Automated Comprehensive CT Assessment of the Risk of Diabetes and Associated Cardiometabolic Conditions

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Abbreviations

AI, artificial intelligence; AUC = area under the receiver operating characteristic curve, CAC = coronary artery calcium, DXA = dual-energy X-ray absorptiometry, PDFF = proton density fat fraction, SMI = skeletal muscle mass index, T2DM = type 2 diabetes mellitus, VS = visceral to subcutaneous fat

Summary Statement

Automated multiorgan CT analysis identified individuals at current and future risk of type 2 diabetes and other cardiometabolic comorbidities in a cohort of Korean adults who underwent health screening with ^{18}F-fluorodeoxyglucose PET/CT.

Key Results

- In a retrospective study of 32166 Korean adults who underwent health screening including ^{18}F-fluorodeoxyglucose PET/CT, diabetes prevalence and incidence were 5.8% at baseline and 9.0% during the follow-up, respectively.
- Automated CT-derived markers predicted new-onset diabetes, with Harrell C-indices of 0.69 and 0.83 for men and women, respectively.
- Automated CT-derived markers identified fatty liver, metabolic syndrome, coronary artery calcium scores >100, sarcopenia, and osteoporosis (area under the receiver operating characteristic curve values ranging from 0.80 to 0.95).

Abstract

Background

CT, performed for various clinical indications has the potential to predict cardiometabolic diseases. However, the predictive ability of individual CT parameters remains underexplored.

Purpose

To evaluate the ability of automated CT-derived markers to predict diabetes and associated cardiometabolic comorbidities.

Materials and Methods

This retrospective study included Korean adults (age ≥25 years) who underwent health screening with ^{18}F-fluorodeoxyglucose (^{18}F-FDG) PET/CT between January 2012 and December 2015. Fully automated CT markers included visceral/subcutaneous fat, muscle, bone density, liver fat, all normalized to height (m^2) and aortic calcification. Predictive performance was assessed using area under the receiver operating characteristic curve (AUC) and Harrell C-index in the cross-sectional and survival analyses, respectively.

Results

The cross-sectional and cohort analyses included 32166 (mean age, 44.6 years ±5.7 [SD], 28833 men) and 27298 adults (mean age, 43.8 years ±4.8 [SD], 24820 men), respectively. Diabetes prevalence and incidence were 6% at baseline and 9% during the 7.3-year median follow-up, respectively. The visceral fat index showed the highest predictive performance for prevalent and incident diabetes, yielding AUCs of 0.70 (95%CI: 0.68, 0.71) in men and 0.82 (95%CI: 0.78, 0.85) in women, and Harrell C-indices of 0.68 (95%CI: 0.67, 0.69) in men and 0.82 (95%CI: 0.77, 0.86) in women, respectively. Combining the visceral fat, muscle area indices, liver fat fraction, and aortic calcification improved the predictive performance, yielding Harrell C-indices of 0.69 (95%CI: 0.68, 0.71) in men and 0.83 (95%CI: 0.78, 0.87) in women. Visceral fat index AUCs for identifying metabolic syndrome were 0.81 (95%CI:

0.80, 0.81) in men and 0.90 (95%CI: 0.88, 0.91) in women. Automated CT-derived markers also identified US-diagnosed fatty liver, coronary artery calcium scores >100, sarcopenia, and osteoporosis, with AUCs ranging from 0.80 to 0.95.

Conclusion

Automated comprehensive multiorgan CT analysis identified individuals at current and future high risk of diabetes and other cardiometabolic comorbidities.

Introduction

Advances in the application of artificial intelligence (AI) in the field of medicine utilizing various machine- and deep-learning algorithms have revolutionized the landscape of body composition analysis from images, rendering it less labor intensive and less dependent on manual intervention (1, 2). However, lack of systematic integration and a shortage of radiologists have hindered the full utilization of these algorithms in clinical practice (1).

Data from opportunistic use of CT beyond its primary clinical indication have shown promise in incidental osteoporosis screening (3, 4) and in quantifying aortic calcification, visceral and subcutaneous fat, muscle mass, and liver fat content (5-8). Even a single CT image at the level of the third lumbar vertebra (L3) can provide precise information regarding visceral and subcutaneous fat, muscle mass, and bone density (9). CT scans can potentially predict cardiovascular disease events and all-cause mortality, raising the prospect of tangible benefits of CT in patient risk stratification (10-12).

However, the predictive ability of individual imaging parameters for cardiometabolic diseases, traditionally diagnosed using conventional modalities, remains underexplored. Type 2 diabetes mellitus (T2DM) is a common metabolic disorder associated with considerable comorbidities and complications and is frequently diagnosed late (13). Body composition, including muscle mass and differential fat distribution, has the potential to predict T2DM and related complications (14, 15).

The aim of this study was to examine the predictive potential of fully automated comprehensive CT analysis for identifying prevalent and incident diabetes and associated cardiometabolic comorbidities (metabolic syndrome, sarcopenia, osteoporosis, fatty liver, and coronary artery calcium [CAC]) among Korean adults participating in a health screening program (**Fig. S1**). Despite debates over the role of ^{18}F-FDG PET/CT in health screening due

to radiation exposure and costs, its common use for cancer screening in Korea and its availability of long-term follow-up data enabled us to address the aims of this study.

Materials and Methods

This retrospective study was approved by the Institutional Ethics Committee (IRB No. KBSMC 2022-04-028), and the requirement for informed consent was waived.

Patients

In this study, a subset of patients from the Kangbuk Samsung Health Study, a prospective cohort study involving Korean adults who are primarily company employees and their spouses and who are undergoing health screening as per South Korea's Industrial Safety and Health Law was analyzed. Inclusion criteria included those who underwent ^{18}F-FDG PET/CT between 2012 and 2015 as part of a comprehensive health examination (**Supplemental Material** for exclusion criteria details).

Measurements

PET-CT image acquisition

After a minimum 8-hour fast, torso ^{18}F-FDG PET/CT scans were obtained using a GE Healthcare Discovery 600 PET/CT system without the use of contrast materials. Information on imaging acquisition parameters is presented in the **Supplemental Material**.

Body composition, liver, and abdominal aorta calcification analysis

Noncontrast torso CT images from the PET/CT acquisition were processed using Food and Drug Administration-approved commercial software (DeepCatch v1.2.0.0; Medical IP; http://www.medicalip.com) (**Supplemental Material** and **Fig S2**) to measure the sectional areas (cm^2) of skeletal muscle, subcutaneous fat, and visceral fat, normalized to height (m^2) as indices. This study focused on these areas, as well as the visceral to

subcutaneous fat (VS) ratio, and the trabecular density at the L3 level, given their strong predictive value for overall mortality (16). Additionally, the software automatically calculated the volumetric liver density and estimated MR-proton density fat fraction (PDFF) values of the liver based on a deep learning-based image synthesis of MR-PDFF from CT images (**Supplemental Material**). Aortic calcification was calculated based on the Agatston calcium score for all aortic regions in the patient's CT images.

Definition of diabetes and other variables

Data encompassing physical measurements, abdominal ultrasonography, and serum biochemical measurements were systematically collected before ^{18}F-FDG PET/CT as part of the health screening program. Demographic characteristics, health behaviors (smoking, alcohol consumption, and physical activity), medical history, and medication use were assessed using standardized self-administered questionnaires (**Supplemental Material**).

Blood samples taken after 10 hours of fasting included measurements of glucose, hemoglobin A1c, and lipid profiles. T2DM was defined as having one or more of a fasting serum glucose level ≥ 126 mg/dL, a hemoglobin A1c level ≥ 6.5% (≥ 48 mmol/mol), or current use of insulin or glucose-lowering medications for diabetes management. Metabolic syndrome and sarcopenia, assessed through impedance analysis, were defined using standard criteria (**Supplemental Material**) (17-19). The CAC score based on CAC CT was categorized as 0–100 or >100, with scores above 100 indicating a critical threshold for statin eligibility (**Supplemental Material**) (20, 21).

Statistical analysis

Descriptive statistics, including mean (SD), percentage, and median (interquartile range) as appropriate, were used to summarize patient characteristics in the cross-sectional study based on T2DM prevalence and the cohort study on T2DM development among initially diabetes-free individuals. Robust Poisson regression models (22, 23) were used to estimate the prevalence ratios (95%CI) for T2DM and each clinical disease by comparing parameter quartiles with the lowest quartile as the reference, while Cox proportional hazard models were used to determine the hazard ratios (95%CI) for diabetes onset by comparing each of the three other quartiles of each parameter against the reference category of the lowest quartile (see details in the **Supplemental Material**). To assess the relationship between CT-derived markers and diabetes risk, restricted cubic splines with knots at the 5^{th}, 27.5^{th}, 50^{th}, 72.5^{th} and 95^{th} percentiles of the sample distribution were used to provide a flexible estimate of the concentration–response relationship between CT-derived markers and diabetes risk.

The performance of the imaging parameters in predicting diabetes and related cardiometabolic diseases relative to standard or commonly used practical measures was assessed using the area under the receiver operating characteristic curve (AUC). For the combination model incorporating multiple CT-derived measures, predicted probabilities for diabetes were generated using the predict command postestimation after fitting multivariable logistic regression models. Differences in the AUC between anthropometric measures and CT-derived measures were evaluated with the Stata roccomp command. The optimal model was determined as a combination of CT-derived measures that maximized the AUC. In this cohort study, the predictive capabilities of conventional measures and CT-derived imaging parameters were compared using the Harrell C-index, a measure adapted for survival analysis (24). The predictive values of CT-derived markers were compared with those of conventional risk factor models, such as the American Diabetes Association diabetes risk scores and

Leicester Diabetes Risk Scores. To address the issue of multiple testing, Bonferroni adjustment, a method commonly used for multiple testing correction, was applied. This study utilized routinely collected health screening data, with the sample size determined by enrolled patients during the study period. Statistical analyses were performed by two authors (Y.C. and S.R.) using Stata software (version 17.0; StataCorp LP,), with statistical significance defined as $P < .05$.

Results

Patient characteristics

Of 34368 patients who underwent ^{18}F-FDG PET/CT between 2012 and 2015, 2202 patients were excluded to missing diabetes-related data, incomplete image storage, cancer history, liver cirrhosis, and low eGFR, resulting in 32166 subjects for the cross-sectional study (**Fig 1 and supplemental material**). In the cohort study, 27298 individuals who were initially free from diabetes were followed up until December 31, 2022, for incident diabetes.

The cross-sectional study included 32166 (mean age, 44.6 years ±5.7 [SD], 28833 men and 3333 women) (**Table 1**). At baseline, the overall prevalence of T2DM was 5.8%: 6% in men and 3.9% in women. Individuals without T2DM were younger than those with T2DM (mean, 44.1 years ± 5.0 *vs* 47.3 years ± 6.3 [*P* <.001] for men and 46.6 years ± 8.6 *vs* 57.1 years ± 9.8 [*P* <.001] for women) and were less likely to have hypertension (17.2% *vs* 39.6% [*P* <.001] for men and 10.8% *vs* 39.2% [*P* <.001] for women), and use lipid-lowering medications (4.1% *vs* 23.3% [*P* <.001] for men and 4.9% *vs* 28.7% [*P* <.001] for women). Individuals without T2DM also had a lower BMI, waist circumference, and impedance-derived fat index (*P* <.001). The T2DM group exhibited increased impedance-based SMI and CT-derived L3 muscle area indices but decreased muscle density. Initially, the muscle area index was higher in individuals with diabetes, but the difference did not persist after adjusting for age and BMI. The age and BMI-adjusted mean muscle area index was 52.9 (95% CI: 52.8-52.9) for men without diabetes and 52.2 (95% CI: 52.0-52.4) for men with diabetes. For women, the adjusted means showed negligible differences between those without diabetes (39.8 [95% CI: 39.6–39.9] and those with diabetes (40.0 [95% CI: 39.4–40.7]). The T2DM group had higher subcutaneous fat and visceral fat indices, a greater VS fat ratio, lower liver densities, and more aortic calcification (*P* <.001). **Tables S1**–**S3** provide the age- and sex-specific distributions of CT-derived parameters**.** The cohort study included 27298 (mean age,

43.8 years ±4.8, 24820 men) (**Table S4**). The pattern in the difference between individuals without and with incident diabetes was similar to that between those without and with prevalent diabetes across anthropometric, impedance, and CT-derived measures.

Relationship of CT-derived parameters to prevalent diabetes and other cardiometabolic conditions

Table 2 displays the AUCs for both conventional and CT-derived parameters for their association with prevalent diabetes in men and women. In men, the CT-derived L3-visceral fat index, liver PDFF (or liver density), and aortic calcification, which are individual markers, demonstrated higher AUC values for prevalent diabetes than BMI (P <.001). In women, while all three parameters exhibited higher AUC values, only the visceral fat index and aortic calcification showed differences (P <.001). The combined use of visceral fat area, subcutaneous fat, liver PDFF, and aortic calcification yielded the highest AUC for the prevalence of diabetes in both men and women. Specifically, the AUC for this combination was 0.75 (95% CI: 0.74–0.77) for men and 0.85 (95% CI: 0.82–0.89) for women. After adjusting for age, center, and year of examination, the prevalence ratios (95% CI) for diabetes, comparing the quartiles to the lowest quartile (reference), showed distinct patterns for men and women (**Table S5**). In men, the highest prevalence ratio was for liver PDFF, followed by the visceral fat index. Conversely, in women, the highest prevalence ratio was observed for the visceral fat index, followed by the VS ratio, aortic calcification, and liver PDFF. The CT-visceral fat index consistently outperformed the impedance-derived body composition indices (SMI, fat mass index and body fat percentage) in predicting prevalent diabetes (**Table S6**).

Table 3 highlights the discrimination performance of the CT-derived markers in identifying various comorbidities using clinical standards for comparison. Liver PDFF was a reliable measure for identifying US-diagnosed fatty liver, with an AUC (95% CI) of 0.81 (0.80–0.81) in men and 0.80 (0.78–0.82) in women. Aortic calcification demonstrated a high AUC in identifying CAC scores greater than 100, particularly in women, where the AUC reached 0.95 (95% CI: 0.89–1.00). The L3 muscle area index effectively identified sarcopenia via the impedance-based SMI, with an AUC of 0.90 (95% CI: 0.89–0.91) for men and 0.88 (0.83–0.94) for women. In the identification of a T score below -2.5 using spine DXA, L3 trabecular density exhibited AUC values exceeding 0.9 for both sexes. For identifying metabolic syndrome, the visceral fat index had a high AUC: 0.81 (95% CI: 0.80–0.81) in men and 0.90 (95% CI: 0.88–0.91) in women.

Relationship of CT-derived parameters to the development of incident diabetes

Over 183651 person-years of follow-up (median follow-up 7.3 years, up to 10.8 years), 2456 of 27298 participants who were initially without diabetes developed incident T2DM, with an overall incidence rate of 13.4 (95% CI: 12.9–13.9) per 1,000 person-years overall (5.4 [95% CI: 4.4–6.7] for women and 14.1 [95% CI: 13.6–14.7] for men). The visceral fat index was the best predictive single imaging marker for incident T2DM in both sexes, surpassing conventional measures, impedance-derived body composition indices, and clinical models, such as the ADA and Leicester UK diabetes risk models (**Table 4** and **Table S7**). Combining imaging markers increased the AUC for T2DM prediction, with the highest AUC for a combination of the visceral fat index, muscle area index, liver PDFF, and aortic calcification (0.69 [95%CI: 0.68-0.71] in men and 0.83[95%CI: 0.78-0.87] in women). After adjusting for age, center, and examination year, the highest hazard ratios were noted for the visceral fat index. The corresponding multivariable-adjusted hazard ratios for incident T2DM, comparing

the highest quartile to the lowest quartile as a reference category, were 5.19 (95% CI: 4.52–5.96) for men and 44.12 (95% CI: 10.58–184.0) for women (**Tables S8**–**S9**). In spline regression analyses, the risk of diabetes exhibited the most pronounced increase across the spectrum of the visceral fat indices for men (**Figure S3**). For women, diabetes risk sharply increased at values below 20, followed by a steady increase thereafter (**Figure S4**).

Discussion

In this cohort study of Korean adults, CT-derived body composition parameters, particularly the visceral fat index, were excellent predictors of prevalent and incident diabetes, outperforming traditional anthropometric and clinical risk models for both sexes. Combining CT-derived markers, including visceral fat, muscle area, liver PDFF, and aortic calcification, improved T2DM risk prediction model performance and accurately identified corresponding comorbidities. In individuals with T2DM, initial diagnoses often coincide with comorbidities and diabetes-related complications, affecting medication choices (13). CT-derived imaging markers may facilitate a more tailored and precise diabetes treatment strategy.

Building on previous research linking CT-derived body composition to diabetes diagnosis (14, 25), our findings, obtained from a real-world health screening environment with regular diabetes evaluations, highlight the potential CT imaging to enhance preventive care and risk assessment through opportunistic CT screening, as previously recommended by Pickhardt (12).

In our study, CT-derived visceral fat alone outperformed conventional T2DM prediction models, with its predictive performance improving when combined with other CT-derived imaging markers. This index also identified metabolic syndrome (26). Additionally, abdominal obesity, measured by the waist-to-hip ratio or waist circumference, better predicts diabetic retinopathy, diabetic kidney disease and CVD than BMI (27). Given that CT is the reference standard for precisely quantifying visceral fat, an accurate assessment of visceral obesity could predict both the risk of diabetes and its complications. Over 55–70% of individuals with T2DM also have metabolic dysfunction-associated steatotic liver disease (28), with a heightened risk of liver-related complications, leading to clinical guidelines advocating routine screening for this condition (13). T2DM is linked to an increased risk of

sarcopenia (29). In our research, patients with T2DM exhibited higher muscle mass but lower muscle density on CT scans, a disparity that disappeared after adjusting for BMI and age. Identifying lower muscle density, which is indicative of myosteatosis, is crucial because it is adversely associated with muscle strength and mortality (30), underscoring the need to assess both muscle mass and quality for a comprehensive muscle health evaluation.

Aortic calcification, associated with cardiovascular mortality and sharing CVD risk factors with CAC (31), accurately identified CAC >100 in our study. This potentially identifies individuals with T2DM at high atherosclerotic CVD risk (>20 per 1000 person-years), necessitating intensive treatment initiation (21, 32). Our study identified aortic calcification as a predictor of incident diabetes, suggesting that vascular calcification serves an integrative marker of aging and overall health encompassing CVD risk, and influences diabetes onset (33, 34).

In our study, CT-derived markers had a stronger association with diabetes and metabolic syndrome in women than in men, consistent with the findings of Pickhardt et al., who reported greater predictive accuracy in women (26). These sex-specific differences might be related to sexually dimorphic risk factors for cardiometabolic diseases (35). Premenopausal women, influenced by estrogen, tend to accumulate more gluteal-femoral adipose tissue, which is associated with better insulin sensitivity and a preference for lipid storage in subcutaneous rather than visceral fat (35). This estrogen-related fat distribution might explain the superior ability of CT imaging to predict diabetes risk in women (36), highlighting the importance of considering sex-specific factors and accurate fat distribution data from CT scans in risk assessment.

Our study had limitations, including diagnosing T2DM with a single measurement of fasting glucose and HbA1c, diverging from typical clinical practices requiring repeat testing.

However, HbA1c shows reliable preanalytical stability and resistance to immediate influences such as stress and exercise, aiding in accurately determining T2DM incidence (37). The minimum ages of individuals with prevalent and incident diabetes were 37 and 39 years, respectively, making type 1 diabetes unlikely in this age group. Second, we could not analyze pancreatic fat, a predictor of diabetes (14), suggesting a direction for future research. Our findings' generalizability might be limited, as we focused on young and middle-aged Koreans, potentially not representing the broader population. Additionally, while liver ultrasonography was almost universally conducted within the cohort, other tests, such as bone mineral density and CAC scans, were performed, often based on participant preference, possibly introducing selection bias. However, its impact on the diagnostic utility of CT-derived image markers for diagnosing CAC or osteoporosis is expected to be minimal, given that there is no anticipated association between these conditions and CT-derived markers when participants were selecting examinations. Future research should include an unselected population to validate our findings across different demographics.

In conclusion, CT-derived parameters, particularly the visceral fat area index, outperformed traditional methods for predicting T2DM in both sexes. Combining CT-derived markers, including visceral and subcutaneous fat areas, muscle area, liver fat fraction, aortic calcification, improved T2DM risk prediction performance and facilitated screening for multiple diabetes-associated comorbidities, offering tailored risk stratification. Achieving more efficient and safer approaches through reduced radiation exposure and targeted multiorgan assessments remains a necessity and caution is warranted when considering the clinical applicability of these findings for practice.

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Table 1. Baseline Characteristics of the participants by prevalent diabetes

Characteristic	Men without Diabetes (*n* = 27090)	Men with Diabetes (*n* = 1743)	Women without Diabetes (*n* = 3203)	Women with Diabetes (*n* = 130)	*P* value for without diabetes *vs* with diabetes	
					Men	Women
Age (years)*	44.1 ± 5.0	47.3 ± 6.3	46.6 ± 8.6	57.1 ± 9.8	<.001	<.001
Age range (years)	27–80	37–77	29–83	39–78		
Current smoking (%)	8761 (33.4)	628 (37.9)	75 (2.7)	3 (2.9)	<.001	.89
Alcohol user (%)	8656 (32.8)	696 (41.5)	179 (6.4)	4 (4.1)	<.001	.36
HEPA (%)	3788 (14.2)	293 (17.2)	383 (12.3)	31 (24.4)	<.001	<.001
Lipid-lowering drugs (%)	1111 (4.1)	403 (23.3)	157 (4.9)	37 (28.7)	<.001	<.001
Hypertension (%)	4667 (17.2)	690 (39.6)	347 (10.8)	51 (39.2)	<.001	<.001
Metabolic syndrome (%)	7095 (26.2)	1180 (67.7)	215 (6.7)	55 (42.3)	<.001	<.001
Anthropometry						
BMI (kg/m^2)*	24.5 ± 2.7	25.9 ± 3.2	22.3 ± 3.0	24.7 ± 4.1	<.001	<.001
Waist circumference (cm)*	86.1 ± 7.3	90.2 ± 8.1	76.9 ± 8.2	83.9 ± 10.6	<.001	<.001
Impedance analysis						
Fat percentage*	23.1 ± 4.9	25.5 ± 5.3	30.5 ± 5.9	33.9 ± 6.3	<.001	<.001
Fat mass per height^2†	5.6 (4.5–6.7)	6.4 (5.3–7.8)	6.6 (5.4–8.2)	8.1 (6.6–10.0)	<.001	<.001
Skeletal muscle mass (kg)†	31.3 (29.0–33.6)	31.8 (29.4–34.3)	20.9 (19.4–22.5)	20.6 (18.8–23.0)	<.001	.45
ASM (kg)†	23.8 (22.0–25.6)	24.1 (22.1–25.9)	15.6 (14.4–17.0)	15.1 (13.5–17.3)	<.001	.52
SMI (ASM/height^2)†	8.0 (7.6–8.4)	8.1 (7.7–8.6)	6.1 (5.8–6.5)	6.3 (5.8–6.8)	<.001	<.001
CT-derived measures						
Muscle area index at L3†	52.3 (47.9–57.2)	54.3 (49.4–59.5)	39.2 (36.2–42.7)	42.1 (38.7–46.9)	<.001	<.001
Muscle density (HU)†	45.1 (42.1–48.1)	44.2 (40.8–47.3)	38.3 (34.1–41.8)	34.5 (30.1–37.7)	<.001	<.001
Visceral fat index at L3†	41.0 (29.4–53.4)	54.3 (42.3–68.0)	17.7 (9.0–29.9)	42.7 (30.3–54.8)	<.001	<.001
Visceral fat density (HU)†	-92.4 (-96.0–-88.5)	-92.5 (-95.8–-89.3)	-92.2 (-96.6–-87.1)	-94.1 (-98.2–-89.8)	.002	.008
SC fat index at L3†	42.8 (33.6–53.6)	45.0 (35.2–56.8)	56.9 (43.0–73.2)	69.7 (54.4–89.0)	<.001	<.001
SC fat density (HU)†	-91.6 (-95.3–-87.5)	-89.8 (-93.6–-85.7)	-96.3 (-99.7–-92.2)	-96.3 (-99.1–-91.7)	<.001	.83
VS ratio†	0.9 (0.7–1.2)	1.2 (0.9–1.5)	0.3 (0.2–0.4)	0.6 (0.4–0.8)	<.001	<.001
Vertebral density (HU)†	272.3 (243.9–303.7)	269.9 (238.5–302.2)	299.4 (256.5–337.9)	249.1 (210.0–291.5)	.003	<.001
Liver density (HU)†	55.4 (50.7–59.0)	50.6 (42.9–55.5)	55.8 (52.6–58.8)	51.4 (43.5–55.9)	<.001	<.001
Liver PDFF†	6.8 (5.5–8.7)	8.7 (6.8–12.3)	6.2 (5.2–7.5)	8.2 (6.4–12.2)	<.001	<.001
Aortic calcification (Agatston score)†	9.5 (2.9–48.6)	57.2 (7.6–327.1)	5.7 (1.9–21.9)	122.5(14.3–636.1)	<.001	<.001

Note. –Except where noted, data are numbers of patients, with percentages in parentheses. Alcohol users refers to individuals who consume ≥20 g of ethanol per day. HEPA refers to engaging in either (1) vigorous-intensity activities for at least 3 days per week, totaling 1500 or more metabolic equivalent task (MET) minutes per week, or (2) a combination of walking, moderate-intensity, or vigorous-intensity activities across 7 days, achieving a minimum of 3000 MET minutes per week.
Abbreviations: ASM = appendicular skeletal muscle mass, BMI = body mass index (calculated as weight in kilograms divided by height in meters squared), HEPA = health-enhancing physical activity, HU = Hounsfield units, L3 = third lumbar vertebra, PDFF = proton density fat fraction, SC = subcutaneous, SMI = skeletal muscle index, VS ratio = visceral-to-subcutaneous fat ratio
* Normally distributed continuous variables as expressed as mean (SD).
†Nonnormally distributed continuous variables expressed as median (IQR).

Table 2. Discrimination performance of CT-derived parameters in identifying prevalent diabetes

Variable	Men (n=28833)			Women (n= 3333)		
	AUC (95% CI)	*P* value for reference *vs* listed variable		AUC (95% CI)	*P* value for reference *vs* listed variable	
Anthropometric measures						
Body mass index	0.64 (0.62–0.65)	reference		0.68 (0.64–0.73)	reference	
Waist circumference	0.65 (0.63–0.66)	.01	reference	0.71 (0.67–0.76)	.03	reference
Impedance analysis						
Body fat percentage	0.63 (0.61–0.64)	.16	.002	0.66 (0.61–0.71)	.13	.003
Fat mass per height^2	0.64 (0.63–0.65)	.27	.20	0.68 (0.63–0.72)	.48	.01
SMI (ASM/height^2)	0.57 (0.55–0.58)	<.001*	<.001*	0.57 (0.50–0.63)	<.001*	<.001*
CT-derived measures						
Muscle area index at L3	0.58 (0.56–0.59)	<.001*	<.001*	0.65 (0.60–0.70)	.06	.006
Visceral fat index at L3	0.70 (0.68–0.71)	<.001*	<.001*	0.82 (0.78–0.85)	<.001*	<.001*
Subcutaneous fat index at L3	0.54 (0.53–0.56)	<.001*	<.001*	0.66 (0.62–0.70)	.13	.002
VS ratio	0.67 (0.66–0.69)	<.001*	.003	0.80 (0.76–0.84)	<.001*	<.001*
Muscle density, HU	0.56 (0.55–0.57)	<.001*	<.001*	0.68 (0.64–0.73)	.94	.27
Visceral fat density, HU	0.51 (0.50–0.53)	<.001*	<.001*	0.58 (0.53–0.63)	.001	<.001*
Subcutaneous fat density, HU	0.58 (0.57–0.60)	<.001*	<.001*	0.51 (0.47–0.56)	<.001*	<.001*
Vertebral density, HU	0.52 (0.51–0.54)	<.001*	<.001*	0.70 (0.66–0.75)	.63	.72
Liver PDFF	0.68 (0.66–0.69)	<.001*	<.001*	0.73 (0.68–0.77)	.11	.64
Liver density, HU	0.68 (0.66–0.69)	<.001*	<.001*	0.72 (0.67–0.77)	.24	.88
Aortic calcification	0.67 (0.66–0.69)	<.001*	.008	0.78 (0.74–0.82)	.003	.03
Combination of CT-derived measures						
Visceral fat index + Subcutaneous fat index	0.70 (0.69–0.72)	<.001*	<.001*	0.82 (0.79–0.86)	<.001*	<.001*
Visceral fat index + Muscle area index	0.70 (0.68–0.71)	<.001*	<.001*	0.82 (0.78–0.85)	<.001*	<.001*
Visceral fat index + Visceral fat density	0.70 (0.69–0.72)	<.001*	<.001*	0.83 (0.79–0.86)	<.001*	<.001*
Visceral fat index + Liver PDFF	0.72 (0.71–0.73)	<.001*	<.001*	0.82 (0.79–0.86)	<.001*	<.001*
Visceral fat index + Liver density	0.71 (0.70–0.73)	<.001*	<.001*	0.82 (0.78–0.85)	<.001*	<.001*
Visceral fat index + Aortic calcification	0.73 (0.72–0.74)	<.001*	<.001*	0.83 (0.80–0.87)	<.001*	<.001*
Visceral fat index + Aortic calcification + Liver PDFF	0.75 (0.74–0.76)	<.001*	<.001*	0.84 (0.81–0.87)	<.001*	<.001*
Visceral fat index + Aortic calcification + Liver PDFF + Subcutaneous fat index	0.75 (0.74–0.77)	<.001*	<.001*	0.85 (0.82–0.89)	<.001*	<.001*

Note. – asterisk (*) indicates that the P-value remained significant after Bonferroni correction. To address the issue of multiple testing, statistical significance was assessed using the Bonferroni adjustment for the

45 separate tests conducted for each sex, with a significance threshold set at α/45 (α divided by 45, 0.001 instead of 0.05).

CT-derived measures, including muscle area, visceral fat area, and subcutaneous fat area at the L3 level, were normalized by dividing each individual area by the square of height. Body fat percentage was calculated using fat mass multiplied by 100 and then divided by the total body weight in kilograms. Abbreviations: ASM = appendicular skeletal muscle mass, AUC = area under the receiver operating characteristic curve, HU = Hounsfield units, L3 = third lumbar vertebra, PDFF = proton density fat fraction, SMI = skeletal muscle index, VS ratio = visceral-to-subcutaneous ratio

Table 3. Discrimination performance of CT-derived parameters in identifying other cardiometabolic conditions

Variable	AUC (95% CI)	
	Men (n=28833)	Women (n= 3333)
Fatty liver based on US		
Subjects with available US data / subjects with fatty liver (*n*)	28824/13563	3332/614
Liver PDFF	0.81 (0.80–0.81)	0.80 (0.78–0.82)
Liver density, HU	0.81 (0.80–0.81)	0.79 (0.77–0.81)
Coronary artery calcium (>100)		
Subjects with available CAC CT data / subjects with CAC >100 (*n*)	4515/164	263/8
Aortic calcification	0.84 (0.80–0.87)	0.95 (0.89–1.00)
Sarcopenia		
Subjects with impedance data / subjects with sarcopenia(*n*)	27517/591	3034/21
Muscle area index at L3	0.90 (0.89–0.91)	0.88 (0.83–0.94)
Osteoporosis		
Subjects with available DXA data / subjects with osteoporosis (*n*)	819/66	630/60
Vertebral density, HU	0.91 (0.85–0.96)	0.92 (0.88–0.95)
Metabolic syndrome		
Subjects with available components / subjects with metabolic syndrome (*n*)	28831/8275	3333/270
Muscle area index at L3	0.67 (0.66–0.68)	0.77 (0.74–0.80)
Visceral fat index at L3	0.81 (0.80–0.81)	0.90 (0.88–0.91)
Subcutaneous fat index at L3	0.71 (0.70– 0.71)	0.80 (0.77– 0.82)
Visceral-to-subcutaneous fat ratio	0.65 (0.65–0.66)	0.82 (0.80–0.84)
Muscle density, HU	0.54 (0.53–0.55)	0.70 (0.66–0.73)
Visceral fat density, HU	0.57 (0.56–0.58)	0.67 (0.64–0.69)
Subcutaneous fat density, HU	0.51 (0.50–0.52)	0.57 (0.54–0.60)
Vertebral density HU	0.52 (0.51–0.53)	0.67 (0.64–0.71)
Liver PDFF	0.64 (0.64–0.65)	0.75 (0.72–0.78)
Liver density, HU	0.64 (0.64–0.65)	0.73 (0.70–0.77)
Aortic calcification	0.58 (0.57–0.59)	0.73 (0.69–0.76)

Note. – "*n*" denotes the available sample size relevant to each reported outcome and the corresponding number of subjects with each condition.

The L3-level sectional areas (cm^2) of skeletal muscle were utilized for the analysis and subsequently normalized to height (m^2), referred to as the muscle area index.
Abbreviations: AUC = area under the receiver operating characteristic curve, CAC = coronary artery calcium, DXA = dual-energy X-ray absorptiometry, HU = Hounsfield units, L3 = third lumbar vertebra, PDFF = proton density fat fraction.

Table 4. Predictive abilities of various measures for identifying incident diabetes

Variable	Men (n=24820)			Women (n=2478)		
	Harrell C index (95% CI)	*P* value*	*P* value†	Harrell C index (95% CI)	*P* value*	*P* value†
Clinical prediction model						
ADA score	0.64 (0.63–0.65)	<.001‡		0.80 (0.75–0.85)	Reference	
Leicester UK diabetes risk	0.65 (0.64–0.67)	Reference		0.78 (0.73–0.83)	.30	
Anthropometric measures						
Body mass index	0.66 (0.65–0.67)	.56	Reference	0.77 (0.72–0.82)	.34	.73
Waist circumference	0.65 (0.64–0.66)	.47	.06	0.77 (0.73–0.82)	.38	Reference
Impedance analysis						
Body fat percentage	0.63 (0.61–0.64)	<.001‡	<.001‡	0.74 (0.68–0.80)	.04	.03
Fat mass per height^2	0.65 (0.63–0.66)	.10	<.001‡	0.76 (0.70–0.82)	.21	.37
SMI (ASM/height^2)	0.61 (0.60–0.62)	<.001‡	<.001‡	0.69 (0.62–0.75)	.002	.005
AI-automated CT measures						
Muscle area index at L3	0.61 (0.60–0.62)	<.001‡	<.001‡	0.72 (0.67–0.78)	.03	.04
Visceral fat index at L3	0.68 (0.67–0.69)	<.001‡	<.001‡	0.82 (0.77–0.86)	.43	.02
Subcutaneous fat index at L3	0.59 (0.58–0.60)	<.001‡	<.001‡	0.76 (0.70–0.81)	.11	.23
Visceral-to-subcutaneous fat ratio	0.61 (0.60–0.62)	<.001‡	<.001‡	0.75 (0.71–0.80)	.17	.44
Muscle density, HU	0.51 (0.50–0.52)	<.001‡	<.001‡	0.63 (0.57–0.70)	<.001‡	<.001‡
Visceral fat density, HU	0.54 (0.53–0.56)	<.001‡	<.001‡	0.65 (0.59–0.70)	<.001‡	<.001‡
Subcutaneous fat density, HU	0.52 (0.51–0.53)	<.001‡	<.001‡	0.57 (0.51–0.63)	<.001‡	<.001‡
Vertebral density HU	0.50 (0.49–0.51)	<.001‡	<.001‡	0.55 (0.48–0.62)	<.001‡	<.001‡
Liver PDFF	0.63 (0.61–0.64)	<.001‡	<.001‡	0.67 (0.60–0.74)	.001	.003
Liver density, HU	0.63 (0.61–0.64)	<.001‡	<.001‡	0.65 (0.58–0.72)	<.001‡	.001
Aortic calcification	0.56 (0.55–0.58)	<.001‡	<.001‡	0.60 (0.53–0.67)	<.001‡	<.001‡
Combination of AI-automated CT measures						
Visceral fat index + Subcutaneous fat index	0.68 (0.67–0.69)	<.001‡	<.001‡	0.82 (0.77–0.86)	.45	.007
Visceral fat index + Muscle area index	0.68 (0.67–0.69)	<.001‡	<.001‡	0.82 (0.78–0.87)	.34	.006
Visceral fat index + Visceral fat density, HU	0.68 (0.67–0.69)	<.001‡	<.001‡	0.81 (0.77–0.86)	.53	.04
Visceral fat index + Liver PDFF	0.69 (0.68–0.70)	<.001‡	<.001‡	0.82 (0.77–0.86)	.40	.01
Visceral fat index + Liver density, HU	0.69 (0.68–0.70)	<.001‡	<.001‡	0.82 (0.77–0.86)	.43	.02
Visceral fat index + Aortic calcification	0.68 (0.67–0.69)	<.001‡	<.001‡	0.82 (0.78–0.86)	.33	.008
Visceral fat index + Muscle area index + Liver PDFF	0.69 (0.68–0.70)	<.001‡	<.001‡	0.82 (0.78–0.87)	.33	.006
Visceral fat index + Muscle	0.69 (0.68–0.71)	<.001‡	<.001‡	0.83 (0.78–0.87)	.22	.002

area index + Liver PDFF + Aortic calcification	

Note. – [*]*P* value compared with the reference (highest Harrell C index among clinical prediction models); [†]*P* value compared with the reference (highest Harrell C index among conventional anthropometric measurements): double dagger (‡) indicates that the P-value remained significant after Bonferroni correction. To address the issue of multiple testing, statistical significance was assessed using the Bonferroni adjustment for the 48 separate tests conducted for each sex, with a significance threshold set at α/48 (α divided by 48, 0.001 instead of 0.05).

Abbreviations: ADA = American Diabetes Association, AI = artificial intelligence, ASM = appendicular skeletal muscle mass, HU = Hounsfield units, L3 = third lumbar vertebra, PDFF = proton density fat fraction, SMI = skeletal muscle index.

Figure legends

Figure 1. Flow chart for the selection of the study participants

AI, artificial intelligence; eGFR, estimated glomerular filtration rate; HbA1c, glycated hemoglobin.

SUPPLEMENTAl MATERIALS

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S1. Study Population Selection Procedure

This study, part of the Kangbuk Samsung Health Study (KSHS), involved Korean adults who underwent 18F-FDG PET-CT scans between 2012 and 2015 (n=34368). After baseline exclusions (*n* = 2202), which included missing diabetes-related data including glucose, glycated hemoglobin or medication for diabetes (*n* = 1448), AI program inference errors, incomplete image storage (*n* = 4), history of cancer (*n* = 702), suspected malignancies based on PET-CT (*n* = 9), liver cirrhosis on US (*n* = 30), and low estimated glomerular filtration rates defined as eGFR <30 ml/min/1.73m^2 (*n* = 11), 32166 subjects remained for the cross-sectional study (**Fig. 1**). To investigate the prospective association between CT-derived image markers and incident diabetes development, we further excluded those with baseline diabetes (*n* = 1873) and those without additional follow-up visits until end of 2022 (*n* = 3145), leaving 27298 individuals in the cohort study.

S2. Measurements

S2-1. *PET-CT image acquisition*

Torso CT images, with a 3.75 mm slice thickness and 40–120 mA current range at a 120 kVp energy level, were taken from the skull base to the mid-thigh. PET imaging, taking 2.5–3 min per bed position in 2D mode, covered the area from the proximal thigh to the skull base. The average radiation dose from the CT component typically remains below 3–4 mSv, whereas the effective dose of a PET-CT scan, determined by the injected activity, generally does not exceed 8–10 mSv in either women or men. (N.B. A single chest x-ray exposes the patient to about 0.1 mSv, which is about the same amount of radiation people are exposed to naturally over the course of about 10 days).

S2-2. ***CT-based Body composition analysis***

DeepCatch v1.2.0 conducts automated CT analyses, encompassing automatic volumetric segmentation and L3 localization, and categorizes body components into 128 anatomical classes: skin, subcutaneous fat, muscle, visceral fat, bone, internal organs and vessels, central nervous system, liver, spleen, thoracolumbar vertebrae, and aorta (**Fig S2**). For body composition analysis, the software utilized twenty-seven segmentation results of subcutaneous fat, muscle, and visceral fat, enabling the automatic calculation of their volumes and densities. After segmentation, the software also facilitated the automatic labeling of body composition areas in the L3-level cross-sectional image.

The average dice scores for muscle, visceral fat, and subcutaneous fat ranged from 96.8% to 99.2%, 95.1% to 98.9%, and 97.1% to 99.7%, respectively, as observed in the domestic validation sets (8). The average Dice score for corresponding structures in the external test sets was 93.4% (individual thoracolumbar vertebrae without anatomical variations). An experienced radiologist (S.Y.), blinded to the clinical information, reviewed and confirmed the segmentation results.

Furthermore, the software performed 3D segmentation of the liver and spleen and automatically calculated their volumes and densities. To precisely estimate Proton Density Fat Fraction (PDFF) from computed tomography (CT) scans, we leveraged a deep learning-based image synthesis tool, provided by DeepCatch software. A pre-existing linear estimation can estimate PDFF values from CT images based on a predefined correlation with mean Hounsfield Unit (HU) values (7), but its accuracy may vary due to image quality, noise, or artifact. Instead,

our approach employs a synthetic MR-PDFF mapping that directly computes average values by generating synthetic MR-PDFF images from original CT images. The development of the synthetic MR-PDFF mapping technique is grounded in a model-based learning paradigm (23), which utilizes known linear relationships. We designed the synthetic MR-PDFF mapping algorithm to correct unrealistic MR-PDFF estimations—such as negative values or those exceeding 100%. This correction is achieved by referencing the values of adjacent voxels to ensure the transformed images reflect realistic MR-PDFF values within physiological norms. Consequently, it enhances the reliability and consistency of MR-PDFF estimations across different image qualities, effectively mitigating the image quality, noise or artifacts present in the original images. Our software calculates the PDFF based on the volumetric density of entire liver area.

In the vertebral analysis, software was used to automatically detect a specific vertebral level and extract the average density of the trabecular bone area at this level. Aortic calcification was calculated based on the Agatston calcium score for all aortic regions, including ascending aorta, aortic arch, and descending aorta in the patient's CT images (38).

S2-3. ***Measurements of clinical variables***

Trained nurses measured anthropometric parameters and sitting blood pressure. Height was measured to the nearest 0.1 cm using a stadiometer with participants standing barefoot, while waist circumference was assessed to the nearest 0.1 cm at the midpoint between the rib cage bottom and the iliac crest with subjects in a standard posture. Hypertension was defined as a BP reading of 140/90 mmHg or current use of antihypertensive medication.

Metabolic syndrome was defined as having at least three of the following metabolic abnormalities (17, 18): 1) abdominal obesity, 2) fasting glucose level ≥ 100 mg/dL or current use of glucose-lowering agents, 3) BP ≥ 130/85 mmHg or current use of BP-lowering agents, 4) elevated triglyceride level (≥ 150 mg/dL) or current use of lipid-lowering agents, or 5) low HDL-C (< 40 mg/dl in men or < 50 mg/dl in women) (39). Abdominal obesity was defined as waist circumference ≥90 cm for men and ≥85 cm for women, which are specific for Korean populations (18, 40).

Fat and muscle mass were measured using a multi-frequency bioelectrical impedance analysis device (InBody 720; Biospace Inc., Seoul, Korea). This technique is known for its accuracy and strong correlation with dual-energy X-ray absorptiometry (DXA) for fat mass and appendicular skeletal muscle mass (ASM) (41, 42). ASM is defined as the total lean mass in the limbs. The Skeletal Muscle Mass Index (SMI) was calculated using BIA with the formula: SMI (kg/m^2) =as ASM (kg) divided by height $(m)^2$. Sarcopenia is categorized based on SMI: Class I sarcopenia is an SMI one to two standard deviations below the mean of young adults, while Class II sarcopenia is an SMI more than two standard deviations below the mean of young adults (19), the focus of this study.

Coronary artery calcification was assessed using a GE Lightspeed VCT XTe-64 slice multidetector CT scanner (GE Healthcare, Chicago, IL, USA) following a standard protocol (17), including a 2.5-mm thickness, 400-ms rotation time, 120-kV tube voltage, 124-mAS (310 mA × 0.4 s) tube current, electrocardiogram-gated dose modulation, and no intravenous contrast medium. Skilled technicians semi-automatically analyzed the CACS using GE Smartscore software (GE Healthcare), which was confirmed by experienced radiologists using a 512 × 512 matrix in the axial plane, identifying CAC areas with a standard calcium threshold of 130

Hounsfield units. The inter- and intra-observer reliabilities of the CACS were excellent, with an intraclass correlation coefficient of 0.99. (17) CACS was computed using Agatston units and was divided into four categories (0, 1–100, and >100), with >100 serving as a significant threshold for statin eligibility (20, 21). We acknowledge the importance of categorizing CAC scores using the Society of Cardiovascular Computed Tomography (SCCT) Coronary Artery Calcium Data and Reporting System (CAC-DRS) scoring system (21), which includes specific ranges such as 100-299 and >300, each with its clinical significance. Unfortunately, our dataset had a limited number of cases with CAC scores above 300, totaling 57 cases (4 in women and 53 in men), restricting our analysis of CT-derived markers in this higher risk category.

Bone mineral density was assessed using dual-energy X-ray absorptiometry (DXA) and osteoporosis was defined as T-scores < -2.5, using the mean BMD values from L1 to L4.

The level of physical activity was evaluated using the validated Korean version of the International Physical Activity Questionnaire Short Form (43, 44). Based on the questionnaire, physical activity is categorized into three levels: inactive, minimally active, and health-enhancing physical activity (43). Health-enhancing physical activity refers to engaging in either: (1) vigorous-intensity activities for at least 3 days per week, totaling 1500 or more metabolic equivalent task (MET) minutes per week, or (2) a combination of walking, moderate-intensity, or vigorous-intensity activities across 7 days, achieving a minimum of 3000 MET minutes per week. Smoking status was categorized as either never/former or current smoker. Average alcohol consumption was stratified into none/≤20 g/day and >20 g/day categories. We also estimated conventional risk factor models including age, family history of diabetes, hypertension, BMI, and waist circumference, such as the ADA (American Diabetes Association) diabetes risk scores and Leicester Diabetes Risk Scores. (45, 46)

Experienced radiologists who were blinded to the study objectives conducted abdominal ultrasound examinations. Fatty liver was diagnosed according to established criteria, which included the presence of diffuse, increased fine echoes within the liver parenchyma compared to the parenchyma of the kidney or spleen, deep beam attenuation, and bright vessel walls (47). The reliability of fatty liver diagnosis with this method is excellent, with an inter-observer kappa statistic of 0.74 and an intra-observer kappa statistic of 0.94 (47).

Bone mineral density was assessed using dual-energy X-ray absorptiometry (DXA) with either the Prodigy system (GE Healthcare, Madison, WI, USA) or HOLOGIC QDR 4500 W (Hologic Inc., Bedford, MA, USA). Osteoporosis was defined as T-scores < -2.5, using the mean BMD values from L1 to L4, following the criteria established by The World Health Organization (WHO) (48).

S3. Statistical analysis

The robust Poisson regression model is a popular approach for estimating risk ratios for binary response variables (22, 23). We conducted a robust Poisson regression model using the glm command with the log link and the Poisson family in STATA and applied the vce (robust) option to obtain robust standard errors for the parameter estimates, thus controlling for mild violation of underlying assumptions.

We used Harrell's C index, which is an estimate of the concordance probability and is suitable for evaluating discrimination in survival time outcomes (24). The concordance probability is the most commonly applied global measure of discrimination when the outcome is survival time (24). Harrell's C index was estimated using the Stata command 'somersd' (49).

S4. Supplemental References

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Supplemental Table S1. Distribution of muscle area index, muscle density and vertebral density at L3-level

Age groups	Number	Mean	SD	Percentile								
				Min	5th	10th	25th	50th	75th	90th	95th	Max
Muscle area index at L3 level*												
Men												
25–39 years	6254	52.7	7	29.5	41.8	44	47.9	52.3	57.2	61.7	64.8	83.4
40–49 years	18366	52.9	7.1	24.6	42	44.1	48	52.5	57.4	62.1	65	87.7
50–59 years	3848	52.9	7	28.6	41.7	44.3	48.2	52.6	57.4	61.9	64.9	85
≥60 years	395	50.2	7	31.5	38.6	41.2	45.1	50.1	55	58.9	61.6	73.3
Overall	28863	52.8	7.1	24.6	41.9	44.1	48	52.5	57.3	62	64.9	87.7
Women												
25–39 years	770	38.5	4.8	25.7	31.2	32.6	35.1	38.3	41.1	44.6	46.7	64.6
40–49 years	1510	39.3	5.2	26.1	31.7	33.3	35.9	38.8	42.3	46.1	48.5	62.8
50–59 years	661	41.4	5.3	26.6	33.7	35.1	37.8	41	44.5	48.3	49.9	65.1
≥60 years	401	41.2	5	27.1	33.5	35	37.9	41.3	44.1	47.4	50	60.2
Overall	3342	39.8	5.3	25.7	31.9	33.5	36.3	39.3	42.8	46.6	48.8	65.1
Muscle density, HU†												
Men												
25–39 years	6256	45.8	4.4	5.1	38.5	40.3	43.1	45.9	48.7	51.3	52.8	61.7
40–49 years	18388	45	4.6	13.6	37.3	39.2	42.1	45.2	48.1	50.7	52.3	69.1
50–59 years	3855	43.5	4.8	11.8	35.7	37.5	40.6	43.6	46.7	49.4	50.9	73.1
≥60 years	398	39.2	5.3	18.8	29.8	32.3	36.2	39.8	43.2	45.2	46.5	51
Overall	28897	44.9	4.7	5.1	37.1	39	42	45.1	48	50.7	52.2	73.1
Women												
25–39 years	771	40.1	4.5	22.1	32	34.2	37.4	40.7	43.2	45.4	46.7	52.5
40–49 years	1511	39.1	4.9	14.5	30.6	32.8	36.1	39.5	42.3	44.8	46.5	69.7
50–59 years	662	34.8	5.6	10.7	25.2	27..6	31.5	35	38.6	41.4	43.2	51.4
≥60 years	402	30.2	6.2	4.6	19.1	21.9	26.5	31	34.7	37	38.5	50.7
Overall	3346	37.4	6.1	4.6	26.3	29.6	33.9	38.1	41.7	44.2	45.8	69.7
Vertebral density†												
Men												
25–39 years	6256	280.7	44.1	159.6	214.2	227.2	250.2	277	307.6	337.6	359.3	488.5
40–49 years	18388	276.2	46.2	116.8	208.1	220.8	244.5	272.9	304	335.5	355.5	994.5
50–59 years	3855	266.3	48.7	116	196.1	208.7	232.8	262.5	295.8	327.4	350.1	865.9
≥60 years	398	238.2	45.9	136.1	169.6	182.2	203.9	233.4	267.8	301.1	327.8	399.4
Overall	28897	275.4	46.5	116	206.2	219.4	243.6	272.2	303.6	334.9	355.2	994.5
Women												
25–39 years	771	320.2	46.3	178.3	248.6	263.7	288.1	317.7	351.5	377.8	400.2	462.7
40–49 years	1511	317.2	49.4	176.8	239.6	255.2	284.4	316.7	348.9	377.8	400.4	859
50–59 years	662	257.9	50.5	111.3	184.7	195.8	222.5	252.7	288.2	322	348.6	443.2
≥60 years	402	229.5	72.7	112.3	154.5	166.4	190.2	221.8	252.3	291.5	320.1	971.8
Overall	3346	295.6	62.4	111.3	192.3	216.3	254.5	297.2	336.9	368	390.9	971.8

*The L3-level sectional areas (cm^2) of skeletal muscle were utilized for the analysis and subsequently normalized to height (m^2), referred to as muscle area index.
†The L3-level muscle attenuation and vertebral attenuation, Hounsfield units

Abbreviations: SD, standard deviation

Supplemental Table S2. Distribution of visceral fat index and visceral fat density at L3, as well as subcutaneous fat index and subcutaneous fat density at the L3 level

Age groups	Number	Mean	SD	Percentile								
				Min	5th	10th	25th	50th	75th	90th	95th	Max
Visceral fat index*												
Men												
25–39 years	6254	39.4	17.2	2	12.6	17.6	27.3	38.4	50.3	61.5	69.2	125.5
40–49 years	18366	43	18.2	0	13.9	19.8	30.5	42.1	54.5	66.3	74.2	155.1
50–59 years	3848	46.6	19.7	1.9	15.3	21.9	33.3	45.5	58.9	71.7	80	141.4
≥60 years	395	47.7	23.4	2	10.6	16.9	31	45.8	62.7	78.5	90.6	121.8
Overall	28863	42.7	18.4	0	13.6	19.4	29.9	41.8	54.3	66.4	74.4	155.1
Women												
25–39 years	770	15	11.8	0.8	3.1	4.1	6.5	11.8	20	30.3	38.9	97.6
40–49 years	1510	19.1	14.8	1.1	3.7	4.8	8.2	15.2	25.9	37.8	48.7	98.6
50–59 years	661	30.3	17.1	0.8	7.3	10.1	17.7	28	40.3	52	63.8	125.1
≥60 years	401	36	17.3	3.1	11.5	15.8	23.5	34.6	45.6	61.8	68.5	98
Overall	3342	22.4	16.7	0.8	3.8	5.3	9.3	18.3	31	45.2	55.1	125.1
Visceral fat density, HU†												
Men												
25–39 years	6256	-91.4	6.2	-112.5	-100.2	-98.6	-95.4	-91.8	-88	-83.8	-80.4	-50
40–49 years	18387	-92.1	6.2	-118.7	-101	-99.2	-96.1	-92.6	-88.7	-84.6	-81.4	-27.5
50–59 years	3855	-91.9	6.3	-112.1	-100.7	-99.2	-96	-92.5	-88.7	-84.4	-80.9	-54.4
≥60 years	398	-89.9	8.3	-107	-99.5	-97.9	-94.6	-91.4	-87.3	-80.5	-73.7	-19.2
Overall	28896	-91.9	6.2	-118.7	-100.8	-99.1	-96	-92.4	-88.5	-84.4	-81	-19.2
Women												
25–39 years	771	-90.2	8	-119.6	-102.6	-99.8	-95.5	-90.6	-85.2	-80.3	-77	-62.3
40–49 years	1511	-91.1	7.8	-114.5	-103.7	-100.4	-95.9	-91.3	-86.4	-81.7	-78	-44.9
50–59 years	662	-94	6.5	-115.8	-104.4	-101.6	-98	-94.3	-90.1	-86.2	-83.6	-67.5
≥60 years	402	-93.8	6.2	-110.2	-102.8	-101.4	-97.9	-94.4	-90.4	-86.1	-83.5	-67.7
Overall	3346	-91.8	7.6	-119.6	-103.4	-100.8	-96.7	-92.2	-87.1	-82.4	-78.8	-44.9
Subcutaneous fat index*												
Men												
25–39 years	6254	46.5	18.2	2.1	20.6	26	34.4	44.3	56.2	69.6	79.8	162.9
40–49 years	18366	45.1	16.8	2.4	21.4	26.3	34	43.1	54.1	66.2	75	161.1
50–59 years	3848	41.7	14.4	4.2	20.2	25.1	32.2	40.2	49.9	59.8	66.9	152.3
≥60 years	395	39.5	15.3	5	16.4	21.7	30	37.8	47.1	58.8	68.5	94.5
Overall	28863	44.9	16.8	2.1	21.1	26	33.7	42.9	53.9	66.1	75.1	162.9
Women												
25–39 years	770	53	22.5	8.1	23.3	28	37.7	50	64.3	82.1	92.6	186.2
40–49 years	1510	56.8	23.6	8.3	25.4	29.9	40.1	53.5	69.2	87	101.5	190.8
50–59 years	661	70	24.2	10.7	36.9	43.1	53.7	66.9	82.2	100.5	114	226.7
≥60 years	401	69.9	21.3	19	39	45.1	54.4	68.4	82.8	96.8	107.5	141.7
Overall	3342	60.1	24.2	8.1	26.5	31.8	43.4	57.3	73.8	91.8	103.4	226.7
Subcutaneous												

fat density, HU†												
Men												
25–39 years	6256	-91	6.8	-108.5	-100.3	-98.5	-95.4	-91.7	-87.5	-83.3	-79.8	-34.7
40–49 years	18388	-90.9	6.7	-110.9	-100.3	-98.4	-95.3	-91.6	-87.6	-83.1	-79.9	-38.4
50–59 years	3855	-89.6	7	-108.4	-99.1	-97.3	-94.1	-90.3	-86.3	-81.5	-77.6	-40.2
≥60 years	398	-87.7	9	-102.7	-97.8	-96.1	-92.8	-89	-84.9	-79	-74.3	-7.5
Overall	28897	-90.7	6.8	-110.9	-100.1	-98.3	-95.2	-91.5	-87.4	-82.9	-79.4	-7.5
Women												
25–39 years	771	-94.2	7.5	-108.5	-103.9	-102.4	-99.3	-95.7	-90.3	-83.9	-79.5	-62.9
40–49 years	1511	-94.7	7.1	-107.5	-103.7	-102.3	-99.5	-95.8	-91.7	-85.5	-80.9	-41.9
50–59 years	662	-96.7	5.1	-107.7	-103.9	-102.7	-100.2	-97.3	-94	-90.3	-87.7	-75.9
≥60 years	402	-96.8	5.3	-117.8	-104.2	-102.9	-99.9	-97.3	-94.1	-90.6	-88	-71.8
Overall	3346	-95.2	6.7	-117.8	-103.9	-102.5	-99.6	-96.3	-92.2	-86.4	-82.4	-41.9

*The L3-level sectional areas (cm^2) of visceral fat and subcutaneous fat were utilized for the analysis and subsequently normalized to height (m^2), referred to as the visceral fat index and subcutaneous fat index, respectively.
†The L3-level visceral fat and subcutaneous fat attenuation, Hounsfield units
Abbreviations: HU = Hounsfield units; SD = standard deviation

Supplemental Table S3. Distribution of liver density and volumetric liver fat fraction

Age groups	Number	Mean	SD	Percentile								
				Min	5th	10th	25th	50th	75th	90th	95th	Max
Liver density, HU												
Men												
25–39 years	6256	53.4	8.4	8.4	36.4	42.2	50.1	55.2	58.9	61.9	63.5	79.1
40–49 years	18388	53.7	8	8.2	37.7	43.1	50.3	55.3	58.9	61.9	63.7	76
50–59 years	3855	53.9	7	15.1	40.2	45	50.6	55	58.4	61.4	63.3	80.8
≥60 years	398	51.8	6.4	17.7	40	44.2	48.9	52.7	56	58.6	60.2	66.9
Overall	28897	53.6	8	8.2	37.8	43.2	50.3	55.2	58.8	61.8	63.6	80.8
Women												
25–39 years	771	56.2	5.4	5.1	48.7	51.4	53.9	56.4	59.5	61.7	62.9	67.4
40–49 years	1511	55.7	5.9	12.5	46.3	49.8	53.5	56.4	59.2	61.7	62.9	67.4
50–59 years	662	53.1	6.8	18.8	39.8	45.3	50.1	54.1	57.5	60.2	61.8	66.7
≥60 years	402	51.9	6.5	12.3	40	44.1	49	52.8	56.3	58.6	60.5	68.1
Overall	3346	54.8	6.3	5.1	44.2	48	52.4	55.7	58.7	61.3	62.5	68.1
Liver PDFF												
Men												
25–39 years	6283	7.9	3.7	1.7	4.1	4.6	5.6	6.9	9	12.6	15.7	31.3
40–49 years	18342	7.8	3.5	1.7	4	4.5	5.5	6.9	8.9	12.2	15	31.8
50–59 years	3815	7.6	3	1.5	4.2	4.7	5.7	7	8.8	11.3	13.7	27.4
≥60 years	393	8.4	2.9	3.1	5.1	5.6	6.5	7.9	9.5	11.8	13.6	26.1
Overall	28833	7.8	3.5	1.5	4.1	4.6	5.6	6.9	8.9	12.2	15	31.8
Women												
25–39 years	773	6.3	2.4	2.5	3.8	4.2	5	6	6.9	8	9.2	33.8
40–49 years	1506	6.5	2.6	2.4	3.9	4.2	5	6	7.3	8.9	10.5	29.1
50–59 years	655	7.6	3.1	2.9	4.3	4.7	5.7	6.9	8.6	11.1	13.9	25.6
≥60 years	399	8	3	3.3	4.6	5.2	6	7.3	8.9	11.5	14	29.5
Overall	3333	6.9	2.8	2.4	3.9	4.4	5.2	6.3	7.6	9.6	11.5	33.8

Abbreviations: HU = Hounsfield units, PDFF = Proton Density Fat Fraction, SD = standard deviation

Supplemental table S4. Baseline characteristics of the participants by development of incident diabetes

Characteristic	Men without Incident Diabetes (*n* = 22448)	Men with Incident Diabetes (*n* = 2372)	Women without Incident Diabetes (*n* = 2394)	Women with Incident Diabetes (*n* = 84)	*P* value for without diabetes *vs* with diabetes	
					Men	Women
Age (years)*	43.7 ± 4.5	43.8 ± 4.3	44.4 ± 7.0	48.0 ± 8.7	.75	<.001
Age range (years)	30–76	38–75	35–83	39–72		
Current smoking (%)	7032 (32.3)	941 (40.6)	50 (2.3)	1 (1.4)	<.001	.60
Alcohol user (%)	6919 (31.6)	896 (38.4)	144 (6.6)	2 (2.7)	<.001	.19
HEPA (%)	3051 (13.8)	336 (14.3)	252 (10.8)	11 (13.4)	.51	.45
Lipid-lowering drugs (%)	811 (3.6)	168 (7.1)	79 (3.3)	10 (12.0)	<.001	<.001
Hypertension (%)	3495 (15.6)	642 (27.1)	174 (7.3)	23 (27.4)	<.001	<.001
Metabolic syndrome (%)	5152 (23.0)	1270 (53.5)	92 (3.8)	32 (38.1)	<.001	<.001
Anthropometry						
BMI (kg/m^2)*	24.3 ± 2.7	25.9 ± 2.9	22.0 ± 2.8	25.4 ± 4.3	<.001	<.001
Waist circumference (cm)*	85.7 ± 7.2	89.7 ± 7.5	75.8 ± 7.6	85.0 ± 10.5	<.001	<.001
Impedance analysis						
Fat percentage*	22.9 ± 4.9	25.2 ± 5.0	29.9 ± 5.8	35.0 ± 5.9	<.001	<.001
Fat mass per height^2†	5.5 (4.5–6.6)	6.4 (5.3–7.8)	6.4 (5.2–7.9)	8.5 (6.9–10.8)	<.001	<.001
Skeletal muscle mass (kg)†	31.2 (29.0–33.5)	32.4 (30.0–34.8)	21.0 (19.4–22.5)	22.1 (20.6–23.9)	<.001	<.001
ASM (kg)†	23.7 (22.0–25.6)	24.5 (22.6–26.4)	15.6 (14.4–17.0)	16.5 (15.1–17.9)	<.001	<.001
SMI (ASM/height^2)†	8.0 (7.6–8.4)	8.2 (7.8–8.6)	6.1 (5.8–6.5)	6.5 (6.1–7.1)	<.001	<.001
CT-derived measures						
Muscle area index at L3†	52.1 (47.7–56.9)	54.9 (50.1–59.9)	38.8 (35.8–42.1)	42.9 (38.3–46.1)	<.001	<.001
Muscle density (HU)†	45.2 (42.2–48.1)	45.1 (42.1–48.1)	39.2 (35.5–42.2)	37.0 (31.0–40.5)	.16	<.001
Visceral fat index at L3†	40.0 (28.5–51.8)	51.4 (39.3–63.3)	15.2 (8.1–26.4)	37.5 (23.6–49.6)	<.001	<.001
Visceral fat density (HU)†	-92.3 (-95.9–-88.4)	-92.9 (-96.2–-89.7)	-91.5 (-96.2–-86.3)	-94.8 (-98.3–-91.2)	.002	<.001
SC fat index at L3†	42.5 (33.4–53.2)	47.5 (37.3–60.0)	54.0 (40.9–69.2)	76.1 (59.8–98.5)	<.001	<.001
SC fat density (HU)†	-91.7 (-95.4–-87.6)	-91.2 (-94.7–-87.4)	-96.0 (-99.5–-91.9)	-97.1 (-99.9–-94.0)	.31	.02
VS ratio	0.9 (0.7–1.2)	1.0 (0.8–1.3)	0.3 (0.2–0.4)	0.5 (0.3–0.6)	<.001	<.001
Vertebral density (HU)†	272.9 (244.7–304.1)	273.7 (244.8–303.8)	308.0 (270.3–342.9)	296.9 (259.1–354.3)	.66	.33
Liver density (HU)†	55.6 (51.2–59.1)	52.1 (45.1–57.1)	56.3 (53.4–59.1)	52.4 (47.4–58.1)	<.001	<.001
Liver PDFF†	6.7 (5.4–8.5)	8.1 (6.2–11.2)	6.1 (5.0–7.2)	7.5 (5.8–10.1)	<.001	<.001
Aortic calcification (Agatston score)†	8.6 (2.9–39.1)	13.4 (3.8–73.4)	4.8 (1.0–13.4)	7.2 (1.9–52.5)	<.001	<.001

Note. –Except where noted, data are numbers of patients, with percentages in parentheses. Alcohol users refers to individuals who consume ≥20 g of ethanol per day. HEPA refers to engaging in either (1) vigorous-intensity activities for at least 3 days per week, totaling 1500 or more metabolic equivalent task (MET) minutes per week, or (2) a combination of walking, moderate-intensity, or vigorous-intensity activities across 7 days, achieving a minimum of 3000 MET minutes per week.
Abbreviations: ASM = appendicular skeletal muscle mass, BMI = body mass index (calculated as weight in kilograms divided by height in meters squared), HEPA = health-enhancing physical activity, HU = Hounsfield units, L3 = third lumbar vertebra, PDFF = proton density fat fraction, SC = subcutaneous, SMI = skeletal muscle index, VS ratio = visceral-to-subcutaneous fat ratio
* Normally distributed continuous variables as expressed as mean (SD).
†Nonnormally distributed continuous variables expressed as median (IQR).

Supplemental table S5. Adjusted prevalence ratio for diabetes according to anthropometry and body composition measures among men and women

Characteristics	Prevalence ratio (95% CI) for diabetes among **men**				
	Per 1 SD increase	Quartile 1	Quartile 2	Quartile 3	Quartile 4
Anthropometry					
Body mass index	1.61 (1.55–1.67)	1.0 (reference)	1.38 (1.18–1.62)	1.71 (1.47–1.99)	3.24 (2.82–3.73)
Waist circumference	1.64 (1.57–1.70)	1.0 (reference)	1.53 (1.29–1.81)	2.20 (1.88–2.58)	3.54 (3.05–4.11)
Impedance analysis					
Body fat percentage	1.52 (1.46–1.59)	1.0 (reference)	1.41 (1.18–1.63)	1.91 (1.62–2.20)	2.98 (2.55–3.40)
Fat mass per height^2	1.54 (1.49–1.60)	1.0 (reference)	1.50 (1.27–1.77)	2.00 (1.71–2.34)	3.36 (2.91–3.89)
SMI (ASM/ height^2)	1.36 (1.29–1.42)	1.0 (reference)	1.14 (0.99–1.32)	1.32 (1.15–1.52)	2.01 (1.77–2.30)
CT measures					
Muscle area index(L3)	1.32 (1.27–1.38)	1.0 (reference)	1.16 (1.01–1.35)	1.44 (1.25–1.65)	1.95 (1.71–2.22)
Visceral fat index (L3)	1.72 (1.65–1.78)	1.0 (reference)	1.55 (1.28–1.89)	2.70 (2.27–3.22)	4.75 (4.02–5.61)
SC fat index (L3)	1.26 (1.21–1.32)	1.0 (reference)	1.12 (0.98–1.28)	1.22 (1.07–1.40)	1.64 (1.44–1.86)
VS fat ratio (L3)	1.34 (1.26–1.43)	1.0 (reference)	1.31 (1.10–1.56)	1.91 (1.62–2.25)	3.34 (2.86–3.89)
Muscle density, HU	0.94 (0.90–0.99)	1.0 (reference)	0.90 (0.80–1.02)	0.91 (0.80–1.04)	0.88 (0.76–1.01)
Visceral fat density, HU	0.91 (0.87–0.95)	1.0 (reference)	1.11 (0.97–1.26)	1.20 (1.05–1.36)	0.85 (0.74–0.98)
SC fat density, HU	1.14 (1.10–1.17)	1.0 (reference)	1.26 (1.08–1.46)	1.60 (1.39–1.85)	1.86 (1.61–2.14)
Vertebral density, HU	1.03 (0.99–1.08)	1.0 (reference)	0.95 (0.84–1.08)	1.03 (0.90–1.17)	1.08 (0.95–1.23)
Liver PDFF	1.54 (1.50–1.58)	1.0 (reference)	1.25 (1.04–1.50)	2.09 (1.77–2.47)	4.13 (3.54–4.81)
Liver density, HU	0.61 (0.60–0.63)	1.0 (reference)	0.50 (0.44–0.55)	0.29 (0.25–0.33)	0.27 (0.23–0.31)
Aortic calcification	1.07 (1.05–1.09)	1.0 (reference)	0.89 (0.75–1.05)	1.32 (1.13–1.54)	2.42 (2.10–2.79)
Characteristics	Prevalence ratio (95% CI) for diabetes among **women**				
	Per 1 SD increase	Quartile 1	Quartile 2	Quartile 3	Quartile 4
Anthropometry					
Body mass index	1.52 (1.31–1.77)	1.0 (reference)	0.70 (0.35–1.39)	1.09 (0.61–1.95)	1.85 (1.04–3.29)
Waist circumference	1.52 (1.27–1.83)	1.0 (reference)	0.74 (0.35–1.61)	1.63 (0.86–3.09)	2.25 (1.17–4.33)
Impedance analysis					
Body fat percentage	1.40 (1.13–1.71)	1.0 (reference)	1.37 (0.51–2.23)	1.38 (0.54–2.22)	2.00 (0.85–3.15)
Fat mass per height^2	1.45 (1.24–1.69)	1.0 (reference)	1.48 (0.75–2.90)	1.52 (0.78–2.94)	2.40 (1.25–4.60)
SMI (ASM/ height^2)	1.44 (1.16–1.79)	1.0 (reference)	0.73 (0.41–1.31)	0.97 (0.56–1.67)	1.49 (0.92–2.43)
CT measures					
Muscle area index(L3)	1.42 (1.19–1.69)	1.0 (reference)	0.66 (0.34–1.26)	1.41 (0.84–2.37)	1.59 (0.95–2.67)
Visceral fat index (L3)	1.84 (1.64–2.05)	1.0 (reference)	4.96 (1.12–22.00)	6.45 (1.53–27.15)	19.89 (4.83–81.79)
SC fat index (L3)	1.35 (1.14–1.58)	1.0 (reference)	1.50 (0.77–2.90)	1.66 (0.87–3.16)	1.94 (1.02–3.68)
VS fat ratio (L3)	1.61 (1.44–1.81)	1.0 (reference)	3.42 (0.97–12.03)	5.27 (1.57–17.64)	12.51 (3.77–41.52)
Muscle density, HU	1.07 (0.90–1.27)	1.0 (reference)	1.43 (0.94–2.17)	1.15 (0.64–2.07)	0.82 (0.39–1.73)
Visceral fat density, HU	0.87 (0.72–1.06)	1.0 (reference)	0.59 (0.38–0.91)	0.71 (0.46–1.09)	0.59 (0.35–0.98)
SC fat density, HU	1.14 (0.96–1.35)	1.0 (reference)	1.50 (0.92–2.44)	1.10 (0.65–1.88)	1.74 (1.06–2.85)
Vertebral density, HU	0.98 (0.83–1.16)	1.0 (reference)	1.05 (0.66–1.68)	0.95 (0.50–1.80)	0.82 (0.41–1.63)
Liver PDFF	1.45 (1.35–1.56)	1.0 (reference)	1.90 (0.88–4.10)	1.86 (0.88–3.95)	3.86 (1.89–7.90)
Liver density, HU	0.66 (0.60–0.72)	1.0 (reference)	0.46 (0.29–0.73)	0.56 (0.35–0.89)	0.33 (0.17–0.63)
Aortic calcification	1.05 (1.00–1.10)	1.0 (reference)	1.07 (0.43–2.67)	1.75 (0.81–3.76)	3.92 (1.87–8.24)

Prevalence ratios (95%CI) were estimated from a robust Poisson regression model using the glm command with the log link and the Poisson family and applied the robust option. The multivariable model was adjusted for age, center, and year of screening.
Abbreviations: ASM = appendicular skeletal muscle mass, CI = confidence interval, HU = Hounsfield units, PDFF = Proton Density Fat Fraction, SC = subcutaneous, SD = standard deviation, SMI = skeletal muscle index, VS ratio = visceral-to-subcutaneous ratio

Quartile distribution for men

Body mass index (kg/m^2): **Q1**, 14.3-22.6; **Q2**, 22.7-24.3; **Q3**, 24.4-26.1; and **Q4,** 26.2-41.7
Waist circumference (cm): **Q1**, 60.0-81.4; **Q2**, 81.5-86.0; **Q3**, 86.1-91.0 ; and Q4, 91.1-139.9
Fat percentage: **Q1**, 2.97-19.8; **Q2**, 19.9-23.0; **Q3**, 23.1-26.3; and **Q4**, 26.4-45.1
Fat mass per height^2: **Q1**, 0.66-4.58; **Q2**, 4.59-5.62; **Q3**, 5.63-6.80; and **Q4**, 6.81-18.54
SMI: **Q1**, 5.06-7.59; **Q2**, 7.60-8.00; **Q3**, 8.01-8.41; and **Q4**, 8.42-10.98
Muscle area index at L3: **Q1**, 24.6-47.9; **Q2**, 48.0-52.4; **Q3**, 52.5-57.2; and **Q4**, 57.3-87.7
Visceral fat index at L3: **Q1**, 0.00-29.8; **Q2**, 29.9-41.7; **Q3**, 41.8-54.2; and **Q4**, 54.3-155.1
SC fat index at L3: **Q1**, 2.07-33.6; **Q2**, 33.7-42.8; **Q3**, 42.9-53.8; and **Q4**, 53.9-162.9
VS fat ratio: **Q1**, 0.00-0.70; **Q2**, 0.71-0.92; **Q3**, 0.93-1.20; and **Q4**, 1.21-9.10
Muscle density: **Q1**, 6.21-41.9; **Q2**, 42.0-45.0; **Q3**, 45.1-47.9; and **Q4**, 48.0-73.1
Visceral fat density: **Q1**, ▼118.7-▼96.0; **Q2**, ▼95.9-▼92.4; **Q3**, ▼92.3-▼88.6; and **Q4**, ▼88.5-▼27.5
SC fat density: **Q1**, ▼111.0-▼95.2; **Q2**, ▼95.1-▼91.5; **Q3**, ▼91.4-▼87.4; and **Q4**, ▼87.3-▼34.7
Vertebral density: **Q1**, 116.0-243.5; **Q2**, 243.6-272.1; **Q3**, 272.2-303.5; and **Q4**, 303.6-994.5
Liver PDFF: **Q1**, 1.49-5.55; **Q2**, 5.56-6.89; **Q3**, 6.90-8.88; and **Q4**, 8.89-31.82
Liver density: **Q1**, 8.2-50.2; **Q2**, 50.3-55.1; **Q3**, 55.2-58.7; and **Q4**, 58.8-80.8
Aortic calcification: **Q1**, 0.0-3.7; **Q2**, 3.8-11.3; **Q3**, 11.4-56.2; and **Q4**, 56.3-16341.2
▼negative

Quartile distribution for Women

Body mass index (kg/m^2): **Q1**, 14.8-20.1; **Q 2**, 20.2-21.9; **Q 3**, 22.0-24.0; and **Q 4,** 24.1-44.5
Waist circumference (cm): **Q1**, 41.7-71.0; **Q2**, 71.1-76.2; **Q3**, 76.3-82.0 ; and **Q** 4, 82.1-132.4
Fat percentage: **Q1**, 13.0-26.3; **Q2**, 26.4-30.5; **Q3**, 30.6-34.6; and **Q4**, 34.7-51.5
Fat mass per height^2: **Q1**, 2.21-5.39; **Q2**, 5.40-6.68; **Q3**, 6.69-8.20; and **Q4**, 8.21-22.90
SMI: **Q1**, 2.20-5.80; **Q2**, 5.81-6.15; **Q3**, 6.16-6.53; and **Q4**, 6.54-9.54
Muscle area index at L3: **Q1**, 25.7-36.2; **Q 2**, 36.3-39.2; **Q3**, 39.3-42.8; and **Q4**, 42.9-65.1
Visceral fat index at L3: **Q1**, 0.8-9.2; **Q2**, 9.3-18.2; **Q3**, 18.3-30.9; and **Q4**, 31.0-125.1
SC fat index at L3: **Q1**, 8.1-43.3; **Q2**, 43.4-57.2; **Q3**, 57.3-73.7; and **Q4**, 73.8-226.7
VS fat ratio: **Q1**, 0.04-0.19; **Q2**, 0.20-0.30; **Q3**, 0.31-0.45; and **Q4**, 0.46-1.72
Muscle density: **Q1**, 4.6-33.8; **Q2**, 33.9-38.0; **Q 3**, 38.1-41.6; and **Q4**, 41.7-69.7
Visceral fat density: **Q1**, ▼119.6-▼96.7; **Q2**, ▼96.6-▼92.3; **Q3**, ▼92.2-▼87.2; and **Q4**, ▼87.1-▼44.9
SC fat density: **Q 1**, ▼117.7-▼99.7; **Q2**, ▼99.6-▼96.3; **Q3**, ▼96.2-▼92.2; and **Q4**, ▼92.1-▼41.9
Vertebral density: **Q1**, 111.3-254.8; **Q2**, 254.9-297.4; **Q3**, 297.5-336.9; and **Q4**, 337.0-971.8
Liver PDFF: **Q1**, 2.35-5.20; **Q2**, 5.21-6.26; **Q3**, 6.27-7.60; and **Q4**, 7.61-33.82
Liver density: **Q1**, 5.1-52.3; **Q2**, 52.4-55.6; **Q3**, 55.7-58.6; and **Q4**, 58.7-68.1
Aortic calcification: **Q1**, 0.0-2.8; **Q2**, 2.9-6.6; **Q3**, 6.7-27.6; and **Q4**, 27.7-14448.2
▼negative

Supplemental Table S6. Discrimination performance of CT-derived parameters in identifying prevalent diabetes

	Men (n=24820)				Women (n=2478)			
	AUROC (95% CI)	*P* value for reference *vs* listed variable			AUROC (95% CI))	*P* value for reference *vs* listed variable		
Impedance analysis								
Body fat percentage	0.63 (0.61–0.64)	reference			0.66 (0.61–0.71)	reference		
Fat mass per height^2	0.64 (0.63–0.65)	<.001*	reference		0.68 (0.63–0.72)	.03	reference	
SMI (ASM/ height^2)	0.57 (0.55–0.58)	<.001*	<.001*	reference	0.57 (0.50–0.63)	.03	<.001*	reference
CT measures								
Muscle area index (L3)	0.58 (0.56–0.59)	<.001*	<.001*	.06	0.65 (0.60–0.70)	.12	.24	<.001*
Visceral fat index (L3)	0.70 (0.68–0.71)	<.001*	<.001*	<.001*	<.001[a]	.001	<.001*	<.001*
Subcutaneous fat index (L3)	0.54 (0.53–0.56)	<.001*	<.001*	.008	0.66 (0.62–0.70)	.73	.19	.004
VS fat ratio (L3)	0.67 (0.66–0.69)	<.001*	<.001*	<.001*	0.80 (0.76–0.84)	.78	<.001*	<.001*
Muscle density, HU	0.56 (0.55–0.57)	<.001*	<.001*	.52	0.68 (0.64–0.73)	.001	.88	.015
Visceral fat density, HU	0.51 (0.50–0.53)	<.001*	<.001*	<.001*	0.58 (0.53–0.63)	.002	<.001*	.78
Subcutaneous fat density, HU	0.58 (0.57–0.60)	<.001*	<.001*	.14	0.51 (0.47–0.56)	<.001*	<.001*	.18
Vertebral density HU	0.52 (0.51–0.54)	<.001*	<.001*	<.001*	0.70 (0.66–0.75)	<.001*	.52	.002
Liver PDFF	0.68 (0.66–0.69)	<.001*	<.001*	<.001*	0.73 (0.68–0.77)	.02	.07	<.001*
Liver density, HU	0.68 (0.66–0.69)	<.001*	<.001*	<.001*	0.72 (0.67–0.77)	.003	.15	<.001*
Aortic calcification	0.67 (0.66–0.69)	<.001*	.002	<.001*	0.78 (0.74–0.82)	.001	.001*	<.001*

Note. –asterisk (*) indicates that the *P* value remained significant after Bonferroni correction. To address the issue of multiple testing, statistical significance was assessed using the Bonferroni adjustment for the 23 separate tests conducted in each sex, with a significance threshold set at α/5 (α divided by 37, 0.001 instead of 0.05).
CT-derived measures, including muscle area, visceral fat area, and subcutaneous fat area at the L3 level, were normalized by dividing each individual area by the square of height.
Abbreviations: ASM = appendicular skeletal muscle mass, AUROC = area under the receiver operating characteristic curve, CI = confidence intervals, HU = Hounsfield units, PDFF = Proton Density Fat Fraction, SMI = skeletal muscle index, VS ratio = visceral-to-subcutaneous ratio

Supplemental Table S7. Predictive abilities of CT-derived parameters for identifying incident diabetes

	Men (n=24820)				Women (n=2478)			
	Harrell's C (95% CI)	*P* value for reference *vs* listed variable			Harrell's C (95% CI)	*P* value for reference *vs* listed variable		
Impedance analysis								
Body fat percentage	0.63 (0.61–0.64)	reference			0.74 (0.68–0.80)	reference		
Fat mass per height^2	0.65 (0.63–0.66)	<.001*	reference		0.76 (0.70–0.82)	.001	reference	
SMI (ASM/ height^2)	0.61 (0.60–0.62)	.007	<.001*	reference	0.69 (0.62–0.75)	.20	.03	reference
CT measures								
Muscle area index (L3)	0.61 (0.60–0.62)	.01	<.001*	.81	0.72 (0.67–0.78)	.54	.12	.21
Visceral fat index (L3)	0.68 (0.67–0.69)	<.001*	<.001*	<.001*	0.82 (0.77–0.86)	<.001*	.001	<.001*
Subcutaneous fat index (L3)	0.59 (0.58–0.60)	<.001*	<.001*	.04	0.76 (0.71–0.81)	.25	.73	.04
VS fat ratio (L3)	0.61 (0.60–0.62)	.06	<.001*	.68	0.75 (0.71–0.80)	.64	.78	.06
Muscle density, HU	0.51 (0.50–0.52)	<.001*	<.001*	<.001*	0.63 (0.57–0.70)	.004	.001	.22
Visceral fat density, HU	0.54 (0.53–0.56)	<.001*	<.001*	<.001*	0.65 (0.59–0.70)	.01	.002	.34
Subcutaneous fat density, HU	0.52 (0.51–0.53)	<.001*	<.001*	<.001*	0.57 (0.51–0.63)	<.001*	<.001*	.02
Vertebral density HU	0.50 (0.49–0.51)	<.001*	<.001*	<.001*	0.55 (0.48–0.62)	<.001*	<.001*	.005
Liver PDFF	0.63 (0.61–0.64)	.85	.002	.03	0.67 (0.60–0.74)	.08	.02	.54
Liver density, HU	0.63 (0.61–0.64)	.92	.003	.03	0.65 (0.58–0.72)	.02	.003	.28
Aortic calcification	0.56 (0.55–0.58)	<.001*	<.001*	<.001*	0.60 (0.53–0.67)	.003	.001	.16

Note. –asterisk (*) indicates that the *P* value remained significant after Bonferroni correction. To address the issue of multiple testing, statistical significance was assessed using the Bonferroni adjustment for the 23 separate tests conducted in each sex, with a significance threshold set at α/5 (α divided by 37, 0.001 instead of 0.05).

Abbreviations: ASM = appendicular skeletal muscle mass, AUROC = area under the receiver operating characteristic curve, CI = confidence intervals, HU = Hounsfield units, PDFF = Proton Density Fat Fraction, SMI = skeletal muscle index, VS ratio = visceral-to-subcutaneous ratio

Supplemental table S8. Adjusted hazard ratios for incident diabetes development according to anthropometric and body composition measurements among men (n=24820)

Characteristics	Hazard ratio (95% CI) for diabetes among men				
	Per 1-SD increase	Quartile 1	Quartile 2	Quartile 3	Quartile 4
Anthropometry					
Body mass index	1.73 (1.66–1.79)	1.0 (reference)	1.62 (1.40–1.88)	2.13 (1.85–2.45)	4.31 (3.70–4.79)
Waist circumference	1.69 (1.63–1.76)	1.0 (reference)	1.72 (1.49–2.00)	2.41 (2.10–2.77)	4.11 (3.60–4.70)
Impedance analysis					
Body fat percentage	1.59 (1.52–1.65)	1.0 (reference)	1.65 (1.43–1.90)	2.28 (1.99–2.60)	3.32 (2.92–3.77)
Fat mass per height^2	1.63 (1.58–1.69)	1.0 (reference)	1.64 (1.42–1.90)	2.38 (2.07–2.73)	3.84 (3.37–4.37)
SMI (ASM/ height^2)	1.49 (1.43–1.56)	1.0 (reference)	1.52 (1.32–1.75)	1.79 (1.56–2.05)	2.85 (2.50–3.23)
CT measures					
Muscle area index(L3)	1.47 (1.41–1.52)	1.0 (reference)	1.51 (1.32–1.72)	1.81 (1.59–2.06)	2.66 (2.35–3.01)
Visceral fat index (L3)	1.82 (1.75–1.89)	1.0 (reference)	1.85 (1.59–2.16)	2.76 (2.39–3.19)	5.19 (4.52–5.96)
SC fat index (L3)	1.37 (1.32–1.42)	1.0 (reference)	1.29 (1.13–1.47)	1.61 (1.42–1.82)	2.33 (2.07–2.62)
VS fat ratio (L3)	1.27 (1.24–1.29)	1.0 (reference)	1.43 (1.25–1.63)	1.78 (1.57–2.02)	2.60 (2.30–2.94)
Muscle density, HU	0.98 (0.94–1.02)	1.0 (reference)	0.98 (0.87–1.10)	0.92 (0.82–1.04)	1.00 (0.89–1.23)
Visceral fat density, HU	0.81 (0.77–0.84)	1.0 (reference)	0.99 (0.89–1.11)	0.95 (0.85–1.07)	0.59 (0.52–0.68)
SC fat density, HU	0.98 (0.94–1.03)	1.0 (reference)	1.14 (1.01–1.28)	1.22 (1.09–1.38)	1.12 (0.99–1.26)
Vertebral density, HU	1.02 (0.98–1.07)	1.0 (reference)	1.00 (0.89–1.12)	1.05 (0.94–1.18)	1.03 (0.91–1.15)
Liver PDFF	1.45 (1.40–1.49)	1.0 (reference)	1.18 (1.03–1.35)	1.49 (1.30–1.70)	2.98 (2.65–3.37)
Liver density, HU	0.67 (0.65–0.69)	1.0 (reference)	0.49 (0.45–0.55)	0.40 (0.35–0.44)	0.33 (0.29–0.37)
Aortic calcification	1.14 (1.09–1.18)	1.0 (reference)	0.91 (0.81–1.02)	1.14 (1.02–1.28)	1.63 (1.45–1.83)

Note. – Adjusted hazard ratios (95%CI) were estimated using the Cox proportional hazards model. The multivariable model was adjusted for age, center, and year of screening.

Abbreviations: ASM = appendicular skeletal muscle mass, CI = confidence interval, HU = Hounsfield units, PDFF = Proton Density Fat Fraction, SC = subcutaneous, SD = standard deviation, SMI = skeletal muscle index, VS ratio = visceral-to-subcutaneous ratio

Quartile distribution for men

Body mass index (kg/m^2) : **Q1**, 14.3-22.6; **Q2**, 22.7-24.3; **Q3**, 24.4-26.1; and **Q4,** 26.2-39.3

Waist circumference (cm) : **Q1**, 60.0-81.4; **Q2**, 81.5-86.0; **Q3**, 86.1-91.0 ; and Q4, 91.1-139.9

Fat percentage : **Q1**, 2.97-19.8; **Q2**, 19.9-23.0; **Q3**, 23.1-26.3; and **Q4**, 26.4-45.1

Fat mass per height^2 : **Q1**, 0.66-4.58; **Q2**, 4.59-5.62; **Q3**, 5.63-6.80; and **Q4**, 6.81-16.97

SMI : **Q1**, 5.06-7.59; **Q2**, 7.60-8.00; **Q3**, 8.01-8.41; and **Q4**, 8.42-10.78

Muscle area index at L3 : **Q1**, 24.6-47.9; **Q2**, 48.0-52.4; **Q3**, 52.5-57.2; and **Q4**, 57.3-87.7

Visceral fat index at L3 : **Q1**, 0.00-29.8; **Q2**, 29.9-41.7; **Q3**, 41.8-54.2; and **Q4**, 54.3-155.1

SC fat index at L3 : **Q1**, 2.07-33.6; **Q2**, 33.7-42.8; **Q3**, 42.9-53.8; and **Q4**, 53.9-160.9

VS fat ratio : **Q1**, 0.00-0.70; **Q2**, 0.71-0.92; **Q3**, 0.93-1.20; and **Q4**, 1.21-9.10

Muscle density : **Q1**, 6.21-41.9; **Q2**, 42.0-45.0; **Q3**, 45.1-47.9; and **Q4**, 48.0-69.1

Visceral fat density : **Q1**, ▼118.7-▼96.0; **Q2**, ▼95.9-▼92.4; **Q3**, ▼92.3-▼88.6; and **Q4**, ▼88.5-▼27.5

SC fat density : **Q1**, ▼111.0-▼95.2; **Q2**, ▼95.1-▼91.5; **Q3**, ▼91.4-▼87.4; and **Q4**, ▼87.3-▼34.7

Vertebral density : **Q1**, 116.0-243.5; **Q2**, 243.6-272.1; **Q3**, 272.2-303.5; and **Q4**, 303.6-994.5

Liver PDFF : **Q1**, 1.49-5.55; **Q2**, 5.56-6.89; **Q3**, 6.90-8.88; and **Q4**, 8.89-31.82

Liver density : **Q1**, 8.2-50.2; **Q2**, 50.3-55.1; **Q3**, 55.2-58.7; and **Q4**, 58.8-80.8

Aortic calcification : **Q1**, 0.0-3.7; **Q2**, 3.8-11.3; **Q3**, 11.4-56.2; and **Q4**, 56.3-15892.0

▼negative

Supplemental table S9. Adjusted hazard ratios for incident diabetes development according to anthropometric and body composition measurements among women (n=2478)

Characteristics	Hazard ratio (95% CI) for diabetes among women				
	Per 1-SD increase	Quartile 1	Quartile 2	Quartile 3	Quartile 4
Anthropometry					
Body mass index	2.18 (1.88–2.53)	1.0 (reference)	3.40 (1.12–10.35)	3.59 (1.83–15.90)	13.54 (4.81–38.11)
Waist circumference	2.37 (1.99–2.82)	1.0 (reference)	3.30 (1.08–10.14)	5.47 (1.86–16.08)	14.83 (5.26–41.80)
Impedance analysis					
Body fat percentage	2.30 (1.85–2.87)	1.0 (reference)	1.88 (0.75–4.71)	3.36 (1.43–7.92)	7.09 (3.14–16.00)
Fat mass per height^2	2.12 (1.82–2.46)	1.0 (reference)	1.44 (0.55–3.79)	2.77 (1.15–6.69)	8.30 (3.70–18.61)
SMI (ASM/ height^2)	1.96 (1.62–2.37)	1.0 (reference)	1.00 (0.43–2.37)	1.69 (0.78–3.63)	3.62 (1.79–7.30)
CT measures					
Muscle area index(L3)	1.77 (1.48–2.10)	1.0 (reference)	2.55 (1.07–6.07)	2.16 (0.89–5.28)	6.55 (2.91–14.73)
Visceral fat index (L3)	2.40 (2.03–2.83)	1.0 (reference)	6.27 (1.40–28.03)	9.38 (2.15–40.96)	44.12 (10.58–184)
SC fat index (L3)	2.07 (1.77–2.42)	1.0 (reference)	2.08 (0.78–5.55)	3.84 (1.54–9.54)	8.80 (3.69–20.98)
VS fat ratio (L3)	1.63 (1.38–1.92)	1.0 (reference)	9.25 (2.14–39.91)	11.96 (2.89–51.19)	27.63 (6.58–116.0)
Muscle density, HU	0.83 (0.65–1.05)	1.0 (reference)	0.69 (0.38–1.26)	0.75 (0.41–1.40)	0.46 (0.22–0.93)
Visceral fat density, HU	0.66 (0.53–0.84)	1.0 (reference)	0.99 (0.59–1.66)	0.50 (0.27–0.93)	0.23 (0.10–0.52)
SC fat density, HU	0.77 (0.59–0.99)	1.0 (reference)	1.01 (0.56–1.82)	0.94 (0.52–1.71)	0.62 (0.31–1.24)
Vertebral density, HU	1.08 (0.88–1.31)	1.0 (reference)	1.75 (0.89–3.43)	1.26 (0.58–2.72)	1.57 (0.75–3.30)
Liver PDFF	1.50 (1.36–1.67)	1.0 (reference)	0.78 (0.37–1.66)	0.93 (0.46–1.91)	3.07 (1.68–5.63)
Liver density, HU	0.63 (0.56–0.72)	1.0 (reference)	0.21 (0.10–0.41)	0.25 (0.13–0.48)	0.34 (0.19–0.60)
Aortic calcification	1.08 (0.83–1.40)	1.0 (reference)	0.70 (0.37–1.35)	0.60 (0.31–1.17)	1.18 (0.60–2.35)

Note. – Adjusted hazard ratios (95%CI) were estimated using the Cox proportional hazards model. The multivariable model was adjusted for age, center, and year of screening.

Abbreviations: ASM = appendicular skeletal muscle mass, CI = confidence interval, HU = Hounsfield units, PDFF = Proton Density Fat Fraction, SC = subcutaneous, SD = standard deviation, SMI = skeletal muscle index, VS ratio = visceral-to-subcutaneous ratio

Quartile distribution for women

Body mass index (kg/m^2) : **Q1**, 14.8-20.1; **Q2**, 20.2-21.9; **Q3**, 22.0-24.0; and **Q4,** 24.1-43.5
Waist circumference (cm) : **Q1**, 53.0-71.0; **Q2**, 71.1-76.2; **Q3**, 76.3-82.0 ; and Q4, 82.1-123.4
Fat percentage : **Q1**, 13.0-26.3; **Q2**, 26.4-30.5; **Q3**, 30.6-34.6; and **Q4**, 34.7-51.5
Fat mass per height^2 : **Q1**, 2.21-5.39; **Q2**, 5.40-6.68; **Q3**, 6.69-8.20; and **Q4**, 8.21-21.85
SMI : **Q1**, 2.20-5.80; **Q2**, 5.81-6.15; **Q3**, 6.16-6.53; and **Q4**, 6.54-9.54
Muscle area index at L3 : **Q1**, 26.1-36.2; **Q2**, 36.3-39.2; **Q3**, 39.3-42.8; and **Q4**, 42.9-65.1
Visceral fat index at L3 : **Q1**, 0.8-9.2; **Q2**, 9.3-18.2; **Q3**, 18.3-30.9; and **Q4**, 31.0-98.5
SC fat index at L3 : **Q1**, 8.1-43.3; **Q2**, 43.4-57.2; **Q3**, 57.3-73.7; and **Q4**, 73.8-190.8
VS fat ratio : **Q1**, 0.04-0.19; **Q2**, 0.20-0.30; **Q3**, 0.31-0.45; and **Q4**, 0.46-1.55
Muscle density : **Q1**, 10.0-33.8; **Q2**, 33.9-38.0; **Q3**, 38.1-41.6; and **Q4**, 41.7-69.7
Visceral fat density : **Q1**, ▼119.6-▼96.7; **Q2**, ▼96.6-▼92.3; **Q3**, ▼92.2-▼87.2; and **Q4**, ▼87.1-▼60.5
SC fat density : **Q1**, ▼109.5-▼99.7; **Q2**, ▼99.6-▼96.3; **Q3**, ▼96.2-▼92.2; and **Q4**, ▼92.1-▼59.9
Vertebral density : **Q1**, 123.1-254.8; **Q2**, 254.9-297.4; **Q3**, 297.5-336.9; and **Q4**, 337.0-859.0
Liver PDFF : **Q1**, 2.35-5.20; **Q2**, 5.21-6.26; **Q3**, 6.27-7.60; and **Q4**, 7.61-33.82
Liver density : **Q1**, 5.1-52.3; **Q2**, 52.4-55.6; **Q3**, 55.7-58.6; and **Q4**, 58.7-68.1
Aortic calcification : **Q1**, 0.0-2.8; **Q2**, 2.9-6.6; **Q3**, 6.7-27.6; and **Q4**, 27.7-10747.0
▼negative

Supplemental Figure S1. Overview of the scheme for comprehensive CT analysis of type 2 diabetes mellitus and cardiometabolic risk assessments

CVD, cardiovascular disease; DXA, dual-energy X-ray absorptiometry.

Supplemental Figure S2. Automated comprehensive CT-based body composition analysis

DeepCatch v1.2.0 conducts automated CT analyses, encompassing automatic volumetric segmentation and L3 localization, and categorizes body components into 128 anatomical classes: skin, subcutaneous fat, muscle, visceral fat, bone, internal organs and vessels, central nervous system, liver, spleen, thoracolumbar vertebrae, and aorta.

AVF, abdominal visceral fat; SF, subcutaneous fat; IO, internal organs; CNS, central nervous system.

Supplemental Figure S3. Multivariable-adjusted hazard ratios (95% confidence intervals) for incident diabetes using the CT-derived image markers as a continuous factor in men. The curves represent adjusted hazard ratios (solid line) and their 95% confidence intervals (dashed lines) for incident diabetes on the basis of restricted cubic splines for the CT-derived image markers with knots at the 5^{th}, 27.5^{th}, 50^{th}, 72.5^{th}, and 95^{th} percentiles of sex-specific sample distribution. The model was adjusted for age, center, and year of screening.

Supplemental Figure S4. Multivariable-adjusted hazard ratios (95% confidence intervals) for incident diabetes using the CT-derived image markers as a continuous factor in women. The curves represent adjusted hazard ratios (solid line) and their 95% confidence intervals (dashed lines) for incident diabetes on the basis of restricted cubic splines for the CT-derived image markers with knots at the 5^{th}, 27.5^{th}, 50^{th}, 72.5^{th}, and 95^{th} percentiles of sex-specific sample distribution. The model was adjusted for age, center, and year of screening.