Appendix E1

Automated Body Composition Analysis from Abdominal CT Examinations

The full image processing system consists of three steps: series selection, slice selection, and segmentation. We give details of each of these steps below.

Series Selection

A study stored in a hospital PACS system typically consists of several series of DICOM images that contain axial, sagittal, and coronal series, as well as localizers and metadata such as dosage reports or transfer records.

We implemented simple criteria that select appropriate series based on the following rules:

• The series must contain at least 20 images. This eliminates localizer images or highly-targeted scans that may not cover the full abdominal region.

• The "Image Type" tag (0008, 0008) was checked to ensure that either the scan has all of the following three characteristics: "Original," "Primary," "Axial," OR the list of "Image Type" characteristics exactly matched a whitelist of other exceptions. Additionally, any series with characteristics related to dual-energy material decomposition images were excluded.

It is common for multiple series to pass this series selection step in a given study. In this case, all series that met the criteria were processed and then the series with the greatest slice thickness, series slice number and visceral fat area were chosen with sequential tie breaking.

Slice Selection

The slice selection model consists of a DenseNet convolutional neural network architecture model (28), adapted to perform regression onto a single continuous-valued variable and trained to predict a saturated offset of the input slice from the L3 slice. The model takes as input the slices downsampled to 256×256 pixels. To train the model, a dataset of slices with known offsets from L3 (according to manual labeling) were used and the model was trained using mean absolute error loss between the output and the known offset passed through a sigmoid function.

The chosen model from our validation experiments consisted of 4 densely-connected blocks with 12 layers in each dense block and with a growth rate of 12 channels per convolutional layer (25). Each convolutional layer in the network was followed by a batch normalization layer and a rectified linear unit (ReLU) activation. Between each layer, the image is average-pooled across both spatial dimensions by a factor of 2 and a channel bottleneck factor of 0.5 is applied.

When new test series are processed by the model, the entire series is fed into the model's input, one slice at a time. The predicted values are assembled into an array based on the slice ordering, which is then smoothed slightly to eliminate small deviations. Next, zero-crossing points (marking points where the predicted offset from L3 is zero) are interpolated from the

array, and the closest slice to the zero-crossing location is selected. Any series with multiple zero-crossing points were passed to a more sophisticated slice selection postprocessing procedure that found peaks in the cross-correlation of the predicted saturated distance signal with the expected saturated distance signal based on the known slice spacing. These cases were also flagged for manual review, along with any cases with no zero-crossings.

Segmentation Model

The segmentation model consists of a U-Net architecture (29) that operates on the image selected by the slice selection process at full image resolution image. The model is trained on manual ground truth masks with labels of the three tissues of interest (muscle, visceral fat, and subcutaneous fat). The mean dice loss across the three classes was applied to train the model (42).

The architecture selected from our validation experiments consists of 5 downsampling and upsampling blocks, with a single convolutional layer per block (25). After every downsampling block the spatial resolution of the image is halved and the number of feature channels (initially 16) is doubled. Conversely, after every upsampling block the spatial resolution of the image is doubled and the number of feature channels is halved. Batch normalization and ReLU activations are applied after each convolutional layer.

After the segmentation process is complete, the number of pixels of each tissue in the segmentation mask is determined, and this is translated into a physical area using the known pixel spacing from the imaging metadata.

Supplementary Statistical Methods

Equivalency Testing

The discrepancy between reported muscle area, subcutaneous fat, visceral fat, and table position between Reader 1+2 and the machine learning algorithm was assessed within images using geometric mean ratio—the ratio of the geometric means (the *nth* root of *n* numbers) of the two measures being compared (31)—and TOST (two one-sided *t* tests) equivalence tests with a type I error of 0.05. The predefined equivalence bounds of interest were 0.95 and 1.05 for the ratio of Reader 1+2 and the machine learning algorithm (ie, the margin of equivalence was ± 5%). As table position has values below zero, the difference between Reader 1+2 and the machine learning algorithm was used instead of the ratio with bounds of -3.7 and 3.7, representing a change in 5% from the mean of all measurements (ie, the margin of equivalence was ± 5%) (32).

The standard deviation across each reader's scores was calculated for all metrics. The variance of muscle area, subcutaneous fat area, visceral fat area, and table position were compared between each reader (1, 2, and 1+2) and the machine learning algorithm using an extension of Levene's test that accounts for clustered data using robust standard errors and nonnormality through a 10% trimmed mean (33). No correction was made for multiple testing.

Reference Curves

Reference curves over age by race and gender were created for the BC areas and indexes (areas divided by height squared), height, weight, and BMI using the LMSP and LMST methods through the *lms* function of the GAMLSS package in R statistical software (33-35). Q-statistics,

worm plots, and visual assessment of the estimated centile curves were used to assess model fit, and smoothness was manually tuned when necessary. Furthermore, centile curves were only created for white non-Hispanic and black individuals as the number of patients self-reporting as other races in the cohort were too small to produce stable curves; additionally, due to a scarcity of data in the tails of age distributions, white non-Hispanic centile curves were truncated to the ages of 18 to 90 years, black female from 18 to 75, and black male from 18 to 70.

Comparison of Sarcopenia Calculation Methods

The percentage of patients in the cross-sectional population cohort with sarcopenia was calculated using a previously published threshold, where skeletal muscle index (SMI) below 55 cm^2/m^2 for males and 39 cm^2/m^2 for females indicates sarcopenia (7). In the 7,229 patients with SMI data, the percentage with sarcopenia was 35%. For normalized SMI data, a z-score cutoff of-0.40 was chosen to classify 35% of the subgroup as having sarcopenia. It was of interest to determine how the percentage of patients classified with sarcopenia defined by the fixed sex-specific thresholds varies by age category and race when compared with the value of 35%. Treating 35% as a parameter, two-sided Pearson's χ^2 goodness-of-fit tests were performed across age categories (18–30, 30–40, 40–50, 50–60, 60–70, 70–80, 80+ years) and across race (white non-Hispanic, black) where the null hypotheses were that the percentage with sarcopenia within each age category is equal to 35% and the percentage within each race is equal to 35%.

Survival Analyses

To evaluate the associations between death within 2 years after the date of the CT examination, hazard ratios with 95% confidence intervals (CI) were calculated using Cox proportional hazards models. Follow-up was measured as time from the time of exposure (abdominal CT examination) until death. Administrative right censoring was applied after two years of follow-up. Reporting of death and date of death were based on data obtained from the electronic medical record and the Social Security Death Index; given the high accuracy of this approach, individuals were assumed to be alive and contributed survival time to the analysis until indication of death.

Predictors of interest were z-scores derived from the BC areas—SMA, VFA, SFA—and the BC indexes. The z-scores were transformed to quartiles and specified as four-level categorical variables. The reference quartile was selected as the quartile with presumed lowest risk (quartile 4 for SMA, quartile 1 for VFA and SFA). Harrell's concordance statistics derived from univariable Cox proportional hazards models were similar for corresponding areas and indexes, thus only areas were considered for multivariable modeling.

Since the derived z-scores are based on patient age, sex, and race, these factors were not adjusted for in multivariable models. As these models required the use of BC z-scores derived from the constructed centile curves, only white non-Hispanic individuals within the age range used for centile curve fitting (18 to 90 years) and black individuals within the age range used for centile curve fitting (females 18 to 75 years; males 18 to 70 years) were included in analysis.

The first multivariable model included all BC areas (SMA, VFA and SFA). The second multivariable model additionally adjusted for a linear trend of weight, specified as a z-score-. An alternate model reported in the supplementary materials linearly adjusted for z-scores derived from BMI (S2 and S3 tables). The third multivariable model included all BC areas, the weight z-score (specified as linear), and a height z-score (specified as linear). The final multivariable

model additionally adjusted for institution (BWH/DFCI or MGH) and cardiovascular risk factors: smoking status, diabetes, and systolic blood pressure (SBP, specified continuously). Kaplan Meier curves were constructed for BC variables up to two years of follow-up.

Martingale residuals were used to assess the proportional hazards assumption and check for curvilinear trends in continuous predictors; likelihood displacement was used to detect any outlying observations that may be overly influential. In models containing weight, height, BMI, smoking or SBP, individuals with missing data were dropped from analysis. Missingness was assumed to be missing completely at random. These values were not multiply imputed as no variables used in the above modeling nor any auxiliary variables were found to be substantially informative for imputation. However, attempts at multiple imputation resulted in models very similar to those presented here. Models were compared using Harrell's concordance statistic. Analyses were performed using R statistical software (version 3.5.1) and SAS 9.4. All testing was two-tailed, the regression coefficients of sets of dummy-coded categorical predictors were tested using joint Wald test, and P values < 0.05 were considered statistically significant.

Reference

42. Milletari F, Navab N, Ahmadi SA. V-Net: Fully Convolutional Neural Networks for Volumetric Medical Image Segmentation. In: 2016 Fourth International Conference on 3D Vision (3DV), Stanford, CA, October 25–28, 2016. Piscataway, NJ: IEEE, 2016.NEW – now 42

Table E1. Equivalence test results for 5% equivalence bounds on skeletal muscle area, subcutaneous fat area, visceral fat area, and table position comparing Reader 1+2 to the fully automated BC pipeline. The geometric mean ratio is the ratio of the geometric means (the *nth* root of *n* numbers) of the two measures being compared.

Measurement (Reader 1+2/Algorithm)	Geometric mean ratio	90% confidence interval	P value	Conclusion
Skeletal muscle area (cm^2)	0.97	0.96 to 0.98	< 0.001	Equivalent
Subcutaneous fat area (cm^2)	1.00	0.99 to 1.02	< 0.001	Equivalent
Visceral fat area (cm^2)	0.99	0.98 to 1.01	< 0.001	Equivalent
Measurement (Reader 1+2-Algorithm)	Mean difference	90% confidence interval	P value	
Table position (mm)	−0.24	−2.02 to 1.54	< 0.01	Equivalent

Table E2. Standard deviation across each reader's scores. Evidence of a difference in variance at the P = .05 level was found only for subcutaneous fat area when comparing Reader 1 to the algorithm (P = .04). There was no significant difference in variance for all other comparisons by reader and BC area or slice selection.

Measurement (SD)	Reader 1	Reader 2	Reader 1+2	Algorithm
Skeletal muscle area (cm^2)	20.8	20.5	20.7	20.6
Subcutaneous fat area (cm^2)	133.7	130.3	133.5	127.5
Visceral fat area (cm^2)	71.7	71.2	71.0	71.4
Table position (mm)	679.5	679.4	679.0	679.8

Table E3. Reference tables for reference curves presented in Figure 1 **grouped by body composition area in cm² ({i} skeletal muscle area, {ii} visceral fat area, {iii} subcutaneous fat area) and indexes in cm²/m² ({iv} skeletal muscle index, {v} visceral fat index, {vi} subcutaneous fat index) for (a) White non-Hispanic female patients [*n* = 4971], (b) White non-Hispanic male patients [*n* = 3963], (c) Black female patients [*n* = 629], and (d) Black male patients [*n* = 319]. Columns represent percentile values. Rows represent age in years.**

{i} a) Skeletal muscle area, white female

	3	5	10	25	50	75	90	95	97
20	88.70	91.98	97.12	106.00	116.44	127.73	138.85	146.06	151.00
25	90.54	93.92	99.22	108.37	119.18	130.96	142.76	150.54	155.94
30	91.67	95.17	100.62	110.00	121.10	133.34	145.81	154.19	160.10
35	91.84	95.44	101.02	110.58	121.88	134.45	147.52	156.49	162.93
40	91.42	95.11	100.80	110.49	121.93	134.75	148.32	157.84	164.79
45	90.59	94.37	100.15	109.93	121.44	134.41	148.34	158.28	165.64
50	88.84	92.65	98.46	108.22	119.67	132.59	146.58	156.67	164.21
55	85.90	89.66	95.38	104.96	116.15	128.77	142.44	152.33	159.72
60	82.70	86.35	91.91	101.21	112.05	124.23	137.36	146.79	153.82
65	79.72	83.24	88.60	97.60	108.09	119.81	132.31	141.18	147.73
70	77.01	80.39	85.55	94.26	104.41	115.67	127.50	135.75	141.76
75	74.22	77.46	82.44	90.86	100.66	111.43	122.53	130.12	135.56
80	71.21	74.32	79.11	87.24	96.68	106.94	117.29	124.22	129.10
85	68.26	71.26	75.90	83.76	92.86	102.62	112.29	118.63	123.03
90	65.46	68.37	72.87	80.50	89.27	98.58	107.63	113.47	117.47

{i} b) Skeletal muscle area, white male

	3	5	10	25	50	75	90	95	97
20	124.49	131.55	141.70	157.37	174.00	191.20	208.49	220.33	228.87
25	127.81	134.80	144.93	160.69	177.56	195.08	212.72	224.78	233.47
30	130.25	137.12	147.15	162.92	179.97	197.81	215.82	228.15	237.03
35	132.36	139.18	149.18	165.04	182.31	200.46	218.81	231.35	240.38
40	134.19	141.10	151.26	167.37	184.94	203.35	221.86	234.43	243.44
45	133.95	141.08	151.53	168.02	185.86	204.34	222.67	234.97	243.70
50	131.01	138.40	149.19	166.11	184.24	202.81	220.97	233.00	241.45
55	124.98	132.40	143.25	160.30	178.58	197.24	215.40	227.35	235.72
60	118.43	125.63	136.23	153.05	171.25	189.96	208.22	220.25	228.67
65	114.58	121.32	131.35	147.47	165.19	183.63	201.77	213.78	222.21
70	111.36	117.57	126.85	141.92	158.62	176.12	193.40	204.86	212.90
75	106.41	112.18	120.80	134.75	150.12	166.09	181.72	191.98	199.13
80	100.49	106.02	114.21	127.24	141.34	155.68	169.40	178.24	184.33
85	94.94	100.32	108.18	120.43	133.35	146.16	158.10	165.64	170.77
90	90.25	95.47	102.97	114.42	126.21	137.61	148.01	154.46	158.79

{i} c) Skeletal muscle area, black female

	5	10	25	50	75	90	95
20	93.19	100.77	113.00	126.51	140.70	154.88	164.40
25	94.61	102.25	114.60	128.28	142.67	157.02	166.64

30	96.19	103.90	116.39	130.26	144.88	159.44	169.18
35	97.62	105.37	117.99	132.04	146.85	161.59	171.44
40	98.58	106.34	119.02	133.17	148.11	162.96	172.87
45	98.61	106.32	118.94	133.07	147.99	162.82	172.69
50	97.42	104.98	117.40	131.33	146.05	160.68	170.39
55	95.11	102.44	114.50	128.07	142.43	156.68	166.14
60	92.15	99.20	110.84	123.96	137.85	151.64	160.77
65	89.24	96.02	107.24	119.92	133.37	146.70	155.51
70	86.33	92.84	103.65	115.90	128.89	141.77	150.28
75	83.37	89.62	100.02	111.82	124.36	136.77	144.97

{i} d) Skeletal muscle area, black male

	5	10	25	50	75	90	95
20	128.33	139.16	157.62	179.55	204.54	231.71	251.31
25	130.73	141.97	160.87	182.89	207.38	233.25	251.44
30	133.00	144.61	163.89	185.94	209.91	234.62	251.60
35	134.91	146.77	166.23	188.16	211.58	235.22	251.19
40	136.23	148.13	167.51	189.10	211.86	234.48	249.57
45	136.78	148.53	167.56	188.60	210.56	232.17	246.45
50	136.52	147.91	166.33	186.62	207.68	228.26	241.76
55	135.23	146.12	163.72	183.07	203.11	222.60	235.33
60	132.98	143.27	159.93	178.25	197.18	215.53	227.47
65	130.27	139.97	155.67	172.94	190.76	207.97	219.13
70	127.52	136.65	151.45	167.73	184.49	200.63	211.06

{ii} a) Visceral fat area, white female

	3	5	10	25	50	75	90	95	97
20	3.24	4.03	5.65	9.93	18.57	34.67	60.77	85.00	105.68
25	3.57	4.60	6.77	12.71	25.03	48.28	85.74	120.02	148.89
30	3.85	5.18	8.04	16.16	33.38	65.87	117.29	163.32	201.41
35	4.06	5.73	9.42	20.15	42.98	85.13	149.44	205.02	249.91
40	4.26	6.33	11.02	24.74	53.32	103.77	176.64	236.84	284.03
45	4.73	7.37	13.40	30.72	65.11	122.06	199.12	259.72	305.76
50	5.79	9.27	17.08	38.62	78.73	140.70	219.40	278.55	322.28
55	7.56	12.06	21.90	47.65	92.61	157.91	236.60	293.63	334.92
60	9.91	15.51	27.34	56.83	105.57	173.01	251.16	306.34	345.68
65	12.52	19.11	32.61	64.92	116.17	184.72	262.02	315.65	353.51
70	14.61	21.85	36.37	70.19	122.44	190.86	266.78	318.89	355.46
75	15.04	22.35	36.91	70.43	121.67	188.12	261.32	311.32	346.31
80	13.72	20.58	34.32	66.08	114.66	177.66	246.98	294.28	327.36
85	11.82	18.02	30.57	59.87	105.03	163.81	228.62	272.90	303.88
90	10.02	15.51	26.75	53.30	94.53	148.44	208.05	248.83	277.40

{ii} b) Visceral fat area, white male

	3	5	10	25	50	75	90	95	97
20	5.33	6.81	9.90	18.39	36.27	70.94	128.79	183.45	230.53
25	7.18	9.91	15.65	30.73	58.89	104.16	164.92	212.76	249.24
30	8.68	13.52	23.73	49.09	91.01	149.05	216.34	263.89	297.80
35	11.42	18.90	34.77	72.17	127.87	196.87	269.42	317.34	350.19

40	16.32	26.49	47.65	95.10	160.54	235.67	309.88	356.88	388.35
45	21.89	34.40	59.73	114.20	185.57	263.78	338.20	384.20	414.59
50	26.93	41.41	70.13	130.22	206.72	288.52	364.94	411.61	442.24
55	30.38	46.23	77.27	141.28	221.75	307.07	386.30	434.51	466.09
60	32.45	49.15	81.61	148.02	231.22	319.42	401.38	451.28	483.99
65	33.80	51.04	84.28	151.91	236.60	326.61	410.51	461.72	495.32
70	34.83	52.37	85.89	153.68	238.66	329.41	414.42	466.49	500.72
75	35.52	53.03	86.10	152.55	236.18	326.23	411.28	463.66	498.22
80	36.02	53.11	84.88	148.35	228.88	316.73	400.73	452.93	487.53
85	36.80	53.13	82.98	142.37	218.59	303.14	385.24	436.82	471.24
90	38.26	53.72	81.56	136.90	208.89	290.23	370.64	421.84	456.29

{ii} c) Visceral fat area, black female

	5	10	25	50	75	90	95
20	2.93	5.13	11.40	23.87	44.78	73.52	96.41
25	3.98	7.13	15.80	32.13	57.76	90.90	116.13
30	5.40	9.85	21.68	42.76	73.96	112.18	140.19
35	7.26	13.36	28.99	55.41	92.49	135.82	166.57
40	9.59	17.61	37.45	69.34	111.98	159.80	192.79
45	12.35	22.42	46.47	83.37	130.59	181.67	216.06
50	15.39	27.47	55.29	96.16	146.42	199.09	233.82
55	18.61	32.51	63.43	107.04	158.81	211.56	245.70
60	21.69	37.01	69.95	114.67	166.10	217.24	249.82
65	24.67	41.10	75.28	120.07	170.13	218.88	249.57
70	27.44	44.68	79.41	123.44	171.40	217.39	246.11
75	29.61	47.25	81.69	123.95	169.01	211.86	238.67

{ii} d) Visceral fat area, black male

	5	10	25	50	75	90	95
20	0.84	2.63	10.64	30.08	61.87	100.95	128.97
25	1.90	5.35	19.15	49.46	95.49	149.12	186.28
30	3.80	9.78	31.48	75.23	137.58	207.01	253.82
35	6.38	15.22	44.72	99.88	174.28	253.97	306.43
40	8.86	19.80	53.71	113.06	189.34	268.32	319.26
45	11.08	23.39	59.14	118.15	190.81	263.85	310.10
50	13.97	28.05	66.64	127.06	198.69	268.81	312.54
55	18.41	35.36	79.44	145.26	220.67	292.80	337.15
60	23.86	44.04	94.10	165.69	245.21	319.71	364.94
65	29.48	52.50	107.18	182.34	263.55	338.20	383.02
70	34.87	60.10	117.71	194.05	274.46	347.13	390.34

{iii} a) Subcutaneous fat area, white female

	3	5	10	25	50	75	90	95	97
20	37.32	44.82	59.22	93.49	153.34	248.39	379.54	486.99	571.58
25	40.28	48.97	65.58	104.56	170.60	270.94	402.40	505.50	584.31
30	43.51	53.52	72.55	116.51	188.78	294.25	426.46	526.49	601.18
35	46.08	57.54	79.19	128.26	206.23	315.16	445.63	540.90	610.43
40	47.13	60.22	84.73	138.97	221.65	331.59	456.96	545.15	608.04
45	48.04	62.79	90.08	148.83	234.80	344.06	463.53	545.03	602.08

	3	5	10	25	50	75	90	95	97
50	51.66	67.62	96.75	158.03	245.13	352.84	467.84	545.02	598.54
55	58.22	74.67	104.29	165.62	251.56	356.76	468.36	542.97	594.62
60	64.93	81.33	110.53	170.28	253.34	354.67	462.17	534.15	584.06
65	69.32	85.41	113.77	171.09	249.97	345.73	447.24	515.35	562.66
70	70.07	85.85	113.30	167.86	241.67	330.26	423.78	486.58	530.30
75	67.10	82.73	109.48	161.33	229.67	310.39	395.31	452.64	492.85
80	60.67	76.60	103.28	153.11	216.34	289.77	367.72	421.60	460.24
85	50.18	67.17	95.05	144.36	203.46	271.21	346.32	401.92	444.23
90	36.44	54.44	84.88	135.95	192.18	256.97	338.86	411.25	474.91

{iii} b) Subcutaneous fat area, white male

	3	5	10	25	50	75	90	95	97
20	13.49	18.41	28.52	54.32	101.48	177.59	283.05	369.74	438.28
25	20.83	27.58	40.90	73.04	128.25	212.68	324.83	414.62	484.59
30	30.37	39.13	55.84	94.20	156.55	247.49	363.99	455.21	525.46
35	40.38	50.86	70.24	112.82	178.78	271.14	385.93	474.22	541.60
40	49.26	60.94	81.99	126.55	192.80	282.50	391.34	473.95	536.62
45	56.56	69.08	91.19	136.55	201.78	287.74	390.22	467.36	525.70
50	61.66	74.72	97.38	142.68	206.03	287.78	384.09	456.30	510.91
55	64.40	77.65	100.27	144.45	204.71	281.14	370.45	437.38	488.10
60	66.72	80.14	102.68	145.69	202.95	274.42	357.45	419.81	467.27
65	68.49	81.93	104.13	145.44	199.06	264.93	341.16	398.64	442.63
70	69.30	82.56	104.03	142.92	192.06	251.48	320.08	372.13	412.27
75	70.81	84.00	104.93	141.75	186.97	240.81	302.96	350.54	387.58
80	72.88	86.16	106.77	141.92	183.84	233.02	289.95	334.06	368.82
85	72.62	85.66	105.43	138.06	175.78	219.45	270.29	310.33	342.37
90	70.41	82.99	101.62	131.29	164.50	202.46	247.12	283.01	312.28

{iii} c) Subcutaneous fat area, black female

	5	10	25	50	75	90	95
20	32.91	57.62	119.01	220.37	360.68	523.37	638.31
25	47.02	74.96	140.10	242.54	379.98	536.19	645.33
30	63.84	94.50	162.61	265.48	399.73	549.57	653.15
35	81.46	114.24	184.54	287.43	418.73	563.03	661.90
40	97.15	131.57	203.68	307.00	436.80	577.91	673.95
45	108.65	144.14	217.51	321.31	450.48	589.97	684.54
50	114.68	150.52	224.12	327.61	455.80	593.79	687.16
55	116.43	151.96	224.69	326.65	452.70	588.21	679.85
60	116.99	151.55	221.98	320.30	441.46	571.44	659.23
65	120.23	153.12	219.40	310.86	422.59	541.67	621.78
70	125.53	156.27	217.20	299.93	399.66	504.93	575.31
75	130.95	159.32	214.66	288.53	376.32	468.00	528.88

{iii} d) Subcutaneous fat area, black male

	5	10	25	50	75	90	95
20	5.45	14.79	47.00	110.45	206.69	328.31	421.79
25	8.21	20.92	61.48	137.09	248.50	387.49	493.91
30	11.95	28.47	77.37	163.78	287.64	440.29	556.76
35	16.21	36.09	90.74	182.56	310.78	467.00	585.84

40	20.18	41.95	97.87	187.49	309.61	456.83	568.52
45	23.68	46.09	100.13	183.06	293.50	425.36	525.20
50	27.58	50.44	102.53	179.36	279.52	398.06	487.68
55	32.89	56.81	108.61	182.28	276.48	387.08	470.63
60	38.98	63.92	115.53	186.55	275.75	379.74	458.27
65	45.56	71.30	122.49	190.83	275.26	373.10	447.01
70	52.66	79.06	129.72	195.52	275.56	367.85	437.64

{iv} a) Skeletal muscle index, white female

	3	5	10	25	50	75	90	95	97
20	33.78	34.96	36.80	40.00	43.87	48.34	53.19	56.67	59.25
25	34.07	35.29	37.20	40.50	44.49	49.07	54.03	57.58	60.21
30	34.30	35.57	37.54	40.95	45.05	49.74	54.80	58.42	61.08
35	34.40	35.71	37.75	41.25	45.44	50.23	55.37	59.04	61.74
40	34.33	35.68	37.76	41.34	45.61	50.46	55.67	59.36	62.08
45	34.02	35.39	37.51	41.14	45.46	50.35	55.57	59.27	61.98
50	33.38	34.76	36.90	40.55	44.87	49.74	54.92	58.57	61.25
55	32.46	33.85	35.99	39.62	43.91	48.71	53.80	57.38	60.00
60	31.49	32.88	35.01	38.61	42.85	47.57	52.56	56.06	58.61
65	30.57	31.96	34.08	37.66	41.84	46.49	51.38	54.79	57.27
70	29.68	31.06	33.18	36.73	40.87	45.44	50.22	53.55	55.96
75	28.81	30.19	32.30	35.83	39.91	44.40	49.07	52.32	54.67
80	27.99	29.37	31.47	34.98	39.01	43.42	48.00	51.16	53.45
85	27.22	28.60	30.71	34.19	38.18	42.52	47.00	50.09	52.32
90	26.47	27.86	29.97	33.43	37.38	41.65	46.04	49.05	51.23

{iv} b) Skeletal muscle index, white male

	3	5	10	25	50	75	90	95	97
20	40.75	42.73	45.64	50.27	55.34	60.66	66.03	69.68	72.31
25	41.17	43.20	46.17	50.90	56.08	61.51	66.99	70.72	73.40
30	41.62	43.69	46.73	51.58	56.87	62.42	68.03	71.84	74.58
35	42.17	44.31	47.45	52.44	57.89	63.61	69.39	73.32	76.14
40	42.56	44.77	48.02	53.18	58.82	64.74	70.72	74.79	77.71
45	42.43	44.70	48.04	53.36	59.16	65.27	71.43	75.63	78.65
50	41.64	43.95	47.36	52.78	58.70	64.94	71.23	75.53	78.62
55	40.12	42.44	45.84	51.27	57.20	63.45	69.76	74.07	77.16
60	38.49	40.78	44.14	49.49	55.34	61.51	67.74	72.00	75.06
65	37.29	39.52	42.81	48.04	53.76	59.78	65.87	70.03	73.02
70	36.24	38.39	41.54	46.55	52.02	57.77	63.58	67.54	70.39
75	35.07	37.09	40.04	44.73	49.84	55.19	60.59	64.27	66.91
80	33.93	35.80	38.55	42.88	47.59	52.52	57.48	60.86	63.28
85	32.95	34.68	37.22	41.22	45.56	50.09	54.63	57.72	59.93
90	32.11	33.71	36.06	39.76	43.75	47.91	52.07	54.90	56.92

{iv} c) Skeletal muscle index, black female

	5	10	25	50	75	90	95
20	33.33	36.46	41.48	46.88	52.28	57.29	60.42
25	34.62	37.58	42.43	47.80	53.31	58.56	61.89
30	35.80	38.62	43.32	48.65	54.27	59.73	63.28

35	36.73	39.45	44.03	49.32	55.00	60.64	64.36
40	37.35	39.99	44.48	49.72	55.41	61.14	64.96
45	37.56	40.16	44.58	49.75	55.38	61.09	64.90
50	37.29	39.89	44.28	49.37	54.87	60.40	64.08
55	36.57	39.21	43.61	48.60	53.90	59.13	62.56
60	35.47	38.20	42.64	47.54	52.58	57.44	60.56
65	34.18	37.03	41.54	46.34	51.12	55.59	58.41
70	32.73	35.77	40.38	45.08	49.60	53.70	56.23
75	31.24	34.49	39.21	43.81	48.07	51.82	54.10

{iv} d) Skeletal muscle index, black male

	5	10	25	50	75	90	95
20	40.24	45.76	54.99	65.24	75.48	84.71	90.23
25	40.96	46.15	54.83	64.47	74.11	82.78	87.97
30	41.59	46.48	54.63	63.70	72.76	80.92	85.81
35	42.14	46.73	54.41	62.93	71.46	79.13	83.72
40	42.61	46.93	54.14	62.16	70.18	77.40	81.71
45	43.01	47.07	53.85	61.39	68.93	75.72	79.78
50	43.33	47.15	53.53	60.62	67.72	74.10	77.92
55	43.59	47.19	53.19	59.86	66.53	72.53	76.12
60	43.79	47.17	52.82	59.09	65.36	71.00	74.38
65	43.94	47.11	52.42	58.32	64.22	69.53	72.70
70	44.03	47.01	52.00	57.55	63.10	68.09	71.08

{v} a) Visceral fat index, white female

	3	5	10	25	50	75	90	95	97
20	1.38	1.68	2.30	3.94	7.33	14.01	25.75	37.50	48.13
25	1.48	1.87	2.69	4.93	9.68	19.06	35.14	50.73	64.40
30	1.56	2.05	3.11	6.11	12.60	25.29	46.37	66.06	82.84
35	1.61	2.21	3.54	7.39	15.72	31.58	56.74	79.21	97.75
40	1.61	2.33	3.97	8.76	18.92	37.39	64.93	88.27	106.87
45	1.68	2.60	4.69	10.75	23.01	43.77	72.46	95.38	112.96
50	1.96	3.18	5.97	13.78	28.54	51.58	81.06	103.32	119.82
55	2.53	4.18	7.85	17.57	34.63	59.34	88.97	110.36	125.80
60	3.45	5.58	10.14	21.58	40.35	65.99	95.32	115.82	130.35
65	4.55	7.14	12.50	25.30	45.35	71.72	100.99	121.06	135.13
70	5.41	8.30	14.13	27.70	48.42	75.13	104.34	124.18	138.01
75	5.60	8.52	14.40	27.96	48.53	74.94	103.72	123.23	136.81
80	5.19	7.96	13.58	26.69	46.80	72.84	101.41	120.85	134.43
85	4.63	7.18	12.42	24.90	44.45	70.19	98.82	118.49	132.29
90	4.10	6.39	11.18	22.80	41.43	66.46	94.77	114.43	128.32

{v} b) Visceral fat index, white male

	3	5	10	25	50	75	90	95	97
20	1.62	2.16	3.28	6.25	12.02	21.87	35.98	47.70	56.95
25	1.94	2.88	4.88	10.02	19.08	32.54	49.20	61.53	70.57
30	2.29	3.85	7.25	15.74	29.35	47.38	67.41	81.13	90.75
35	3.28	5.61	10.75	23.13	41.46	63.73	86.69	101.63	111.79
40	4.81	7.95	14.71	30.32	52.07	76.96	101.39	116.78	127.06

45	6.42	10.27	18.31	36.13	59.90	86.08	111.03	126.44	136.62
50	7.97	12.45	21.56	41.16	66.56	93.96	119.67	135.41	145.74
55	9.27	14.29	24.27	45.24	72.00	100.65	127.42	143.78	154.52
60	10.32	15.74	26.30	48.07	75.65	105.19	132.89	149.85	161.00
65	11.17	16.82	27.65	49.60	77.32	107.13	135.23	152.50	163.89
70	12.11	17.99	29.01	51.08	78.97	109.18	137.86	155.59	167.32
75	13.18	19.18	30.20	52.07	79.86	110.34	139.61	157.86	169.98
80	14.23	20.08	30.63	51.47	78.26	108.16	137.33	155.73	168.02
85	15.15	20.61	30.29	49.44	74.46	102.91	131.19	149.24	161.39
90	15.91	20.83	29.50	46.74	69.66	96.25	123.18	140.59	152.40

{v} c) Visceral fat index, black female

	5	10	25	50	75	90	95
20	0.89	1.76	4.21	8.81	15.89	24.78	31.40
25	1.36	2.63	6.11	12.32	21.45	32.50	40.51
30	2.02	3.84	8.61	16.76	28.24	41.67	51.19
35	2.87	5.33	11.54	21.70	35.48	51.11	61.97
40	3.90	7.07	14.77	26.87	42.70	60.18	72.11
45	5.07	8.97	18.09	31.87	49.35	68.18	80.85
50	6.26	10.85	21.18	36.23	54.77	74.39	87.48
55	7.35	12.56	23.92	39.81	58.93	79.02	92.49
60	8.26	13.98	25.99	42.19	61.26	81.32	94.94
65	9.46	15.50	27.83	43.98	62.55	81.67	94.46
70	10.84	17.08	29.46	45.34	63.17	80.99	92.57
75	12.10	18.42	30.66	46.02	62.92	79.41	89.88

{v} d) Visceral fat index, black male

	5	10	25	50	75	90	95
20	0.68	1.81	6.07	14.97	27.97	42.68	52.69
25	1.19	2.95	9.25	21.84	39.58	59.07	72.07
30	2.02	4.69	13.62	30.52	53.37	77.66	93.52
35	3.15	6.83	18.22	38.36	64.24	90.78	107.74
40	4.06	8.35	20.78	41.43	66.79	92.05	107.90
45	4.71	9.34	22.09	42.18	66.00	89.21	103.62
50	5.74	11.00	24.75	45.44	69.19	91.88	105.81
55	7.35	13.60	29.31	52.06	77.49	101.34	115.83
60	9.63	17.10	35.01	59.87	86.81	111.54	126.35
65	12.42	21.09	40.93	67.27	94.89	119.65	134.27
70	15.12	24.61	45.28	71.48	98.04	121.33	134.91

{vi} a) Subcutaneous fat index, white female

	3	5	10	25	50	75	90	95	97
20	14.42	17.22	22.62	35.60	58.75	96.63	150.79	196.57	233.38
25	15.37	18.66	24.99	39.92	65.52	104.97	157.47	199.15	231.27
30	16.24	20.08	27.41	44.40	72.39	113.26	164.46	203.14	232.00
35	16.82	21.20	29.50	48.32	78.17	119.65	169.02	204.86	230.92
40	17.09	21.98	31.16	51.51	82.55	123.79	170.74	203.72	227.22
45	17.61	23.01	33.02	54.69	86.62	127.47	172.41	203.19	224.79
50	18.98	24.82	35.52	58.21	90.76	131.39	175.12	204.63	225.16

55	21.10	27.25	38.38	61.59	94.31	134.57	177.42	206.14	226.05
60	23.42	29.75	41.07	64.33	96.72	136.19	177.97	205.88	225.20
65	25.29	31.68	42.99	65.91	97.40	135.44	175.49	202.20	220.68
70	26.08	32.43	43.53	65.66	95.56	131.26	168.63	193.51	210.73
75	25.73	31.97	42.72	63.71	91.51	124.25	158.40	181.19	197.03
80	24.57	30.76	41.24	61.16	86.86	116.79	148.14	169.38	184.34
85	22.36	28.71	39.23	58.46	82.37	109.95	139.57	160.46	175.71
90	18.41	25.21	36.31	55.51	78.01	103.88	133.62	156.73	175.02

{vi} b) Subcutaneous fat index, white male

	3	5	10	25	50	75	90	95	97
20	6.58	8.07	10.92	17.70	29.80	50.21	81.64	110.77	136.09
25	8.24	10.30	14.19	23.19	38.33	61.86	94.79	122.82	145.77
30	10.18	12.94	18.11	29.67	48.07	74.78	109.52	137.38	159.29
35	12.23	15.69	22.06	35.85	56.78	85.66	121.35	148.90	170.04
40	14.23	18.20	25.35	40.40	62.41	91.71	126.83	153.33	173.40
45	16.17	20.40	27.91	43.28	65.15	93.58	127.03	151.97	170.74
50	18.18	22.52	30.10	45.29	66.46	93.53	125.05	148.44	165.99
55	20.11	24.41	31.79	46.34	66.30	91.61	120.98	142.78	159.17
60	22.10	26.28	33.38	47.17	65.89	89.51	116.96	137.41	152.85
65	23.73	27.77	34.56	47.56	65.00	86.87	112.23	131.18	145.52
70	24.48	28.38	34.85	47.03	63.08	82.89	105.63	122.52	135.27
75	25.10	28.98	35.34	47.05	62.08	80.21	100.60	115.52	126.69
80	25.82	29.81	36.23	47.76	62.11	78.92	97.35	110.61	120.41
85	25.64	29.65	35.99	47.07	60.41	75.55	91.73	103.14	111.48
90	24.87	28.82	34.93	45.32	57.43	70.78	84.70	94.36	101.35

{vi} c) Subcutaneous fat index, black female

	5	10	25	50	75	90	95
20	12.40	21.74	43.88	78.15	122.68	171.60	204.91
25	17.02	27.60	51.67	88.09	135.03	186.52	221.61
30	22.61	34.28	60.00	98.20	147.05	200.53	236.97
35	28.74	41.22	68.07	107.29	157.07	211.43	248.47
40	35.08	48.10	75.55	115.06	164.84	219.05	255.98
45	41.08	54.33	81.77	120.72	169.44	222.37	258.44
50	45.80	58.98	85.75	123.16	169.62	220.19	254.88
55	48.08	61.35	87.42	122.85	166.64	215.35	249.92
60	47.20	61.12	86.94	120.34	161.56	210.01	247.25
65	47.34	61.15	85.79	116.61	154.49	200.37	237.27
70	49.36	62.04	84.43	112.23	146.12	186.76	219.13
75	83.37	89.62	100.02	111.82	124.36	136.77	144.97

{vi} d) Subcutaneous fat index, black male

	5	10	25	50	75	90	95
20	5.58	12.04	30.42	60.27	99.11	144.55	179.09
25	5.33	11.81	30.27	60.19	99.73	147.43	184.87
30	5.29	11.93	30.50	60.29	100.10	149.52	189.47
35	5.56	12.48	31.14	60.45	99.78	149.32	189.97
40	6.38	13.69	32.24	60.59	98.41	145.63	183.88

45	8.04	15.75	33.94	60.97	96.56	139.87	173.83
50	10.67	18.63	36.24	61.81	94.99	134.22	163.87
55	14.01	22.00	38.93	63.11	94.05	129.67	155.77
60	17.66	25.53	41.80	64.73	93.66	126.22	149.47
65	21.41	29.14	44.81	66.61	93.73	123.68	144.65
70	25.16	32.72	47.83	68.57	94.04	121.73	140.83

Table E4. Reference tables for reference curves presented in Figure 1 **grouped by {i} weight (kg), {ii} BMI (kg/m^2) for (a) White non-Hispanic female patients, (b) White non-Hispanic male patients, (c) Black female patients, and (d) Black male patients. Columns represent percentile values. Rows represent age in years. Sample sizes are provided below.**

{i} a) weight, white female [*n* = 4036]

	3	5	10	25	50	75	90	95	97
20	42.94	45.02	48.24	53.85	61.06	70.7	84.32	97.53	110.17
25	45.97	47.81	50.83	56.56	64.42	74.92	88.51	100.02	109.72
30	47.5	49.4	52.57	58.75	67.42	79.04	93.73	105.68	115.35
35	47.91	49.91	53.27	59.88	69.24	81.81	97.56	110.15	120.19
40	47.58	49.66	53.18	60.13	69.99	83.19	99.58	112.52	122.7
45	47.44	49.61	53.29	60.55	70.81	84.46	101.17	114.17	124.26
50	47.77	50.04	53.87	61.41	71.97	85.85	102.53	115.24	124.96
55	48.05	50.38	54.32	62	72.65	86.37	102.5	114.52	123.56
60	47.88	50.25	54.23	61.93	72.44	85.73	100.99	112.11	120.34
65	47.6	50	54	61.65	71.94	84.69	99	109.23	116.7
70	47.26	49.67	53.65	61.18	71.09	83.12	96.35	105.65	112.37
75	46.18	48.57	52.46	59.68	68.97	80.01	91.93	100.23	106.18
80	44.41	46.77	50.56	57.39	65.94	75.89	86.53	93.95	99.29
85	42.19	44.59	48.34	54.82	62.6	71.49	81.06	87.85	92.85
90	39.18	41.8	45.68	51.95	59.05	67.02	75.87	82.53	87.68

{i} b) weight, white male [*n* = 2898]

	3	5	10	25	50	75	90	95	97
20	51.61	54.32	58.51	65.77	74.69	85.44	98.08	107.99	115.85
25	54.97	57.7	61.97	69.46	78.82	90.25	103.85	114.58	123.13
30	58.37	61.12	65.47	73.19	82.99	95.12	109.71	121.31	130.61
35	61.45	64.23	68.64	76.58	86.78	99.54	115.01	127.37	137.33
40	63.77	66.57	71.05	79.16	89.66	102.88	118.91	131.71	142
45	65.13	67.96	72.48	80.72	91.41	104.85	121.04	133.82	144.01
50	65.48	68.31	72.85	81.14	91.89	105.29	121.21	133.59	143.32
55	64.9	67.71	72.23	80.46	91.1	104.23	119.57	131.26	140.3
60	64	66.78	71.25	79.38	89.81	102.52	117.09	127.96	136.23
65	62.96	65.71	70.13	78.12	88.26	100.41	114	123.9	131.29
70	61.67	64.41	68.78	76.62	86.42	97.88	110.33	119.13	125.56
75	60.23	62.95	67.29	74.96	84.37	95.11	106.4	114.16	119.71
80	58.54	61.25	65.52	72.99	81.98	91.97	102.19	109.04	113.85
85	56.6	59.26	63.44	70.66	79.17	88.44	97.66	103.71	107.9
90	54.59	57.21	61.28	68.22	76.26	84.83	93.17	98.53	102.19

{i} c) weight, black female [*n* = 510]

	5	10	25	50	75	90	95
20	45.76	49.67	57.11	67.37	81.13	98.88	113.75
25	48.47	52.68	60.61	71.4	85.62	103.56	118.26
30	51.2	55.71	64.15	75.46	90.12	108.24	122.79
35	53.71	58.51	67.42	79.2	94.22	112.42	126.78
40	55.98	61.06	70.4	82.6	97.89	116.09	130.22
45	57.45	62.75	72.4	84.82	100.16	118.11	131.84
50	57.5	62.9	72.62	84.96	99.97	117.27	130.31
55	56.6	62	71.63	83.69	98.14	114.55	126.77
60	55.45	60.84	70.32	82.05	95.91	111.42	122.85
65	54.38	59.75	69.12	80.53	93.83	108.54	119.25
70	53	58.33	67.52	78.56	91.25	105.12	115.13
75	51.29	56.54	65.48	76.09	88.12	101.11	110.42

{i} d) weight, black male [*n* = 207]

	5	10	25	50	75	90	95
20	57.45	60.18	67.86	84.48	110.4	135.47	149.17
25	58.17	61.43	69.43	84.89	107.79	131.14	145.77
30	58.82	62.82	71.4	85.29	104.73	126.94	143.06
35	59.63	64.4	73.55	85.7	101.75	122.76	140.04
40	60.67	66.12	75.62	86.1	99.29	118.81	136.42
45	61.9	67.82	77.4	86.51	97.53	115.46	132.61
50	63.09	69.17	78.61	86.92	96.74	113.31	129.42
55	64.08	69.98	79.15	87.33	96.92	112.54	127.23
60	64.97	70.49	79.32	87.74	97.62	112.44	125.53
65	65.9	70.91	79.3	88.15	98.57	112.54	123.91
70	66.93	71.38	79.27	88.57	99.55	112.55	122.2

{ii} a) BMI, white female [*n* = 3900]

	3	5	10	25	50	75	90	95	97
20	17.15	17.68	18.58	20.37	22.92	26.42	30.93	34.67	37.76
25	17.72	18.31	19.3	21.28	24.11	27.98	32.97	37.1	40.49
30	18.15	18.79	19.88	22.05	25.15	29.4	34.84	39.31	42.96
35	18.34	19.03	20.2	22.52	25.86	30.4	36.18	40.87	44.65
40	18.29	19.02	20.26	22.72	26.24	30.99	36.95	41.71	45.5
45	18.23	19	20.31	22.89	26.56	31.47	37.53	42.27	45.98
50	18.28	19.09	20.46	23.17	26.97	31.99	38.04	42.68	46.23
55	18.39	19.24	20.67	23.48	27.37	32.41	38.34	42.76	46.08
60	18.52	19.4	20.88	23.75	27.69	32.66	38.36	42.5	45.55
65	18.61	19.52	21.04	23.96	27.88	32.73	38.13	41.96	44.73
70	18.58	19.5	21.03	23.94	27.78	32.41	37.43	40.91	43.38
75	18.33	19.25	20.77	23.6	27.27	31.59	36.15	39.24	41.41
80	17.97	18.88	20.37	23.11	26.56	30.55	34.66	37.4	39.31
85	17.55	18.46	19.93	22.56	25.8	29.46	33.17	35.63	37.34
90	16.98	17.91	19.37	21.92	24.96	28.31	31.72	33.99	35.58

{ii} b) BMI, white male [*n* = 2726]

	3	5	10	25	50	75	90	95	97
20	18.33	18.91	19.86	21.66	24.07	27.16	30.89	33.8	36.1
25	19.14	19.76	20.78	22.7	25.28	28.58	32.54	35.62	38.02
30	19.94	20.6	21.68	23.73	26.49	30.02	34.22	37.47	39.99
35	20.65	21.35	22.49	24.67	27.61	31.35	35.8	39.2	41.83
40	21.17	21.9	23.11	25.4	28.49	32.42	37.06	40.59	43.3
45	21.47	22.23	23.48	25.86	29.07	33.13	37.88	41.47	44.2
50	21.57	22.34	23.62	26.06	29.33	33.43	38.2	41.76	44.44
55	21.49	22.28	23.57	26.02	29.29	33.36	38.03	41.47	44.04
60	21.34	22.12	23.41	25.84	29.06	33.02	37.5	40.74	43.13
65	21.17	21.94	23.21	25.59	28.71	32.5	36.69	39.68	41.85
70	21.02	21.77	23.01	25.31	28.29	31.85	35.71	38.41	40.35
75	20.89	21.62	22.82	25.02	27.84	31.15	34.67	37.09	38.81
80	20.76	21.47	22.62	24.73	27.38	30.45	33.65	35.81	37.33
85	20.62	21.3	22.41	24.41	26.9	29.74	32.65	34.58	35.93
90	20.46	21.12	22.18	24.08	26.42	29.04	31.69	33.42	34.62

{ii} c) BMI, black female [*n* = 500]

	5	10	25	50	75	90	95
20	17.52	18.92	21.63	25.39	30.35	36.4	41.12
25	18.51	20.03	22.93	26.85	31.91	38.03	42.79
30	19.43	21.11	24.22	28.31	33.5	39.77	44.7
35	20.16	22.04	25.39	29.64	34.95	41.44	46.68
40	20.78	22.87	26.45	30.84	36.24	42.91	48.42
45	21.36	23.57	27.28	31.73	37.11	43.7	49.14
50	21.74	23.94	27.62	32	37.2	43.41	48.38
55	21.81	23.95	27.54	31.77	36.72	42.46	46.91
60	21.66	23.76	27.25	31.32	36.02	41.36	45.42
65	21.46	23.53	26.94	30.87	35.33	40.32	44.06
70	21.23	23.25	26.55	30.32	34.54	39.19	42.62
75	20.93	22.89	26.08	29.68	33.67	37.98	41.11

{ii} d) BMI, black male [*n* = 192]

	5	10	25	50	75	90	95
20	19.49	20.73	23.29	27.34	34.1	45.95	59.37
25	19.72	21	23.6	27.66	34.2	45.28	57.61
30	19.95	21.25	23.89	27.88	34.06	43.85	54.16
35	20.17	21.5	24.14	28.04	33.74	42.07	50.07
40	20.39	21.74	24.38	28.15	33.38	40.39	46.5
45	20.62	21.99	24.61	28.24	33.04	39.02	43.81
50	20.86	22.24	24.85	28.34	32.76	37.93	41.82
55	21.11	22.5	25.08	28.44	32.51	37.05	40.31
60	21.37	22.76	25.31	28.53	32.31	36.33	39.11
65	21.64	23.03	25.54	28.63	32.13	35.74	38.15
70	21.91	23.3	25.76	28.73	31.99	35.24	37.35