**Abstract:** Impaired lung function is a risk factor for cardiovascular (CV) events. However, it has not been well established whether FVC reduction even within normal range is associated with cardiovascular disease (CVD) risk and whether reduced FVC is an independent relationship of CVD irrespective of metabolic syndrome. Thus, we aimed to explore the relationship between FVC and CV-event risk using the FRs beyond the presence of metabolic syndrome or abdominal obesity in a representative Korean population based on data from the nationwide Korea National Health and Nutrition Examination Survey (KNHANES IV).

The study population included 9688 subjects ≥30 years of age with no previous diagnosis of CVD and obstructive lung disease. Using a logistic regression model and area under the curve (AUC) analysis, we evaluated the relationship between FVC quintiles and CV-event risk using the Framingham Risk Score (FRS; ≥10% or ≥20%). In addition, we examined the effect of FVC on CV-event risk based on the presence of metabolic syndrome (MetS) and abdominal obesity.

After adjusting for covariates, comparison of subjects in the lowest FVC (% pred) quintile (Q1) with those in the highest quintile (Q5) yielded an odds ratio (OR) of 2.27 (95% CI, 1.91–2.71) for intermediate and high risk, and 2.89 (95% CI, 2.31–3.61) for high risk. The ORs for cardiovascular risk using FRS also increased irrespective of the presence of abdominal obesity and MetS without significant interaction. Furthermore, the addition of FVC status to MetS status and abdominal obesity status significantly increased the AUC of the model predicting CV-event risk (P < 0.001 and P < 0.001).

Our study demonstrates that FVC is inversely associated with 10-year CV-event risk, irrespective of MetS and abdominal obesity in the general population without obstructive lung disease. Furthermore, the addition of FVC to MetS or abdominal obesity increased prediction of CVD event risks, implying a potential role of FVC to predict CV events.

**INTRODUCTION**

Cardiovascular diseases (CVDs), including coronary, cerebrovascular, peripheral arterial disease, and heart failure, are leading causes of morbidity and mortality worldwide. It is well recognized that risk factors such as hypertension, diabetes mellitus (DM), high cholesterol levels, and obesity contribute to the development of CVD. Metabolic syndrome (MetS) is the clustering of these cardiovascular risk factors including abdominal obesity, dyslipidemia, hypertension, insulin resistance, and prothrombotic states that can promote CVD.

Although several risk scores have been used for predicting CVD risk, the Framingham Risk Score (FRS) is the most popular global risk algorithm for estimating 10-year cardiovascular (CV)-event risk. The FRS uses multiple risk factors such as age, sex, smoking history, systolic blood pressure, total cholesterol levels, high-density lipoprotein (HDL), cholesterol levels, and diabetes status in individuals not previously diagnosed with CVD.

Impaired lung function, such as reduced forced expiratory volume in 1 s (FEV1) and forced vital capacity (FVC), is another risk factor for CVD morbidity and mortality. Several previous studies have shown that both obstructive and restrictive lung function impairment have a positive independent relationship with MetS, with abdominal obesity playing a critical role. However, it has not been well established whether FVC reduction even within normal range is associated with cardiovascular disease (CVD) risk. In addition, although chronic obstructive pulmonary disease (COPD) representing reduced FEV1 has been shown to be a risk factor for CVD and MetS, there have been few population-based studies which...
reported the relationship between FVC and FRS-assessed future CVD risk after adequately adjusting the covariates such as the presence of MetS or abdominal obesity, both of which have been found to play a role in the development of CVD.

Therefore, in the present study, we aimed to determine whether there exists an independent relationship between FVC and CV-event risk using the FRS beyond the presence of metabolic syndrome or abdominal obesity in a representative Korean population based on data from the nationwide Korea National Health and Nutrition Examination Survey (KNHANES).

**METHODS**

**Subjects**

KNHANES is a cross-sectional, nationwide, population-based health survey that uses complex, stratified, multistage cluster sampling. We used KNHANES to select a representative nationwide sample of the noninstitutionalized Korean population conducted by the Korea Centers for Disease Control and Prevention (KCDC). The KNHANES has been conducted periodically since 1998, and a fourth survey was conducted between July 2007 and December 2009. We performed a retrospective review of the data from the fourth KNHANES.

Among 24,871 potential subjects, a total of 9688 subjects were included in our study. Subjects <30 years of age \( n = 8969 \) were excluded, as an FRS could not be calculated for this population. We also excluded subjects \( n = 6213 \) who had been previously diagnosed with myocardial infarction, angina pectoris, stroke, asthma or COPD, and/or had an obstructive pattern in spirometry \( \text{FEV}_1/\text{FVC} < 70\% \). Lastly, 1 subject with missing values of height and weight was excluded.

The KNHANES received ethical approval by the Institutional Review Board of the KCDC (IRB No: 2007-02-CON-04-P; 2008-04EXP-01-C, 2009-01CON-03-2C), and written consent was obtained from all of the participants. In addition, the study was conducted in accordance with the ethical principles of the Declaration of Helsinki.

**Measurements**

**Anthropometric Measurements and Blood Tests**

Height, weight, waist circumference (WC), systolic and diastolic blood pressures (BP) were measured. Blood pressure (BP) was measured 3 times by nurses trained in mercury sphygmomanometer use, with the participants in a seated position after a 5 min rest. The final BP value was obtained by averaging the values of the second and third BP measurements. Height and weight were measured by using an automatic height, weight \( \text{WC} \) was standing. Blood samples were obtained after 12 h of fasting. Total cholesterol, triglyceride levels, and HDL cholesterol levels were enzymatically measured, whereas low-density lipoprotein (LDL) cholesterol levels were calculated using the Friedewald equation:

\[
(\text{LDL}-\text{cholesterol}) = (\text{total cholesterol}) - (\text{HDL}-\text{cholesterol}) - (\text{triglyceride})/5.
\]

White blood cell (WBC) counts and ferritin levels were measured automatically with laserflow cytometry and immunoradiometric assay, respectively.

**Framingham Risk Score Calculation and Cardiovascular Risk Stratification**

FRS was calculated based on risk factors including gender, age, total cholesterol, HDL cholesterol, systolic BP, treatment for hypertension, smoking status, and DM status. The Framingham risk groups (taking all risk factors into account) were defined by risk percentages \(< 10\%\), intermediate \(10–20\%\), high \(> 20\%\).

**Lung Function Measurement**

Spirometry was performed as recommended by the American Thoracic Society. We analyzed only data from subjects with 2 or more acceptable spirometry performances. Absolute values of FVC and \( \text{FEV}_1 \) were obtained, and the percentage predicted values \( \% \text{pred} \) for \( \text{FEV}_1 \) and FVC were calculated from the following equations obtained in a representative Korean sample:

\[
\text{Predicted FVC} = 4.8434 - (0.00008633 \times \text{age} [\text{years}]) + (0.05292 \times \text{height} [\text{cm}]) + (0.01095 \times \text{weight} [\text{kg}])
\]

\[
\text{Predicted FEV}_1 = -3.4132 - (0.0002484 \times \text{age} [\text{years}]) + (0.04578 \times \text{height} [\text{cm}])
\]

We analyzed the patients according to the quintile of FVC \( \% \text{pred} \) excluding patients exhibiting an obstructive pattern \( \text{FEV}_1/\text{FVC} < 70\% \). To evaluate the relationship between FVC \( \% \text{pred} \) and Framingham risk, we divided subjects into quintiles based on FVC \( \% \text{pred} \) quintile 1\{Q1\}, \(< 84\%\); quintile 2\{Q2\}, \(84–90\%\); quintile 3\{Q3\}, \(91–95\%\); quintile 4\{Q4\}, \(96–102\%\); quintile 5\{Q5\}, \(\geq 103\%\).

**Metabolic Syndrome (MetS) Diagnosis**

Metabolic syndrome was defined by the American Heart Association/National Heart, Lung, and Blood institute (AHA/NHLBI), whereas WC was defined by the Western Pacific Region of WHO for obesity (WPRO) criteria. In our population, the diagnosis of MetS was made if the patient had 3 or more of the following risk factors: (a) abdominal obesity \( \text{WC} \geq 90 \text{ cm} \), (b) \( \text{BP} \geq 130/85 \text{ mm Hg} \), (c) HDL cholesterol level \(< 40 \text{ mg/dL} \) \( (1.0 \text{ mmol/L}) \), (d) triglyceride level \( \geq 150 \text{ mg/dL} \) \( (1.7 \text{ mmol/L}) \), (e) fasting glucose level \( \geq 100 \text{ mg/dL} \) \( (5.6 \text{ mmol/L}) \).
Statistical Analysis

Baseline characteristics across quintiles were compared using ANOVA for continuous variables and a Cochran-Armitage trend test for dichotomous variables. A logistic regression model was used to assess the relationship between FVC (% pred) quintiles and CV-event risk using FRS (≥ 10% or ≥ 20%) using Q5 (ie, the group with the highest FVC [% pred]) as the referent. In multivariate analysis, 3 models were constructed. Model 1 was adjusted for sex, smoking, education, abdominal obesity, obesity, medical history of DM, and hypertension. Model 2 was additionally adjusted for physical activity, white blood cell counts, LDL-cholesterol, and serum ferritin. Model 3 included the presence of metabolic syndrome as a confounding factor, but excluded abdominal obesity, obesity, and medical history of DM, and hypertension. Furthermore, to maximize evaluation of the effect of FVC on CV-event risk, FVC values were dichotomized into an FVC-Q1 group and an FVC-Q2-5 group. In the final model, we analyzed dichotomized FVC-MetS interaction and dichotomized FVC-abdominal obesity for CV-event risk. Area under the curve (AUC) or the C statistic was performed to evaluate CV-event risk beyond MetS and abdominal obesity. All statistical analyses were performed using IBM SPSS Statistics for windows, version 22.0 (Armonk, NY) and STATA 13 (STATA, College station, TX).

RESULTS

Clinical Characteristics by FVC Quintile

Clinical characteristics of the study population based on FVC (% pred) quintile are presented in Table 1. Waist circumference, prevalence of WC-defined abdominal obesity, BMI, prevalence of BMI-defined obesity, DM, hypertension, and MetS were inversely associated with FVC (% pred), whereas the physical activity level was similar across FVC (% pred) quintiles. The mean values of white blood cells counts, total cholesterol, triglycerides, and ferritin had a significant inverse relationship with FVC (% pred), whereas HDL cholesterol had a significant positive relationship with FVC (% pred). Proportions of subjects with intermediate or high 10-year CV-event risk stratified by the FRS group

| TABLE 1. Comparisons of Demographics, Comorbidities, and Physical and Biochemical Measurements According to the Quintiles of FVC % Predicted Value |
|-------------------------------------------------|
| **FVC (% Pred) Quintile**                       |
| **Q1 (<84%)** | **Q2 (84–90%)** | **Q3 (91–95%)** | **Q4 (96–102%)** | **Q5 (>103%)** | **P for Trend** |
| n = 2132 | n = 1970 | n = 2020 | n = 1694 | n = 1872 |  |
| Demographics | | | | | |
| Age, years | 55.3 ± 13.7 | 50.3 ± 12.5 | 48.9 ± 12.1 | 47.8 ± 12.1 | 48.4 ± 12.5 | <0.001 |
| Male sex, % | 45.5 | 41.4 | 42.0 | 40.2 | 36.1 | <0.001 |
| Waist circumference, cm | 85.2 ± 10.1 | 83.4 ± 9.6 | 82.8 ± 8.8 | 81.8 ± 8.2 | 80.6 ± 7.9 | <0.001 |
| Abdominal obesity, % | 33.1 | 25.7 | 21.5 | 16.2 | 11.5 | <0.001 |
| BMI, kg/m² | 24.8 ± 3.6 | 24.4 ± 3.4 | 24.2 ± 3.0 | 23.9 ± 2.8 | 23.5 ± 2.6 | <0.001 |
| BMI ≥ 25 kg/m², % | 45.7 | 39.9 | 37.6 | 30.7 | 27.5 | <0.001 |
| Lifetime non-smoker, % | 58.5 | 60.2 | 59.4 | 59.6 | 61.8 | 0.087 |
| Comorbidities | | | | | |
| Diabetes mellitus, % | 13.8 | 7.5 | 6.5 | 4.3 | 4.2 | <0.001 |
| Hypertension, % | 29.6 | 21.3 | 17.2 | 15.1 | 13.3 | <0.001 |
| Metabolic syndrome, % | 42.6 | 32.2 | 26.3 | 22.4 | 18.8 | <0.001 |
| Physical activity | | | | | 0.072 |
| Low | 44.7 | 45.7 | 45.2 | 44.1 | 43.4 | |
| Moderate | 40.2 | 37.6 | 37.0 | 38.9 | 38.7 | |
| Severe | 15.1 | 16.8 | 17.9 | 17.0 | 17.9 | |
| Education | | | | | 0.106 |
| Less than elementary education | 35.4 | 26.4 | 23.5 | 22.8 | 26.2 | |
| Secondary education | 13.7 | 12.1 | 12.5 | 12.9 | 12.6 | |
| Higher education | 27.8 | 34.8 | 35.4 | 35.8 | 36.7 | |
| College education or more | 23.0 | 26.7 | 28.6 | 28.5 | 24.5 | |
| Physical and biochemical measurements | | | | | |
| Systolic blood pressure, mm Hg | 123.2 ± 18.2 | 119.4 ± 17.3 | 117.5 ± 16.7 | 117.2 ± 16.4 | 115.9 ± 15.3 | <0.001 |
| Diastolic blood pressure, mm Hg | 78.6 ± 10.8 | 78.1 ± 10.8 | 77.3 ± 10.6 | 77.2 ± 11.0 | 76.1 ± 10.4 | <0.001 |
| White blood cell count, /µL | 6368 ± 1849 | 6164 ± 1763 | 6086 ± 1693 | 5993 ± 1682 | 5882 ± 1688 | <0.001 |
| Total cholesterol, mg/dL | 192.6 ± 36.3 | 194.0 ± 35.0 | 192.6 ± 34.5 | 190.6 ± 33.9 | 189.0 ± 36.0 | <0.001 |
| Triglycerides, mg/dL | 154.2 ± 116.2 | 147.9 ± 110.3 | 142.7 ± 110.4 | 138.5 ± 122.4 | 127.9 ± 110.0 | <0.001 |
| HDL cholesterol, mg/dL | 47.4 ± 12.0 | 49.1 ± 12.3 | 49.8 ± 12.7 | 50.1 ± 12.0 | 50.7 ± 12.7 | <0.001 |
| LDL cholesterol, mg/dL | 114.4 ± 34.2 | 115.4 ± 33.4 | 114.3 ± 33.4 | 112.7 ± 33.4 | 112.7 ± 33.4 | 0.078 |
| Ferritin | 100.2 ± 156.7 | 85.6 ± 99.2 | 83.8 ± 110.2 | 77.3 ± 105.5 | 79.0 ± 168.2 | <0.001 |

Values are expressed as percentages or mean (±standard deviation).

BMI = body mass index, FVC = forced vital capacity, HDL = high-density lipoprotein, LDL = low-density lipoprotein.
increased in a stepwise manner as FVC decreased from highest (Q5) to lowest (Q1) (Figure 1).

**Framingham Risk by FVC Quintile**

The relationships between FVC (% pred) and FRS is shown in Table 2. When the highest quintile (Q5) of FVC (% pred) was considered the referent, the odds ratio (OR) for the FRS/C21 ≥ 10% and ≥ 20% significantly increased as FVC (% pred) quintile decreased (P for trend < 0.001). The ORs in the lowest FVC (% pred) quintile (Q1) for FRS/C21 ≥ 10% and ≥ 20% were 3.09 (95% CI, 2.69–3.54) and 4.08 (95% CI, 3.39–4.92), respectively. This association persisted even after adjustment for covariates (Table 2).

**Framingham Risk by FVC % Quintile Based on the Presence of Metabolic Syndrome and Abdominal Obesity**

The ORs for CV-event risk ≥ 10% in subjects with the lowest FVC values (Q1) with and without MetS were 1.78 (95% CI, 1.46–2.18) and 1.92 (95% CI, 1.62–2.29), respectively, compared to the other groups (Q2, Q3, Q4, and Q5) after adjustment for covariates including sex, smoking, education level, physical activity, white blood cell counts, LDL cholesterol levels, and serum ferritin. The ORs for CV-event risk ≥ 20% in subjects with the lowest FVC values (Q1) with and without MetS were 1.88 (95% CI, 1.55–2.27) and 2.70 (95% CI, 2.16–3.39), respectively, compared to the other groups (Q2, Q3, Q4, and Q5). However, the P values for the interaction between the presence of MetS and FVC quintile for FRS/C21 ≥ 10% and ≥ 20% were 0.754 and 0.069, respectively (Figure 2).

The ORs for CV-event risk ≥ 10% in subjects with the lowest FVC values (Q1) with and without abdominal obesity were 1.88 (95% CI, 1.49–2.95) and 2.13 (95% CI, 1.73–2.64), respectively, compared to the other groups (Q2, Q3, Q4, and Q5). However, the interaction between the presence of abdominal obesity and FVC did not achieve statistical significance after adjustment for covariates including sex, smoking, education level, obesity, comorbidities, physical activity level, WBC counts, LDL cholesterol, and serum ferritin (Figure 2).

**FIGURE 1.** Proportions of subjects with intermediate or high 10-yr CV-event risk by FVC (% pred) quintile. CV = cardiovascular, FVC = forced vital capacity.

**TABLE 2.** Ten-Year Cardiovascular Event Risk According to FVC (% pred) in Patients without Obstructive Lung Disease

| FVC (% Pred) | Unadjusted | Model I Adjusted OR (95% CI) | Model II Adjusted OR (95% CI) | Model III Adjusted OR (95% CI) |
|--------------|------------|-----------------------------|------------------------------|------------------------------|
| Q1 (<84%)    | 3.087 (2.694–3.538) | 2.082 (1.732–2.504) | 2.130 (1.762–2.574) | 2.272 (1.906–2.707) |
| Q2 (84–90%)  | 1.656 (1.439–1.907) | 1.418 (1.174–1.711) | 1.408 (1.161–1.707) | 1.435 (1.199–1.718) |
| Q3 (91–95%)  | 1.408 (1.222–1.622) | 1.329 (1.021–1.603) | 1.351 (1.155–1.678) | 1.365 (1.140–1.633) |
| Q4 (96–102%) | 1.091 (0.938–1.269) | 1.051 (0.863–1.280) | 1.093 (0.893–1.338) | 1.060 (0.877–1.282) |
| Q5 (≤103%)   | Reference | Reference | Reference | Reference |

| P trend       | <0.001    | <0.001     | <0.001     | <0.001     |

**High Cardiovascular Event Risk (Framingham Risk Score ≥ 20%)**

| FVC (% Pred) | Unadjusted | Model I Adjusted OR (95% CI) | Model II Adjusted OR (95% CI) | Model III Adjusted OR (95% CI) |
|--------------|------------|-----------------------------|------------------------------|------------------------------|
| Q1 (<84%)    | 4.083 (3.387–4.921) | 2.639 (2.071–3.363) | 2.678 (2.091–3.431) | 2.888 (2.311–3.608) |
| Q2 (84–90%)  | 2.110 (1.728–2.576) | 1.677 (1.297–2.169) | 1.669 (1.286–2.165) | 1.711 (1.351–2.168) |
| Q3 (91–95%)  | 1.570 (1.277–1.930) | 1.316 (1.012–1.711) | 1.300 (0.995–1.699) | 1.340 (1.051–1.709) |
| Q4 (96–102%) | 1.162 (0.927–1.457) | 1.044 (0.786–1.386) | 1.081 (0.809–1.443) | 1.063 (0.817–1.382) |
| Q5 (≥103%)   | Reference | Reference | Reference | Reference |

| P trend       | <0.001    | <0.001     | <0.001     | <0.001     |

Model I was adjusted for sex, smoking, education, abdominal obesity, obesity, and history of disease (diabetes mellitus, hypertension).

Model II was adjusted for sex, smoking, education, abdominal obesity, obesity, history of disease (diabetes mellitus, hypertension), physical activity, WBC counts, LDL cholesterol, and ferritin.

Model III was adjusted for sex, smoking, education, physical activity, WBC counts, LDL cholesterol, ferritin, and metabolic syndrome.

CI = confidence interval, FVC = forced vital capacity, OR = odds ratio.
Metabolic syndrome status for FRS ≥ 10% and ≥ 20% yielded an AUC of 0.685 (95% CI, 0.675–0.694) and 0.684 (95% CI, 0.671–0.698), respectively. The addition of FVC status significantly increased the AUC of the model to 0.714 (P < 0.0001) and 0.723 (P < 0.0001), respectively. Abdominal obesity status for FRS ≥ 10% and ≥ 20% yielded an AUC of 0.684 (95% CI, 0.673–0.695) and 0.678 (95% CI, 0.664–0.692), respectively. The addition of FVC status significantly increased the AUC of this model to 0.699 (P < 0.0001) and 0.703 (P < 0.0001), respectively, providing additional discrimination for CV-event risk beyond MetS and abdominal obesity (Table 3).

DISCUSSION

According to the results of our study, FVC (% pred) was inversely associated with FRS-determined 10-year CVD-event risk, irrespective of central obesity and MetS, in Koreans without obstructive lung disease. Proportions of subjects in intermediate or high FRS groups gradually increased as FVC decreased from highest (Q5) to lowest (Q1). After adjusting for several factors such as sex, smoking, education level, abdominal obesity, obesity, history of disease (diabetes mellitus, hypertension), physical activity, WBC counts, LDL cholesterol, and ferritin, subjects with the lowest FVC values (Q1) had an intermediate 10-year CV-event risk approximately 2 times greater than that of subjects in the FVC reference group (Q5). Additionally, subjects with the lowest FVC values (Q1) had a high CV-event risk, nearly 3 times greater than that of subjects in the FVC reference group (Q5). The ORs for CV risk using FRS also increased irrespective of the presence of abdominal obesity and MetS. Furthermore, the addition of FVC status significantly increased the AUC of the model with MetS status or abdominal obesity status, providing additional discrimination for cardiovascular event risk beyond MetS and abdominal obesity. We found that the effect of FVC on CV-event risk is important regardless of the presence of MetS or abdominal obesity.

In our study, cardiovascular risk increased from FVC-Q3, ranging from 91% to 95% (often considered normal). This result suggests that both restrictive lung disease and reduced FVC, even within the normal range, may increase the odds of undergoing a CV-event. This observation is consistent with a previous US NHANES follow-up report by Sin et al.15 The group identified that even a modest decline in FEV1 (from a mean of 109% to 88%, a value still considered normal) was associated with a 5-fold increase in ischemic heart disease mortality. Future prospective, longitudinal studies are needed to determine whether there exists a critical FVC threshold that may predict the risk of developing CVD.

Several long-term population studies have suggested an association between FVC and CVD.17,31–34 Some studies have also demonstrated that decreased FVC is associated with electrocardiographic ST-T abnormalities and arterial hypertension.35,36 The decreased lung function has been shown to be related to arterial calcification and stiffness,37,38 which is linked with increased incidence of CVD. However, few studies have evaluated the relationship between FVC and CVD in Asian populations without obstructive lung disease. To date there have been no studies evaluating the effect of FVC on CV-event risk.
Table 3. Area under the Curve Values from the Presence of Metabolic Syndrome and Abdominal Obesity Predict Relationship between Framingham Risk Score and FVC

| Variables                                      | AUC (95% CI)          | P value |
|------------------------------------------------|-----------------------|---------|
| Intermediate and high cardiovascular risk      |                       |         |
| MetS status                                    | 0.6852 (0.6755–0.6949) | <0.0001 |
| MetS status + FVC status*                      | 0.7140 (0.7036–0.7244) | <0.0001 |
| Abdominal obesity status                       | 0.6839 (0.6728–0.6949) |         |
| Abdominal obesity status + FVC status*         | 0.6990 (0.6881–0.7099) |         |
| High cardiovascular risk (Framingham Risk Score ≥ 20%) |                  |         |
| MetS status                                    | 0.6845 (0.6713–0.6977) | <0.0001 |
| MetS status + FVC status*                      | 0.7238 (0.7102–0.7374) |         |
| Abdominal obesity status                       | 0.6776 (0.6636–0.6916) | <0.0001 |
| Abdominal obesity status + FVC status*         | 0.7031 (0.6893–0.7169) |         |

AUC = area under the curve, CI = confidence interval, FVC = forced vital capacity, MetS = metabolic syndrome. * FVC status defined as FVC Q1 or other. † P value for comparison with model of next step.

There are several limitations in our study. First, this study evaluated the risk of CVD indirectly using FRS, rather than mortality or morbidity of CVD. Future longitudinal studies are needed to verify the relationship between FRS and CVD. Second, because serum CRP was not included in the KNHNS, we were unable to adjust serum CRP, widely considered a key inflammatory marker related to decreased lung function. Instead, we adjusted WBC and ferritin, also known to be important indicators of systemic inflammation related to CVD.

Finally, population’s diverse profession could not be categorized based on physical activity, although Leischik et al showed that sedentary occupations are associated with lower HDL cholesterol, higher LDL cholesterol, and higher waist circumferences, compared with occupation with highly physical activity. The investigation of the independent relationship between FVC and CV-event risk after the adjustment of professions based on sedentary lifestyle will be necessary.

In conclusion, this study clearly demonstrated a significant association between decreased FVC and increased CV-event risk in a Korean population without obstructive lung disease, irrespective of MetS and abdominal obesity, and suggested the promising role of FVC for prediction of CV events beyond MetS or abdominal obesity.

REFERENCES

1. Lopez AD, Mathers CD, Ezzati M, et al. Global and regional burden of disease and risk factors, 2001: systematic analysis of population health data. Lancet. 2006;367:1747–1757.
2. He J, Gu D, Wu X, et al. Major causes of death among men and women in China. N Engl J Med. 2005;353:1124–1134.
3. Kannel WB. Blood pressure as a cardiovascular risk factor: prevention and treatment. JAMA. 1996;275:1517–1576.
4. Austin MA, Hokanson JE, Edwards KL. Hypertriglyceridemia as a cardiovascular risk factor. Am J Cardiol. 1998;81:7B–12B.
5. Stamler J, Stamler R, Neaton JD. Blood pressure, systolic and diastolic, and cardiovascular risks. US population data. Arch Intern Med. 1993;153:598–615.
6. Stamler J, Vaccaro O, Neaton JD, et al. Diabetes, other risk factors, and 12-yr cardiovascular mortality for men screened in the Multiple Risk Factor Intervention Trial. Diabetes Care. 1993;16:434–444.
7. Sowers JR. Obesity as a cardiovascular risk factor. Am J Med. 2003;115(Suppl 8A):37S–41S.
8. Galassi A, Reynolds K, He J. Metabolic syndrome and risk of cardiovascular disease: a meta-analysis. Am J Med. 2006;119:812–819.
9. Gami AS, Witt BJ, Howard DE, et al. Metabolic syndrome and risk of incident cardiovascular events and death: a systematic review and meta-analysis of longitudinal studies. J Am Coll Cardiol. 2007;49:403–414.
10. Conroy RM, Pyorala K, Fitzgerald AP, et al., group Sp. Estimation of ten-year risk of fatal cardiovascular disease in Europe: the SCORE project. Eur Heart J. 2003;24:987–1003.
11. Mendis S, Lindholm LH, Mancia G, et al. World Health Organization (WHO) and International Society of Hypertension (ISH) risk prediction charts: assessment of cardiovascular risk for prevention and control of cardiovascular disease in low and middle-income countries. J Hypertens. 2007;25:1578–1582.
12. Lee SH, Jang Y, Oh DJ, et al. A coronary heart disease prediction model: the Korean Heart Study. BMJ Open. 2014;4:e005025.
13. D’Agostino RB Sr, Vasan RS, Pencina MJ, et al. General cardiovascular risk profile for use in primary care: the Framingham Heart Study. Circulation. 2008;117:743–753.
14. Selvarajah S, Kaur G, Haniff J, et al. Comparison of the Framingham Risk Score, SCORE and WHO/ISH cardiovascular risk prediction models in an Asian population. Int J Cardiol. 2014;176:211–218.
15. Sin DD, Wu L, Man SF. The relationship between reduced lung function and cardiovascular mortality: a population-based study and a systematic review of the literature. Chest. 2005;127:1952–1959.
16. Sin DD, Man SF. Chronic obstructive pulmonary disease as a risk factor for cardiovascular morbidity and mortality. Proc Am Thorac Soc. 2005;2:8–11.
17. Min KB, Min JY. Reduced lung function, C-reactive protein, and increased risk of cardiovascular mortality. Circ J. 2014;78:2309–2316.
18. Lee HM, Le H, Lee BT, et al. Forced vital capacity paired with Framingham Risk Score for prediction of all-cause mortality. Eur Respir J. 2010;36:1002–1006.
19. Leone N, Courbon D, Thomas F, et al. Lung function impairment and metabolic syndrome: the critical role of abdominal obesity. Am J Respir Crit Care Med. 2009;179:509–516.
20. Paek YJ, Jung KS, Hwang YI, et al. Association between low pulmonary function and metabolic risk factors in Korean adults: the Korean National Health and Nutrition Survey. Metabolism. 2010;59:1300–1306.
21. Wehrmeister FC, Menezes AM, Muniz LC, et al. Waist circumference and pulmonary function: a systematic review and meta-analysis. Syst Rev. 2012;1:55.
22. Breyer MK, Spruit MA, Hanson CK, et al. Prevalence of metabolic syndrome in COPD patients and its consequences. PLoS One. 2014;9:e89013.
23. Kim Y. The Korea National Health and Nutrition Examination Survey (KNHANES): current status and challenges. Epidemiol Health. 2014;36:e2014002.
24. Pellegrino R, Viegi G, Brusasco V, et al. Interpretative strategies for lung function tests. Eur Respir J. 2005;26:948–968.
25. Kanazawa M, Yoshiike N, Osaka T, et al. Criterria and classification of obesity in Japan and Asia-Oceania. World Rev Nutr Diet. 2005;94:1–12.
26. Friedewald WT, Levy RI, Fredrickson DS. Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. Clin Chem. 1972;18:499–502.
27. Lee HT, Shin J, Min SY, et al. Relationship between bone mineral density and a 10-year risk for coronary artery disease in a healthy Korean population: the Korea National Health and Nutrition Examination Survey 2008-2010. Coron Artery Dis. 2015;26:66–71.
28. Standardization of Spriometry, 1994 Update. American Thoracic Society. Am J Respir Crit Care Med. 1995;152:1107–1136.
29. Choi JK, Paek DM, Lee JO. Normal predictive values of spriometry in Korean population. Tuberc Respir Dis. 2005;58:230–242.
30. Grundy SM, Cleeman JI, Daniels SR, et al. Diagnosis and management of the metabolic syndrome: an American Heart Association/ National Heart, Lung, and Blood Institute Scientific Statement. Circulation. 2005;112:2735–2752.
31. Kannell WB, Hubert H, Lew EA. Vital capacity as a predictor of cardiovascular disease: the Framingham study. Am Heart J. 1983;105:311–315.
32. Kannell WB, D’Agostino RB, Silbershatz H. Use of vital capacity for cardiac failure risk estimation in persons with coronary disease and left ventricular hypertrophy. Am J Cardiol. 1996;77:1155–1158.
33. Johnston AK, Mannino DM, Hagan GW, et al. Relationship between lung function impairment and incidence or recurrence of cardiovascular events in a middle-aged cohort. Thorax. 2008;63:599–605.
34. Engstrom G, Melander O, Hedblad B. Population-based study of lung function and incidence of heart failure hospitalisations. Thorax. 2010;65:633–638.
35. Nakajima K, Li Y, Fuchigami H, et al. Low Vital Capacity and Electrocardiographic ST-T Abnormalities in Asymptomatic Adults. Palmd Med. 2012;460:98.
36. Jacobs DR Jr, Yatsuya H, Hearst MO, et al. Rate of decline of forced vital capacity predicts future arterial hypertension: the Coronary Artery Risk Development in Young Adults Study. Hypertension. 2012;59:219–225.
37. Park HY, Lim SY, Hwang JH, et al. Lung function, coronary artery calcification, and metabolic syndrome in 4905 Korean males. Respir Med. 2010;104:1326–1335.
38. Bolton CE, Cockcroft JR, Sahtz R, et al. Lung function in mid-life compared with later life is a stronger predictor of arterial stiffness in men: the Caerphilly Prospective Study. Int J Epidemiol. 2009;38:867–876.
39. Fuza-Luces C, Garatachea N, Berger NA, et al. Exercise is the real polypill. Physiology (Bethesda). 2013;28:330–358.
40. Salome CM, King GG, Berend N. Physiology of obesity and effects on lung function. J Appl Physiol (1985). 2010;108:206–211.
41. Gregor MF, Hotamisligil GS. Inflammatory mechanisms in obesity. Annu Rev Immunol. 2011;29:415–445.
42. Wellen KE, Hotamisligil GS. Obesity-induced inflammatory changes in adipose tissue. J Clin Invest. 2003;112:1785–1788.
43. Visser M, Bouter LM, McQuillan GM, et al. Elevated C-reactive protein levels in overweight and obese adults. JAMA. 1999;282:2131–2135.
44. Festa A, D’Agostino R Jr, Williams K, et al. The relation of body fat mass and distribution to markers of chronic inflammation. Int J Obes Relat Metab Disord. 2001;25:1407–1415.
45. Engstrom G, Lind P, Hedblad B, et al. Lung function and cardiovascular risk: relationship with inflammation-sensitive plasma proteins. Circulation. 2002;106:2555–2560.
46. Fogarty AW, Jones S, Britton JR, et al. Systemic inflammation and decline in lung function in a general population: a prospective study. Thorax. 2007;62:515–520.
47. Gonzalez AS, Guerrero DB, Soto MB, et al. Metabolic syndrome, insulin resistance and the inflammation markers C-reactive protein and ferritin. *Eur J Clin Nutr.* 2006;60:802–809.

48. Vozarova B, Weyer C, Lindsay RS, et al. High white blood cell count is associated with a worsening of insulin sensitivity and predicts the development of type 2 diabetes. *Diabetes.* 2002;51:455–461.

49. Leischik R, Foshag P, Strauss M, et al. Aerobic capacity, physical activity and metabolic risk factors in firefighters compared with police officers and sedentary clerks. *PLoS One.* 2015;10:e0133113.