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ORIGINAL RESEARCH

The Association of Subscapular Skinfold with All-Cause, Cardiovascular and Cerebrovascular Mortality

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Xiao-Cong Liu[1]
Lin Liu[1]
Yu-Ling Yu[1]
Jia-Yi Huang[1]
Chao-Lei Chen[1]
Kenneth Lo[2]
Yu-Qing Huang[1]
Ying-Qing Feng[1]

[1]Department of Cardiology, Guangdong Provincial Key Laboratory of Coronary Heart Disease Prevention, Guangdong Cardiovascular Institute, Guangdong Provincial People's Hospital, Guangdong Academy of Medical Sciences, School of Medicine, South China University of Technology, Guangzhou 510080, People's Republic of China; [2]Centre for Global Cardiometabolic Health, Department of Epidemiology, Brown University, Providence, RI, USA

Purpose: Previous studies suggested inconsistent relationship between subscapular skinfold and all-cause, cardiovascular, and cerebrovascular mortality. Therefore, the present study aimed to investigate the associations between subscapular skinfold with all-cause, cardiovascular, and cerebrovascular mortality.

Patients and Methods: Data were collected from the National Health and Nutrition Examination Survey (NHANES, 1999–2006) with follow-up data through 31 December 2015. Participants were categorized by subscapular skinfold quartiles. The hazard ratios (HRs) and 95% confidence intervals (CIs) were evaluated using the multivariate Cox regression model and subgroup analysis. Kaplan–Meier curves were used to present cause-specific mortalities and used Cox cubic regression splines to examine the association of subscapular skinfold with cause-specific mortalities.

Results: A total of 16,402 subjects (49.61% male) were involved in our study. After a mean follow-up of 141.73 months, there were 3078 (18.77%), 392 (2.39%), and 128 (0.78%) cases of all-cause, cardiovascular, and cerebrovascular mortality, respectively. Participants in the highest quartile of subscapular skinfold (≥24.80mm) versus the lowest (<13.20mm) had lower risk for all-cause mortality (HR, 0.71; 95% CI, 0.57–0.89; P for trend = 0.007) and cardiovascular mortality (HR, 0.44; 95% CI, 0.23–0.83; P for trend = 0.023) in the fully adjusted model. In the age-stratified analysis, subscapular skinfold was only inversely associated with all-cause and cardiovascular disease mortality in people ≥65 years of age (all P-interaction <0.001). No significant difference was found between subscapular skinfold and cerebrovascular mortality (all P > 0.05).

Conclusion: Subscapular skinfold showed an inverse association with all-cause and cardiovascular disease mortality in people aged ≥65 years.

Keywords: all-cause mortality, cardiovascular disease, cerebrovascular disease, NHANES, subscapular skinfold

Correspondence: Yu-Qing Huang; Ying-Qing Feng
Department of Cardiology, Guangdong Provincial Key Laboratory of Coronary Heart Disease Prevention, Guangdong Cardiovascular Institute, Guangdong Provincial People's Hospital, Guangdong Academy of Medical Sciences, School of Medicine, South China University of Technology, Guangzhou 510080, People's Republic of China
Tel/Fax +86-20-83827812
Email hyq513@126.com; 651792209@qq.com

Introduction

According to the Global Burden of Disease study data, the prevalence of obesity has doubled in more than 70 countries and has continuously increased worldwide since 1980, approximately 107.7 million children and 603.7 million adults with obesity all over the world in 2015.[1] Overweight and obesity are established risk factors for multiple chronic diseases, including cardiovascular diseases,[2–4] cerebrovascular diseases,[5] type 2 diabetes,[6] cancer,[7] and other disease conditions,[8,9] as well as all-cause mortality.[10] Body mass index (BMI) is the most common indicator for

adiposity in epidemiological research. However, "obesity paradox" has been consistently reported.[11–13] One of the essential explanations is that BMI fails to describe body fat distribution as an index of adiposity,[14,15] when studies have emphasized that the accumulation of visceral and ectopic fat is an independent risk marker of cardiovascular and metabolic morbidity and mortality.[2,3] Moreover, visceral and ectopic fat is usually measured by magnetic resonance imaging (MRI) and computerized tomography (CT) imaging. However, the measurement of visceral and ectopic fat is limited in clinical practice and research studies due to the high operation cost. Therefore, alternative indicators were explored, such as skinfold thickness. Skinfold thickness is a simple-to-use index to examine trunk and overall obesity.[16] Some reports suggested that skinfold thickness could be used to measure obesity with the advantage of indicating fat distribution.[17,18] An increase in subscapular skinfold was associated with cardiovascular mortality in previous studies,[19,20] but few studies have examined its link with all-cause and cerebrovascular mortality. Therefore, the aim of the present study was sought to examine the association of subscapular skinfold thickness with all-cause, cardiovascular, and cerebrovascular disease mortalities in US adults from the National Health and Nutrition Examination Survey (NHANES) 1999–2006.

Patients and Methods

Study Design and Study Population

The NHANES is designed to assess the health and nutritional status of adults and children in the United States. Data for analyses were included from the NHANES 1999–2006 with follow-up data through 31 December 2015. Details of recruitment, procedures, population characteristics, and study design for NHANES are available for online access at https://www.cdc.gov/nchs/nhanes/index.htm. Our study included 16,402 participants who were ≥18 years of age with data of subscapular skinfold thickness, and we excluded subjects who missed mortality data (Figure 1).

Subscapular Skinfold Measurement

Subscapular skinfold was measured in millimeters using the Holtain skinfold caliper by trained personnel at the inferior angle of the right scapula according to NHANES protocols. The protocol stipulates that each skinfold should consist of a double thickness of skin and underlying adipose tissue. The Holtain calipers are designed to provide accurate measurements up to a maximum of 45.0 mm.

Covariates

Weight, height, and blood pressure were measured by trained personnel in a Mobile Examination Center (MEC). BMI was calculated as weight divided by height (kg/m^2).

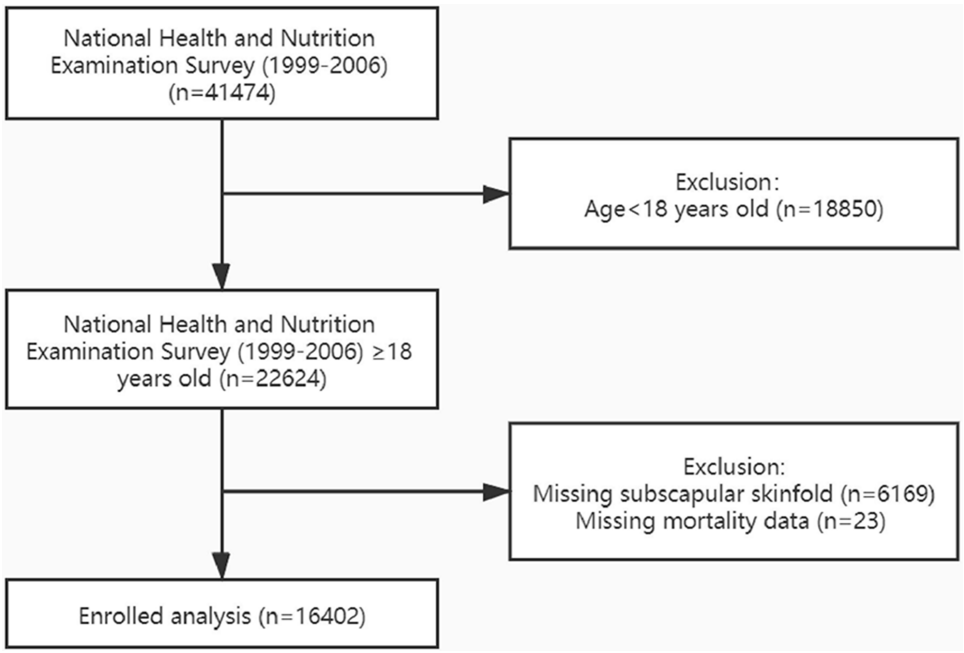

Figure 1 The research flow chart.

Information on age, gender, race (dichotomized into white or non-white), marital status (dichotomized into married or others), education level (dichotomized into less than high school or high school or above), alcohol consumption, smoking (dichotomized into yes or no), and history of cardiovascular diseases (CVD) were self-reported through questionnaire interviews. Prescription medication use was assessed by self-report and verified by interviewers through the examination of medication containers. The biochemistry profile, including total cholesterol (TC, mg/dl), high-density lipoprotein cholesterol (HDL-C, mg/dl), and C-reactive protein (CRP, mg/dl), was collected from laboratory measurements. Estimated glomerular filtration rate (mL/min/1.73 m^2) (eGFR) was calculated based on the Modification of Diet in Renal Disease formula (MDRD).[21] Hypertension was defined as systolic blood pressures (SBP) ≥140mmHg and/or diastolic blood pressure (DBP) ≥90mmHg, taking antihypertensive medications, or self-reported history of hypertension.[22] Diabetes was defined as FBG ≥ 126mg/dl, hemoglobin A1c (HbA1C) ≥6.5%, self-report, or using hypoglycemic agents.[23] Full detailed procedures on questionnaires and test methods can be found on the website (https://wwwn.cdc.gov/nchs/nhanes/Default.aspx).

Mortality Data

National Center for Health Statistics has linked mortality data from NHANES to death certificate data in the National Death Index. Mortality data were extracted from the data of the survey participants, based on a probabilistic match between NHANES and the National Death Index records through 31 December 2015. All-cause mortality included deaths from all causes. Cardiovascular (I00-I09, I11, I13, I20-I51) and cerebrovascular (I60-I69) mortality as defined by International Classification of Diseases, 10th Edition, Clinical Modification System codes derived from death-certificate data. Detailed mortality variables can be referred to on the website (https://www.cdc.gov/nchs/data-linkage/mortalitypublic.htm).

Statistical Methods

Subjects were categorized by subscapular skinfold thickness in quartiles (Q1:<13.20mm, Q2:13.20–18.70mm, Q3:18.71–24.79mm, Q4≥24.80mm). Baseline characteristics for the groups of participants were described using frequencies with percentages for categorical variables, and means with standard deviations (SD) for continuous variables. Subgroup difference was examined using chi-square tests, one-way ANOVA, Fisher test, or Kruskal–Wallis *H*-test whenever appropriate. The Kaplan–Meier curves were used to present the rate of all-cause, cardiovascular, and cerebrovascular mortality. Survival rates by subscapular skinfold thickness were compared using the Log rank test. Hazard ratios (HRs) and 95% confidence intervals (CIs) were estimated using Cox proportional hazards regression models. Several regression models were built. Model I only included subscapular skinfold thickness, Model II was adjusted for age, gender, and BMI. Model III was additionally adjusted for race, education level, married, smoking, alcohol consumption, SBP, eGFR, HDL-C, TC, CRP, comorbidities (hypertension, diabetes, and cardiovascular disease), and medication use (antihypertensive drugs, hypoglycemic agents, antiplatelet drugs, and lipid-lowering drugs). A test of the trend across the quartiles of subscapular skinfold thickness was also performed. Cox cubic spline regression models, adjusted for the same covariates in Model III, were used to examine the potential associations of subscapular skinfold thickness with cause-specific mortalities. Subgroup analyses were conducted by stratifying age (<65 or ≥65 years), gender (male or female), race (white or non-white), and BMI (<25 or ≥25 kg/m^2) to investigate potential sources of heterogeneity. Statistical significance was detected by $P < 0.05$. All analyses were performed with R version 3.6.3 (R Foundation for Statistical Computing, Vienna, Austria).

Results

Baseline Characteristics

A total of 16,402 participants were involved in the study and 8137 (49.61%) were males. The average age was 45.80 (SD=20.78) years. Table 1 shows the baseline characteristics of all participants. In general, the mean values of subscapular skinfold thickness from the lowest to highest quartiles were 10.05 (SD, 1.95), 15.95 (SD, 1.59), 21.58 (SD, 1.74), and 30.03 (SD, 3.96). There were 3078 (18.77%) participants died during the mean follow-up period of 141.73 (SD, 42.14) months, 392 (2.39%) from cardiovascular diseases, and 128 (0.78%) from cerebrovascular diseases. Significant differences were detected in most variables (all $P < 0.01$), except for education level, the prevalence of cardiovascular diseases, the use of antiplatelet drug, and cerebrovascular mortality.

The Relationship Between Subscapular Skinfold and All-Cause, Cardiovascular, and Cerebrovascular Diseases Mortality

Multivariable-adjusted Cox Cubic spline regression models showed an inverse association between subscapular skinfold and all-cause and cardiovascular mortality (Figure 2). The

Table 1 Baseline Demographic and Clinical Parameters Among Participants by Subscapular Skinfold Quartiles

	Total	Subscapular Skinfold Thickness, mm				P-value
		Q1: <13.20	Q2: 13.20–18.70	Q3: 18.71–24.79	Q4: ≥24.80	
Number	16,402	4063	4120	4103	4116	
Age, years	45.80 ± 20.78	41.51 ± 22.93	46.55 ± 21.34	48.57 ± 19.71	46.52 ± 18.23	<0.001
Age ≥ 65 years, n (%)	3894 (23.74)	919 (22.62)	1070 (25.97)	1087 (26.49)	818 (19.87)	<0.001
Subscapular skinfold, mm	19.43 ± 7.78	10.05 ± 1.95	15.95 ± 1.59	21.58 ± 1.74	30.03 ± 3.96	<0.001
Body mass index, kg/m^2	26.48 ± 4.96	21.94 ± 2.80	25.27 ± 3.18	27.59 ± 3.56	31.04 ± 4.87	<0.001
Systolic blood pressure, mmHg	117.42 ± 14.79	115.00 ± 14.20	117.06 ± 14.54	118.63 ± 14.90	119.07 ± 15.18	<0.001
Diastolic blood pressure, mmHg	68.34 ± 12.92	66.20 ± 12.97	67.70 ± 12.76	69.12 ± 12.99	70.43 ± 12.56	<0.001
Total cholesterol, mg/dL	198.52 ± 43.90	184.82 ± 43.33	199.18 ± 42.73	205.50 ± 43.98	204.18 ± 42.50	<0.001
HDL cholesterol, mg/dL	53.60 ± 15.90	58.22 ± 16.81	54.08 ± 15.79	51.61 ± 15.41	50.50 ± 14.36	<0.001
C-reactive protein, mg/L	0.65 ± 1.50	0.59 ± 1.72	0.63 ± 1.49	0.67 ± 1.46	0.71 ± 1.30	0.003
Alcohol consumption, gm	9.45 ± 29.48	11.84 ± 38.23	10.87 ± 29.23	8.46 ± 23.54	6.71 ± 24.63	<0.001
eGFR, mg/min/1.73m^2	93.83 ± 34.59	95.81 ± 34.38	92.64 ± 32.52	92.28 ± 34.05	94.65 ± 37.12	<0.001
Gender-Male, n (%)	8137 (49.61)	2289 (56.34)	2215 (53.76)	2071 (50.48)	1562 (37.95)	<0.001
Smoking, n (%)	7093 (48.99)	1703 (53.57)	1840 (50.34)	1854 (48.51)	1696 (44.39)	<0.001
Race-white, n (%)	8151 (49.70)	2189 (53.88)	2130 (51.70)	2032 (49.52)	1800 (43.73)	<0.001
Education level- High school or above, n (%)	11,098 (67.77)	2762 (68.15)	2775 (67.50)	2748 (67.07)	2813 (68.36)	0.580
Marital status-Married, n (%)	7898 (49.39)	1438 (36.11)	2056 (51.40)	2258 (56.24)	2146 (53.73)	<0.001
Comorbidities, n (%)						
Cardiovascular disease	605 (4.20)	114 (3.60)	153 (4.21)	186 (4.87)	152 (4.00)	0.058
Diabetes	1537 (9.37)	157 (3.86)	310 (7.52)	511 (12.45)	559 (13.58)	<0.001
Hypertension	5034 (30.69)	853 (20.99)	1174 (28.50)	1435 (34.97)	1572 (38.19)	<0.001
Treatment, n (%)						
Antihypertensive drugs	2952 (18.00)	508 (12.50)	687 (16.67)	858 (20.91)	899 (21.84)	<0.001
Lipid-lowering drugs	1328 (8.10)	171 (4.21)	321 (7.79)	417 (10.16)	419 (10.18)	<0.001
Hypoglycemic agents	761 (4.64)	66 (1.62)	136 (3.30)	270 (6.58)	289 (7.02)	<0.001
Antiplatelet drugs	195 (1.19)	38 (0.94)	43 (1.04)	58 (1.41)	56 (1.36)	0.124
Outcomes, n (%)						
All-cause mortality	3078 (18.77)	876 (21.56)	827 (20.07)	794 (19.35)	581 (14.12)	<0.001
Cardiovascular disease mortality	392 (2.39)	119 (2.93)	115 (2.79)	88 (2.14)	70 (1.70)	<0.001
Cerebrovascular disease mortality	128 (0.78)	34 (0.84)	35 (0.85)	38 (0.93)	21 (0.51)	0.143

Note: Values are mean ± standardized differences or n (%).
Abbreviations: Q, quartile; HDL, high-density lipoprotein; eGFR, estimated glomerular filtration rate.

association between subscapular skinfold and cerebrovascular mortality showed no statistical significance. As shown in Table 2, when treating subscapular skinfold as a categorical variable, people in the upper (Q4) versus the lowest quartile (Q1) had a reduced risk of all-cause (HR, 0.71; 95% CI, 0.57–0.89; P = 0.002) and cardiovascular mortality (HR, 0.44; 95% CI, 0.23–0.83; P = 0.011) after adjusted for multivariate in Model III. When treating subscapular skinfold as a continuous variable, subscapular skinfold was inversely associated with all-cause (HR, 0.98; 95% CI, 0.97–0.98; P < 0.001) and cardiovascular mortality (HR, 0.97; 95% CI, 0.96–0.98; P < 0.001) in univariate analysis. However, after being adjusted for confounders (Model III), subscapular skinfold inversely associated with all-cause mortality (HR, 0.98; 95% CI, 0.97–0.99; P < 0.001) but showed no significant association with cardiovascular mortality (HR, 0.97; 95% CI, 0.94–1.00; P = 0.083). Kaplan–Meier survival curves, as shown in Figure 3, also demonstrate the significant differences in all-cause mortality and cardiovascular mortality (all P < 0.001). No analyses showed significant associations between subscapular skinfold and cerebrovascular mortality.

Subgroup Analysis of Subscapular Skinfold with All-Cause, Cardiovascular and Cerebrovascular Mortality

Table 3 shows the subgroup analysis for the association of subscapular skinfold with all-cause and cardiovascular mortality, when being treated as a continuous variable. We found

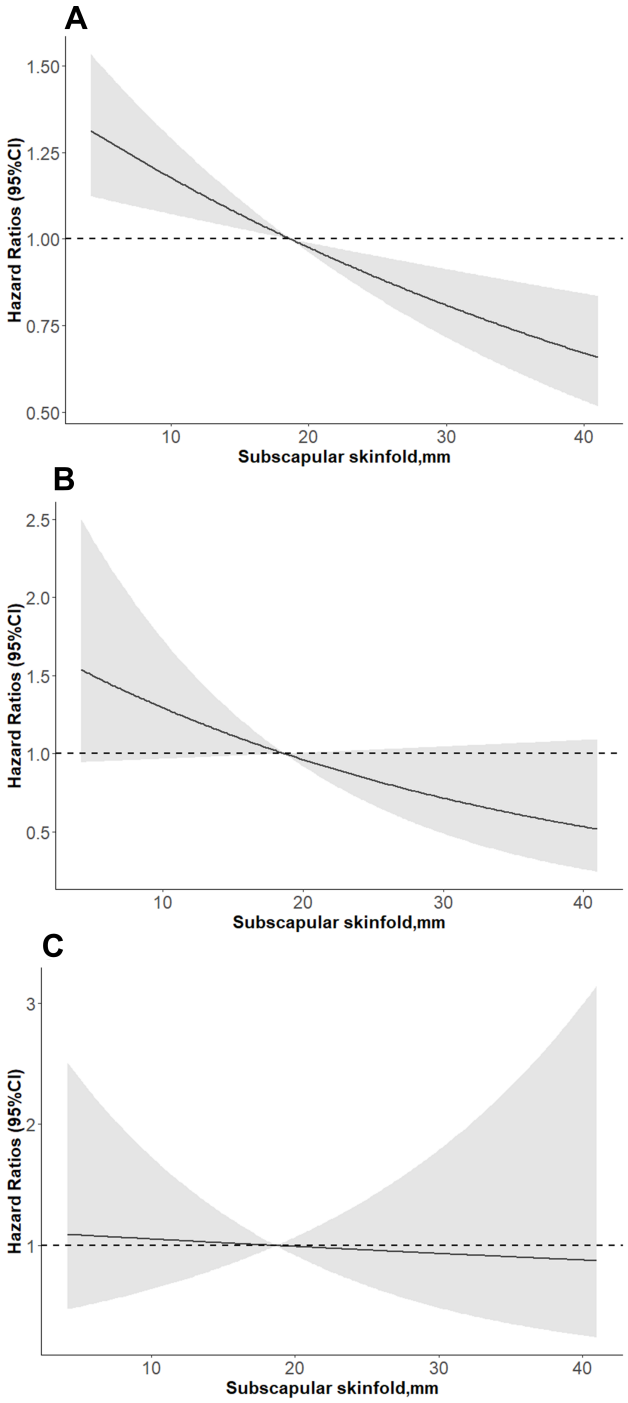

Figure 2 Association of subscapular skinfold thickness with all-cause (**A**), cardiovascular (**B**), and cerebrovascular (**C**) mortality using Cox cubic spline regression models. Adjusted for age, gender, race, education level, married, smoking, alcohol consumption, body mass index, systolic blood pressure, estimated glomerular filtration rate, high-density lipoprotein cholesterol, total cholesterol, C-reactive protein, hypertension, diabetes, cardiovascular disease, antihypertensive drugs, hypoglycemic agents, antiplatelet drugs, and lipid-lowering drugs.

that subscapular skinfold was only associated with all-cause (HR, 0.97; 95% CI, 0.96–0.98, P < 0.001) and cardiovascular mortality (HR, 0.96; 95% CI, 0.92–0.99, P = 0.028) in people ≥65 years (all P-interaction <0.001). No significant difference was found in other subgroup analyses.

Discussion

In the present study, subscapular skinfold was inversely associated with all-cause and cardiovascular mortality in people ≥65 years. No significant relationship had been found between subscapular skinfold and cerebrovascular mortality.

"Obesity paradox" has been widely reported in previous studies when using BMI as an index of adiposity,[13] suggesting that people with higher than normal weight have lower all-cause mortality. Epidemiological data suggest that the relationship between obesity and all-cause mortality in the general population follows a U-shaped pattern, and the nadir of the curve was observed at the overweight population.[24] Similar findings were reported in studies that used CHD, heart failure, atrial fibrillation, diabetes mellitus, and other disease conditions as outcomes.[6,7,11,14,25] This is likely because BMI being an inaccurate indicator of body fatness.[15] Skinfold thickness may serve as an alternative but its role in clinical practice and research investigation has not been confirmed.

The results from previous studies concerning the effects of subscapular skinfold are inconsistent. Studies conducted before the 1990s have mostly demonstrated a positive association of subscapular skinfold with all-cause and cardiovascular mortality.[16,19,20,26] However, the more recent studies tended to have different findings. Kalmijn's study in older Japanese-American men showed that higher subscapular skinfold was associated with lower mortality risk and Loh's study in UK white males revealed no association.[27,28] Our study found that subscapular skinfold shows an inverse association with all-cause and cardiovascular mortality, which was independent from BMI. The vast changes in people's lifestyle and diet structure, as well as the widespread use of statins in recent years, might lead to a transition of the impact of obesity on public health, as the use of established lipid-modifying drugs has indisputably reduced the risk of having an ASCVD event.[29] Subscapular skinfold may also reflect the level of subcutaneous fat.[30] Therefore, subscapular skinfold may indicate subcutaneous fat storage. Inadequate subcutaneous adipose tissue expansion in face of excess dietary fat leads to visceral and ectopic fat deposition, inflammatory/adipokine dysregulation and insulin resistance.[3,4] In contrary, certain subcutaneous fat regions appear to be metabolically, immunologically, and mechanically protective, and acting as

Table 2 Multivariate Cox Regression Analysis of Subscapular Skinfold with Cause-Specific Mortality

	Model I HR (95% CI), P-value	Model II HR (95% CI), P-value	Model III HR (95% CI), P-value
All-cause mortality			
Subscapular Skinfold (per mm increment)	0.98 (0.97, 0.98) <0.001	0.97 (0.97, 0.98) <0.001	0.98 (0.97, 0.99) <0.001
Subscapular skinfold group			
Q1	1.0	1.0	1.0
Q2	0.92 (0.84, 1.01) 0.079	0.71 (0.64, 0.78) <0.001	0.74 (0.63, 0.88) <0.001
Q3	0.88 (0.80, 0.97) 0.009	0.68 (0.61, 0.76) <0.001	0.75 (0.63, 0.90) 0.002
Q4	0.62 (0.56, 0.69) <0.001	0.60 (0.53, 0.69) <0.001	0.71 (0.57, 0.89) 0.002
P for trend	<0.001	<0.001	0.007
Cardiovascular mortality			
Subscapular Skinfold (per mm increment)	0.97 (0.96, 0.98) <0.001	0.98 (0.96, 1.00) 0.017	0.97 (0.94, 1.00) 0.083
Subscapular skinfold group			
Q1	1.0	1.0	1.0
Q2	0.94 (0.73, 1.21) 0.619	0.77 (0.58, 1.02) 0.064	0.41 (0.24, 0.69) <0.001
Q3	0.72 (0.54, 0.94) 0.017	0.65 (0.47, 0.89) 0.007	0.49 (0.29, 0.82) 0.008
Q4	0.55 (0.41, 0.74) <0.001	0.66 (0.45, 0.97) 0.033	0.44 (0.23, 0.83) 0.011
P for trend	<0.001	0.015	0.023
Cerebrovascular mortality			
Subscapular Skinfold (per mm increment)	0.98 (0.96, 1.00) 0.086	1.00 (0.97, 1.03) 0.937	0.99 (0.94, 1.05) 0.838
Subscapular skinfold group			
Q1	1.0	1.0	1.0
Q2	1.00 (0.62, 1.60) 0.995	0.88 (0.52, 1.47) 0.622	0.80 (0.31, 2.05) 0.641
Q3	1.08 (0.68, 1.72) 0.740	1.02 (0.59, 1.77) 0.931	0.74 (0.27, 2.01) 0.553
Q4	0.58 (0.34, 1.00) 0.051	0.76 (0.38, 1.54) 0.445	0.66 (0.20, 2.15) 0.491
P for trend	0.100	0.653	0.501

Notes: Model I adjust for none; Model II adjust for age, gender, and body mass index; Model III adjust for age, gender, race, education level, married, smoking, alcohol consumption, body mass index, systolic blood pressure, estimated glomerular filtration rate, high-density lipoprotein cholesterol, total cholesterol, C-reactive protein, comorbidities (hypertension, diabetes, and cardiovascular disease), and medication use (antihypertensive drugs, hypoglycemic agents, antiplatelet drugs, and lipid-lowering drugs).
Abbreviations: HR, hazard ratios; CI, confidence intervals; Q, quartile.

a sink to sequester potentially lipotoxic fatty acids.[31] Nevertheless, the precise role of subscapular skinfold in body-fat distribution remains to be investigated.

In addition, it is worth noting that subscapular skinfold was only associated with all-cause and cardiovascular mortality in people ≥65 years, which was in accordance with

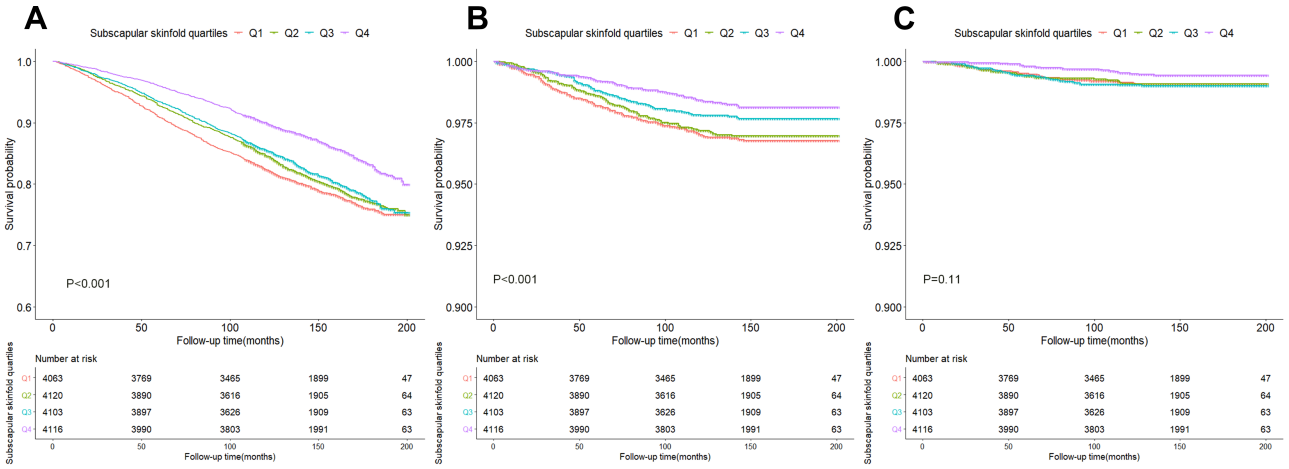

Figure 3 Kaplan–Meier survival curves of all-cause (**A**), cardiovascular (**B**), and cerebrovascular (**C**) mortality based on subscapular skinfold quartiles.

Table 3 Subgroup Analysis of Subscapular Skinfold with All-Cause and Cardiovascular Mortality

	All-Cause Mortality		Cardiovascular Mortality	
	HR (95% CI), P-value	**P-interaction**	**HR (95% CI), P-value**	**P-interaction**
Age, years		<0.001		<0.001
<65	0.99 (0.97, 1.01) 0.188		0.97 (0.91, 1.03) 0.301	
≥65	0.97 (0.96, 0.98) <0.001		0.96 (0.92, 0.99) 0.028	
Gender		0.797		0.236
Male	0.99 (0.97, 1.00) 0.044		0.99 (0.95, 1.04) 0.796	
Female	0.97 (0.96, 0.99) 0.002		0.92 (0.87, 0.98) 0.007	
Race		0.749		0.403
Non-white	0.98 (0.96, 1.00) 0.014		0.94 (0.89, 1.00) 0.041	
White	0.98 (0.97, 1.00) 0.013		0.99 (0.94, 1.03) 0.509	
BMI, kg/m^2		0.203		0.800
<25	0.94 (0.92, 0.97) <0.001		0.92 (0.87, 0.99) 0.017	
≥25	0.99 (0.98, 1.00) 0.044		0.99 (0.95, 1.03) 0.534	

Note: When analyzing a subgroup variable, age, gender, race, education level, married, smoking, alcohol consumption, body mass index, systolic blood pressure, estimated glomerular filtration rate, high-density lipoprotein cholesterol, total cholesterol, C-reactive protein, comorbidities (hypertension, diabetes, and cardiovascular disease), and medication use (antihypertensive drugs, hypoglycemic agents, antiplatelet drugs, and lipid-lowering drugs) except the variable itself.
Abbreviations: HR, hazard ratios; CI, confidence intervals.

reports from other studies. Chinese Atrial fibrillation registry study found that the "obesity paradox" between high BMI and reduced mortality rate in patients with AF was confined to those with age ≥65 years.[25] The Shizuoka Elderly Cohort Study and The Honolulu Heart Program also found that overweight/obesity was inversely associated with mortality in older people, whether defined by BMI or skinfold thickness.[27,32] Previous epidemiological studies in the general population have indicated that the relative risk of mortality associated with excess adiposity is lower among older persons.[33] It appears that adiposity may have less severe threats on health for older adults than that for young people. Instead, overweight/obesity was associated with lower risk of all-cause mortality in older persons.[34] One probable explanation is that people with obesity may have a higher metabolic reserve than lean or normal weight individuals. Obesity might protect against cachexia and energy wasting, with a much more notable effect in older patients with frailty when comorbidities and poor homeostatic reserve are obvious.[34] However, obesity and aging are both associated with a higher prevalence of hypertension and other chronic diseases, which may lead to a higher chance of early diagnosis and treatment for severe illnesses. Meanwhile, weight loss will almost certainly have preceded the diagnosis of cancer or be associated with other wasting chronic diseases from which participants may have died, and this would tend to confuse any real association.[19] Further studies are needed to establish the precise role of advanced aging in obesity paradox and all-cause mortality.

However, our study has several limitations that should be noted. First, the study population was relatively young, which limited the power to reveal the true association. Second, there were no direct measurements of body fat distribution like MRI or CT that could help us to establish the relationship between subscapular skinfold thickness and adiposity. Third, our study is an observational study; no clear conclusions can be drawn when causality has not been involved. Fourth, we were not able to exclude pregnant and lactating ladies. Fifth, the sample of the general population in the United States may limit the applicability in other regions and ethnic populations.

Conclusions

Subscapular skinfold was inversely associated with all-cause and cardiovascular mortality, and the inverse association only occurred in people ≥65 years. Subscapular skinfold was not significantly associated with cerebrovascular mortality. The association of subscapular skinfold with all-cause and specific mortality is needed more researches to clarify.

Data Sharing Statement

The datasets analyzed during the current study are publicly available at https://www.cdc.gov/nchs/nhanes/index.htm.

Ethics Approval and Informed Consent

The survey protocol was approved by the Institutional Review Board of the Centers for Disease Control and Prevention (Protocol #98-12, Protocol #2005-06, Continuation of Protocol #2005-06, Protocol #2011-17). Written informed consent was obtained from all subjects.

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Disclosure

The authors report no conflicts of interest in this work.

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