year risk for the first hard ASCVD events defined as nonfatal myocardial infarction (MI) or fatal CHD, or fatal or nonfatal stroke [5]. The ACC/AHA recommends use of the PCE in the treatment of blood cholesterol [6,7] or high blood pressure (BP) [8] for the primary prevention of ASCVD in adults aged 40 to 79 years. After the release of the 2013 ACC/AHA guidelines, there has been an issue that the PCE may overestimate or underestimate the risk in several populations [5,7]. Indeed, risk overestimation by the PCE has been reported in East Asians [9], Europeans [10], and a contemporary United States (US) population [11]. On the other hand, in South Asians [12] and Native Americans [13], the PCE underestimated actual ASCVD risk. The PCE was developed based on data from cohorts representative of the US population including the Atherosclerosis Risk in Communities study [14], Cardiovascular Health Study [15], Coronary Artery Risk Development in Young Adults [16], and Framingham Original and Offspring cohorts [17,18]. Accordingly, the PCE calculates 10-year ASCVD risk for non-Hispanic whites and African Americans. The equations for non-Hispanic whites can be used for Hispanics, Asians, and Native Americans, but their accuracy has not been evaluated sufficiently in these populations. The performance of risk prediction models for ASCVD depends not only on country-specific race/ethnicity, but also on the prevalence of CVD or risk factors, available interventions to reduce ASCVD events, and socioeconomic status [7]. Therefore, the PCE should be validated in each population to be used for the primary prevention of ASCVD.

In this regard, we conducted the present study (1) to investigate the performance of the PCE for predicting ASCVD risk with 10-year cumulative incidence of ASCVD and (2) to compare it with that of the Framingham Global Cardiovascular Disease Risk Score (FRS-CVD) and the Korean Risk Prediction Model (KRPM) using a large, prospective, community-based cohort in Korea.

METHODS

Study population and ethical statement

The Korean Genome and Epidemiology Study (KOGES)-Ansan and Ansung study is an ongoing, prospective, community-based cohort study that includes urban and rural residents in Korea. The study design and methods have been detailed elsewhere [19]. Briefly, 10,030 individuals aged 40 to 69 years were voluntarily enrolled in the baseline study between 2001 and 2002, and underwent biennial examinations including a questionnaire, physical examination, and clinical measurements through 2016. Among these participants, we excluded individuals who had a history of ASCVD at the baseline study (n=299), had insufficient data to calculate ASCVD risk (n=866), and were lost to follow-up after the baseline study (n=1,113). Finally, 7,932 individuals (3,778 men and 4,154 women) were included in the present study (Supplementary Fig. 1). The study protocol was approved by the Institutional Review Board of the Seoul National University Boramae Medical Center (IRB No. 07-2016-18). All participants provided written informed consent for the baseline and follow-up data.

Outcome measurements

We defined an ASCVD event as the first occurrence of nonfatal MI, unstable angina, stable angina pectoris, nonfatal ischemic stroke, transient ischemic attack (TIA), and death from ASCVD. The procedures for determining incident ASCVD have been previously described [20]. Briefly, individuals identified by self-reported ASCVD were examined through in-depth interviews and a review of their medical records. Nonfatal MI, unstable angina, and stable angina pectoris were confirmed by changes in the electrocardiogram or cardiac enzymes, coronary angiographic findings, a history of coronary intervention or coronary artery bypass grafting, and medications. Nonfatal ischemic stroke and TIA were confirmed by symptoms and/or signs, findings on computed tomography or magnetic resonance imaging, a history of procedure or surgery, and medications. Deaths from ASCVD were verified by family interviews or death certificates.

ASCVD risk prediction models

We calculated 10-year ASCVD risk by the PCE, FRS-CVD, and KRPM. The FRS-CVD [21] was developed to assess 10-year risk of CVD including a composite of CHD (angina pectoris, coronary insufficiency, MI, and coronary death), cere-

brovascular events (ischemic stroke, TIA, and hemorrhagic stroke), peripheral artery disease, and heart failure based on data from original and offspring cohorts of the Framingham Heart Study [22,23]. The KRPM [24] was developed to estimate 10-year risk of ASCVD comprised of nonfatal or fatal MI, and nonfatal or fatal stroke using data from the Korean Heart Study (KHS) [25]. For the PCE, we used sex-specific equations for both non-Hispanic whites (PCE-WH) and African Americans (PCE-AA) because there was no specific equation for Koreans.

Statistical analysis

Continuous variables are presented as mean±standard deviation. Categorical variables are reported as frequencies and proportions. We analyzed men and women separately because of sex differences in cardiovascular risk factors [26] and the burden of CVD [27], and sex-specific prediction models for ASCVD. From the KOGES-Ansan and Ansung study, Cox regression analyses were performed to assess 10-year cumulative incidence of ASCVD after confirming that the assumption of proportionality of hazards was met. The performance of ASCVD risk prediction models was evaluated by calibration and discrimination. Calibration, agreement between predicted and observed risks, was performed by comparing predictive risk with observed events in each decile of model-based probabilities using the Hosmer-Lemeshow chi-square test [28]. A lower chi-square value (χ^2) and statistical insignificance ($P \geq 0.05$) indicates the goodness of fit of the models. We also calculated discordance between predicted and observed risks. Discrimination, capability to classify individuals with and without events, was evaluated by the C-statistic or the area under the receiving operating characteristic curve [29]. The C-statistic >0.7 indicates good discrimination. Additionally, we recalibrated the PCE for individuals of the KOGES-Ansan and Ansung study to match the predicted and observed risk using a previously proposed method [30]. In the recalibration, we took the regression coefficients from the ACC/AHA PCE's Cox models, but the mean values were used from the KOGES-Ansan and Ansung study for risk factors (Supplementary Table 1). We also developed new equations of the PCE using equation parameters of the PCE-WH and PCE-AA (Supplementary Table 1). Two-fold cross validation (1/2 training set and 1/2 test set) was repeated 100 times to estimate and evaluate the performance of candidate models. We selected the model with the highest average-test area under the receiving operating characteristic curve as the best model. A P value <0.05 was regarded as statistically significant. All statistical analyses were performed using R version 3.4.2 (R Foundation for Statistical Computing, Vienna, Austria) and GraphPad Prism 5 (GraphPad Software Inc., San Diego, CA, USA).

RESULTS

Characteristics of the study participants

Baseline characteristics of the study participants are shown in Table 1 and Supplementary Table 2. In men, the mean age was 51.3±8.6 years and body mass index (BMI) was 24.3±2.9 kg/m^2. In women, the mean age was 52.4±9.0 years and BMI was 24.9±3.3 kg/m^2. Total cholesterol levels, high density lipoprotein cholesterol levels, systolic BP, and the proportion of individuals with DM were comparable between men and women. However, the proportions of individuals with hypertension and BP treatment were higher in women (17.6% and 13.1%, respectively) than in men (13.6% and 8.5%, respectively). Current smokers were highly prevalent in men (48.1%) compared with women (3.4%).

The prevalence of risk factors in the KOGES cohort and study cohorts of the PCE, FRS-CVD [21], and KRPM [24] is shown in Table 1 and Supplementary Table 2. In men, the proportion of BP treatment was lower in the KOGES cohort (8.5%) than in the PCE-WH (16.9%), PCE-AA (31.2%), and KRPM (10.1%) cohorts. The prevalence of DM was lower in the KOGES cohort (7.8%) than in the PCE-WH (8.8%), PCE-AA (15.9%), and KRPM (10.5%) cohorts. Current smokers were highly prevalent in the KOGES cohort (48.1%) compared with the PCE-WH (25.5%) and PCE-AA (35.5%) cohorts, but similar to the KRPM (49.4%) cohort. In women, the proportion of BP treatment was lower in the KOGES cohort (13.1%) than in the PCE-WH (18.5%) and PCE-AA (40.8%) cohorts. The prevalence of DM in the KOGES cohort (6.0%) was comparable with that in the PCE-WH (6.3%) cohort but lower than that in the PCE-AA (17.4%) cohort. Current smokers were less prevalent in the KOGES cohort (3.4%) compared with the PCE-WH (24.9%), PCE-AA (22.7%), and FRS-CVD (34.2%) cohorts.

Cumulative incidence and observed risk of ASCVD

During the mean follow-up of 8.4±2.7 years, 598 ASCVD events (305 in men and 293 in women) occurred; 317 nonfatal CHD including nonfatal MI, unstable angina, or stable angina

pectoris, 216 nonfatal stroke or TIA, and 89 deaths from ASCVD (Table 2). Twenty-four individuals had both CHD and ischemic stroke or TIA between the examination cycles. The cumulative incidence of ASCVD per 100,000 person-years was

Table 1. Baseline characteristics of the study participants

Characteristic	KOGES	PCE-WH[a]	PCE-AA[a]	FRS-CVD	KRPM	*P* value
Men	3,778	9,098	1,647	3,969	119,715	
Age, yr	51.3±8.6	56.2±6.5	55.4±5.6	48.5±10.8	50.1±7.9	<0.001
Total cholesterol, mg/dL	192±36	211±38	208±43	213±39	197±35	<0.001
HDL-C, mg/dL	44±10	44±12	51±17	45±12	48±11	<0.001
Systolic BP, mm Hg	125±17	124±16	129±20	130±18	125±18	<0.001
BP treatment, %	8.5	16.9	31.2	10.1	NA	<0.001[b]
Diabetes mellitus, %	7.8	8.8	15.9	6.5	10.5	<0.001
Current smoker, %	48.1	25.5	35.5	35.2	49.4	<0.001
Women	4,154	11,240	2,641	4,522	80,295	
Age, yr	52.4±9.0	56.8±6.5	55.3±5.4	49.1±11.1	51.8±8.1	<0.001
Total cholesterol, mg/dL	191±35	221±41	214±44	215±44	201±37	<0.001
HDL-C, mg/dL	46±10	58±16	59±17	58±15	54±13	<0.001
Systolic BP, mm Hg	124±20	121±18	127±20	126±20	125±20	<0.001
BP treatment, %	13.1	18.5	40.8	11.8	NA	<0.001[b]
Diabetes mellitus, %	6.0	6.3	17.4	3.8	7.4	<0.001
Current smoker, %	3.4	24.9	22.7	34.2	4.5	<0.001

Values are presented as mean±standard deviation or percentage.
KOGES, Korean Genome and Epidemiology Study; PCE-WH, Pooled Cohort Equations for non-Hispanic whites; PCE-AA, Pooled Cohort Equations for African Americans; FRS-CVD, Framingham Global Cardiovascular Risk Score; KRPM, Korean Risk Prediction Model; HDL-C, high density lipoprotein cholesterol; BP, blood pressure; NA, not applicable.
[a]Demographic characteristics of the PCE-WH and PCE-AA cohorts were calculated as weighted averages and pooled standard deviations based on data from Supplementary Table 2, [b]The KRPM data were not included in the analysis.

Table 2. Predicted and observed risks of atherosclerotic cardiovascular disease among participants from the KOGES-Ansan and Ansung study

Variable	Predicted risk, %	Observed risk, % (*n*)	Absolute difference	Discordance, %[a]	C-statistic	Calibration	
						χ^2 statistic	*P* value
Men (*n*=3,778)							
PCE-WH	8.51	8.05 (305)	0.46	6	0.731	10.59	0.226
PCE-AA	9.13	8.05 (305)	1.08	13	0.730	17.13	0.029
FRS-CVD	15.34	8.05 (305)	7.29	91	0.730	177.71	<0.001
KRPM	5.55	8.05 (305)	−2.50	−31	0.735	58.39	<0.001
Women (*n*=4,154)							
PCE-WH	3.58	7.05 (293)	−3.47	−49	0.726	258.62	<0.001
PCE-AA	5.29	7.05 (293)	−1.76	−25	0.732	107.08	<0.001
FRS-CVD	7.23	7.05 (293)	0.18	3	0.726	24.70	0.002
KRPM	4.85	7.05 (293)	−2.20	−31	0.729	67.27	<0.001

KOGES, Korean Genome and Epidemiology Study; PCE-WH, Pooled Cohort Equations for non-Hispanic whites; PCE-AA, Pooled Cohort Equations for African Americans; FRS-CVD, Framingham Global Cardiovascular Risk Score; KRPM, Korean Risk Prediction Model.
[a]Discordance is defined as (predicted risk−observed risk)/observed risk×100.

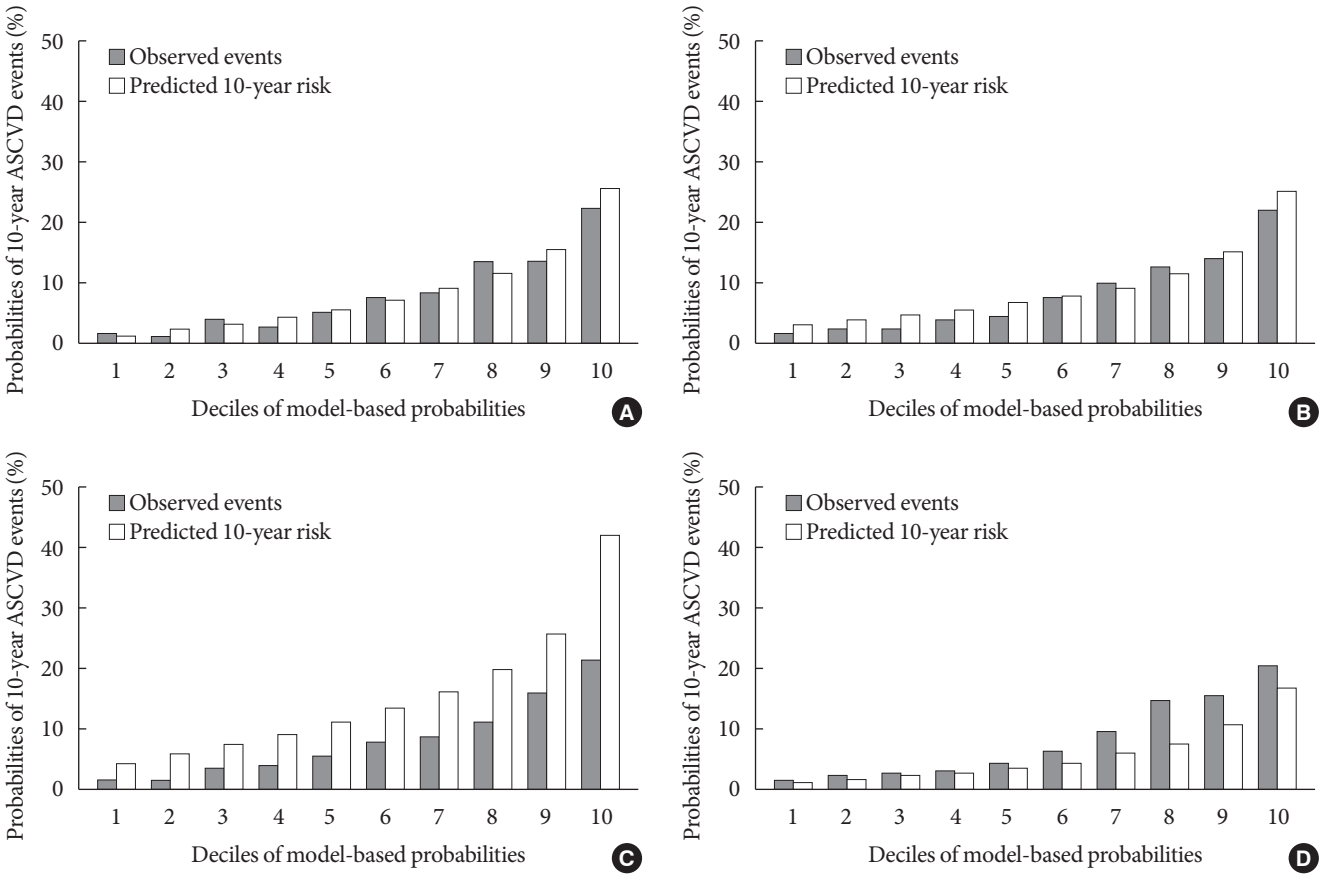

Fig. 1. Ten-year probabilities of atherosclerotic cardiovascular disease (ASCVD) in men from the Korean Genome and Epidemiology Study (KOGES)-Ansan and Ansung study. (A) The Pooled Cohort Equations for non-Hispanic whites. (B) The Pooled Cohort Equations for African Americans. (C) The Framingham Global Cardiovascular Risk Score. (D) The Korean Risk Prediction Model.

968.8 for men and 839.3 for women (Supplementary Table 3). The observed 10-year ASCVD risk was 8.05% for men and 7.05% for women (Table 2).

Performance of the ASCVD risk prediction models

The PCE-WH and PCE-AA moderately overestimated ASCVD risk for men by 6% and 13%, respectively, with good calibration (PCE-WH: $\chi^2=10.59$, $P=0.226$; PCE-AA: $\chi^2=17.13$, $P=0.029$) (Table 2, Fig. 1A and B). However, for women, the PCE-WH and PCE-AA underestimated ASCVD risk by −49% and −25%, respectively, with poor calibration (PCE-WH: $\chi^2=258.62$, $P<0.001$; PCE-AA: $\chi^2=107.08$, $P<0.001$) (Table 2, Fig. 2A and B). The FRS-CVD overestimated ASCVD risk for men (91%) with poor calibration ($\chi^2=177.71$, $P<0.001$) (Table 2, Fig. 1C). On the other hand, the FRS-CVD predicted ASCVD risk for women accurately (3%) but showed poor calibration ($\chi^2=24.70$, $P=0.002$) due to the disagreement between the predicted and observed risks in the 5th to 7th deciles (Table 2, Fig. 2C). The KRPM underestimated ASCVD risk for both men (−31%) and women (−31%) with poor calibration (men: $\chi^2=58.39$, $P<0.001$; women: $\chi^2=67.27$, $P<0.001$) (Table 2, Figs. 1D and 2D). In discrimination, the C-statistic showed good discrimination for all models in men (PCE-WH, 0.731; PCE-AA, 0.730; FRS-CVD, 0.730; KRPM, 0.735) and women (PCE-WH, 0.726; PCE-AA, 0.732; FRS-CVD, 0.726; KRPM, 0.729) (Table 2), which showed a reliable classification of individuals with and without ASCVD events.

Recalibration of the PCE

The PCE-WH and PCE-AA were recalibrated for individuals of the KOGES-Ansan and Ansung study. The recalibrated PCE improved calibration substantially in men (PCE-WH: $\chi^2=18.94$, $P=0.015$; PCE-AA: $\chi^2=15.24$, $P=0.055$) (Fig. 3A and B) but not in women (PCE-WH: $\chi^2=103.56$, $P<0.001$; PCE-AA:

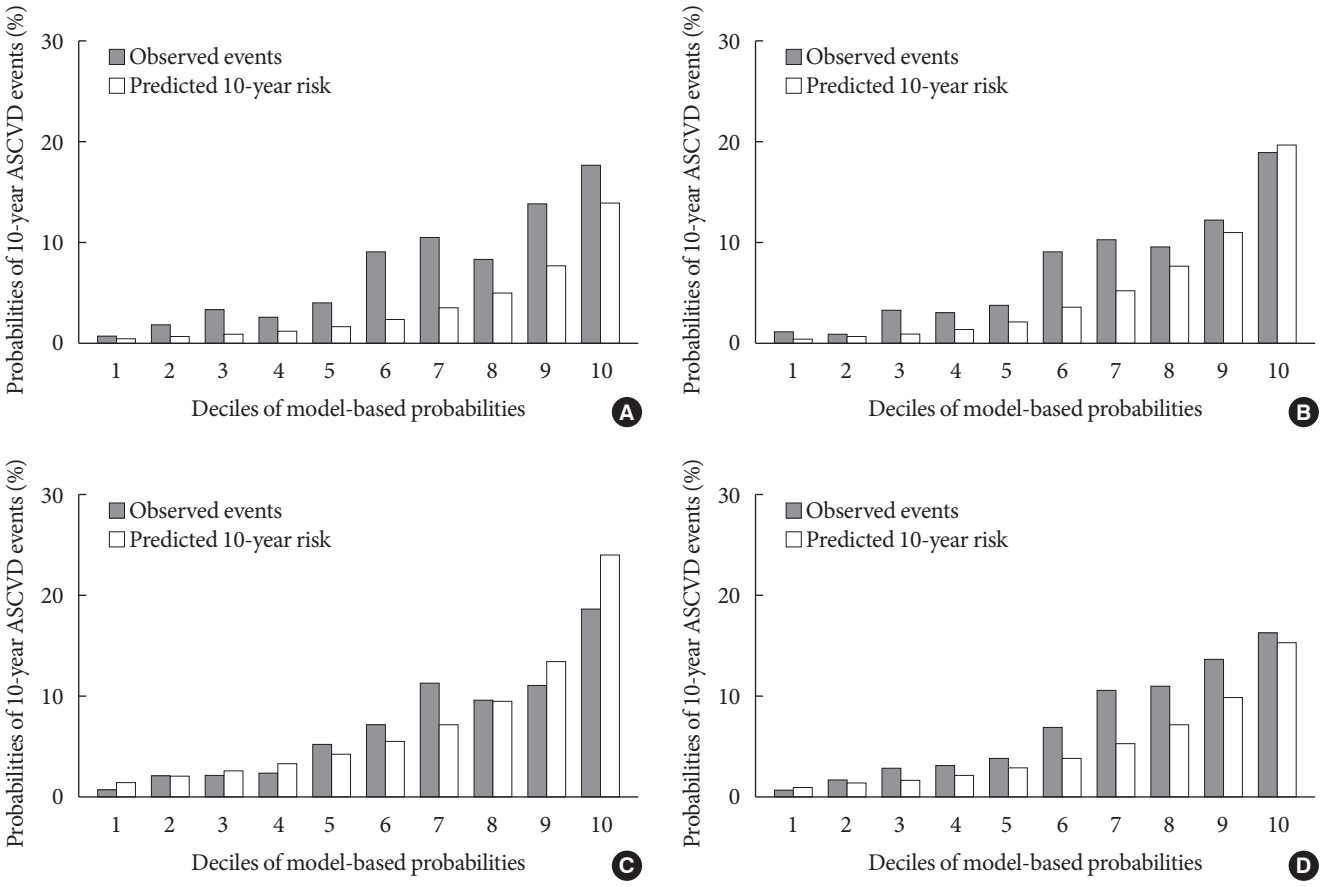

Fig. 2. Ten-year probabilities of atherosclerotic cardiovascular disease (ASCVD) in women from the Korean Genome and Epidemiology Study (KOGES)-Ansan and Ansung study. (A) The Pooled Cohort Equations for non-Hispanic whites. (B) The Pooled Cohort Equations for African Americans. (C) The Framingham Global Cardiovascular Risk Score. (D) The Korean Risk Prediction Model.

$\chi^2=133.57$, $P<0.001$) (Fig. 3C and D). The recalibrated PCE did not affect discrimination.

New equations of the PCE

We developed new equations of the PCE for individuals of the KOGES-Ansan and Ansung study. The new equations improved the calibration substantially in men ($\chi^2=11.95$, $P=0.153$) (Fig. 3E) but not in women ($\chi^2=16.47$, $P=0.036$) (Fig. 3F). The new equations did not affect discrimination (Supplementary Table 1).

DISCUSSION

In the present study, the PCE overestimated 10-year ASCVD risk for men but underestimated the risk for women in the KOGES-Ansan and Ansung study. The PCE had a better predictive ability for incident ASCVD than the FRS-CVD and KRPM in men. We also found that the recalibration or new equations of the PCE using data from the KOGES-Ansan and Ansung study substantially improved the estimates in men. However, in women, the FRS-CVD predicted ASCVD risk most accurately compared with the PCE and KRPM. The PCE, FRS-CVD, and KRPM had good discrimination in the KOGES-Ansan and Ansung study.

The PCE-WH and PCE-AA moderately overestimated ASCVD risk for men in the KOGES-Ansan and Ansung study. Risk overestimation by the PCE has been reported in external validation studies including Asian populations [9,31]. In the Multi-Ethnic Study of Atherosclerosis (MESA), a prospective community-based cohort of US adults including white, black, Chinese, and Hispanic Americans, overestimation of ASCVD risk was observed in all ethnic groups and it was highest in

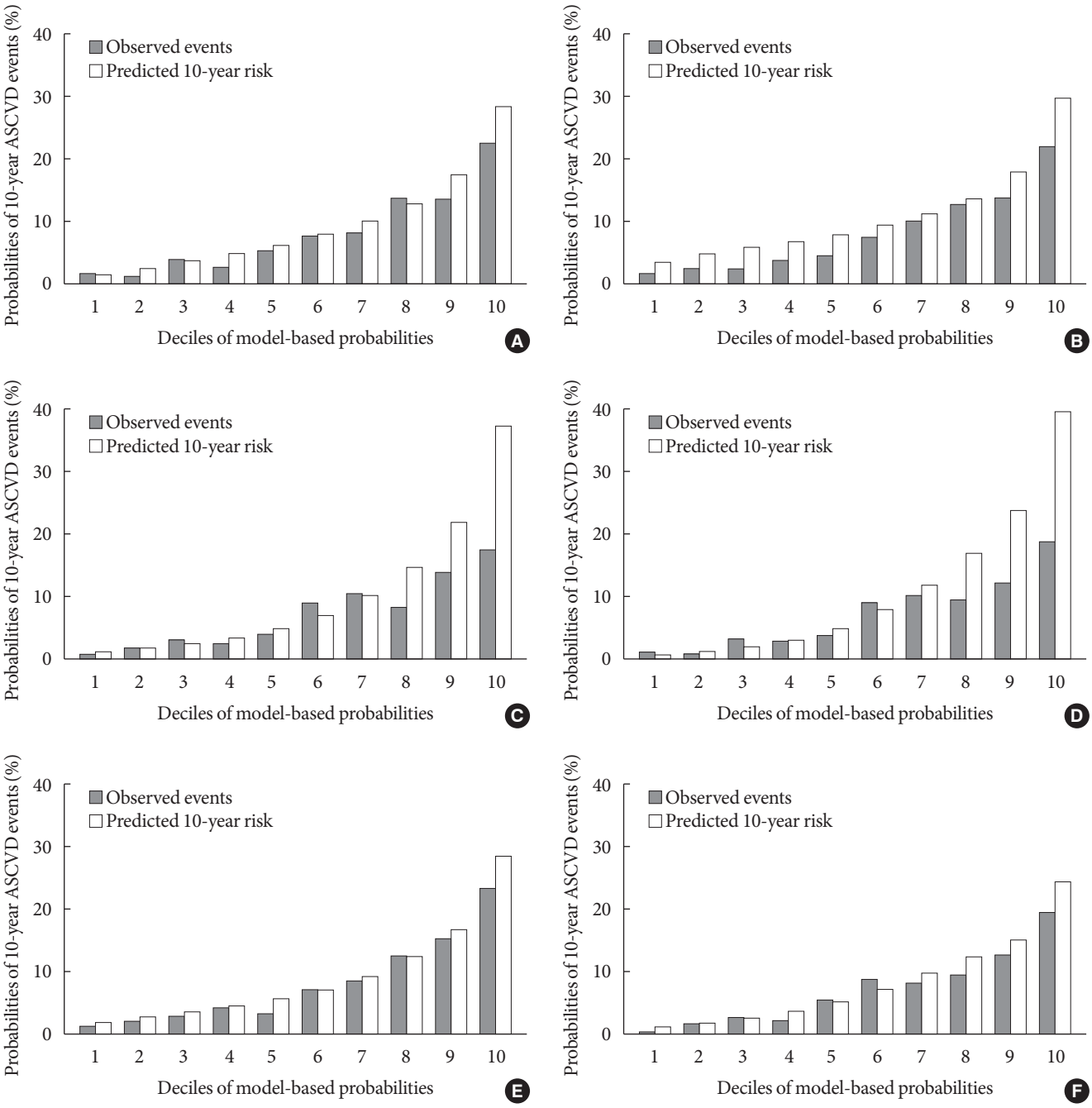

Fig. 3. Ten-year probabilities of atherosclerotic cardiovascular disease (ASCVD) in men and women from the Korean Genome and Epidemiology Study (KOGES)-Ansan and Ansung study using the recalibrated and new Pooled Cohort Equations. (A) The recalibrated Pooled Cohort Equations for non-Hispanic whites in men. (B) The recalibrated Pooled Cohort Equations for African Americans in men. (C) The recalibrated Pooled Cohort Equations for non-Hispanic whites in women. (D) The recalibrated Pooled Cohort Equations for African Americans in women. (E) The new Pooled Cohort Equations in men. (F) The new Pooled Cohort Equations in women.

Chinese [9]. In the KHS, a prospective cohort study in Korea, the PCE also overestimated ASCVD risk for men [24]. The discordance between the predicted and observed risks may result from racial/ethnic differences in genetic predisposition,

environment, and cardiovascular risk factors between the development and validation cohorts. Compared with Western populations, East Asians have lower rates of traditional cardiovascular risk factors including obesity [32] and hypercholesterolemia [33]. In our study, the participants also had lower levels of risk factors than the US population [34], except for a greater proportion of current smokers in men. On the other hand, the PCE-WH and PCE-AA showed good calibration for men in the KOGES-Ansan and Ansung study. The predictive ability of the PCE could be affected by changes in the CVD epidemiology with an improvement in the control risk factors. In Korea, total CVD mortality has significantly decreased over the last 30 years [35], which could be largely due to improvement in the management of hypertension [36]. However, in a sensitivity analysis of the MESA, treatment including anti-hypertensive agents, lipid-lowering agents, aspirin, and coronary revascularization did not explain risk overestimation by the PCE [31]. Therefore, additional validation is needed to evaluate the performance of the PCE in Korean men.

The PCE-WH and PCE-AA underestimated ASCVD risk for women in the KOGES-Ansan and Ansung study, which is different from the risk overestimation in men. In line with our findings, ASCVD risk was underestimated for women in the KHS [24] and was less overestimated for women than for men in the MESA [31]. These results suggest that there are sex differences in cardiovascular risk factors that lead to a higher ASCVD risk in women than in men [37,38]. In the INTERHEART study, risk factors for CHD were similar between men and women, but their impact including hypertension and DM were greater in women than in men [39]. However, in the present study, the prevalence of DM and current smoking in women was lower than that of the PCE cohorts, which could not explain risk underestimation by the PCE. Nontraditional risk factors specific to women, such as gestational DM, hypertensive disorders of pregnancy, and menopause [37], might be associated with poor calibration, although they were not evaluated in our study. Moreover, the pathophysiology of ischemic heart disease (IHD) could be different between men and women. Women are more likely to have stable angina pectoris than men because microvascular dysfunction [40], plaque erosion with distal embolization [41], and impaired vasoreactivity [42] are more prominent than obstructive CHD. For this reason, it is possible that more ASCVD events were ascertained by identifying stable IHD in the present study. Further investigation of cardiovascular risk factors and pathophysiology is needed to apply the PCE to Korean women.

In the present study, recalibration and new equations of the PCE substantially improved the predictive accuracy in men but not in women. In the recalibration and new equations, we used the coefficients and mean values for risk factors from the KOGES-Ansan and Ansung study. Previous studies have suggested that using the recalibrated PCE with data from cohorts can improve ASCVD risk estimates in a population [9,11,24,43]. However, a recent study using six US cohorts failed to improve the accuracy of the PCE by simply applying the derivation process to a newer cohort data [44]. Moreover, recalibration could not be applied to the PCE when the degree of miscalibration varied in different risk groups [45]. In the present study, the participants of the KOGES-Ansan and Ansung study showed varying degrees of miscalibration across the predicted risks in women. Consequently, recalibration of the PCE should be performed considering characteristics of the cohort data, the degree of miscalibration, and statistical methods in further studies.

The FRS-CVD overestimated ASCVD risk for men but showed accurate risk prediction for women in the KOGES-Ansan and Ansung study. Previously, the FRS-CVD overestimated ASCVD risk in US [31], European [46], and Asian populations [47]. However, its performance has not been evaluated in the Korean population. In men, risk overestimation may be associated with lower levels of total cholesterol and systolic BP in the KOGES cohort than in the Framingham Heart Study and the Framingham Offspring Study [22,23]. In women, the KOGES cohort had lower proportions of current smokers but a higher prevalence of DM and lower levels of high density lipoprotein cholesterol than the Framingham Heart Study and the Framingham Offspring Study [22,23]. Given the probably higher ASCVD risk in women than in men, as inferred from the PCE, it is plausible that the FRS-CVD showed an accurate prediction in women. In the MESA and Hong Kong Chinese, the FRS-CVD was also useful for predicting ASCVD risk for women [31,45]. Taken these together, the FRS-CVD should be reevaluated in a modern cohort with multi-ethnic groups including East Asian populations.

Finally, the KRPM underestimated ASCVD risk for both men and women in the KOGES-Ansan and Ansung study. The KRPM [24] was developed from the KHS [25], which was composed of individuals aged 30 to 74 years who visited health promotion centers for a medical checkup. Individuals in the KHS had fewer cardiovascular risk factors than the general

Korean population [25]. Thus, it is not surprising that the KRPM underestimated ASCVD risk in the community-based cohort. Moreover, the KRPM provided accurate risk prediction in the KHS cohort [24], but it was not validated in other populations. Therefore, further studies are required before the KRPM can be used in place of the PCE or other ASCVD risk prediction models in Koreans.

The strength of our study is that we assessed 10-year cumulative incidence of ASCVD in a large-scale, prospective, community-based cohort in Korea. To ascertain ASCVD events comprehensively, we excluded heart or vascular diseases not associated with atherosclerosis through in-depth interviews and a review of medical records. However, the present study has some limitations. First, some risk factors, such as smoking status and prior diagnosis of hypertension or DM, were self-reported rather than directly measured, which could raise concerns about imprecision. Second, we did not evaluate the effects of interventions on cardiovascular risk factors or ASCVD during the follow-up period.

In conclusion, the PCE overestimated ASCVD risk for men and underestimated the risk for women in a large, prospective, community-based cohort in Korea. The PCE-WH and the FRS-CVD provided an accurate prediction of ASCVD in men and women, respectively, in the absence of a reliable risk prediction model specific to Koreans.

SUPPLEMENTARY MATERIALS

Supplementary materials related to this article can be found online at https://doi.org/10.4093/dmj.2019.0061.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

AUTHOR CONTRIBUTIONS

Conception or design: J.H.B., M.K.M.
Acquisition, analysis or interpretation of data: J.H.B., M.K.M., S.O., B.K.K., N.H.C., M.K.L.
Drafting the work of revising: J.H.B., M.K.M., S.O., B.K.K.
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