Supplementary material

Association between sarcopenia and cardiovascular disease among middle-aged and older adults: Findings from the China Health and Retirement Longitudinal Study

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Table S1 Baseline characteristics of 11863 participants without CVD by sarcopenia status in the longitudinal analysis

Characteristics	No sarcopenia (n=8425)	Possible sarcopenia (n=2627)	Sarcopenia (n=811)	*P*
Age, y	57.5 ± 8.4	64.4 ± 10.0 ***	67.5 ± 10.5 ***	<0.001
Male, n (%)	4178 (49.6)	1018 (38.8) ***	460 (56.7) ***	<0.001
Married (vs others)	7728 (91.7)	2086 (79.4) ***	645 (79.5) ***	<0.001
Rural (vs urban)	7462 (88.6)	2373 (90.3) *	769 (94.8) ***	<0.001
Smoking[a]	2429 (34.1)	641 (27.1) ***	315 (41.9) ***	<0.001
Drinking[a]	2208 (37.2)	573 (27.7) ***	232 (35.5)	<0.001
Educational level[a]				
Elementary school or below	4116 (66.3)	1831 (81.5) ***	611 (86.1) ***	<0.001
Secondary school	2149 (32.3)	407 (18.1) ***	95 (13.4) ***	
College and above	91 (1.4)	10 (0.4) ***	4 (0.6)	
BMI category, n (%)				
Underweight	349 (4.1)	134 (5.1) *	168 (20.7) ***	<0.001
Normal weight	4069 (48.3)	1274 (48.5)	500 (61.7) ***	
Overweight or obese	4007 (47.6)	1219 (46.4)	143 (17.6) ***	
Blood pressure, mm Hg				
Systolic	127 ± 19	131 ± 21 ***	128 ± 21	<0.001
Diastolic	76 ± 12	75 ± 12 **	73 ± 11 ***	<0.001
Comorbidities, n (%)				
Hypertension	2253 (26.7)	959 (36.5) ***	242 (29.8)	<0.001
Dyslipidemia	569 (6.8)	201 (7.7)	30 (3.7) **	<0.001
Diabetes	574 (6.8)	239 (9.1) ***	61 (7.5)	<0.001
Kidney disease	402 (4.8)	149 (5.7)	52 (6.4) *	0.011
History of medication use, n (%)				
Diabetes medications[a]	379 (4.5)	177 (6.8) ***	37 (4.6)	<0.001
Hypertension medications[a]	1479 (17.8)	754 (29.2) ***	171 (21.6) **	<0.001
Lipid-lowering therapy[a]	490 (5.9)	177 (6.9)	30 (3.8) *	0.005
Metabolic biomarkers[b]				
Total cholesterol, mg/dL	184.4 ± 36.0	183.7 ± 36.6	177.3 ± 33.9 ***	<0.001
Triglycerides, mg/dL	114.2 (83.2, 170.8)	119.5 (85.8, 174.3)	92.0 (70.0, 132.7) ***	<0.001
LDL cholesterol, mg/dL	102.5 ± 28.7	102.4 ± 28.7	97.9 ± 26.8 ***	<0.001
HDL cholesterol, mg/dL	51.5 ± 11.3	50.6 ± 11.4 **	53.9 ± 13.2 ***	<0.001
eGFR, mL/min/1.73 m^2	97.0 ± 21.6	94.6 ± 23.8 ***	94.2 ± 24.4 ***	<0.001
Handgrip strength, kg	33.0 ± 9.2	21.9 ± 10.0 ***	22.1 ± 7.7 ***	<0.001
ASM/Ht^2, kg/m^2	7.2 ± 1.5	7.5 ± 1.0 ***	5.6 ± 2.2 ***	<0.001

Data are shown as means ± standard deviation, median (interquartile range), or numbers (percentages).

[a] Missing data: 1615 for smoking, 3208 for drinking, 2249 for educational level, 116 for diabetes medications, 196 for hypertension medications and 220 for lipid-lowering therapy.

[b] Measured in subpopulation of 9753 participants.

Abbreviation: ASM, appendicular skeletal muscle; BMI, body mass index; CVD, cardiovascular disease; LDL, low-density lipoprotein; HDL, high-density lipoprotein; eGFR, estimated glomerular filtration rate.

Significant at $^*P < 0.05$, $^{**}P < 0.01$ and $^{***}P < 0.001$ compared to no sarcopenia group.

Table S2. Cross-sectional association between sarcopenia status, CVD and its components among all participants

Outcome	Cases, n (%)	OR (95% CI)		
		Model 1[a]	Model 2[b]	Model 3[c]
Cardiovascular disease				
No sarcopenia (n=10280)	1026 (10.0)	Reference	Reference	Reference
Possible sarcopenia (n=3685)	668 (18.1)	1.46 (1.30–1.63) ***	1.54 (1.36–1.74) ***	1.29 (1.13–1.48) ***
Sarcopenia (n=1172)	211 (18.0)	1.35 (1.14–1.61) **	1.71 (1.41–2.06) ***	1.72 (1.40–2.10) ***
Heart disease				
No sarcopenia (n=10280)	936 (9.1)	Reference	Reference	Reference
Possible sarcopenia (n=3685)	564 (15.3)	1.31 (1.16–1.48) ***	1.39 (1.22–1.59) ***	1.17 (1.01–1.35) *
Sarcopenia (n=1172)	179 (15.3)	1.25 (1.04–1.50) *	1.59 (1.30–1.95) ***	1.55 (1.25–1.93) ***
Stroke				
No sarcopenia (n=10280)	120 (1.2)	Reference	Reference	Reference
Possible sarcopenia (n=3685)	146 (4.0)	2.75 (2.11–3.58) ***	2.74 (2.07–3.65) ***	2.18 (1.60–2.97) ***
Sarcopenia (n=1172)	44 (3.8)	2.18 (1.49–3.18) ***	2.48 (1.63–3.77) ***	2.70 (1.75–4.16) ***

Abbreviation: OR, Odds ratio; CVD, cardiovascular disease.

[a] Model 1 was adjusted for age, sex.

[b] Model 2 was adjusted for age, sex, residence, marital status, educational level, smoking status, drinking status and body mass index.

[c] Model 3 was adjusted as model 2 with further adjustment for systolic blood pressure, diastolic blood pressure; history of hypertension, dyslipidemia, diabetes and chronic kidney disease; and use hypertension medications, diabetes medications, and lipid-lowering therapy.

[+]$P < 0.1$.

[*]$P < 0.05$.

[**]$P < 0.01$.

[***]$P < 0.001$.

Table S3. Cross-sectional association of sarcopenia status with CVD in subpopulations of 12318 participants with metabolic biomarkers measurements

Outcome	OR (95% CI)		
	Cardiovascular disease	**Heart disease**	**Stroke**
No sarcopenia	Reference	Reference	Reference
Possible sarcopenia			
Model 3[c]	1.29 (1.12–1.50)[**]	1.14 (0.98–1.33)[+]	2.28 (1.63–3.19)[***]
Model adjusted as model 3 plus			
Total Cholesterol	1.29 (1.12–1.50)[**]	1.14 (0.98–1.33)[+]	2.28 (1.62–3.19)[***]
LDL cholesterol	1.29 (1.11–1.49)[**]	1.14 (0.98–1.33)[+]	2.28 (1.63–3.20)[***]
HDL cholesterol	1.29 (1.11–1.49)[**]	1.14 (0.98–1.33)[+]	2.26 (1.61–3.16)[***]
Triglycerides	1.29 (1.12–1.50)[**]	1.14 (0.98–1.34)[+]	2.28 (1.63–3.20)[***]
eGFR	1.29 (1.12–1.50)[**]	1.14 (0.98–1.34)[+]	2.34 (1.66–3.28)[***]
All biomarkers	1.29 (1.12–1.50)[**]	1.14 (0.97–1.33)	2.31 (1.65–3.24)[***]
Sarcopenia			
Model 3[c]	1.62 (1.29–2.03)[***]	1.46 (1.15–1.86)[**]	2.66 (1.63–4.33)[***]
Model adjusted as model 3 plus			
Total Cholesterol	1.62 (1.29–2.03)[***]	1.46 (1.15–1.86)[**]	2.65 (1.63–4.32)[***]
LDL cholesterol	1.61 (1.28–2.02)[***]	1.45 (1.14–1.85)[**]	2.67 (1.64–4.35)[***]
HDL cholesterol	1.62 (1.29–2.03)[***]	1.46 (1.15–1.86)[**]	2.65 (1.62–4.32)[***]
Triglycerides	1.62 (1.29–2.04)[***]	1.47 (1.16–1.87)[**]	2.67 (1.64–4.35)[***]
eGFR	1.62 (1.29–2.03)[***]	1.45 (1.14–1.85)[**]	2.79 (1.71–4.56)[***]
All biomarkers	1.62 (1.29–2.03)[***]	1.45 (1.14–1.85)[**]	2.82 (1.73–4.61)[***]

Abbreviation: CVD, cardiovascular disease; ORs, odds ratios; LDL, low-density lipoprotein; HDL, high-density lipoprotein; eGFR, estimated glomerular filtration rate.

[c] Model 3 was adjusted for age, sex, residence, marital status, educational level, smoking status, drinking status and body mass index, systolic blood pressure, diastolic blood pressure; history of hypertension, dyslipidemia, diabetes and chronic kidney disease; and use hypertension medications, diabetes medications, and lipid-lowering therapy.

[+] $P < 0.1$.

[*] $P < 0.05$.

[**] $P < 0.01$.

[***] $P < 0.001$.

Table S4. Longitudinal association of sarcopenia status with CVD in subpopulations of 9753 participants with metabolic biomarkers measurements

Outcome	HR (95% CI)		
	Cardiovascular disease	**Heart disease**	**Stroke**
No sarcopenia	Reference	Reference	Reference
Possible sarcopenia			
Model 3[c]	1.21 (1.03–1.43) *	1.05 (0.84–1.30)	1.59 (1.24–2.03) ***
Model adjusted as model 3 plus			
Total Cholesterol	1.21 (1.03–1.43) *	1.05 (0.84–1.30)	1.59 (1.24–2.04) ***
LDL cholesterol	1.21 (1.03–1.43) *	1.05 (0.84–1.30)	1.59 (1.24–2.04) ***
HDL cholesterol	1.21 (1.03–1.43) *	1.04 (0.84–1.30)	1.57 (1.23–2.02) ***
Triglycerides	1.21 (1.03–1.44) *	1.05 (0.84–1.30)	1.59 (1.24–2.04) ***
eGFR	1.21 (1.03–1.44) *	1.05 (0.84–1.30)	1.60 (1.25–2.05) ***
All biomarkers	1.21 (1.03–1.43) *	1.04 (0.84–1.30)	1.60 (1.25–2.05) ***
Sarcopenia			
Model 3[c]	1.37 (1.05–1.79) *	1.23 (0.87–1.74)	1.72 (1.18–2.52) **
Model adjusted as model 3 plus			
Total Cholesterol	1.37 (1.05–1.79) *	1.23 (0.87–1.74)	1.73 (1.18–2.53) **
LDL cholesterol	1.37 (1.05–1.79) *	1.23 (0.87–1.74)	1.72 (1.18–2.52) **
HDL cholesterol	1.37 (1.05–1.79) *	1.23 (0.87–1.74)	1.72 (1.17–2.51) **
Triglycerides	1.38 (1.06–1.80) *	1.24 (0.87–1.75)	1.74 (1.19–2.55) **
eGFR	1.38 (1.06–1.79) *	1.23 (0.87–1.74)	1.75 (1.19–2.56) **
All biomarkers	1.39 (1.06–1.81) *	1.23 (0.87–1.74)	1.77 (1.21–2.59) **

Abbreviation: CVD, cardiovascular disease; HR, hazard ratio; LDL, low-density lipoprotein; HDL, high-density lipoprotein; eGFR, estimated glomerular filtration rate.

[c] Model 3 was adjusted for age, sex, residence, marital status, educational level, smoking status, drinking status and body mass index, systolic blood pressure, diastolic blood pressure; history of hypertension, dyslipidemia, diabetes and chronic kidney disease; and use hypertension medications, diabetes medications, and lipid-lowering therapy.

[+] $P < 0.1$.

[*] $P < 0.05$.

[**] $P < 0.01$.

[***] $P < 0.001$.

Table S5. Risk of newly onset CVD between possible sarcopenia and sarcopenia subgroups

Outcome	Cases, No.	Incidence Rate, per 1000 Person-Years	HR (95% CI)		
			Model 1[a]	Model 2[b]	Model 3[c]
CVD					
Possible sarcopenia	376	39.67	Reference	Reference	Reference
Sarcopenia	108	36.99	0.90 (0.73, 1.12)	1.01 (0.79, 1.30)	1.09 (0.84, 1.40)
Heart disease					
Possible sarcopenia	217	22.67	Reference	Reference	Reference
Sarcopenia	66	22.35	0.99 (0.75, 1.31)	1.10 (0.80, 1.51)	1.13 (0.81, 1.58)
Stroke					
Possible sarcopenia	184	19.18	Reference	Reference	Reference
Sarcopenia	51	17.17	0.73 (0.53, 1.00)[+]	0.81 (0.57, 1.16)	0.90 (0.63, 1.30)

Abbreviation: HR, hazard ratio; CVD, cardiovascular disease.

[a] Model 1 was adjusted for age, sex.

[b] Model 2 was adjusted for age, sex, residence, marital status, educational level, smoking status, drinking status and body mass index.

[c] Model 3 was adjusted as model 2 with further adjustment for systolic blood pressure, diastolic blood pressure; history of hypertension, dyslipidemia, diabetes and chronic kidney disease; and use hypertension medications, diabetes medications, and lipid-lowering therapy.

[+] $P < 0.1$.

Table S6. Cross-sectional association between low muscle mass alone and CVD stratified by sex in CHARLS 2015

Outcome	Cases, n (%)	OR (95% CI) Model 1[a]	Model 2[b]	Model 3[c]
Cardiovascular disease				
Men (n=5104)				
Reference (n=4093)	375 (9.2)	1	1	1
Low muscle mass alone (n=1011)	77 (7.6)	0.54 (0.42–0.71) ***	0.78 (0.55–1.10)	0.95 (0.66–1.37)
Women (n=5176)				
Reference (n=4086)	447 (10.9)	1	1	1
Low muscle mass alone (n=1090)	127 (11.7)	1.07 (0.86–1.32)	1.13 (0.90–1.43)	1.11 (0.87–1.42)
Heart disease				
Men (n=5104)				
Reference (n=4093)	419 (10.3)	1	1	1
Low muscle mass alone (n=1011)	119 (10.9)	0.58 (0.44–0.77) ***	0.63 (0.90–1.29)	0.73 (1.08–1.59)
Women (n=5176)				
Reference (n=4086)	457 (11.1)	1	1	1
Low muscle mass alone (n=1090)	81 (7.8)	1.07 (0.86–1.33)	1.14 (0.90–1.45)	1.12 (0.87–1.44)
Stroke				
Men (n=5104)				
Reference (n=4093)	60 (1.5)	1	1	1
Low muscle mass alone (n=1011)	11 (1.1)	0.52 (0.27–1.00)	0.67 (0.28–1.53)	0.32 (0.79–1.97)
Women (n=5176)				
Reference (n=4086)	39 (1.0)	1	1	1
Low muscle mass alone (n=1090)	10 (0.9)	0.95 (0.47–1.92)	0.87 (0.40–1.89)	0.86 (0.37–2.00)

Abbreviation: OR, odds ratio; CVD, cardiovascular disease.

Reference was a group of the participants without any sarcopenia components; Low muscle mass alone: low muscle mass with neither low grip strength nor slow physical performance.

[a] Model 1 was adjusted for age.

[b] Model 2 was adjusted for age, residence, marital status, educational level, smoking status, drinking status and body mass index.

[c] Model 3 was adjusted as model 2 with further adjustment for systolic blood pressure, diastolic blood pressure; history of hypertension, dyslipidemia, diabetes and chronic kidney disease; and use hypertension medications, diabetes medications, and lipid-lowering therapy.

*$P < 0.05$.

**$P < 0.01$.

***$P < 0.001$.

Table S7. Longitudinal association of low muscle mass alone with incident CVD stratified by sex, 2015-2018

Outcome	Cases, No.	Incidence Rate, per 1000 Person-Years	HR (95% CI)		
			Model 1[a]	Model 2[b]	Model 3[c]
Cardiovascular disease					
Men (n=4178)					
Reference (n=3343)	309	25.36	1	1	1
Low muscle mass alone (n=835)	57	18.54	0.62 (0.46–0.83) [**]	0.72 (0.49–1.06)	0.85 (0.57–1.27)
Women (n=4247)					
Reference (n=3399)	353	28.70	1	1	1
Low muscle mass alone (n=848)	70	22.60	0.80 (0.62–1.04) [+]	0.73 (0.54–0.99) [*]	0.74 (0.54–1.02)
Heart disease					
Men (n=4178)					
Reference (n=3343)	193	15.72	1	1	1
Low muscle mass alone (n=835)	41	13.30	0.75 (0.53–1.06)	0.89 (0.54–1.47)	0.96 (0.57–1.60)
Women (n=4247)					
Reference (n=3399)	267	21.57	1	1	1
Low muscle mass alone (n=848)	49	15.76	0.72 (0.53–0.98) [*]	0.67 (0.46–0.97) [*]	0.68 (0.46–1.00) [+]
Stroke					
Men (n=4178)					
Reference (n=3343)	132	10.72	1	1	1
Low muscle mass alone (n=835)	18	5.84	0.41 (0.25–0.68) [**]	0.44 (0.23–0.82) [**]	0.58 (0.31–1.10)
Women (n=4247)					
Reference (n=3399)	100	7.95	1	1	1
Low muscle mass alone (n=848)	23	7.28	0.95 (0.60–1.49)	0.83 (0.50–1.38)	0.87 (0.51–1.47)

Abbreviation: HR, hazard ratio; CVD, cardiovascular disease. Reference was a group of the participants without any sarcopenia components; Low muscle mass alone: low muscle mass with neither low grip strength nor slow physical performance.

[a] Model 1 was adjusted for age

[b] Model 2 was adjusted for age, residence, marital status, educational level, smoking status, drinking status and body mass index.

[c] Model 3 was adjusted as model 2 with further adjustment for systolic blood pressure, diastolic blood pressure; history of hypertension, dyslipidemia, diabetes and chronic kidney disease; and use hypertension medications, diabetes medications, and lipid-lowering therapy.

[+] $P < 0.1$.

[*] $P < 0.05$.

[**] $P < 0.01$.