Original Article

The Geriatric Nutritional Risk Index predicts mortality in nonagenarians and centenarians receiving home care

Hui Wang MD[1,2], Shan Hai MD[1], Yan Zhou MD[1], Ping Liu MM[1], Bi-Rong Dong MD[1]

[1]*Center of gerontology and geriatrics, West China Hospital, Sichuan University, China*
[2]*Collaborative innovation center of Sichuan for elderly care and health, Chengdu, China*

Background and Objectives: The increasing prevalence of malnutrition in old people is related to the risk of illness and death. A number of screening tools to detect malnutrition have been used in the elderly to assess nutritional status and predict prognosis. The aim of the present study was to investigate the ability of the Geriatric Nutritional Risk Index (GNRI) to assess nutritional status and predict mortality in very old home-care people by using a cross-sectional study of Chinese older people aged 90–105 years. **Methods and Study Design:** The present study was based on a 4-year follow-up of mortality data from a previous cross-sectional study. The study was conducted with a very elderly population with a mean age of 93.5±3.2 years (n=716; 230 men and 486 women). In 2005, trained researchers performed face-to-face interviews and physical and geriatric assessments to obtain information on sociodemographic factors, self-reported medical diseases, geriatric-specific conditions, anthropometric factors, biochemical data, and the GNRI score. In 2009, vital status were requested from the local government. **Results:** After 4 years of follow-up, 371 participants died (125 men and 246 women, 51.8%). The median follow-up time was significantly worse in the nutritional risk group (GNRI ≤98) (30.26±15.80 vs 42.27±11.82 months, p<0.001). Activities of daily living (ADL) impairment (hazard ratio [HR]=1.414, 95% CI=1.121–1.783), and GNRI score (HR=0.92, 95% CI=0.908–0.932) were associated with all-cause mortality according to a Cox regression analysis. **Conclusions:** The GNRI, a nutrition-related risk index, can predict mortality in very old Chinese home-care people.

Key Words: elderly, Geriatric Nutritional Risk Index, malnutrition, mortality, albumin

INTRODUCTION

The global elderly population (>65 years) has gradually increased over the past few decades. Several studies have revealed that older people are at risk of acute and chronic diseases such as trauma, infection, and inflammation which may alter metabolism, appetite, or absorption or assimilation of nutrients, and consequently lead to malnutrition.[1] Malnutrition also may increase the risk of illness, prolong hospital stay and significantly contributes to morbidity and mortality in the elderly.[2,3] A relatively low prevalence of malnutrition was found in free-living elderly (2–10%) and a considerably higher prevalence was found in the hospitalized or institutionalized elderly (30–60%).[4] A study corroborated that early nutritional screening improves recognition of malnourished patients in hospitals and that nutritional therapy in such patients results in a shorter length of stay.[5] A number of screening tools that identify patients who might benefit clinically from nutritional support have been used in community, nursing homes, and hospitals. For example, the European Society for Clinical Nutrition and Metabolism and the American Society for Parenteral and Enteral Nutrition recommend the use of the Mini Nutritional Assessment (MNA) and Subjective Global Assessment (SGA), respectively, for elderly patients.[6]

Another screening tool, the Geriatric Nutritional Risk Index (GNRI), was created by modifying the Nutritional Risk Index (NRI).[7] Owing to the difficulties in establishing usual body weight in the elderly, usual body weight in the NRI was replaced with ideal body weight in the GNRI. Cereda et al investigated the impact of the GNRI, length of stay, and weight loss during hospitalization in elderly patients[8] and found that the GNRI can predict all-cause and cardiovascular mortality.[9] Sebastian et al found that the GNRI can predict increased future healthcare costs and higher risk of hospitalization in independent-living older adults.[10] However, most of the literature regarding the GNRI have focused on elderly inpatients. Very little research has been conducted regarding the use of the GNRI in home-care resident elderly, especially the very old.

Thus, the aim of the present study was to investigate the ability of the GNRI to assess nutritional status and predict mortality in Chinese people aged 90–105 years receiving home care by using a cross-sectional study.

Corresponding Author: Prof Bi-Rong Dong, The Center of Gerontology and Geriatrics, West China Hospital, Sichuan University, 37 Guoxue Lane, Chengdu, 610041 China.
Tel: +86-28-85422321; Fax: +86-028-85422321
Email: birongdong@163.com
Manuscript received 05 May 2016. Initial review completed 21 July 2016. Revision accepted 22 August 2016.
doi: 10.6133/apjcn.022017.10

METHODS

Study design

The present study was based on mortality data from the 4-year follow-up in a previous cross-sectional study of a very elderly population from Dujiangyan (Sichuan Province, Southwest China). In the summer of 2005, researchers from the Department of Geriatrics of Sichuan University conducted a cross-sectional study called the Project of Longevity and Aging in Dujiangyan (PLAD). The aim of the PLAD was to investigate the relationships among environment, genetics, lifestyle, cognitive function, longevity, and age-related chronic conditions. A total of 1115 residents aged ≥90 years were screened, with a remarkable "capture rate" of 870 residents (78%). In 2009, after 4 years of follow-up, mortality data were requested from local government registries for the period from the summer of 2005 (original date of the PLAD study) to the summer of 2009. Of the original 870 participants, 128 (39 men and 89 women) were excluded from the study owing to lack of information regarding height, weight or albumin; 26 participants (10 men and 16 women) were excluded due to missing vital status, reasons for missing vital status information included the change of the residence and the inability of the local government to complete the search in the given time. The interview was conducted with 716 people (230 men and 486 women).

Informed consent was obtained from all the participants or their legal proxies. The study was approved by the Sichuan University Research Ethics Committee and conformed to the provisions of the Declaration of Helsinki in 1995.

Nutritional assessment

Anthropometry and biochemistry

Body weight, height, mid arm circumference (MAC) and calf circumference (CC) were measured, and body mass index (BMI) was calculated by using standard equations.[11] Venous blood samples were collected after an overnight fast to measure the levels of plasma glucose, plasma lipid, and serum albumin and other biochemical indicators.

Geriatric Nutritional Risk Index

The risk of nutrition-related health complications was assessed by using the GNRI.[7] This tool requires the evaluation of serum albumin level, weight, and height, and the calculation of ideal body weight by using Lorentz's formula. The score is derived by using the following equation: GNRI = (1.489 × albumin [g/L]) + (41.7 × weight / ideal body weight).[12] When weight exceeded the ideal body weight, a score of 1 was assigned as the weight-to-ideal body weight ratio. Then, the patients were classified as at major risk (GNRI <82), moderate risk (82-<92), low risk (92–98), and no risk (GNRI >98).[7] To compare the subjects with low GNRI values with those with normal GNRI, we merged the major-, moderate-, and low-risk groups into the low GNRI group, by using a cutoff score of 98.

Assessment of covariates

Covariates in the analyses included age, sex, education level, and functional status, which was measured as activities of daily living (ADL) by using the Katz Index. Impaired ADL was defined as impairment in one or more of the six basic ADLs (feeding, dressing, grooming, bathing, walking, and toileting).[13] Cognitive status was measured by using the Mini-Mental State Examination (MMSE). The individuals were categorized as follows: possible dementia (MMSE score, between 0 and 18), mild cognitive impairment (between 19 and 24), and normal (between 25 and 30), according to educational level. Because the MMSE relies heavily on visual and auditory abilities, especially at advanced ages,[14,15] the prevalence of visual or hearing impairment is high among nonagenarians and centenarians. In our study, only 51 subjects had scores higher than 24 (37 in men and 14 in women, normal) and 229 subjects had scores between 19 and 24 (93 in men and 136 in women, mild cognitive impairment). Therefore, the cognitive impairment was defined as a score of <19.[16,17] Visual impairment, hearing impairment, falls and fractures in the past year were reported by participants or an accompanying family member. In addition, major chronic diseases and the number of chronic diseases that could be potentially related with mortality were also assessed by trained personnel by using a self-reported questionnaire. These diseases included osteoarthritis, gastrointestinal diseases, cardiovascular and cerebrovascular disease (CCVD; including hypertension, chronic heart failure, chronic heart disease, cerebrovascular disease, and peripheral vascular disease), respiratory diseases, chronic renal disease, cancer, and diabetes.

Statistical analysis

All of the statistical analyses were performed by using SPSS version18.0 for Windows (IBM Corp, Armonk, NY). Baseline characteristics were compared among the groups (alive or deceased) by using the independent t tests for continuous variables and Pearson Chi-Square tests or Fisher exact tests (when an expected cell count was <1) for categorical variables.

Kaplan-Meier curves were plotted by using the log-rank test to demonstrate the association between survival and nutritional risk (low GNRI scores). As age, sex, anthropometry, chronic diseases, and geriatric conditions (ADL impairment, cognitive impairment, hearing and visual impairment, falls, and fractures) are viewed as general factors closely related with mortality in old people, multivariable Cox regression models were used to estimate the hazard ratios (HRs) to identify the independent predictors of mortality.

RESULTS

Baseline characteristics

Among the 716 participants, the mean age was 93.5±3.2 years (range, 90–105 years), and 42 residents were centenarians. The mean ages of the men and women were 93.1±3.0 and 93.7±3.3 years, respectively. 90% of the participants lived in the countryside, 80.3% were farmers, and 73% had no formal education. Impaired ADL and cognitive impairment were present in 32.3% and 45.3% of the participants, respectively. At least one chronic disease was present in 74% of the participants. The most prevalent diseases were osteoarthritis (29.2%), gastrointestinal diseases (17.0%), and respiratory diseases

(14.8%). The mean GNRI score was 98.9±8.3, without significant difference between the men and women (99.29±7.33 vs 98.70±8.80; p=0.147). The prevalence rates of major, moderate, low, and no nutritional risks were 2.2%, 16.9%, 25.3%, and 55.6%, respectively, and the prevalence of overall nutritional risk is 44.4% in all the participants.

Nutritional risk and mortality

Characteristics of participants

During the 4-year follow-up, 371 participants died (125 men and 246 women, 51.8%). The participants were classified according to survival status (Table 1). In the independent t tests, age was the only sociodemographic variable that was significantly associated with mortality risk (93.24±3.21 vs 93.76±3.17 years; p=0.01). No significant differences in sex, educational level, smoking, and drink were found. A higher number of comorbidities were found in deceased group (0.97±0.86 vs 1.12±0.92; p=0.043). No significant differences in body weight, height and BMI were observed in the living participants (41.30±8.15 vs 41.13±8.52 kg, p=0.785; 146.43±10.53 vs 146.56±9.72 cm, p=0.839; and 19.26±3.16 vs 19.11±3.33 kg/m^2, p=0.555). MAC and albumin level correlated negatively to mortality (p<0.05). The prevalent geriatric conditions were hearing problems (55.6%), falls (52.2%), vision problems (43.6%), cognitive impairment (39.1%), ADL impairment (32.1%), and fracture (9.8%). Only ADL and cognitive impairments were significantly associated with mortality risk. The GNRI, a nutritional variable, significantly differed between the living and deceased groups (102.78±7.37 vs 95.26±7.55, p=0.007). The prevalence rates of major, moderate, low, and no-nutritional risks in the living group were 0.3%, 5.5%, 17.7%, and 76.5%, respectively. The prevalence in the deceased group were 4.0%, 27.5%, 32.3%, and 36.1%, respectively.

Nutritional risk and all-cause mortality

Survival curves were plotted by the Kaplan-Meier method (Figure 1). The median follow-up time was significantly worse in the nutritional risk group (GNRI ≤98) than in the no-nutritional risk group (GNRI >98), (30.26±15.80 vs 42.27±11.82 months, p<0.001). In the adjusted Cox regression analysis, only two variables were associated with increased all-cause mortality as follows: ADL impairment (HR=1.414; 95% CI, 1.121–1.783) and the GNRI (HR=0.92; 95% CI, 0.908–0.932; Table 2). The other variables were not associated with all-cause mortality over the 4-year follow-up period

DISCUSSION

To the best of our knowledge, this is the first study that describes the use of the GNRI, which enables the determination of the risk of malnutrition-related mortality, in a long-lived community-dwelling population with mean age of 93.5±3.2 years. With a GNRI score of ≤98 as the nutrition-related risk index in the present study, the prevalence of nutritional risk was 42.7%. This was much higher than the nutritional risk of community-dwelling elderly (26%) and nearly similar to the prevalence of hospitalized patients (68.5%).[18] The participants in our study were all

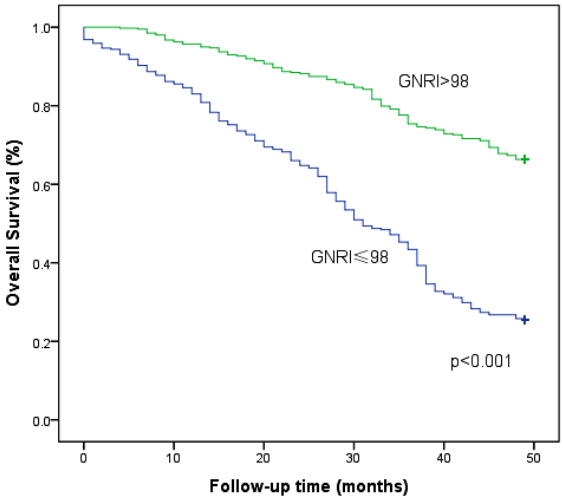

Figure 1. Participants with nutritional risk (GNRI ≤98) had significantly worse all-cause survival than participants without nutritional risk (GNRI >98). Survival curves were plotted by the Kaplan-Meier method. GNRI: Geriatric Nutritional Risk Index.

nonagenarians and centenarians, and our study revealed that age negatively affects nutritional status, which was similar to previous study.[19] Another study in Taiwan with a representative cohort of elderly people aged >53 years (n=4,440) also reported that the proportion of malnutritional free-living elderly increased from 0.88% to 5.30% with advancing age, from 53–60 to >80 years old, while the proportion of the risk of malnutrition increased from 8.08% to 23.96%.[20]

The prevalence of malnutrition is significant (15–60%) in elderly patients who were hospitalized, living in nursing homes, or in home-care programs.[18] In the past two decades, a number of geriatric assessment instruments have been developed for use in the diagnosis and treatment high-risk elderly patients. The European Society of Parenteral and Enteral Nutrition recommends the MNA as the criterion standard in the identification of malnutrition in elderly patients.[6] It is economical and can be completed in about 15 min. However, because the participants in the present study were very old (mean age, 93.5 years), with hearing problems (55.6%), visual problems (43.6%), and cognitive impairment (39.1%), they had difficulty answering the questionnaire. Performing the GNRI takes only a few min (for weight and height measurements and blood sample collection) and has low participant burden.[21] Thus, GNRI can be used in very old participants, especially those with cognitive, hearing, or visual impairment. The relationship between GNRI score and mortality is substantial in our research; the mean score was approximately 8% (102.78±7.37 vs 95.26±7.55) higher in the living group. Moreover, we merged the major-, moderate- and low-risk groups into the low GNRI group by using a cutoff score of 98. The mean survival time was significantly worse in the participants with low GNRI scores than in those with normal GNRI scores according to the Kaplan-Meier survival curve and Cox regression analysis. Furthermore, these associations were independent of other established correlates of mortality, including socioeconomic characteristics, lifestyle factors, coexisting chronic diseases, and geriatric conditions. Previous stud-

Table 1. Comparison of characteristics of Chinese nonagenarians and centenarians according to vital status after 4-year follow-up

	Alive	Deceased	t or Pearson chi-square	*p*
Age, year	93.24±3.21	93.76±3.17	-2.176	0.01
Male/female	105/240	125/246	0.869	0.352
Education level			0.082	0.775
Illiteracy	248/342	271/369		
Literacy	59/342	64/369		
Primary school	26/342	24/369		
Secondary school	7/342	7/369		
>Secondary school	2/342	3/369		
Alcohol intake			0.093	0.761
Current	94/339	90/366		
Former	53/339	73/366		
No	192/339	203/366		
Smoking			0.902	0.343
Current	156/341	155/368		
Former	70/341	79/368		
No	115/341	134/368		
Choronic diseases				
Osteoarthritis	93/259	116/282	1.56	0.213
Cardiovascular disease	55/337	59/369	0.382	0.537
Respiratory diseases	40/223	66/251	4.779	0.029
Chronic renal disease	7/198	9/223	0.072	0.789
Gastrointestinal diseases	54/233	68/266	0.382	0.537
Cancer	3/221	4/249	0.049	0.824
Diabetes	1/203	7/228	3.934	0.048
Number of comorbidities	0.97±0.86	1.12±0.92	-2.031	0.043
Geriatric conditions				
ADL impairment	94/341	136/371	6.761	0.01
Cognitive impairment	141/301	180/317	6.15	0.013
Vision problems	149/294	163/321	0.001	0.981
Hearing problems	182/296	216/333	0.768	0.381
Falls	176/333	198/358	0.418	0.518
Fractures	31/326	39/349	0.502	0.479
MAC, cm	23.43±3.62	22.90±3.57	1.972	0.049
CC, cm	25.88±3.39	26.24±3.65	-1.347	0.178
Albumin, g/L	43.30±3.51	42.45±3.41	3.291	0.001
Weight, kg	41.30±8.15	41.13±8.52	0.273	0.785
Height, m	146.43±10.53	146.56±9.72	-0.177	0.839
BMI, kg/m^2	19.26±3.16	19.11±3.33	0.591	0.555
Underweight (<18.5)	149/345	162/371		
Normal (18.5-23)	161/345	168/371		
Overweight (23-27)	32/345	37/371		
Obesity (>27)	4/345	4/371		
GNRI	102.78±7.37	95.26±7.55	2.718	0.007

MAC: mid arm circumference; CC: calf circumference; ADL: activities of daily living; GNRI: Geriatric Nutritional Risk Index.
†Baseline characteristics were compared between alive and deceased groups, using Pearson Chi-Square tests or Fisher exact test (where an expected cell count was <5) for categorical variables and independent t test for continuous variables
*p<0.05 was considered to be statistically significant.

Table 2. The relation of mortality and geriatric conditions, nutritional and anthropometric variables according to Cox multivariate regression analysis (adjusted HR and 95% CI)

	B	S.E.	*p*	HR	95% CI
GNRI	-0.084	0.007	<0.001	0.92	0.908-0.932
ADL impairment	0.346	0.118	0.003	1.414	1.121-1.783

ADL: activities of daily living; GNRI: Geriatric Nutritional Risk Index
†Age, gender, ADL impairment, cognitive impairment and other variables that were significant at a p<0.05 in the unadjusted analyses were entered into the Cox regression models
*p<0.05 was considered to be statistically significant.

ies have investigated the relationship between GNRI score and mortality. For example, Cereda et al reported that all-cause and cardiovascular mortality were significantly associated with nutritional risk, as assessed by using the GNRI tool.[9]

In our study, the albumin level was 42.86±3.48 g/L and did not significantly correlate with mortality. This observation conflicts with the result of some previous

studies that found that the albumin was a major measure of malnutrition and a long-term predictor of mortality.[22] However the population, which has a mean age of 74.6 years, was quite different from ours. Our study was conducted in a long-lived community-dwelling population with a mean age of 93.5±3.20 years, and 54.6% of the participants reported to have chronic diseases. Previous research studies showed that serum albumin level might be related more with hydration or inflammation.[7,23] This may explain the lack of correlation between albumin level and mortality in our study. As both extremes of BMI confer increased risk of mortality in older persons, an inverted U-shaped curve has been invoked as the model of survival according to BMI.[24,25] However, no significant difference was observed in our study. The populations of most previous studies were younger than that of our research. Another important feature of our study is that the mean BMI was 19.18±3.25 kg/m^2, and only 9.8% of the participants were overweight or obesity. Thus, the GNRI, with the additional information for ideal weight, might predict nutrition-related mortality better than albumin level or BMI.

However, some limitations should be taken into account for the correct interpretation of data. Nowadays, a number of screening tools have been used to identify the nutritional status of the elderly. In our study, we used only the GNRI as the nutritional screening tool and did not compare GNRI with other commonly applied tools such as MNA. In the future study, we will compare the GNRI with other screening tools.

Conclusions

In conclusion, the GNRI is a nutrition-related risk index that enables the prediction of mortality in elderly people, who are often malnourished. Furthermore, because of its convenience, it can be used in elderly patients who have difficulty finishing a questionnaire.

ACKNOWLEDGEMENTS

The authors are grateful to our volunteers for participating in the study.

AUTHOR DISCLOSURES

This work was supported by the fund for discipline development from West China Hospital of Sichuan University (No. HK05001). No sponsors had any role in the design, methods, subject recruitment, data collections, analysis, or preparation of this manuscript. None of the authors of this paper has any competing interests related to the study.

REFERENCES

1. Goldwasser P, Feldman J. Association of serum albumin and mortality risk. J Clin Epidemiol. 1997;50:693-703. doi: 10.1016/S0895-4356(97)00015-2.
2. Chen CC, Schilling LS, Lyder CH. A concept analysis of malnutrition in the elderly. J Adv Nurs. 2001;36:131-42. doi: 10.1046/j.1365-2648.2001.01950.x.
3. DiMaria-Ghalili RA, Amella E. Nutrition in older adults. Am J Nurs. 2005;105:40-50. doi: 10.1097/00000446-200503000-00020.
4. Guigoz Y, Vellas B, Garry PJ. Assessing the nutritional status of the elderly: the Mini Nutritional Assessment as part of the geriatric evaluation. Nutr Rev. 1996;54:59-65.
5. Kruizenga HM, Van Tulder MW, Seidell JC, Thijs A, Ader HJ, Van Bokhorst-de van der Schueren MA. Effectiveness and cost-effectiveness of early screening and treatment of malnourished patients. Am J Clin Nutr. 2005;82:1082-9.
6. Kondrup J, Allison SP, Elia M, Vellas B, Plauth M. ESPEN Guidelines for Nutrition Screening 2002. Clin Nutr. 2003;22:415-21. doi: 10.1016/s0261-5614(03)00098-0.
7. Bouillanne O, Morineau G, Dupont C, Coulombel I, Vincent JP, Nicolis I, Benazeth S, Cynober L, Aussel C. Geriatric Nutritional Risk Index: a new index for evaluating at-risk elderly medical patients. Am J Clin Nutr. 2005;82:777-83.
8. Cereda E, Klersy C, Pedrolli C, Cameletti B, Bonardi C, Quarleri L, Cappello S, Bonoldi A, Bonadeo E, Caccialanza R. The Geriatric Nutritional Risk Index predicts hospital length of stay and in-hospital weight loss in elderly patients. Clin Nutr. 2015;34:74-8. doi: 10.1016/j.clnu.2014.01.017
9. Cereda E, Pedrolli C, Zagami A, Vanotti A, Piffer S, Opizzi A, Rondanelli M, Caccialanza R. Nutritional screening and mortality in newly institutionalised elderly: a comparison between the geriatric nutritional risk index and the mini nutritional assessment. Clin Nutr. 2011;30:793-8. doi: 10.1016/j.clnu.2011.04.006.
10. Baumeister SE, Fischer B, Doring A, Koenig W, Zierer A, John J, Heier M, Meisinge C. The Geriatric Nutritional Risk Index predicts increased healthcare costs and hospitalization in a cohort of community-dwelling older adults: results from the MONICA/KORA Augsburg cohort study, 1994-2005. Nutrition. 2011;27:534-42. doi: 10.1016/j.nut.2010.06.005.
11. WHO expert consultation. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. Lancet. 2004;363:157-63. doi: 10.1016/S0140-6736(03)15268-3
12. Pablo AM, Izaga MA, Alday LA. Assessment of nutritional status on hospital admission: nutritional scores. Eur J Clin Nutr. 2003;57:824-31. doi: 10.1038/sj.ejcn.1601616.
13. Lawton MP, Brody EM. Assessment of older people: self-maintaining and instrumental activities of daily living. Gerontologist. 1969;9:179-86.
14. Holtsberg PA, Poon LW, Noble CA, Martin P. Mini-Mental State Exam status of community-dwelling cognitively intact centenarians. Int Psychogeriatr. 1995;7:417-27.
15. Reischies FM, Geiselmann B. Age-related cognitive decline and vision impairment affecting the detection of dementia syndrome in old age. Br J Psychiatry. 1997;171:449-51.
16. Tombaugh TN, McIntyre NJ. The Mini-mental State Exam: a comprehensive review. J Am Geriatr Soc. 1992;40:922-35. doi: 10.1111/j.1532-5415.1992.tb01992.x.
17. Zhou Y, Flaherty JH, Huang CQ, Lu ZC, Dong BR. Association between body mass index and cognitive function among Chinese nonagenarians/centenarians. Dement Geriatr Cogn Disord. 2010;30:517-24. doi: 10.1159/000322110.
18. Guigoz Y. The Mini Nutritional Assessment (MNA) review of the literature--What does it tell us? J Nutr Health Aging. 2006;10:466-87.
19. Alves de Rezende CH, Marquez Cunha T, Alvarenga Junior V, Penha-Silva N. Dependence of Mini-Nutritional Assessment scores with age and some hematological variables in elderly institutionalized patients. Gerontology. 2005;51:316-21. doi: 10.1159/000086368.
20. Tsai AC, Chang JM, Lin H, Chuang YL, Lin SH, Lin YH. Assessment of the nutritional risk of >53-year-old men and women in Taiwan. Public health nutrition. 2004;7:69-76. doi: 10.1079/phn2003519
21. Cereda E, Limonta D, Pusani C, Vanotti A. Geriatric nutritional risk index: a possible indicator of short-term mortality in acutely hospitalized older people. J Am Geriatr

Soc. 2006;54:1011-2. doi: 10.1111/j.1532-5415.2006.00754.x.
22. Sahyoun NR, Jacques PF, Dallal G, Russell RM. Use of albumin as a predictor of mortality in community dwelling and institutionalized elderly populations. J Clin Epidemiol. 1996;49:981-8.
23. Omran ML, Morley JE. Assessment of protein energy malnutrition in older persons, Part II: Laboratory evaluation. Nutrition. 2000;16:131-40. doi: 10.1016/S0899-9007(99)00251-8.
24. Harris T, Cook EF, Garrison R, Higgins M, Kannel W, Goldman L. Body mass index and mortality among nonsmoking older persons. The Framingham Heart Study. JAMA. 1988;259:1520-4. doi: 10.1001/jama.259.10.1520.
25. Forbes GB. Lean body mass-body fat interrelationships in humans. Nutr Rev. 1987;45:225-31.