Triceps skinfold thickness is associated with all-cause mortality independent of BMI among maintenance hemodialysis patients

Yaya Yang[1,†], Yan Huang[1,†], Qiuxia Zhong,[1] Chaoying Xia[1], Jieyu Wang[1], Xiaolei Lan[1], Yaozhong Kong[2], Qijun Wan[3], Yumin Li[4], Sheng Huang[5], Yan Liu[6], Aiqun Liu[7], Fanna Liu[8], Xianhui Qin[1], Youbao Li[1] and Min Liang[1,*]

[1]National Clinical Research Center for Kidney Disease, Nanfang Hospital; Guangdong Provincial Clinical Research Center for Kidney Disease; National Key Laboratory for Prevention and Treatment of Multi-organ Injury; Nephrology Department, Nanfang Hospital, Southern Medical University, Guangzhou, China,
[2]Nephrology Department, the First People's Hospital of Foshan, Foshan, China,
[3]Nephrology Department, Shenzhen Second People's Hospital, Shenzhen, China,
[4]Nephrology Department, Huadu District People's Hospital of Guangzhou, Guangzhou, China,
[5]Nephrology Department, Southern Medical University Affiliated Nanhai Hospital, Foshan, China,
[6]Nephrology Department, Guangzhou Red Cross Hospital, Medical College of Jinan University, Guangzhou, China,
[7]Nephrology Department, The Third Affiliated Hospital of Southern Medical University, Guangzhou, China,
[8]Nephrology Department, Jinan University First Affiliated Hospital, Guangzhou, China.

[*] **Correspondence:** Min Liang; Email: nfyylm@163.com

† These authors have contributed equally to this work

This peer-reviewed article has been accepted for publication but not yet copyedited or typeset, and so may be subject to change during the production process. The article is considered published and may be cited using its DOI
10.1017/S0007114525000741
The British Journal of Nutrition is published by Cambridge University Press on behalf of The Nutrition Society

Abstract

Triceps skinfold thickness (TSF) is a surrogate marker of subcutaneous fat. Evidence is limited about the association of sex-specific TSF with the risk of all-cause mortality among maintenance hemodialysis (MHD) patients. We aimed to investigate the longitudinal relationship of TSF with all-cause mortality among MHD patients. A multicenter prospective cohort study was performed in 1034 patients undergoing MHD. The primary outcome was all-cause mortality. Multivariable Cox proportional hazards models were used to evaluate the association of TSF with the risk of mortality. The mean (standard deviation) age of the study population was 54.1 (15.1) years. 599 (57.9%) of the participants were male. The median (interquartile range) of TSF was 9.7 (6.3–13.3 mm) in males and 12.7 (10.0–18.0 mm) in females. Over a median follow up of 4.4 years (interquartile range, 2.4-7.9 years), there were 548 (53.0%) deaths. When TSF was assessed as sex-specific quartiles, compared with those in quartile 1, the adjusted HRs (95%CIs) of all-cause mortality in quartile 2, quartile 3 and quartile 4 were 0.93 (0.73, 1.19), 0.75 (0.58, 0.97) and 0.69 (0.52, 0.92), respectively (*P* for trend =0.005). Moreover, when analyzed by sex, increased TSF (≥9.7 mm for males and ≥18mm for females) was significantly associated with a reduced risk of all-cause mortality (quartile 3-4 *vs.* quartile 1-2; HR, 0.70; 95%CI: 0.55, 0.90 in males; quartile 4 *vs.* Quartile 1-3; HR, 0.69; 95%CI: 0.48, 1.00 in females). In conclusion, high TSF was significantly associated with lower risk of all-cause mortality in MHD patients.

Keywords: fat distribution; subcutaneous fat; triceps skinfold thickness; mortality; maintenance hemodialysis

Abbreviations: BMI, body mass index; BUN, blood urea nitrogen; CI, confidence interval; CRP, C-reactive protein; CVD, cardiovascular disease; HR, hazard ratio; MAC, mid-arm circumference; MAMC, mid-arm muscle circumference; MHD, maintenance hemodialysis; TC, total cholesterol; TSF, triceps skinfold thickness; WHR, waist-to-hip ratio.

Introduction

Patients undergoing maintenance hemodialysis (MHD) face a high risk of poor prognosis and mortality [1]. Given its substantial health care costs and morbidity, screening and identifying modifiable risk factors associated with mortality is critical to optimize patient care and outcomes.

Several studies have highlighted a paradoxical association of a higher body mass index (BMI) and improved survival among MHD patients [2–3]. However, BMI lacks the ability to distinguish fat distribution. It has been suggested that subcutaneous and central fat have different effects on disease and prognosis, potentially surpassing BMI in determining the health risks [4-7]. Triceps skinfold thickness (TSF) [8] and waist-to-hip ratio (WHR) [9] emerged as effective and economical anthropometric measures for assessing subcutaneous fat and central fat, respectively. While numerous previous studies have demonstrated a correlation between abdominal obesity and an elevated mortality risk among hemodialysis patients [10-12], data on subcutaneous fat in relation to mortality risk are limited, with few studies reporting a negative or null correlation [13-16]. Additionally, there exists a notable disparity in TSF distribution between men and women [17], and the aforementioned studies did not account for this difference [13-16]. Thus, it remains unclear whether sex differences affect the role of TSF in the prognostic assessment of MHD patients. Furthermore, the data for effect modification of the relationship between TSF and all-cause mortality are scant.

To address the above knowledge gaps, the current study aimed to evaluate the relationship between sex-specific TSF with mortality risk and to explore the potential modifiers of the association between TSF and mortality risk.

Materials and Methods

Study population and design

The study design and some of the findings have been previously published [12, 18]. Briefly, the study enrolled 1302 prevalent dialysis patients from January 2014 to December 2015 from eight hemodialysis centers in Guangdong, China (Nanfang Hospital, Guangzhou Red Cross Hospital, the First People's Hospital of Foshan, Huadu District People's Hospital of

Guangzhou, Jinan University First Affiliated Hospital, the Third Affiliated Hospital of Southern Medical University, Nanhai District People's Hospital of Foshan, and the Second People's Hospital of Shenzhen). The study was designed to evaluate nutritional status and its impact on the prognosis of patients undergoing MHD.

Inclusion criteria encompassed patients aged over 18 years, prevalent dialysis patients receiving hemodialysis for more than 3 months and with a normal oral dietary intake (not receiving enteral or parenteral nutrition). Exclusion criteria included hyperthyroidism, acute infection, liver cirrhosis, multiple organ failure, serious gastrointestinal disease, cognitive disorder and advanced malignant tumor.

This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects/patients were approved by the Medical Ethics Committee of Nanfang Hospital (NFEC-201210-Y5). Written informed consent was obtained from all subjects/patients.

Anthropometric measurements

Anthropometric measurements were performed by trained research staff following standardized protocols, as recommended by the Kidney Disease Outcomes Quality Initiative guideline [19]. All measurements were conducted after a dialysis session when the patients were at dry weight. BMI was calculated as weight/height squared (kg/m^2). Waist circumference was measured over the unclothed abdomen at the midpoint of the lower ribs and iliac crest in the midaxillary line. Hip circumference was measured around the widest part of buttocks. Waist-to-Hip Ratio (WHR) was defined as ratio of waist circumference to hip circumference.

Mid-arm measurements, including TSF and mid-arm circumference (MAC), were performed on the non-arteriovenous fistula arm. MAC was measured at the midpoint between the acromion and the olecranon, which was located after bending the arm to a 90° angle at the elbow. TSF thickness was measured at the mid-point of the posterior line between the olecranon and the tip of the acromion. TSF thickness was measured three times per participant and the mean measurement was used for analysis. All measurements were recorded to the nearest 0.1 cm. Mid-arm muscle circumference (MAMC) was calculated from

MAC and TSF using the formula: MAMC (cm)=MAC(cm)-π×(TSF(mm)/10). Inter-rater reliability for triceps skinfold and mid-arm circumference was evaluated among investigators on 30 patients using Bland–Altman plots (Supplemental Table 1).

Assessment of covariates

Data on sociodemographic characteristics, disease history, current medications, and lifestyle information were obtained following a standard operating procedure during the baseline interview. Pre-dialysis blood tests were performed for biochemical indicators, including serum albumin, blood urea nitrogen (BUN), C-reactive protein (CRP), triglyceride, total cholesterol (TC), calcium, phosphate and hemoglobin. Kt/V was calculated using urea kinetic modeling formulas: Kt/V=-ln (R-0.008×t) + (4-3.5×R) ×UF/W, where R is the ratio of postdialysis to predialysis serum urea nitrogen; t is time of dialysis in hours; UF is the amount of ultrafiltration (in L), and W is postdialysis weight (in kg) [20].

Outcomes

The primary outcome of interest was all-cause mortality, which was defined as deaths due to any reasons. Survival data including date and cause of death was obtained by death certificates from hospitals, telephone follow-up as well as linking to the national mortality surveillance system from the Chinese Center for Disease Control and Prevention via national identification number of the participants [21].

All patients were followed until death, transfer to kidney transplantation, peritoneal dialysis, loss to follow-up or the end of study on August 2023.

Statistical analysis

Population characteristics are presented as mean (SD) or median (interquartile range) for continuous variables and counts (proportions) for categorical variables by sex-specific TSF quartiles. Comparison of baseline characteristics was performed by χ 2 test for categorical variables, and ANOVA tests or Kruskal-Wallis tests for continuous variables.

Shapiro-Wilk's normality test was used to detect the normal distribution of the data. The distribution of TSF was found to be significantly skewed ($P < 0.05$). We performed restricted cubic spline Cox regression analyses to test for linearity and explore the shape of the relation between natural log-transformed TSF and all-cause mortality risk. The relation of

sex-specific TSF with all-cause mortality was estimated using Cox proportional hazards models (hazard ratio [HR] and 95% confidence interval [CI]). As there was a notable difference in TSF distribution between men and women, we also examined the relations of TSF with all-cause mortality separated by sex. Model 1 was adjusted for demographics (centers, age), lifestyle factors (smoking and alcohol intake), history of disease (diabetes mellitus, hypertension, cardiovascular disease) and laboratory values (albumin, triglycerides, total cholesterol, C-reactive protein, calcium, phosphorus), dialysis duration and Kt/V. Model 2 was adjusted for variables in model 1 plus anthropometrics (BMI, MAMC, WHR). The proportional hazards assumption was tested by the Schoenfeld residuals test, and no significant deviation from proportionality in hazards over time was detected (P>0.05).

Possible modifications on the relationship of TSF and all-cause mortality were assessed for variables including age, diabetes mellitus, history of cardiovascular disease, BMI, WHR, serum triglyceride, CRP and serum albumin levels. Each subgroup analysis adjusted, if not stratified, for the covariates in model 2.

A two-tailed $P < 0.05$ was considered to be statistically significant in all analyses. The results of the subgroup analyses were interpreted as exploratory. R software (version 4.1.3, http://www. R-project.org) was used for all statistical analyses.

Results

Baseline characteristics of participants

As illustrated in the flow chart, of the 1302 participants (shown in supplemental Figure 1), the following participants were excluded: 2 participants enrolling twice; 8 participants receiving peritoneal dialysis; 163 participants having a dialysis duration < 3 months; 18 participants with missing data for TSF or BMI; 34 participants with missing data on CRP and 43 participants with missing data on other covariates. The characteristics of the included (n = 1034) and excluded (n = 268) participants are shown in Supplemental Table 2. The final sample consisted of 1034 participants.

Baseline characteristics of participants were presented by sex-specific TSF quartiles in Table 1. The mean age of the study population was 54.1 (15.1) years; 599 (57.9%) participants were male. The average BMI and WHR were 21.2 (3.5) kg/m^2 and 0.90 (0.07), respectively. The

median (interquartile range) of TSF was 9.7 (6.3–13.3 mm) in males and 12.7 (10.0–18.0 mm) in females. The distribution of TSF was displayed in Supplemental Figure 2.

In males, the median (interquartile range) TSF values across Quartiles 1 to 4 were 4.5 (3.7, 5.8) mm, 8.0 (7.0, 8.7) mm, 11.0 (10.0, 12.0) mm and 16.3 (14.3, 18.7) mm, respectively. Corresponding values in females were 7.7 (5.7, 8.7) mm, 11.3 (10.3, 12.0) mm, 15.0 (13.8, 16.3) mm, and 21.0 (19.6, 24.0) mm. Participants in higher quartile of TSF were younger, more likely to have diabetes mellitus; had higher waist, WHR, CRP, phosphorus, triglycerides, TC levels and lower MAMC and Kt/V. The baseline characteristics by sex are also presented in Supplemental Table 3 (males) and Supplemental Table 4 (females).

Association of TSF with all-cause mortality among MHD patients

During a median follow-up of 4.4 years (interquartile range, 2.4-7.9 years) (5031 person-years), there were 548 (53.0%) deaths. The leading causes of death were CVD death [297 (28.7%)] and infection-related death [104 (10.1%)].

Overall, TSF was inversely associated with the risk of all-cause mortality in MDH patients (Figure 1). When TSF was assessed as sex-specific quartiles, compared with those in the first quartile, the adjusted HRs (95% confidence interval (CI)) in quartile 2, quartile 3 and quartile 4 were 0.93 (0.73, 1.19), 0.75 (0.58, 0.97) and 0.69 (0.52, 0.92), respectively (*P* for trend =0.005). In male participants, when compared to those in quartile 1-2, a significantly lower risk of all-cause mortality was found in quartile 3-4 (≥9.7mm; HR: 0.70, 95%CI: 0.55, 0.90). However, among female participants, those in quartile 4 (≥18mm; HR: 0.75, 95%CI: 0.47,1.21) tended to have lower all-cause mortality, but the HR did not reach statistical significance in comparison with those in quartile 1 (<10mm). As the HRs in the quartiles 1–3 were similar, we defined the participants in quartiles 1–3 (<18mm) as low TSF group and those in quartile 4 (≥18mm) as high TSF group. Compared with those in low TSF group, those in high TSF group showed a significantly lower all-cause mortality risk (HR: 0.69, 95%CI: 0.48, 1.00) (Table 2).

The relationship between sex-specific TSF and CVD mortality, infection-related mortality and non-CVD mortality were also analyzed. The similar trends were found (Supplemental Table 5).

Stratified analyses by potential effect modifiers

Stratified analyses were performed to assess the relationship of TSF with mortality risk in various subgroups. None of the variables, including age, diabetes mellitus, history of CVD, BMI, WHR, serum albumin, triglyceride and CRP, significantly modified the relationship of TSF with mortality risk in males (shown in Supplemental Figure 3) and females (shown in Supplemental Figure 4) (*P* for interactions≥0.05).

Discussion

To our knowledge, this is the first prospective study to demonstrate the association of sex-specific TSF with mortality risk during a median follow up of 4.4 years among MHD patients. We found that increased TSF is associated with lower all-cause mortality and the association was stronger in men as compared to women.

A few prior studies have evaluated the relationship between TSF and the risk of all-cause mortality among MHD patients, yielding inconsistent results. In the Hemodialysis Study, where the mean TSF was 16.3mm, a significant association was found between high TSF and a reduced all-cause mortality [13]. Similarly, a study involving 242 MHD patients in Serbia (mean: 10.1mm for men and 15.4mm for women) demonstrated that TSF was associated with all-cause death (per 1 mm increment, HR: 0.95; 95%CI: 0.92-0.98) [15]. In contrast, the National Institutes of Health–sponsored Nutritional and Inflammatory Evaluation in Dialysis (NIED) Study, with a mean TSF of 17.5mm, did not find a significant relationship between TSF and all-cause mortality [22]. Rodrigues et al. reported that TSF was not associated with mortality risk in 173 older MHD patients (>60 years) [14]. However, most of the previous studies were conducted in Western populations with higher TSF than Asian populations, and characterized by small sample sizes, a short duration of follow up or potential bias (no adjustment for BMI or WHR). Importantly, the effect of sex on the association of TSF with mortality risk was not examined. The present study, with a large sample size, a long follow up period, and comprehensive adjustment of major traditional risk factors, prospectively observed the association between TSF and the risk of all-cause mortality in Asian MHD patients.

Our study has revealed a noteworthy correlation between higher TSF and a reduced risk of all-cause mortality among MDH patients. The underlying mechanisms linking TSF and all-cause mortality are not fully elucidated, but it is biologically plausible. First, a higher TSF may signify better nutritional reserves, which may confer survival advantages during chronic illness [23]. Furthermore, TSF is a well-recognized indicator of subcutaneous adipose tissue and peripheral fat distribution, which have several metabolic benefits. Subcutaneous fat plays an important role in storing energy and may act as a buffer against ectopic fat deposition [24]. Adiponectin, an adipokine predominantly secreted by subcutaneous adipose, exhibits anti-inflammatory properties and enhance insulin sensitivity [25]. Additionally, compared with visceral depots, subcutaneous fat may release lower concentrations of potentially harmful metabolites, such as interleukin-6 (IL-6), tumor necrosis factor-alpha (TNF-α) and free fatty acids [26]. Nonetheless, it is crucial to note that further research is warranted to validate and expand upon our findings.

In this study, the inverse association between TSF and all-cause mortality was stronger in men as compared to women, which may be due to the sex differences in body fat distribution. Women typically have a greater total body fat mass and are more prone to accumulate subcutaneous fat, whereas, men are more likely to accumulate visceral fat, which is associated with adverse health events [4, 27]. It has been reported that for any given waist circumference, women have more subcutaneous fat than men [28]. In the present study, men had a significantly lower TSF values than women (10.4 *vs.* 14.2 mm). This lower TSF may indicate a greater vulnerability to the impact of reduced subcutaneous fat on poor outcomes in men. However, future studies are needed to verify our results and to further explore the underlying mechanisms regarding this topic.

In our study, we observed that the MHD patients had relatively low TSF values but demonstrated a higher WHR when compared to the general population in China. In the present study, the mean (SD) of TSF was 12.0 (6.1) mm, and the median (interquartile range) was 10.8 (8.0, 15.3) mm. The mean WHR was 0.90 (0.07). In comparison, data from the China Health and Nutrition Survey (CHNS) study indicated that the general population had higher TSF values (mean 14.3 mm) and a lower WHR of 0.85 [29]. This disparity in fat

distribution emphasizes the importance of investigating the relationship between fat distribution patterns and poor outcomes in MHD patients. TSF is related with subcutaneous fat and WHR indicated visceral fat, which is associated with increased risk of cardiovascular disease and poor outcomes [12, 30]. As such, we speculated that the combination of low TSF and high WHR may implicate an unfavorable fat distribution pattern. Therefore, the assessment of both TSF and WHR may be crucial in predicting the risk of all-cause mortality and stratifying preventive and treatment strategies for individuals at risk of poor outcomes.

Several limitations in our study deserve mentioning. First, the current study cannot exclude potential residual confounding from unmeasured factors. Second, there were no direct measurements of adiposity (e.g. computed tomography, magnetic resonance tomography or dual energy X-ray absorptiometry) in the current study. Given the high cost, lack of availability, and radiation hazard of these tools, they are not feasible for epidemiological studies and for routine clinical use. TSF is a simple, cheap and easy anthropometric index for evaluating subcutaneous fat, and has been validated in several populations [8, 31-32]. Third, anthropometric measurements were assessed only at baseline and the change in TSF was not considered during the follow up. Fourth, MAC was measured only once. However, the investigators were well-trained and had a good command of the research protocol and standard operating procedures. Finally, this study was conducted in the south of China, where the population has a relatively lower BMI level [33]. Therefore, the results are not generalizable to other ethnic groups.

Conclusions

In conclusion, the present study found that increased TSF was associated with lower risk of all-cause mortality and the association was stronger in men as compared to women. Our study highlighted that, in addition to BMI, TSF can serve as a valuable and practical anthropometric measure to predict the mortality risk among MHD patients.

Acknowledgements

We thank the participants, investigators and staff for their contribution to this study.

Financial Support:

This work was supported by the National Key Research and Development Program of China (2021YFC2500200); Key Technologies R&D Program of Guangdong Province (2023B1111030004); Clinical Research Program of Nanfang Hospital, Southern Medical University (2019CR021; 2023CR038); Clinical Research Program of Southern Medical University (LC2019ZD005; LC2024NF003); National Natural Science Foundation of China (82470760); President Foundation of Nanfang Hospital，Southern Medical University (2022H013).

Conflict of interest statement:

The authors declare that they have no competing interest.

Authors' contributions:

Study concept and design: Yaya Yang, Yan Huang and Min Liang; data acquisition: Yaya Yang, Yan Huang, Qiuxia Zhong, Chaoying Xia, Jieyu Wang, Xiaolei Lan, Yaozhong Kong, Qijun Wan, Yumin Li, Sheng Huang, Yan Liu, Aiqun Liu, Fanna Liu, Xianhui Qin, Youbao Li; data analysis: Yaya Yang, Yan Huang; data interpretation: all authors; draft manuscript: Yaya Yang, Yan Huang; manuscript review: all authors. All authors contributed important intellectual content during manuscript drafting or revision. All authors read and approved the final manuscript.

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Table 1. Population characteristics by sex-specific triceps thickness skinfold quartiles.

Characteristics	Total	Sex-specific triceps skinfold thickness, mm				*P*
		Quartile 1	Quartile 2	Quartile 3	Quartile 4	
N	1034	245	264	257	268	
Male, n (%)	599 (57.9)	137 (55.9)	156 (59.1)	154 (59.9)	152 (56.7)	0.769
Age, years	54.1 ± 15.1	55.0 ± 15.4	53.5 ± 15.2	55.7 ± 14.7	52.2 ± 15.0	0.042
Current alcohol drinking, n (%)	38 (3.7)	9 (3.7)	12 (4.5)	6 (2.3)	11 (4.1)	0.571
Current smoking, n (%)	150 (14.5)	37 (15.1)	41 (15.5)	34 (13.2)	38 (14.2)	0.884
Comorbidities						
Diabetes mellitus, n (%)	277 (26.8)	54 (22.0)	59 (22.3)	82 (31.9)	82 (30.6)	0.012
Hypertension, n (%)	889 (86.0)	214 (87.3)	228 (86.4)	227 (88.3)	220 (82.1)	0.175
History of CVD, n (%)	200 (19.3)	54 (22.0)	57 (21.6)	46 (17.9)	43 (16.0)	0.24
Physical examination						
BMI, kg/m^2	21.2 ± 3.4	19.1 ± 2.5	20.7 ± 2.8	21.8 ± 2.9	23.2 ± 3.7	<0.001
WHR	0.90 ± 0.07	0.89 ± 0.07	0.90 ± 0.07	0.91 ± 0.07	0.91 ± 0.06	<0.001
Mid-arm muscle circumference, mm	19.9 ± 2.7	19.7 ± 2.5	20.3 ± 2.8	20.1 ± 2.7	19.6 ± 2.7	0.011
Triceps skinfold thickness, mm	10.8 (8.0, 15.3)	5.7 (4.0, 7.5)	9.0 (8.0, 10.7)	12.2 (10.7, 14.3)	18.8 (16.2, 22.0)	<0.001

Laboratory variables						
Albumin, g/L	3.8 ± 0.4	3.8 ± 0.4	3.8 ± 0.4	3.8 ± 0.4	3.8 ± 0.37	0.410
CRP, mg/L	2.7 (1.0, 7.3)	2.3 (0.9, 6.8)	2.4 (0.8, 6.6)	2.6 (1.0, 8.0)	3.2 (1.3, 8.1)	0.033
Calcium, mg/dL	8.7 ± 1.1	8.7 ± 1.1	8.6 ± 1.1	8.7 ± 1.0	8.7 ± 1.0	0.357
Phosphorus, mg/dL	6.6 ± 2.0	6.5 ± 2.0	6.4 ± 2.0	6.7 ± 2.0	7.0 ± 2.0	0.001
Triglycerides, mg/dL	164. 5 ± 121.9	121.2 ± 70.6	159.2 ± 128.2	179.1 ± 118.6	195.3 ± 142.7	<0.001
Total cholesterol, mg/dL	159.9 ± 43.5	157.6 ± 42.2	155.3 ± 41.7	160.6 ± 43.1	165.7 ± 46.2	0.035
Dialysis vintage, months	24.4 (12.4, 50.6)	28.1 (12.4, 57.0)	25.5 (12.6, 49.8)	24.1 (11.5, 44.4)	23.0 (12.3, 49.4)	0.162
Kt/V[a] ratio	1.3 ± 0.4	1.4 ± 0.5	1.4 ± 0.5	1.3 ± 0.4	1.2 ± 0.4	<0.001

Data are expressed as mean ± SD, median (interquartile range) or n (%).

Abbreviations: CVD, cardiovascular diseases; BMI, body mass index; WHR, waist-to-hip ratio; CRP, C-reactive protein.

[a]Kt shows effective urea clearance and duration of dialysis, and V represents the volume of distribution of urea in the body, calculated as Kt/V=-ln(post-BUN/pre-BUN–0.0083t)+(4–3.53post-BUN/pre-BUN) ×UF/postweight, where t is effective dialysis time and UF is ultrafiltration.

Table 2. The association between triceps skinfold thickness with the risk of all-cause mortality.

Triceps skinfold thickness, mm	No. of events (%)	Adjusted Model 1		Adjusted Model 2	
		HR(95%CI)	*P*	HR(95%CI)	*P*
Sex-specific Quartiles					
Q1	140(57.1)	Ref		Ref	
Q2	139(52.7)	0.99(0.78,1.26)	0.934	0.93(0.73,1.19)	0.584
Q3	140(54.5)	0.80(0.63,1.02)	0.075	0.75(0.58,0.97)	0.030
Q4	129(48.1)	0.79(0.61,1.02)	0.067	0.69(0.52,0.92)	0.012
P for trend			0.025		0.005
Male					
Quartiles					
Q1 (<6.3)	81(59.1)	Ref		Ref	
Q2 (6.3-9.7)	88(56.4)	0.92(0.68,1.26)	0.610	0.82(0.60,1.13)	0.230
Q3 (9.7-13.3)	87(56.5)	0.69(0.50,0.94)	0.019	0.62(0.44,0.87)	0.005
Q4 (≥13.3)	72(47.4)	0.76(0.54,1.06)	0.106	0.62(0.42,0.91)	0.016
Categories					
Q1-Q2 (<9.7)	169(57.7)	Ref		Ref	
Q3-Q4 (≥9.7)	159(52.0)	0.75(0.59,0.94)	0.012	0.70(0.55,0.90)	0.005
Female					
Quartiles					

Q1 (<10.0)	59(54.6)	Ref		Ref	
Q2 (10.0-12.7)	51(47.2)	1.18(0.80,1.75)	0.399	1.16(0.78,1.73)	0.470
Q3 (12.7-18.0)	53(51.5)	1.17(0.78,1.75)	0.456	1.09(0.70,1.67)	0.708
Q4 (≥18.0)	57(49.1)	0.84(0.56,1.26)	0.397	0.75(0.47,1.21)	0.244
Categories					
Q1-Q3 (<18.0)	163(51.1)	Ref		Ref	
Q4 (≥18.0)	57(49.1)	0.75(0.54,1.04)	0.089	0.69(0.48,1.00)	0.048

[*] Model 1 adjusted for age, dialysis centers, diabetes mellitus, hypertension, history of CVD, smoking, alcohol drinking, dialysis vintage, Kt/V ratio, albumin, triglyceride, calcium-phosphorus product, C-reactive protein.

[†] Model 2 adjusted for model 1 plus BMI, waist-to-hip ratio and Mid-arm muscle circumference.

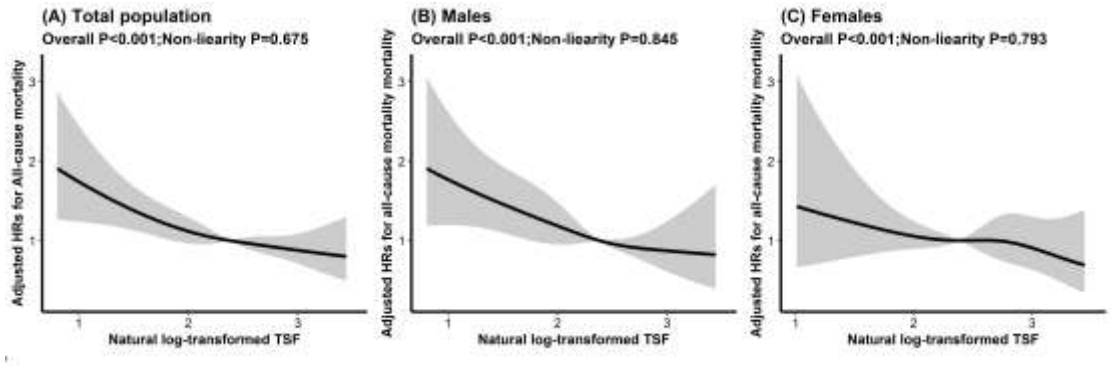

Figure 1. Relationship of triceps skinfold thickness with the risk of all-cause mortality among total population (A), males (B) and females (C) based on restricted cubic splines.

*Adjusted for dialysis centers, age, sex, smoking, alcohol drinking, diabetes mellitus, history of CVD, hypertension, albumin, C-reactive protein, triglycerides, total cholesterol, calcium, phosphorus, dialysis vintage, Kt/V, BMI, waist-to-hip ratio and mid-arm muscle circumference.