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Associations between nutrition literacy and possible sarcopenia among older adults in Bengbu, China

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Running title: Nutrition Literacy and possible Sarcopenia

Abstract

To explore the associations between nutrition literacy (NL) and possible sarcopenia in older Chinese adults. A cross-sectional study was conducted. NL was assessed using a 12-item short-form NL scale. Possible sarcopenia was identified using SARC-CALF. Logistic regression was used to calculate odds ratios (ORs) and 95% confidence intervals (CIs) for NL and the incidence of possible sarcopenia. A total of 1,338 older individuals, aged 71.41 ± 6.84 years, were enrolled in this study. After confounders were adjusted for, older adults in the upper quartile of NL were found to be 52% less likely to have possible sarcopenia than those in the lower quartile of NL (OR = 0.48, 95% CI: 0.29–0.77). The associations between NL and possible sarcopenia were present only in those who lived in rural areas (OR: 0.38, 95% CI: 0.19–0.77), had a primary school education or less (OR: 0.21, 95% CI: 0.09–0.48), had a monthly income <3,000 RMB (OR: 0.39, 95% CI: 0.22–0.70), and had chronic diseases (OR: 0.37, 95% CI: 0.22–0.63). Moreover, an interaction effect was observed between having a chronic disease and junior high school education and being in the upper quartile of NL. The prevalence of possible sarcopenia in older Chinese adults is substantial, with prevalence decreasing with increasing NL. Moreover, the association between NL and possible sarcopenia varies by residence type, education level, monthly income, and chronic disease experience. Targeted NL interventions are required to prevent and manage sarcopenia in older adults, particularly those with low socioeconomic status and chronic diseases.

Keywords: Older people, nutrition, nutrition literacy, possible sarcopenia

List of abbreviations:

NL: nutrition literacy, B: regression coefficient, SE: standard error, CIs: confidence intervals, ORs: odds ratios, NL-SF12: The 12-item short-form NL scale

Highlights

One in four older adults in Bengbu, China has possible sarcopenia.

High NL levels are associated with a low incidence of possible sarcopenia.

Socioeconomic status and disease influence NL and possible sarcopenia rates.

1. Introduction

Aging is a critical public health challenge in China, where more than sarcopenia 290 million Chinese people (21.1% of the overall Chinese population) were older than 60 years in 2023. This proportion is predicted to reach 38.8% by 2050[1,2] As they age, older individuals face a variety of health challenges, including an increased incidence of sarcopenia. One meta-analysis of 35 studies from several countries reported that the estimated overall prevalence of sarcopenia in adults over the age of 60 was 10%[3]. By contrast, in older Chinese older individuals, this prevalence is 18% for men and 16.4% for women[4]. Sarcopenia is a progressive, systemic decrease of the muscle mass and strength of skeletal muscles that is associated with a wide range of consequences, such as functional decline, falls, broken bones, physical disability, poor oncological prognosis, metabolic disorders, depression, poor quality of life, and death, substantially increasing the risk of hospitalization[5-7]. These physical burdens are also associated with substantial medical and economic burdens[8], rendering sarcopenia an urgent health challenge for older adults[9,10].

Although the occurrence and progression of sarcopenia depend on several factors, diet is highly crucial[11]. The maintenance of skeletal muscular mass depends on the balance of protein synthesis and decomposition in the body. As the body's metabolism declines with age and the body's musculoskeletal systems become less efficient, older adults are prone to malnutrition or overnutrition, which may result in deficiencies of vitamins and micronutrients and cause a decline in skeletal musculature mass and power[12]. Consuming milk, dairy products, and protein supplements can increase bone mineral density and muscle strength, preventing or delaying sarcopenia[13]. Despite the proven benefits of balanced diets, many studies have focused exclusively on single foods or nutrients.

Nutrition literacy (NL) refers to the ability to access, analyze, and utilize basic nutritional messages or services and make informed nutritional decisions as a result[14]. NL is a crucial health skill for older adults. Specifically, NL encourages individuals to select healthy foods, and a lack of NL contributes to the consumption of diets of low quality[15,16]. NL thus improves nutrition and health. However, to date, no study has reported the associations between NL and the incidence of sarcopenia. Therefore, this study examined the associations

between NL and possible sarcopenia in people from China.

2. Methods

2.1 Participants and procedure

This cross-sectional study was conducted in May 2023 in Bengbu City, Anhui Province, China. The study participants were invited to participate through urban–rural stratified multistage random sampling. In the first stage, two urban areas and two rural counties and townships were selected as urban and rural sampling points using random sampling. In the second stage, two streets and two towns/villages were selected at random from each of the urban areas, counties, or townships identified in stage 1. In the third stage, 110 households were selected at random from the streets or towns/villages identified in stage 2, and all members of the households who met the inclusion criteria were invited to participate as the target population. The inclusion criteria were being ≥18 years old, being conscious, being able to communicate verbally without impediment, and being able to complete the questionnaires either independently or under the guidance of the researchers. All participants participated voluntarily and signed an informed consent form. The authors designed and administered a structured questionnaire to obtain demographic information, lifestyle behaviors, NL, and sarcopenia-related data in a face-to-face interview. This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by the Ethics Committee of Bengbu Medical College [2021-099].

A total of 2400 individuals were invited to participate in the survey by community workers. Of these, 2287 engaged in the interview process, with 2279 ultimately completing the questionnaire, yielding a completion rate of 95.0%. Given that sarcopenia is prevalent mainly in older adults, this study selected those aged 60 years and above as study population. Among 1355 older adults who are 60-year-old years and above in the survey, 17 (1.3%) were excluded due to incomplete data on NL and sarcopenia, and finally, the remaining 1338 were included in this study. There was no difference in characteristics between lost sample and final sample.

2.2 NL Assessment

The 12-item short-form NL scale (NL-SF12)[17] was used to assess the NL of the participants along two domains (nutrition cognition and nutrition skills), and six dimensions (knowledge, understanding, obtaining skills, applying skills, interactive skills, and critical skills). Each item on the NL-SF12 is rated on a 5-point Likert scale, with higher scores indicating higher NL. In this study, NL was divided into four quartiles. The instrument had acceptable reliability for Chinese adults[17,18]. The NL-SF12 generally showed good model-data fit (Table S1) and convergent validity (TableS2), and had a Cronbach's alpha coefficient of 0.870 in this study.

2.3 Identification of possible sarcopenia

Possible sarcopenia was identified using the strength, assistance, rising, climbing, and falling (SARC-F) instrument in conjunction with measurements of calf circumference (SARC-CALF). The SARC-CALF is recommended as a screening tool for sarcopenia by the Asian Working Group for Sarcopenia[19], with adequate sensitivity and specificity[20]. The SARC-CALF instrument enhances the sensitivity of the identification of sarcopenia, which is low when the SARC-F is used alone. The questionnaire portion comprise questions in five categories: strength (S), assistance with walking (A), rising from a chair ©, climbing stairs (C), and falls (F), with endpoints ranging from 0 "*not at all*" to 2 "*very much*," with a total possible score of 10[21]. If the circumference of the calf was less than 34 centimeters for men or 33 centimeters for women[19], 10 points were added to the SARC-F assessment; in all other cases, no additional points were added. The SARC-CALF is scored by summing the SARC-F points and the calf circumference points. A score of ≥11 on the SARC-CALF indicates possible sarcopenia[19].

2.4 Other variables

A range of potential confounders were controlled for, comprising sociodemographic factors, lifestyle factors, and chronic disease status, to ensure the results were reliable. Data were collected on age, sex, area of residence (*urban*, *rural*), smoking status (*never smoked*, *used to smoke*, and *currently smoking*), drinking status (*never drank*, *used to drink*, and *currently*

drinking), exercise (*never exercised*, *used to exercise*, and *regularly exercising*), education (*primary school and below, junior high school* and *senior high school and above*), occupation (*farmer*, *separated/retired staff* and *others*), marital status (*married* and *others* [*unmarried*, *divorced*, or *widowed*]), monthly income (*<3000 RMB* and *≥3000 RMB*), chronic disease status (*yes* [Suffering from any one or more of high blood pressure, diabetes, heart disease, stroke and cerebrovascular disease, bronchitis, digestive disease, osteoporosis, dyslipidemia, arthritis, rheumatism, low back disease, cancer and so on.] or *no*), body mass index (BMI; *underweight* [<18.5 kg/m^2], *normal* [18.5–23.9 kg/m^2], *overweight* [24–27.9 kg/m^2], or *obese* [≥28 kg/m^2]), and average daily protein intake, which is based on food frequency questionnaires.

2.5 Statistical analysis

Continuous variables are presented as means ± standard deviations (SDs), and categorical variables are presented as frequencies and percentages. An analysis of variance was performed to explore the association of age (continuous variable) with NL and sarcopenia, and a chi-squared test was employed to determine the associations between categorical variables. Binary logistic regression was used to calculate odds ratios (ORs) and 95% confidence intervals (CIs) for the associations between NL and possible sarcopenia. We also conducted subgroup analyses to assess whether variations in the associations of NL with possible sarcopenia were associated with different residence types, education levels, monthly incomes, or having chronic diseases. Finally, interaction analyses were conducted to determine the associations between different residence types, education levels, monthly incomes, or having chronic diseases and NL. Data were analyzed using SPSS 25.0, with a P value < 0.05 considered statistically significant.

3. Results

3.1 Participant characteristics

Of the 1338 participants in this study, the mean age of the participants (SD) was 71.41 (6.84) years; over half (54.56%) were women, 47.23% resided in urban areas, 78.70% were married, over half (58.65%) had a primary school education or less, and most had monthly incomes

<3000 RMB (76.91%), at least one chronic disease (85.35%), and the average daily protein intake (SD) was 55.86 (27.67) grams.

Participants were likely to be in the upper quartile of NL if they were younger, women, lived in an urban area, had a history of drinking, regularly exercised, were educated to the senior high school level or above, were unemployed, were married, had high monthly incomes, did not have chronic diseases, and have a higher average daily protein intake.

3.2 Associations between NL levels and sarcopenia

Figure 1 illustrates the incidence of possible sarcopenia by NL quartile. The higher the NL quartile, the lower the incidence of possible sarcopenia. This association was observed across two NL domains and six NL dimensions. Table 2 presents the ORs for having possible sarcopenia for the NL quartiles. After adjusting for potential confounders, individuals in the upper quartile of NL were 52% less likely to have possible sarcopenia than those in the lowest quartile of NL (OR: 0.48, 95% CI: 0.29–0.77). Individuals in the upper quartile of nutrition skills were 61% less likely to have possible sarcopenia than those in the lower quartile of nutrition skills (OR: 0.40, 95% CI: 0.22–0.71); however, no differences were found for nutrition cognition. Across the six dimensions, older adults in the third quartile of obtaining skills were 44% less likely to have possible sarcopenia (OR: 0.55, 95% CI: 0.32–0.96), and those in the third quartile of interactive skills were 34% less likely to have possible sarcopenia (OR: 0.65, 95% CI: 0.43–0.99) than participants in the lowest quartile of the corresponding dimensions; however, no difference was found for the other four dimensions.

3.3 Subgroup analysis

Figure 2 illustrates the low rates of possible sarcopenia of the older adults in the upper quartile of NL following subgroup analyses. This association between high NL and low rates of possible sarcopenia was observed for older adults in rural areas (OR: 0.38, 95% CI: 0.19–0.77) with primary school education or less (OR: 0.21, 95% CI: 0.09–0.48) with a monthly income <3,000 RMB (OR: 0.39, 95% CI: 0.22–0.70) who had chronic diseases (OR:

0.37, 95% CI: 0.22–0.63), but not for older adults in urban areas with a senior high school education or higher with monthly incomes ≥3,000 RMB who did not have chronic diseases.

3.4 Interaction between NL and chronic diseases on sarcopenia

To investigate variations in the association between NL and possible sarcopenia depending on different residence types, education levels, monthly incomes, or having chronic diseases we derived the P for interaction for the interaction between NL and residence types, education levels, monthly incomes, or having chronic diseases. Compared with older adults with less than primary education and scored in the lowest quartile of NL, those with junior high school education in the upper quartile of NL had a lower prevalence of possible sarcopenia; compared with older individuals who had no chronic diseases and scored in the lowest quartile of NL, those with chronic diseases in the upper quartile of NL had a lower prevalence of possible sarcopenia; no significant interaction was found between the other variables (Figure 2).

4. Discussion

The present study is the first to investigate the associations between NL and possible sarcopenia in older adults in Bengbu, China. The results revealed a negative correlation between NL and possible sarcopenia, indicating that improving NL may be an effective method to reduce the incidence of possible sarcopenia. Because one in four older Chinese in Bengbu has possible sarcopenia, the condition is an urgent public health challenge.

This study revealed that higher levels of NL are associated with a lower likelihood of having possible sarcopenia. NL is a critical factor in shaping healthy eating behaviors[15]. Our study shows that older people with higher NL are more likely to consume more protein, and that insufficient protein intake is likely to lead to sarcopenia[22]. At least one study has demonstrated a positive correlation between higher levels of NL and healthier eating behaviors[23]. Diet quality directly affects muscle mass and strength, and those with healthier diets experience a lower incidence of sarcopenia[24]. Hence, improving NL may reduce the risk of sarcopenia by improving healthy eating behavior. This study also observed that high levels of nutrition cognition were not associated with possible sarcopenia. However, the

contribution of nutritional knowledge to diet quality depended on the interactions of several factors[25]. Moreover, increased nutrition knowledge does not necessarily lead to favorable attitudes toward goods containing information about health[26]; understanding of health messages is typically based on subjective ideas that are prone to misinterpretation[27] or on misinformation that leads individuals to feel confused, anxious, or incapable of making wise decisions about the foods they consume. In this study, obtaining skills and interactive skills were negatively associated with possible sarcopenia. This may be because participation in food preparation[28] or cooking meals directly[29] positively influences food choices, a process requiring nutritional obtaining and interactive skills. Additionally, reviewing information on nutrition labels has been demonstrated to be associated with making healthier food purchasing decisions[30]. Furthermore, at least one study reported the benefits of applying skills and critical skills in improving eating behaviors[31], although the authors of that study did not examine the associations of these skills with sarcopenia. Nevertheless, the results of these studies suggest that improving NL is an effective method of controlling the incidence of sarcopenia.

In the present study, a notable discrepancy in the prevalence of possible sarcopenia was observed between older adults residing in rural (33.43%) and urban (15.35%) areas. These findings are consistent with those of earlier studies[32]. One explanation for these findings may be the higher rates of self-care and physical activity in older adults in urban areas than older adults in rural areas[33], because self-care and physical activity reduce the incidence of sarcopenia[34]. Moreover, living conditions in rural areas are poor, and many older individuals are malnourished[35] and face obstacles to engaging in physical activity, such as insufficient facilities and long travel distances[36]. Additionally, access to healthcare in the Chinese countryside is poor, exacerbating the difficulties of older individuals experiencing sarcopenia[37]. NL levels also vary widely between rural and urban areas. Older adults in urban areas generally have more resources, education, and access to health care and health insurance than those in rural areas[38]. Furthermore, malnutrition rates in rural areas are nearly double those in urban areas[39]. Rural older adults are not only at high risk for sarcopenia but also have relatively low levels of nutrition, so improving NL is likely to be effective in

decreasing the prevalence of sarcopenia among rural older adults by improving nutritional status; however the negative association between NL and possible sarcopenia is difficult to establish when it comes to older adults persons in urban regions with better overall health and socioeconomic status. This shows that the prevalence of possible sarcopenia is more severe in rural regions, and that attention should be paid to improving the situation of sarcopenia in rural older persons, and that the prevalence of sarcopenia in this area might be effectively reduced by improving NL.

Households with high levels of education and high monthly incomes typically have higher levels of nutritional knowledge[40]. Education levels are thus positively associated with NL[41], and those with low monthly incomes typically have low levels of NL[42]. High levels of household income and education are also associated with a lower prevalence of sarcopenia[43]. The results of the interaction also showed that higher NL in older persons with relatively higher education could synergistically reduce the risk of possible sarcopenia in older persons.Thus, the educational and material advantages of adults in urban areas are also associated with a lower risk of sarcopenia. So, in the present study, NL was significantly and negatively associated with sarcopenia only in older adults with low educational attainment with monthly incomes of <3,000 RMB.

Having chronic diseases also affects the associations between NL and possible sarcopenia in older individuals. At least one study revealed a negative association between NL and multimorbidity, with low levels of NL associated with unhealthy dietary patterns and nutritional status, and high levels of NL associated with a lower risk of multimorbidity[41]. Additionally, muscle loss is a common manifestation of a variety of chronic diseases, such as chronic kidney disease[44], chronic liver disease[45], cardiovascular disease[46], and cancer[47]. Thus, older adults with chronic diseases are more susceptible to possible sarcopenia, a result generally consistent with our findings. Because older individuals without chronic diseases have greater muscle mass and strength[48], a lower incidence of sarcopenia, and superior overall health, the effects of improving NL on sarcopenia are noticeably less pronounced in such individuals. Our study suggests that NL is negatively associated with possible sarcopenia only in older adults with chronic diseases. Further analyses revealed the

interaction between chronic disease and NL on possible sarcopenia: having high NL and having a chronic disease were synergistically associated with a lower incidence of sarcopenia. Moreover, some studies have revealed that the self-management of chronic diseases improves quality of life[49]. As the Chinese proverb says, "A long illness makes a good doctor (i.e., capable of handling their illness)." Older adults with chronic diseases tend to pay more attention to their nutrition and diet, increasing the influence of NL on sarcopenia. Hence, enhancing NL may enable older individuals with chronic diseases to better manage the risks of sarcopenia.

Our study has some limitations. First, the cross-sectional design precluded indicating causality. Secondly, although we have conducted uniform survey and measurement training to control the quality of survey, there may still be some recall bias in self-reported data. Third, sarcopenia was screened and identified primarily by the SARC-F questionnaires, but not an objective measurement and clinical diagnosis. The urban-rural difference in the prevalence of sarcopenia could be due to the use of the questionnaire.

5. Conclusions

High NL is associated with a low risk for possible sarcopenia. Our results indicate that improving NL may be an effective method of controlling sarcopenia in older adults. However, the association between NL and the incidence of possible sarcopenia varied across residence location, education level, monthly income, and chronic disease status. Our findings suggest that greater educational efforts should be targeted at rural, less-educated, lower-income, and chronically ill older adults when developing intervention measures to prevent sarcopenia.

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Conflict of Interest

The authors declare no conflicts of interest.

Authorship

Jing Du: Conceptualization, Data curation, Writing—Original draft preparation. Yan Cui: Methodology. Ling Yang: Visualization, Investigation. Yuhui Sun: Supervision. Xi Tian: Software, Validation. Xiaoting Hu: Software, Validation. Huaqing Liu: Design, Writing—Review and Editing.

References

1. World Population Prospects - Population Division - United Nations. Published 2019. Accessed March 23, 2024. https://population.un.org/wpp/

2. National Bureau of Statistics. Published January 18, 2024. Accessed March 23, 2024. https://www.stats.gov.cn/xxgk/jd/sjjd2020/202401/t20240118_1946711.html

3. Shafiee G, Keshtkar A, Soltani A, Ahadi Z, Larijani B, Heshmat R. Prevalence of sarcopenia in the world: a systematic review and meta- analysis of general population studies. J Diabetes Metab Disord. 2017 May 16;16:21. doi: 10.1186/s40200-017-0302-x

4. Chen Z, Li WY, Ho M, Chau PH. The Prevalence of Sarcopenia in Chinese Older Adults: Meta-Analysis and Meta-Regression. Nutrients. 2021 Apr 24;13(5):1441. doi: 10.3390/nu13051441

5. Xia L, Zhao R, Wan Q, Wu Y, Zhou Y, Wang Y, et al. Sarcopenia and adverse health-related outcomes: An umbrella review of meta-analyses of observational studies. Cancer Med. 2020 Nov;9(21):7964-7978. doi: 10.1002/cam4.3428

6. Zhang X, Zhang W, Wang C, Tao W, Dou Q, Yang Y. Sarcopenia as a predictor of hospitalization among older people: a systematic review and meta-analysis. BMC Geriatr. 2018 Aug 22;18(1):188. doi: 10.1186/s12877-018-0878-0

7. Yang M, Liu Y, Zuo Y, Tang H. Sarcopenia for predicting falls and hospitalization in community-dwelling older adults: EWGSOP versus EWGSOP2. Sci Rep. 2019 Nov

27;9(1):17636. doi: 10.1038/s41598-019-53522-6

8. Beaudart C, Zaaria M, Pasleau F, Reginster JY, Bruyère O. Health Outcomes of Sarcopenia: A Systematic Review and Meta-Analysis. PLoS One. 2017 Jan 17;12(1):e0169548. doi: 10.1371/journal.pone.0169548

9. Cruz-Jentoft AJ, Sayer AA. Sarcopenia. Lancet. 2019 Jun 29;393(10191):2636-2646. doi: 10.1016/S0140-6736(19)31138-9IF

10. Dhillon RJ, Hasni S. Pathogenesis and Management of Sarcopenia. Clin Geriatr Med. 2017 Feb;33(1):17-26. doi: 10.1016/j.cger.2016.08.002

11. Anton SD, Hida A, Mankowski R, Layne A, Solberg LM, Mainous AG, et al. Nutrition and Exercise in Sarcopenia. Curr Protein Pept Sci. 2018;19(7):649-667. doi: 10.2174/1389203717666161227144349

12. Papadopoulou SK. Sarcopenia: A Contemporary Health Problem among Older Adult Populations. Nutrients. 2020 May 1;12(5):1293. doi: 10.3390/nu12051293

13. Papadopoulou SK, Papadimitriou K, Voulgaridou G, Georgaki E, Tsotidou E, Zantidou O, et al. Exercise and Nutrition Impact on Osteoporosis and Sarcopenia-The Incidence of Osteosarcopenia: A Narrative Review. Nutrients. 2021 Dec 16;13(12):4499. doi: 10.3390/nu13124499

14. Thornton LE, Jeffery RW, Crawford DA. Barriers to avoiding fast-food consumption in an environment supportive of unhealthy eating. Public Health Nutr. 2013 Dec;16(12):2105-13. doi: 10.1017/S1368980012005083

15. Taylor MK, Sullivan DK, Ellerbeck EF, Gajewski BJ, Gibbs HD. Nutrition literacy predicts adherence to healthy/unhealthy diet patterns in adults with a nutrition-related chronic condition. Public Health Nutr. 2019 Aug;22(12):2157-2169. doi: 10.1017/S1368980019001289

16. Spronk I, Kullen C, Burdon C, O'Connor H. Relationship between nutrition knowledge and dietary intake. Br J Nutr. 2014 May 28;111(10):1713-26. doi: 10.1017/S0007114514000087

17. Mo G, Han S, Gao T, Sun Q, Zhang M, Liu H. Development and validation of a novel short-form nutrition literacy measurement tool for Chinese college students. Front Public Health. 2022 Sep 9;10:962371. doi: 10.3389/fpubh.2022.962371

18. Zhang Y, Sun Q, Zhang M, Mo G, Liu H. Nutrition Literacy Measurement Tool With Multiple Features for Chinese Adults. Food Nutr Bull. 2022 Jun;43(2):189-200. doi: 10.1177/03795721211073221

19. Chen LK, Woo J, Assantachai P, Auyeung TW, Chou MY, Iijima K, et al. Asian Working Group for Sarcopenia: 2019 Consensus Update on Sarcopenia Diagnosis and Treatment. J Am Med Dir Assoc. 2020 Mar;21(3):300-307.e2. doi: 10.1016/j.jamda.2019.12.012

20. Chen CY, Tseng WC, Yang YH, Chen CL, Lin LL, Chen FP, et al. Calf Circumference as an Optimal Choice of Four Screening Tools for Sarcopenia Among Ethnic Chinese Older Adults in Assisted Living. Clin Interv Aging. 2020 Dec 23;15:2415-2422. doi: 10.2147/CIA.S287207

21. Malmstrom TK, Morley JE. SARC-F: a simple questionnaire to rapidly diagnose sarcopenia. J Am Med Dir Assoc. 2013 Aug;14(8):531-2. doi: 10.1016/j.jamda.2013.05.018

22. Coelho-Junior HJ, Calvani R, Azzolino D, Picca A, Tosato M, Landi F, et al. Protein Intake and Sarcopenia in Older Adults: A Systematic Review and Meta-Analysis. Int J Environ Res Public Health. 2022 Jul 18;19(14):8718. doi: 10.3390/ijerph19148718

23. Liao LL, Lai IJ, Chang LC. Nutrition literacy is associated with healthy-eating behaviour among college students in Taiwan. Health Educ J. 2019;78(7):756-769. doi:10.1177/0017896919836132

24. Bloom I, Shand C, Cooper C, Robinson S, Baird J. Diet Quality and Sarcopenia in Older Adults: A Systematic Review. Nutrients. 2018 Mar 5;10(3):308. doi: 10.3390/nu10030308

25. Wardle J, Parmenter K, Waller J. Nutrition knowledge and food intake. Appetite. 2000;34(3):269-275. doi:10.1006/appe.1999.0311

26. Wills JM, Storcksdieck genannt Bonsmann S, Kolka M, et al. European consumers and health claims: attitudes, understanding and purchasing behaviour. Proc Nutr Soc. 2012 May;71(2):229-36. doi: 10.1017/S0029665112000043

27. Dickson-Spillmann M, Siegrist M. Consumers' knowledge of healthy diets and its correlation with dietary behaviour. J Hum Nutr Diet. 2011 Feb;24(1):54-60. doi: 10.1111/j.1365-277X.2010.01124.x

28. Laska MN, Larson NI, Neumark-Sztainer D, Story M. Does involvement in food preparation track from adolescence to young adulthood and is it associated with better dietary quality? Findings from a 10-year longitudinal study. Public Health Nutr. 2012 Jul;15(7):1150-8. doi: 10.1017/S1368980011003004

29. Da Rocha Leal FM, De Oliveira BMPM, Pereira SSR. Relationship between cooking habits and skills and Mediterranean diet in a sample of Portuguese adolescents. Perspect Public Health. 2011;131(6):283-287. doi:10.1177/1757913911419909

30. Ni Mhurchu C, Eyles H, Jiang Y, Blakely T. Do nutrition labels influence healthier food choices? Analysis of label viewing behaviour and subsequent food purchases in a labelling intervention trial. Appetite. 2018 Feb 1;121:360-365. doi: 10.1016/j.appet.2017.11.105

31. Qi Q, Sun Q, Yang L, Cui Y, Du J, Liu H. High nutrition literacy linked with low frequency of take-out food consumption in chinese college students. BMC Public Health. 2023 Jun 13;23(1):1132. doi: 10.1186/s12889-023-16078-9

32. Gao L, Jiang J, Yang M, Hao Q, Luo L, Dong B. Prevalence of Sarcopenia and Associated Factors in Chinese Community-Dwelling Elderly: Comparison Between Rural and Urban Areas. J Am Med Dir Assoc. 2015 Nov 1;16(11):1003.e1-6. doi: 10.1016/j.jamda.2015.07.020

33. Paek, Hyun Hee, Jeong Ja Kim. Comparison of quality of life according to physical activities of the elderly with chronic diseases between urban and rural areas. J Korean Soc Occup Ther. 2013;21(3):75-86.

34. Iolascon G, Di Pietro G, Gimigliano F, Mauro GL, Moretti A, Giamattei MT, et al. Physical exercise and sarcopenia in older people: position paper of the Italian Society of Orthopaedics and Medicine (OrtoMed). Clin Cases Miner Bone Metab. 2014 Sep;11(3):215-21.

35. Zhang G, Kang J, Jing S, Chen Y, Deng T, Xu H, et al. Meat, vegetable, and fruit consumption among urban and rural elders aged 60+ years in regional China: a population-level nutritional study. J Nutr Sci. 2023 Nov 30;12:e120. doi: 10.1017/jns.2023.104

36. Zheng J, An R. Satisfaction with local exercise facility: a rural-urban comparison in China. Rural Remote Health. 2015 Jan-Mar;15(1):2990.

37. Li XM, Kou J, Yu Z, Xiao YY, Meng Q, He LP. Health Equity of Rural Residents in Southwest China. Front Public Health. 2021 Mar 23;9:611583. doi: 10.3389/fpubh.2021.611583

38. Su B, Shen X, Wei Z. Leisure Life in Later Years: Differences between Rural and Urban Elderly Residents in China. J Leis Res. 2006;38(3):381-397. doi:10.1080/00222216.2006.11950084

39. Crichton M, Craven D, Mackay H, Marx W, de van der Schueren M, Marshall S. A systematic review, meta-analysis and meta-regression of the prevalence of protein-energy malnutrition: associations with geographical region and sex. Age Ageing. 2019 Jan 1;48(1):38-48. doi: 10.1093/ageing/afy144

40. Dallongeville J, Marécaux N, Cottel D, Bingham A, Amouyel P. Association between nutrition knowledge and nutritional intake in middle-aged men from Northern France. Public Health Nutr. 2001 Feb;4(1):27-33. doi: 10.1079/phn200052

41. Aihemaitijiang S, Ye C, Halimulati M, Huang X, Wang R, Zhang Z. Development and Validation of Nutrition Literacy Questionnaire for the Chinese Elderly. Nutrients. 2022 Feb 27;14(5):1005. doi: 10.3390/nu14051005

42. Camargo JT, Ramirez M, Gajewski BJ, Sullivan DK, Carlson SE, Gibbs HD. Nutrition

Literacy Among Latina/x People During Pregnancy Is Associated With Socioeconomic Position. J Acad Nutr Diet. 2022 Nov;122(11):2097-2105. doi: 10.1016/j.jand.2022.05.011

43. Wan H, Hu YH, Li WP, Wang Q, Su H, Chenshu JY, et al. Quality of life, household income, and dietary habits are associated with the risk of sarcopenia among the Chinese elderly. Aging Clin Exp Res. 2024 Feb 9;36(1):29. doi: 10.1007/s40520-023-02656-9

44. Sabatino A, Cuppari L, Stenvinkel P, Lindholm B, Avesani CM. Sarcopenia in chronic kidney disease: what have we learned so far? J Nephrol. 2021 Aug;34(4):1347-1372. doi: 10.1007/s40620-020-00840-y

45. Allen SL, Quinlan JI, Dhaliwal A, Armstrong MJ, Elsharkawy AM, Greig CA, et al. Sarcopenia in chronic liver disease: mechanisms and countermeasures. Am J Physiol Gastrointest Liver Physiol. 2021 Mar 1;320(3):G241-G257. doi: 10.1152/ajpgi.00373.2020

46. Damluji AA, Alfaraidhy M, AlHajri N, Rohant NN, Kumar M, Al Malouf C, et al. Sarcopenia and Cardiovascular Diseases. Circulation. 2023 May 16;147(20):1534-1553. doi: 10.1161/CIRCULATIONAHA.123.064071

47. Peterson SJ, Mozer M. Differentiating Sarcopenia and Cachexia Among Patients With Cancer. Nutr Clin Pract. 2017 Feb;32(1):30-39. doi: 10.1177/0884533616680354

48. Sinclair AJ, Abdelhafiz AH, Rodríguez-Mañas L. Frailty and sarcopenia - newly emerging and high impact complications of diabetes. J Diabetes Complications. 2017 Sep;31(9):1465-1473. doi: 10.1016/j.jdiacomp.2017.05.003

49. Allegrante JP, Wells MT, Peterson JC. Interventions to Support Behavioral Self-Management of Chronic Diseases. Annu Rev Public Health. 2019 Apr 1;40:127-146. doi: 10.1146/annurev-publhealth-040218-044008

Table 1 Nutrition Literacy in Participants.

Baseline characteristic	Overall	Nutrition literacy				*P-value*
		Q1(12-30)	Q2(31-35)	Q3(36-41)	Q4(42-60)	
N(%)	1338	359(26.83)	336(25.11)	322(24.07)	321(23.99)	
Age(Mean，SD)	71.41(6.84)	72.67(6.81)	71.57(6.98)	71.52(6.95)	69.73(6.30)	<0.001
Sex, n(%)						<0.001
Male	608(45.44)	137(38.16)	145(43.15)	173(53.73)	153(47.66)	
Female	730(54.56)	222(61.84)	191(56.85)	149(46.27)	168(52.34)	
Residence, n(%)						<0.001
City	632(47.23)	105(29.25)	129(38.39)	176(54.66)	222(69.16)	
Rural	706(52.77)	254(70.75)	207(61.61)	146(45.34)	99(30.84)	
Smoking status, n(%)						0.051
Never smoked	904(67.56)	260(72.42)	231(68.75)	198(61.49)	215(66.98)	
Used to smoke	167(12.48)	40(11.14)	36(10.71)	44(13.66)	47(14.64)	
Currently smoking	267(19.96)	59(16.43)	69(20.54)	80(24.84)	59(18.38)	
Drinking status, n(%)						0.021

Never drank	836(62.48)	248(69.08)	209(62.20)	189(58.70)	190(59.19)	
Used to drink	186(13.90)	38(10.58)	39(11.61)	55(17.08)	54(16.82)	
Currently drinking	316(23.62)	73(20.33)	88(26.19)	78(24.22)	77(23.99)	
Exercise, n(%)						<0.001
Never exercised	370(27.72)	164(45.68)	103(30.75)	66(20.50)	37(11.60)	
Past exercise	114(8.54)	17(4.74)	42(12.54)	31(9.63)	24(7.52)	
Current exercise	851(63.75)	178(49.58)	190(56.72)	225(69.88)	258(80.88)	
Education, n(%)						<0.001
primary school and below	783(58.65)	303(84.40)	239(71.13)	160(50.00)	81(25.31)	
Junior high school	302(22.62)	45(12.53)	67(19.54)	88(27.50)	102(31.88)	
High school and above	250(18.73)	11(3.06)	30(8.93)	72(22.50)	137(42.81)	
Type of occupation, n(%)						<0.001
Farmers	464(34.76)	164(45.68)	150(45.05)	99(30.75)	51(15.89)	
Separated/retired staff	618(46.29)	105(29.25)	120(36.04)	167(51.86)	226(70.40)	
Others	253(18.95)	90(25.07)	63(18.92)	56(17.39)	44(13.71)	
Marital status, n(%)						0.009
Married	1053(78.70)	267(74.37)	255(75.89)	263(81.68)	268(83.49)	

Others	285(21.30)	92(25.63)	81(24.11)	59(18.32)	53(16.51)	
Monthly income, n(%)						<0.001
<3000RMB	1019(76.91)	327(91.85)	283(85.76)	229(72.01)	180(56.07)	
≥3000RMB	306(23.09)	29(8.15)	47(14.24)	89(27.99)	141(43.93)	
Chronic diseases status, n(%)						<0.001
No	196(14.65)	38(10.58)	32(9.52)	65(20.19)	61(19.00)	
Yes	1142(85.35)	321(89.42)	304(90.48)	257(79.81)	260(81.00)	
BMI, n(%)						0.514
<18.5 kg/m2	31(2.32)	8(2.24)	8(2.40)	9(2.80)	6(1.87)	
18.5-23.9 kg/m2	505(37.86)	140(39.22)	118(35.33)	129(40.06)	118(36.76)	
24-27.9 kg/m2	559(41.90)	143(40.06)	145(43.41)	121(37.58)	150(46.73)	
≥28 kg/m2	239(17.92)	66(18.49)	63(18.86)	63(19.57)	47(14.64)	
Average daily protein intake, g (Mean，SD)	55.86(27.67)	51.92(27.47)	51.01(21.47)	57.95(29.97)	63.19(29.50)	<0.001

Data are presented as mean (SD) or n (%)

Table 2 Logistic regression modelling for nutrition literacy and sarcopenia

Characteristics	*B*	*SE*	Sarcopenia *OR*（95% *CI*)	*P-value*
Nutrition literacy(Q1)				
Q2	-0.09	0.19	0.91(0.63-1.32)	0.620
Q3	-0.34	0.21	0.71(0.47-1.07)	0.104
Q4	-0.75	0.25	0.48(0.29-0.77)	0.003
Nutrition cognition(Q1)				
Q2	0.14	0.20	1.15(0.78-1.70)	0.475
Q3	0.21	0.25	1.24(0.77-2.00)	0.385
Q4	0.14	0.27	1.15(0.67-1.96)	0.622
Knowledge(Q1)				
Q2	0.18	0.18	1.20(0.84-1.70)	0.313
Q3	0.46	0.25	1.58(0.97-2.58)	0.064
Q4	0.10	0.29	1.11(0.63-1.94)	0.728
Understanding(Q1)				
Q2	0.04	0.20	1.04(0.70-1.54)	0.853
Q3	0.41	0.34	1.51(0.77-2.93)	0.228
Q4	0.03	0.30	1.03(0.57-1.84)	0.924
Nutrition skills(Q1)				
Q2	-0.18	0.20	0.84(0.57-1.24)	0.375
Q3	-0.41	0.23	0.66(0.43-1.03)	0.066
Q4	-0.92	0.30	0.40(0.22-0.71)	0.002
Obtaining skills(Q1)				
Q2	0.11	0.23	1.11(0.70-1.76)	0.653
Q3	-0.59	0.28	0.55(0.32-0.96)	0.037
Q4	-0.37	0.29	0.69(0.39-1.21)	0.196
Applying skills(Q1)				

Q2	0.04	0.21	1.04(0.68-1.57)	0.864
Q3	0.20	0.22	1.22(0.79-1.86)	0.371
Q4	-0.29	0.25	0.75(0.46-1.22)	0.243
Interactive skills(Q1)				
Q2	-0.24	0.21	0.79(0.52-1.19)	0.264
Q3	-0.43	0.21	0.65(0.43-0.99)	0.044
Q4	-0.06	0.29	0.95(0.54-1.66)	0.844
Critical skills(Q1)				
Q2	-0.003	0.19	1.00(0.69-1.44)	0.985
Q3	-0.05	0.28	0.96(0.55-1.65)	0.869
Q4	-0.41	0.27	0.67(0.39-1.13)	0.129

B: regression coefficient. SE: standard error. OR: odds ratio. CI: confidence interval. The results are adjusted for age, sex, residential location type, smoking status, drinking status, exercise habits, education level, occupation, marital status, monthly income, chronic diseases, BMI, and average daily protein intake.

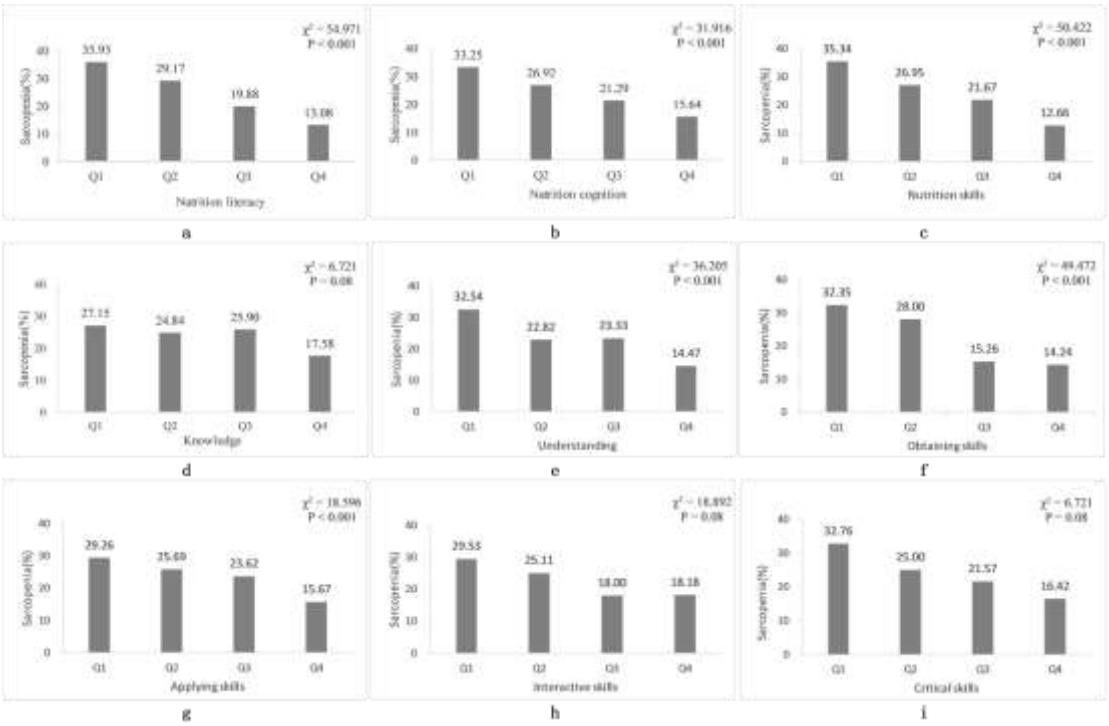

Figure 1. Prevalence of sarcopenia according to quartiles of nutrition literacy.

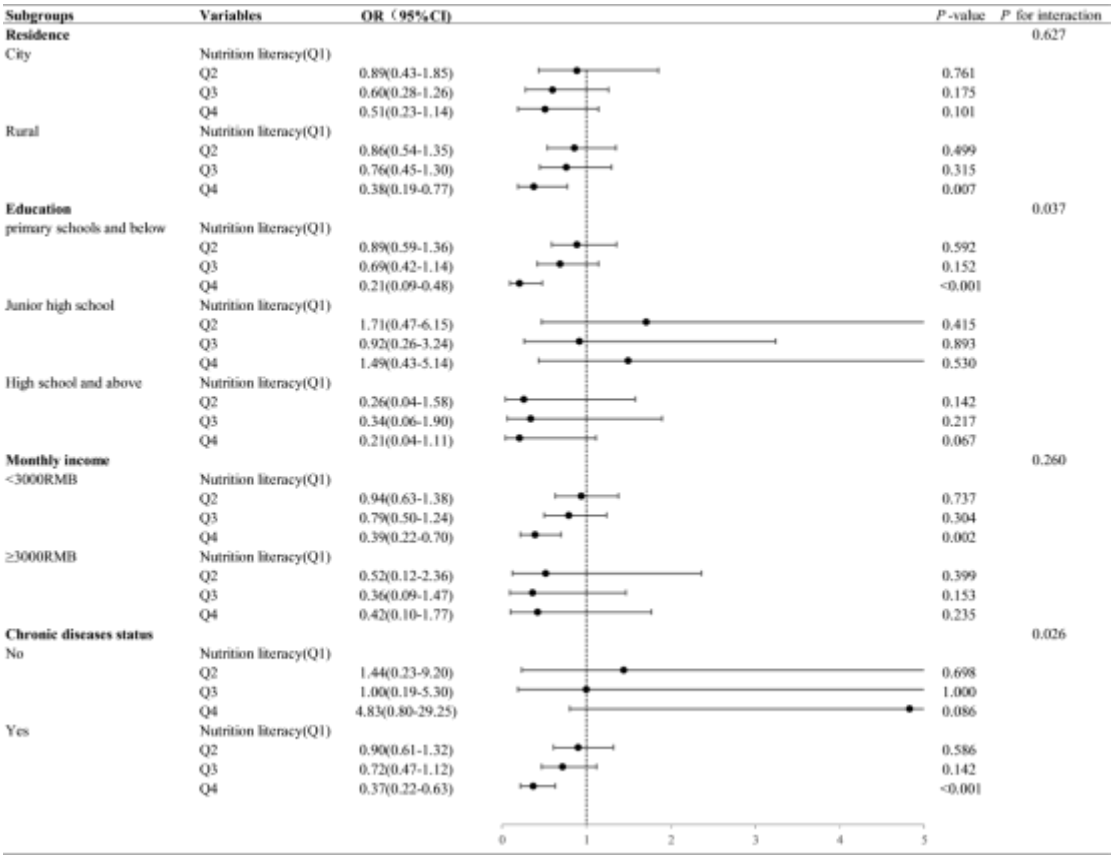

Figure 2. Associations of nutrition literacy with sarcopenia stratified by residential area type, education level, monthly income, and chronic diseases, and their interaction with nutrition literacy for sarcopenia.

OR: odds ratio. CI: confidence interval. The results are adjusted for age, sex, residence, smoking status, drinking status, exercise habits, education levels, occupation, marital status, monthly income, chronic diseases, BMI, and average daily protein intake.