Chronic kidney disease and estimated glomerular filtration rate according to body composition in Korean adults with normal BMI

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Background

Body composition contributes to both risk and outcome of chronic kidney disease (CKD). Dual-energy X-ray absorptiometry (DXA) is the reference method for the assessment of body composition in clinical research. An accurate understanding of the relationships of sarcopenia and obesity with renal function is essential.

Methods

We analysed 10,734 adults from the Korean National Health and Nutrition Examination Survey (KNHANES), whose body mass index (BMI) was within the normal range (18.5-24.9 kg/m^2) and who had undergone DXA (QDR 4500A, Hologic Inc., Waltham, MA, USA), laboratory measurements and cardiovascular risk factors. The KNHANES is a nationally representative cross-sectional survey of the general population in Korea and is regularly conducted by the Korea Centers of Disease Control and Prevention (KCDC) of the Ministry of Health and Welfare. The KNHANES (website: https://knhanes.cdc.go.kr/knhanes /index.do) is performed year-round, which is a similar data collection method to that used in the United States NHANES.

We categorized body composition into four phenotypes (normal, sarcopenia alone, obesity alone and sarcopenic obesity) based on appendicular lean mass index (ALMI) and total body fat percentage (TBF%). To calculate the odds ratio for CKD and glomerular hyperfiltration, logistic regression analyses were performed.

CKD was defined as eGFR < 60 ml/min per 1.73m^2 or a urine protein ≥ 1 (+) by a dipstick test.

Glomerular hyperfiltration was defined as eGFR ≥ 120 ml/min per 1.73 m^2.

Total body fat percentage (TBF%) was calculated as TBF × 100/total mass.

Appendicular lean mass index (ALMI), a measure of relative muscle mass that accounts for the scaling of appendicular lean body mass with height. ALMI was calculated as the sum of lean mass for the arms and legs/height^2 (kg/m^2).

Obese by DXA, if their TBF% was higher than the sex-specific 60th percentile for the DXA study sample of all KNHANES participants. For Korean men, this cut-point was 23.59% body fat; for Korean women, it was 34.63% body fat.

Sarcopenia by DXA has been defined by European Working Group on Sarcopenia in Older People (EWGSOP) and International Sarcopenia Conference Working Group (IWGS) as ALMI is ≤ 7.23 kg/m^2 in men and ≤ 5.67 kg/m^2 in women.

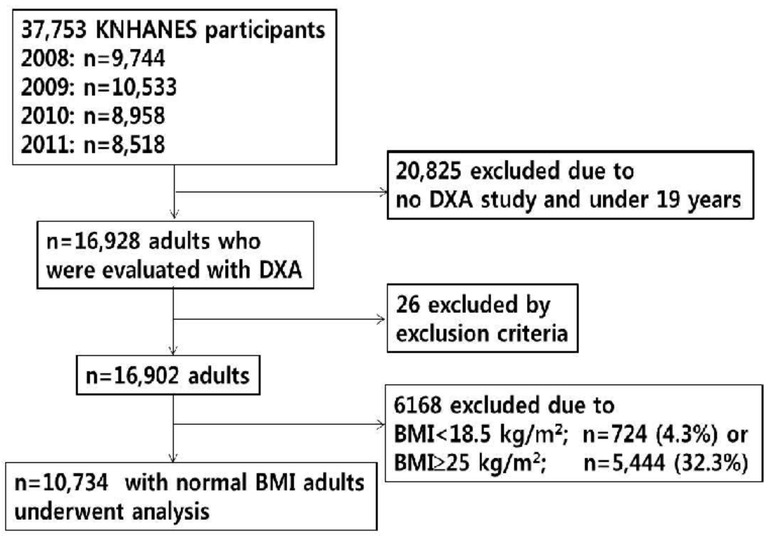

Figure 1. Flow chart of 10,734 study participants with normal BMI.

Results

Table 1. Characteristics of the Korean National Health and Nutrition Examination Survey (KNHANES) participants with a normal BMI according to body composition phenotype

	Total	Normal	Sarcopenia alone	Obesity alone	Sarcopenic obesity	P-value
Number, n (%)	10734 (100%)	6325 (58.9)	1535 (14.3)	1722 (16.0)	1152 (10.7)	
Age (years)	49.5 ± 16.1	48.2 ± 15.5	50.0 ± 17.5	50.7 ± 15.5	54.0 ± 16.8	<0.001
Female (%)	56.3	57.7	61.0	55.2	58.2	<0.001
Low quartile income (%)	19.9	18.9	24.1	17.9	23.0	<0.001
Less than high school education (%)	37.2	35.9	38.1	36.8	43.7	<0.001
Current smoker (%)	33.1	35.0	33.5	30.3	26.4	<0.001
MET, min/week	2248 ± 3118	2512 ± 3401	1927 ± 2795	1988 ± 2652	1616 ± 2263	<0.001
Total calorie intake (cal)	1914 ± 823	1996 ± 877	1760 ± 695	1859 ± 743	1757 ± 726	<0.001
Calorie/weight (cal/kg)	32.8 ± 13.2	33.8 ± 13.9	33.8 ± 12.7	29.6 ± 10.9	30.9 ± 12.0	<0.001
Protein/weight (g/kg)	1.16 ± 0.60	1.19 ± 0.63	1.18 ± 0.58	1.06 ± 0.53	1.10 ± 0.56	<0.001
Hypertension (%)	25.0	22.8	21.6	30.9	32.6	<0.001
Diabetes (%)	7.7	6.6	8.9	7.4	12.3	<0.001
Hyperlipidemia (%)	10.4	8.6	8.0	15.8	14.8	<0.001
History of CVD (%)	3.8	3.2	3.3	4.7	7.1	<0.001
Total cholesterol (mg/dl)	186 ± 35	184 ± 35	182 ± 34	194 ± 35	191 ± 36	<0.001
HOMA-IR	2.16 ± 1.74	2.06 ± 1.21	2.06 ± 1.52	2.49 ± 1.37	2.40 ± 3.71	<0.001
eGFR, (ml/min/1.73 m^2)	96.5 ± 16.6	97.0 ± 15.5	98.7 ± 17.7	94.7 ± 16.6	94.1 ± 19.4	<0.001
Proteinuria (%)	1.0	0.7	1.2	1.2	1.8	<0.001
eGFR < 60ml/min/1.73 m^2 (%)	2.3	1.8	2.0	2.5	5.4	<0.001
CKD (%)	3.0	2.3	2.9	3.4	6.5	<0.001
Glomerular hyperfiltration (%)	6.7	5.7	10.9	5.9	8.0	<0.001
BMI (kg/m^2)	22.21 ± 1.72	22.31 ± 1.57	20.12 ± 1.02	23.80 ± 0.87	22.10 ± 1.39	<0.001
Body weight (kg)	58.7 ± 8.1	59.4 ± 8.0	52.2 ± 5.8	63.1 ± 7.5	57.0 ± 6.6	<0.001
Height (cm)	162.2 ± 9.1	162.8 ± 9.3	160.9 ± 8.4	162.5 ± 9.0	160.5 ± 8.6	<0.001
Waist circumference (cm)	77.8 ± 7.1	77.5 ± 6.7	72.7 ± 6.1	82.8 ± 5.8	79.1 ± 6.9	<0.001
ALMI (kg/m^2)	6.79 ± 1.07	7.14 ± 1.01	5.97 ± 0.77	6.85 ± 0.91	5.90 ± 0.80	<0.001
Total body fat (%)	26.9 ± 7.3	24.4 ± 6.7	26.3 ± 6.4	32.0 ± 5.7	33.6 ± 6.1	<0.001

Table 2. Characteristics of 10,738 KNHANES participants with a normal BMI according to eGFR category

	eGFR (ml/min per 1.73 m^2)						
	<60	60-74	75-89	90-104	105-119	≥120	P-value
Number, n (%)	249 (2.3)	793 (7.4)	2429 (22.6)	3882 (31.5)	2659 (24.8)	722 (6.7)	
Age (years)	72.2 ± 8.6	66.7 ± 11.4	59.9 ± 13.5	50.4 ± 12.9	37.6 ± 7.9	27.0 ± 5.3	<0.001
Female (%)	47.0	46.2	47.3	54.9	64.5	78.5	<0.001
Low quartile income (%)	43.7	40.4	30.1	17.2	8.6	11.7	<0.001
Less than high school education (%)	73.1	62.4	55.9	41.5	12.4	3.1	<0.001
Current smoker (%)	36.5	36.6	36.2	32.6	31.5	26.5	0.002
MET (min/week)	1514 ± 1967	1989 ± 2669	2228 ± 3068	2424 ± 3259	2205 ± 3209	2061 ± 2867	<0.001
Total calorie intake (cal)	1526 ± 599	1761 ± 734	1876 ± 784	1950 ± 824	2002 ± 897	1843 ± 752	<0.001
Calorie/Weight (cal/kg)	27.0 ± 10.0	30.4 ± 11.6	32.1 ± 12.4	33.2 ± 13.2	34.3 ± 14.4	32.9 ± 13.3	<0.001
Protein/Weight (g/kg)	0.89 ± 0.46	1.01 ± 0.61	1.10 ± 0.53	1.18 ± 0.60	1.25 ± 0.66	1.20 ± 0.60	<0.001
Hypertension (%)	76.5	53.4	36.7	24.4	8.3	1.8	<0.001
Diabetes (%)	33.3	18.5	10.2	7.2	2.3	1.1	<0.001
Hyperlipidemia (%)	24.3	16.1	14.2	11.3	4.8	1.7	<0.001
History of CVD (%)	22.2	9.9	5.9	3.0	0.6	0.3	<0.001
Total cholesterol (mg/dl)	186 ± 44	190 ± 36	192 ± 35	189 ± 35	179 ± 33	168 ± 29	<0.001
HOMA-IR	2.83 ± 2.04	2.39 ± 1.46	2.23 ± 2.79	2.13 ± 1.36	2.04 ± 1.06	2.14 ± 1.10	<0.001
Proteinuria (%)	11.3	1.5	0.9	0.7	0.5	0.4	<0.001
BMI (kg/m^2)	22.58 ± 1.57	22.57 ± 1.65	22.47 ± 1.66	22.33 ± 1.69	21.92 ± 1.72	21.31 ± 1.74	<0.001
Body weight (kg)	57.0 ± 8.6	58.2 ± 8.3	58.7 ± 8.3	59.1 ± 8.1	58.7 ± 7.9	57.0 ± 7.6	<0.001
Height (cm)	158.4 ± 9.9	160.2 ± 9.4	161.3 ± 9.4	162.5 ± 9.2	163.5 ± 8.6	163.2 ± 7.6	<0.001
Waist circumference (cm)	82.1 ± 6.6	81.0 ± 6.9	79.7 ± 6.9	78.3 ± 6.7	75.4 ± 6.5	73.0 ± 6.6	<0.001
ALMI (kg/m^2)	6.67 ± 0.88	6.91 ± 0.99	6.96 ± 1.06	6.87 ± 1.08	6.66 ± 1.06	6.26 ± 0.99	<0.001[a]
Total body fat (%)	28.0 ± 5.8	26.7 ± 7.0	26.2 ± 7.3	26.6 ± 7.5	27.2 ± 7.2	29.2 ± 6.8	<0.001[a]
Normal (%)	45.3	51.5	58.5	61.6	61.3	49.9	<0.001
Sarcopenia alone (%)	12.1	14.4	13.0	12.2	16.3	23.3	<0.001
Obesity alone (%)	17.4	21.3	16.9	16.5	13.4	14.1	<0.001
Sarcopenic obesity (%)	25.1	12.9	11.5	9.7	9.0	12.7	<0.001

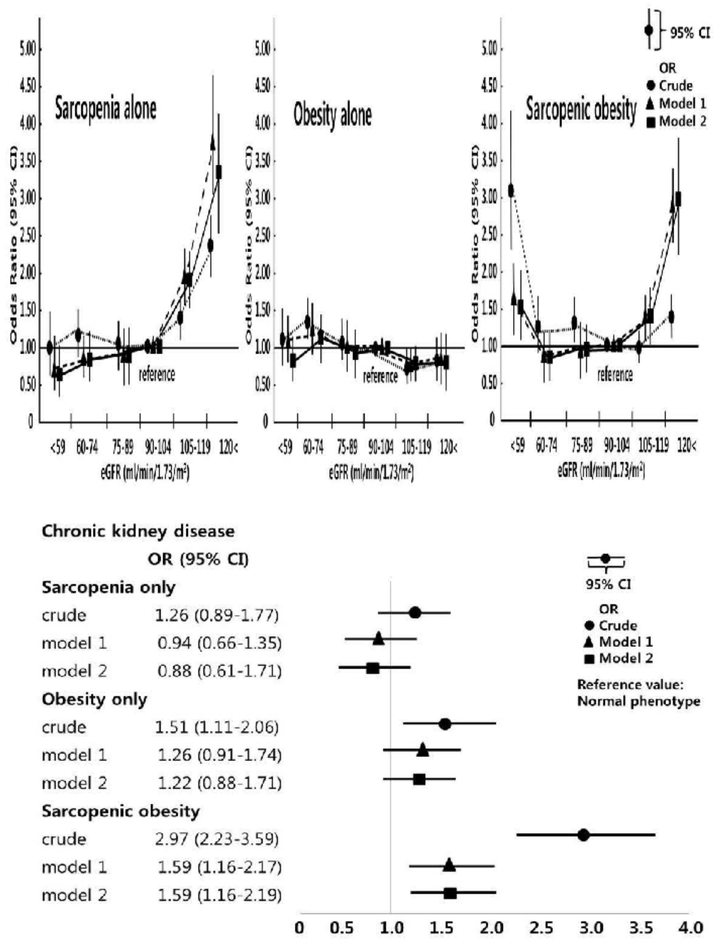

Figure 2. Odds ratios (95% confidence interval) of body composition phenotypes according to estimate glomelular filtration rate (eGFR). Model 1 was adjusted for age, gender, diabetes, hypertension, hyperlipidemia and cardiovascular disease. Model 2 was adjusted for model 1 variables, metabolic equivalent (MET), protein intake, poverty, education and smoking.

Figure 3. Odds ratios (95% confidence interval) of low eGFR and chronic kidney disease for body composition phenotypes compared with normal. Sarcopenic obesity is associated with CKD.

Model 1 was adjusted for age, gender, diabetes, hypertension, hyperlipidemia and cardiovascular disease. Model 2 was adjusted for model 1 variables, metabolic equivalent (MET), protein intake, poverty, education and smoking.

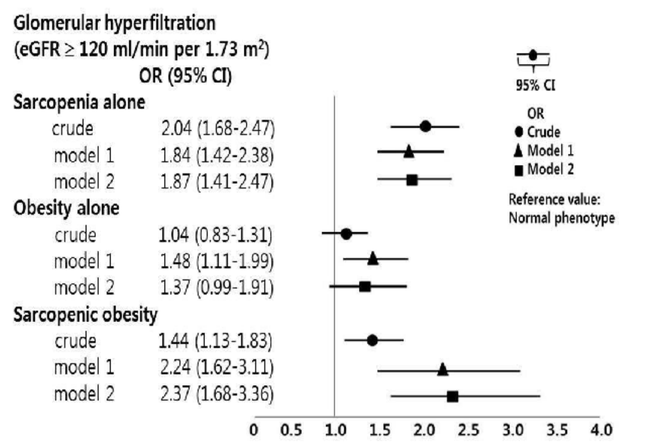

Figure 4. Odds ratios (95% confidence interval) of glomerular hyperfiltration for body composition phenotypes compared with normal. Sarocopenia and sarcopenic obesity are associated with glomerular hyperfiltration.

Model 1 was adjusted for age, gender, diabetes, hypertension, hyperlipidemia and cardiovascular disease. Model 2 was adjusted for model 1 variables, MET, protein intake, poverty, education and smoking.

-Sarcopenia alone (14.3%), obesity alone (16.0%) and sarcopenic obesity (10.7%) were prevalent even among participants with normal BMI.

-The association between sarcopenia alone and eGFR was J-shaped, while that between sarcopenic obesity and eGFR was U-shaped.

-Compared with the normal phenotype, sarcopenic obesity had an elevated OR for CKD (OR=1.59; 95% CI: 1.16-2.19). Sarcopenia alone (OR=1.87; 95% CI: 1.41-2.47) and sarcopenic obesity (OR=2.37; 95% CI 1.68-3.36) had elevated OR for glomerular hyperfiltration after model 2 adjustment.

Conclusions

These findings suggest that decreased muscle mass and coexistence with excess adiposity have some adverse effect on renal function even among Korean adults with normal BMI.

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