UNIVERSA MEDICINA

January-April, 2011 *Vol.30 - No.1*

Protein intake as a determinant factor of physical activity in older persons

Rina K Kusumaratna* and Adi Hidayat*

ABSTRACT

*Department of Community Medicine
Medical Faculty,
Trisakti University

Correspondence
Dr. dr. Rina K. Kusumaratna, M.Kes.
Department of Community Medicine
Medical Faculty,
Trisakti University
Jl. Kyai Tapa No.260
Grogol - Jakarta 11440
Phone: 021-5672731 ext.2504
Email:
rkusumaratna@gmail.com

Univ Med 2011;30:36-44.

Worldwide, the proportion of people aged 60 and over is growing faster than any other age group. It has been well-established that the aging process can be associated with increased susceptibility to chronic conditions, disability, and co-morbidity, which however may be minimized or even partially reversed by physical activity. The assessment of physical activity is becoming an increasingly important component in the evaluation of elderly persons. Nutritional intake and status play an essential role in determining the physical activity level potentially capable of minimizing the health burden of older persons. The objective of this study was to find out whether nutritional intake and status were correlated with physical activity in community-dwelling older persons. The study population included 219 aged 60 to 69 years, of whom complete measures of socio-demographic characteristics, nutritional status, nutritional intake and physical activity were obtained. Serum total protein, albumin, globulin and hemoglobin concentration were measured as nutritional indicators (biomarkers). The nutrient content of food intakes was analyzed and calculated by "Nutrisurvey" software. Analysis indicated that there was a significant correlation between nutritional biomarkers [total protein (r=-0.211; p=0.002) and globulin (r=-0.247; p=0.000)] and physical activity. Compared to other food intakes, intakes of carbohydrate (r=0.241; p=0.001) and animal protein (r=0.149; p=0.027) were significantly correlated with physical activity. Our findings lend support to the existence among healthy older persons of a relationship between nutrional intake and status and physical activity.

Key words: Nutritional status, nutritional intake, physical activity, older persons

INTRODUCTION

Relative to the younger age groups, the group of older persons is steadily growing worldwide, as a result of increased longevity. In 2002, the global population of older persons was around 600 millions and is expected to double by the year 2025. Around 80% of the elderly will be living in developing countries.[1,2] Indonesia is one of the nations with a large population of older persons and ranks as number five in the world. Thus, the maintenance of a healthy physical and mental state in the elderly population is an important public health challenge now and in the future.(3) A number of clinical and epidemiological studies have produced confirmatory evidence for a relationship between health (physical and mental), nutrition and quality of life. Many studies have strived to find specific nutrients for older persons that could link nutrition with chronic diseases and could impact on health in later life. Other studies have focused on the preventive effects of physical activity on physical health, while others have highlighted the relationship between nutritional intake and status. One of the factors believed to be important for performance of physical activity is the composition of the diet.

There are as yet no established criteria for optimal nutritional intakes and requirements in older persons. Nutritional status plays an essential role in determining health status and is potentially capable of minimizing the health burden of older persons. Currently a nutritional transition is occurring on a global scale, due to unhealthy lifestyles of younger people, such as declining physical activity, non-nutritious diets, and smoking. The current trend in developing countries is to eat more fat and more refined diets, which has contributed to increased risk of chronic disease. Social and demographic changes have an impact on older persons, in that the aged population has a great risk of food insecurity and suffers from malnutrition.

In facing the expanding older population segment, the WHO and the Jean Mayer USDA Human Nutrition Research Center on Aging at Tufts University in 1998 jointly set up a list of priority concerns comprising documentation of "the nutritional status of older persons, better definition of their nutrient requirements, and identification of factors affecting dietary intake and nutrient absorption in different cultural and environmental settings".(4)

The normal aging process causes multiple physiological changes that could influence the nutrient intake and nutritional status of individuals. Optimal nutrition ensures that the body has sufficient nutrients to maintain its functions, prevent nutritional deficiencies, and delay the onset of degenerative diseases. Recently, there has been a shift in the concept of healthy and successful aging, from an emphasis on number of years to quality of life (QOL) during those years. This shift has led to the view that a healthy lifestyle, specifically optimal food intake and physical activity, are important determinants of QOL and well-being. Exercise is most commonly used for health promotion of older persons, and adequate nutritional intake may be expected to produce an improvement in physical activity. A previous study reported that physical activity is not only of benefit in preventing lifestyle-related disease and functional decline in the older persons, but also in decreasing their mortality.(5) These considerations led to the formulation of the aim of the present study, namely to investigate whether nutritional intake and status have a relationship with physical activity among community-dwelling older persons.

METHODS

Study design

A cross-sectional study was carried out in the Mampang Prapatan district, South Jakarta municipality, DKI Jakarta Province from August to October 2007.

Study subjects

The study enrolled 219 community-dwelling older persons aged 60 to 69 years, who were residents of five sub-districts in the Mampang Prapatan district. Five *kelurahan* were randomly chosen and from these *kelurahan* were selected 8 hamlets *(RW)* with high numbers of resident older persons. Subjects were listed and recruited by simple random sampling from the older persons living in the hamlets**,** especially those who were non-supervised. The inclusion criteria were: male or female persons 60-69 years of age, mobile, independent, able to verbally communicate, willing to join the study and prepared to sign the informed consent form. Exclusion criteria were subjects with dementia or uncontrolled hypertension, and bedridden or physically handicapped persons.

Data collection

The general characteristics of the subjects i.e. identity of respondents, age, date of birth, address, formal education level, history of occupation, financial support (income and expenses), ethnicity and religion, history of health, housing condition, and life style were recorded by interview using a standardized questionnaire.

Anthropometric measurements

The subjects were measured as to height, body weight, and waist circumference. Height was measured using a portable microtoise to the nearest 0.1 cm and weight was measured using Sage portable scales to the nearest 0.1 kg. Body mass index (BMI) was calculated as the weight (kg) divided by the square of the height (m^2). For Asian populations, BMI is classified into the following categories: underweight (<18.5 kg/m^2), normal (18.5–22.9 kg/m^2), overweight (23.0–27.5 kg/m^2), and obese (>27.6 kg/m^2).[6] Waist circumference was measured with the subject wearing light clothing, at a level midway between the lower rib margin and iliac crest, to the nearest cm using a plastic measuring tape.

Nutritional evaluation

Blood was collected from the antecubital vein in the fasting state in early morning. Serum total protein, albumin, globulin and hemoglobin concentration were measured as nutritional indicators.

Dietary intake

Dietary intake was assessed using semi-quantitative-food frequency questionnaire (SQ-FFQ), 2 x 24 hours non-consecutive food recall and weight food. For minimizing memory bias and assist the elderly in recalling the foods consumed, the trial used three-dimensional food models in standard portion sizes. The SQ-FFQ and 24-hour dietary recall assessments were done through interviews administered by the nutritionist on home visits. The nutrient content of food intakes was analyzed and calculated by "Nutrisurvey" software.[7]

Physical activity

Habitual physical activity was calculated using the Short-Form [short version] of the International Physical Activity Questionnaire (SF-IPAQ). The IPAQ short form is an instrument designed primarily for population surveillance of physical activity among adults.[8] The IPAQ was developed as an instrument for cross-national monitoring of physical activity. The SF-IPAQ has been extensively used for measurement of physical activity in the age range of 15 to 69 years, which was the reason for the age limit of 69 years used is the present study. Total physical activity was calculated as MET-minutes/week.

Statistical analysis

The data analysis was by descriptive statistical methods and bivariate analysis by chi square and independent t tests to compare several variables between males and females. Pearson correlation coefficient was used to determine the relationship between nutrional intake and status and physical activity. A p value of <0.05 was regarded as statistically significant. The statistical analysis was performed with the SPSS software package for Windows, version 15 (SPSS Inc., Chicago).

Ethical clearance

Permission and administrative clearance for conducting the study were provided by the District Health Office and the District Health Center. Ethical clearance was given by the

Table 1. Demographic profile and nutritional status by gender (n=219)

Demographic profile and nutritional status	Gender		p^a
	Males n=80 (%)	Females n=139 (%)	
Age (yr) *	64.2 ± 2.9	63.7 ± 2.5	0.241
Education (%)			
Educated	74 (43.0)	98 (57.0)	0.000
Illiterate	6 (12.8)	41 (87.2)	
Marital status (%)			
Married	67 (68.4)	31 (31.6)	0.000
Widowed	13 (10.9)	106 (89.1)	
Unmarried	0 (0.0)	2 (100.0)	
Nutritional status			
Underweight	13 (26.0)	37 (74.0)	0.124
Normal	37 (43.0)	49 (57.0)	
Overweight	23 (41.1)	33 (58.9)	
Obese	7 (25.9)	20 (74.1)	
BMI (kg/m^2) *	22.1 ± 3.4	21.7 ± 4.4	0.480
Weight (kg) *	57.2 ± 9.4	49.5 ± 11.1	0.000
Height (cm) *	160.7 ± 4.3	150.8 ± 3.8	0.000
Waist circumference (cm) *	81.3 ± 10.3	77.7 ± 12.2	0.026

Note : * Mean ± SD; [a] p values were derived from χ^2 and independent t test

Human Ethics Committee of the Faculty of Medicine, University of Indonesia.

RESULTS

Demographic profile and nutritional status

As shown in Table 1, the majority of participants were females (63.5%) with mean age of 63.7 ± 2.5 years. The underweight category was higher in females (74.0%) compared to males (26.0%). Similarly, there were more overweight females (74.1%) than males (25.9%), although the difference was not statistically significant (p=0.124). Most female older persons (87.2%) were illiterate and 31.6% were married. In male older persons, weight, height and waist circumference were significantly higher compared to females.

Nutritional biomarkers

Table 2 compares the nutritional biomarkers between males and females. The hemoglobin concentration was significantly higher among males (14.1 ± 1.5 d/dL) than females (12.7 ± 1.4 g/dL) (p=0.000). However, the globulin concentration was significantly higher in females (3.3 ± 0.7 g/dL) compared to males (3.0 ± 0.5 g/dL) (p=0.018). Total protein, albumin and globulin levels were within the normal ranges in both groups.

Table 2. Mean values of nutritional biomarkers by gender

Nutritional biomarkers	Gender		p^a
	Males (n=80)	Females (n=139)	
Hemoglobin (g/dL)	14.1 ± 1.5	12.7 ± 1.4	0.000
Total protein (g/dL)	7.1 ± 0.9	7.1 ± 1.2	0.614
Albumin (g/dL)	4.0 ± 0.6	3.9± 0.6	0.121
Globulin (g/dL)	3.0 ± 0.5	3.3 ± 0.7	0.018

Note: Values are mean ± SD; [a] p values were derived from independent t test

Table 3. Mean nutritional intakes based on gender

Nutritional intakes	Gender		p[a]
	Males (n=80)	Females (n=139)	
Energy (Kcal)	1251.1 ± 437.2	1056.8 ± 355.8	0.000
Carbohydrate (g)	186.4 ± 66.3	153.3 ± 55.6	0.000
Protein (g)	42.1 ± 16.9	36.2 ± 16.8	0.015
Animal protein (g)	24.3 ± 20.2	15.6 ± 13.1	0.000
Fat (g)	39.1 ± 18.6	36.3 ±15.6	0.245
Vit A (μg)	2355.4 ± 672.4	2424.9 ± 914.6	0.554
Vit C (mg)	68.9 ± 46.8	70.0 ± 54.0	0.879
Vit E (mg)	0.13 ± 0.2	0.29 ± 0.79	0.088
Vit B1 (mg)	0.47 ± 0.21	0.44 ± 0.25	0.381
Vit B2 (mg)	0.82 ± 0.41	0.86 ± 0.51	0.610
Vit B6 (mg)	1.1 ± 0.5	1.0 ± 0.5	0.298
B-carotene (mg)	0.74 ± 0.91	0.66 ± 0.88	0.590
Calcium (mg)	588.2 ± 378.1	695.0 ± 495.7	0.097
Sodium (mg)	329.1 ± 191.4	344.1 ± 261.5	0.654
Potassium (mg)	1850.5 ± 986.7	1903.5 ± 1250.5	0.795
Iron	25.5 ± 18.8	29.4 ± 26.4	0.254
Zinc (mg)	5.7 ± 2.4	5.4 ± 2.7	0.508

Note: Values are mean ± SD; [a] p values were derived from independent t test

Nutritional intakes

Daily intakes of macronutrient and micronutrients are presented in Table 3. Estimated intakes of energy and nutrients were calculated on the basis of the average value of two non-consecutive 24-hour food recall sessions. From these values the distribution of usual intakes in the population was estimated. Micronutrient intakes were calculated on the basis of the SQ-FFQ.

The following usual intakes were obtained: mean intake of total energy per day was 1251.1 ± 437.2 Kcal/day in males, or 61.3% of total energy intake based on Indonesian recommended daily allowances [IRDA] for males. In females, mean intake of total energy per day was 1056.8 ± 355.8 Kcal/day or 66.1% of IRDA, carbohydrate 153.3 ± 55.6 g per day, protein 36.2 ± 16.8 g per day and fat 36.3 ±15.6 g per day. Iron, zinc, vitamin C and â-carotene intakes per person per day were 29.4 ± 26.4 mg, 5.4 ± 2.7, 70.0 ± 54.0 mg, and 0.66 ± 0.88 mg, respectively. There were significance differences of total energy, carbohydrate, total protein and animal protein intakes between males and females (<0.05) (Table 3), with higher intakes of carbohydrate, total protein, and animal protein in males.

The percentages of the nutrient composition in females indicate that average carbohydrate intake accounted for 58.2% of total energy intake, while 10.5% of total energy per day was from protein and 20.4% of total energy per day from fats. In addition, the nutrient composition of the elderly was moderate for protein (normal range 10-20%), within the normal range of 50-60% for carbohydrate, and was high in fat (> 25%) in both groups. The vitamin and mineral intakes in both groups were lower than estimated intakes based on IRDA, especially intakes of vitamin E and zinc, which were considerably below IRDA. From these data it is apparent that there were significant differences in nutritional intakes by gender, except for fat and several micronutrients (Table 3).

Physical activity

Physical activity score in males was 731.5 ± 383.8 MET-minutes/week and in females 590.0 ± 259.7 MET-minutes/week (p=0.001) (data not presented).

Table 4. Relationship between nutritional status and intake and physical activity in all subjects (n=219)

Nutrional status and intake	Physical activity	p[a]
Hemoglobin	0.048	0.481
Total protein	- 0.211	0.002
Albumin	- 0.132	0.051
Globulin	- 0.247	0.000
Body mass index	0.122	0.072
Weight	0.175	0.010
Height	0.169	0.010
Waist circumference	0.058	0.390
Energy	0.078	0.253
Carbohydrate	0.241	0.001
Protein	0.077	0.259
Animal protein	0.149	0.027
Fat	0.047	0.484

[a] p values were derived from Pearson correlation test

Nutritional status, nutritional intakes and physical activity

Table 4 shows the relationship between nutrional intake and status and physical activity. Weight and height were correlated significantly with physical activity (r=0.175; p=0.010 and r=0.169; p=0.010), but BMI and waist circumferences were not significantly correlated with physical activity. The significant correlation between nutritional biomarkers and physical activity comprised serum total protein (r=-0.211; p=0.002) and globulin (r=-0.247; p=0.000). In contrast to other food intakes, intakes of carbohydrate (r=0.241; p=0.001) and animal protein (r=0.149; p=0.027) were significantly correlated with physical activity.

DISCUSSION

The ideal outcome of longevity is to live through the added years as a healthy individual free of disability and disease, and enjoy a good QOL. However, older persons may expect to experience disability and poor QOL, even if they are apparently healthy. As a rule, older persons suffer from nutritional deficiences,[9,10] decreased physical activity,[11] decline in health status,[9] decline in cognitive functions,[11] and impaired functional status,[12] all of which ultimately affect their QOL.[13]

Hemoglobin, total protein, albumin, and globulin levels are widely used as indicators for screening of nutritional status. The older persons in our study had normal values of hemoglobin, total protein, albumin, and globulin. A study among Italian older persons aged 75 to 85 years and Japanese older women aged 60 to 80 years, showed normal hemoglobin and albumin levels in all subjects.[14,15] Our study results showed a significant relationship between blood albumin concentration and physical activity, which was consistent with the results of a previous study indicating that albumin levels in blood were correlated with walking ability and physical fitness.[16] The study conducted by Chin et al.[17] demonstrated that decreased physical activity was the best indicator for frailty and described its relation to nutritional intake and nutritional status. In contradistinction to the albumin-physical activity relationship, there was no significant correlation between energy intake and physical activity in our study. Although blood biomarkers are important for determining nutritional status, a more important point to consider is dietary or nutritional guidance to older persons for ensuring maintenance of proper dietary intakes, especially intakes of protein.

It is known that both exercise and nutrition are important in promoting health in elderly people. In health promotion, the relationship between nutritional intake and/or status and physical activity has to date not been adequately clarified. The present study showed that total energy intakes of both females and males were lower than estimated energy requirements based on IRDA, with moderate protein and normal carbohydrate intakes but high intakes of fat, relative to IRDA, for persons aged 60 years and over. Vitamin and mineral intakes in both groups were also lower than IRDA, especially for intakes of vitamin E and zinc which were considerably below IRDA. Our study results differed from a study in Japan on female subjects aged 60 to 82 years, which showed that intakes of macronutrients, micronutrients and vitamins satisfied estimated energy requirements based on the Japanese Dietary Intake Reference 2005.[15] Intake of antioxidants (vitamin C, â-carotene, vitamin E, and trace minerals such as zinc) is essential for maintaining health and physical activity in old age. According to findings from one of the studies of the Italian InCHIANTI (Invecchiare in Chianti) project, plasma antioxidant concentration significantly correlates with physical performance and leg extension strength in older persons.[18] Socio-economic factors are also important as underlying determinants of morbidity, mortality and malnutrition, including micronutrient deficiency. Educational background can be used to assess the potential vulnerability of a population with poor dietary patterns. In this study only 21.5% of illiteracy was found, and therefore other factors may have affected the dietary pattern. In urban areas, such as Mampang Prapatan, the population depends heavily on cash income, and employment can be a useful indicator of standard of living. In general, older people might be at risk of malnutrition due to impaired energy intake, social isolation or decreased income. In the present study, socio-economic factors, including source of income and employment, could be also used as indicators to identify those older persons at high risk for micronutrient deficiency. Overall, the diet of the subjects conformed to that of other developing nations, being largely composed of foods of plant origin. Their diet includes few animal protein sources, such as meat or poultry, since these are expensive and older persons may be unable to afford them on a regular basis. The association between poverty and nutrition has long been recognized, because poor populations often rely heavily on monotonous plant-based diets low in animal products. In addition, some of the older persons may have difficulties in mastication due to dental problems, such that most of them substitute the softer tofu or tempeh for relatively tough animal protein. Malnutrition in older people is an important problem and is encountered in both community-dwelling and institutionalized older persons. The risk and prevalence of malnutrition rise proportionally with age, making the management of malnutrition among older people an urgent public health need, that is also beneficial from an economic viewpoint.

In general, nutritional requirements change with increasing age. Older people are less efficient in processing and metabolizing their foods, and require lesser amounts of energy. They therefore should consume nutrient-dense foods, in which small servings provide substantial amounts of macro- and micro-nutrients. Inadequate food intake leads to undernutrition among older persons that is difficult to reverse, because low food intakes are likely to increase their risk of energy and nutritional deficiency.

Ideally, older persons should have balanced and varied intakes of macro- and micronutrients for optimum health. However, most subjects in this study had a total energy intake of 63.7%, which is lower than the minimal requirement (80%) of IRDA for persons aged 60+ years. Although in absolute terms the total energy intake of both genders were significantly different, it was mostly inadequate and unbalanced. Most macro- and micronutrient intakes were lower than IRDA for age 60+ years, especially intakes of vitamin C, vitamin E and zinc, which were far below IRDA. Therefore it appears that the diet of the study subjects was relatively poor in macronutrients and energy, but definitely deficient in vitamins and minerals. These results are consistent with those of several studies reporting that 50% of older persons have a micronutrient intake of less than the daily recommended intake, while 10–30% has marginal levels of micronutrients.[9,19] Therefore it should be emphasized to older persons to consume sufficient amounts of animal protein, both for its ready absorbability and micronutrient content. An adequate protein intake results in a positive nitrogen balance, thus accelerating protein synthesis.

Our study did not find a correlation between BMI and physical activity. This agrees with a Swedish study on subjects 60–84 years of age, where no significant difference was found between BMI and leisure time physical activity, both among subjects born in Sweden as well as among Swedish residents born in Iran.(21) Furthermore, in our study a significant correlation was observed between carbohydrate and animal protein intake with physical activity. Similar results were found in elderly Japanese women,(15) which may be explained by the fact that among ordinary older people nutritional intake may relate to physical activity, regardless of the subject's body composition.

Muscle mass gradually declines after age 50 years, and muscle loss leads to muscle weakness; greater risks of falls, fractures, disability, and loss of independence.(22) Some of the age-related muscle weakness and muscle loss is due to physical inactivity, and as such can be reversed or at least minimized through increased physical activity. Strength training can be an effective way for older persons to increase muscular strength and improve balance, and may assist the elderly to cope with a variety of chronic conditions; thus physical activity may have a preventive effect against disease and immobility.(23)

As the world population is growing older and older, the increasing number of older people will present economic and social problems over the next decade. An important goal of research today is to identify possible strategies for ensuring the health of the elderly people in the near future in order to reduce social and economic expenditure. Our data showed that nutrition is correlated with physical activity. Although links between diet, physical activity, and risk of chronic disease have been well documented, more needs to be known about the possibly reciprocal effects of regularly performed physical activity and improved diet in older persons.(24,25)

Several limitations of our study should be mentioned. The cross-sectional design of the study did not permit us to evaluate the causality of daily nutrient intakes on physical activity. Further longitudinal studies are needed to evaluate the role that nutrition status and intake may have on physical performance in older persons. The study population tended to be overweight, which prevented us from assessing the effect of very poor nutrition and may have influenced our findings. To better identify the effects of nutritional intake on physical activity, it may be useful to compare one group of persons with undernutrition with a control group of normal nutritional status. Finally, another limitation of our study was the limited assessment of biomarkers. The evaluation of both dietary intake estimates and biomarkers would have been the ideal combination.

CONCLUSIONS

The present study found differences between actual and recommended dietary patterns of older persons in Indonesia, with both genders having nutrient and energy intakes below IRDA. The protein intake have a relationship with physical activity in healthy elderly people. Albumin blood levels as a targeted marker of nutrition status in blood significantly correlated with physical activity.

ACKNOWLEDGEMENT

The authors wish to thank all the elderly subjects participating in the study, and the Mampang Prapatan Health Center, South Jakarta for their cooperation. The present study was supported by the Faculty of Medicine, Trisakti University.

REFERENCES

1. UNFPA. Population Ageing in East and South-East Asia: current situation and emerging challenges. Population Ageing series No.1, Thailand, 2006.
2. Meydani A, Ahmed T, Meydani SN. Aging, nutritional status and infection in the developing world. Nutr Rev 2005;63:233-46.
3. BAPPENAS, BPS. Projeksi penduduk Indonesia (Indonesia population projection) 2000-2025. Jakarta: Bappenas;2005.
4. Tucker KL, Buranap S. Nutrition and aging in developing countries. J Nutr 2001;131:S2417-23.
5. Burke GL, Arnold AM, Bild DE, Cushman M, Fried LP, Newman A, et al. Factors associated with healthy aging: the cardiovascular health study. J Am Geriatr Soc 2001;49:254-62.
6. World Health Organization. Appropriate body mass index for Asian populations and its implications for policy and intervention strategies. The Lancet 2004;363:157-63.
7. Erhardt J. Nutrition surveys and calculations. 2007. Available at: http://www.nutrisurvey.de/index.html. Accessed October 10, 2009.
8. International Physical Activity Questionnaire (IPAQ) Research Committee. Guidelines for data processing and analysis of the International Physical Activity Questionaire (IPAQ): short and long forms. 2005. Available at: http://www.ipaq.ki.se. Accessed October 11, 2009.
9. WHO Technical Report Series 916. Diet, nutrition and the prevention of chronic diseases. Report of a joint WHO/FAO Expert Consultation Geneva, World Health Organization, 2003.
10. Bartali B, Frongillo EA, Bandinelli S, Lauretani F, Semba RD, Fried LP, Ferrucci L. Low nutrient intake is an essential component of frailty in older persons. J Gerontol A Biol Sci Med Sci 2006; 61:589–93.
11. Fried LP, Tangen CM, Walston J, Newman AB, Hirsch C, Gottdiener J, et al. Frailty in older adults: evidence for a phenotype. J Gerontol A Biol Sci Med Sci 2001;56:M146-56.
12. Inouye SK, Studenski S, Tinetti ME, Kuchel GA. Geriatric syndromes clinical, research and policy implications of a core geriatric concept. J Am Geriatr Soc 2007;55:780-91.
13. Cella D, Nowinski CJ. Measuring quality of life in chronic illness; the functional assessment of chronic illness therapy measurement system. Arch Phys Med Rehabil 2002;83:S10-7.
14. Pasini E, Corsetti G, Bandera F, Tolomin S, Salvetti M, Pedreti E, et al. Nutritional status and physical activity of a selected sample of elderly healthy Italian people. Mediterr J Nutr Metab 2008;1:43-8.
15. Sakato Y, Tanabe K, Nishijima T, Fukunaga T, Kuno S. Relationship between nutrition intake status, nutrition condition and physical fitness in elderly women. Int J Sport Haeth Sci 2006;4:544-54.
16. Kwon J, Suzuki T, Kim H, Yoshida H, Kumagai S, Yoshida T, et al. Health status and physical fitness of undernourished community-dwelling elderly people. Jap Jour Phys Fit Sport Med 2005;54:99-106.
17. Chin A, Paw MJ, de Groot LC, van Gend SV, Schoterman MH, Schouten EG, et al. Inactivity and weight loss: effective criteria to indentify frailty. J Nutr Health Aging 2003;72:55-60.
18. Cesari M, Pahor M, Bartali B, Cherubini A, Penninx BWJH, Williams GR, et al. Antioxidants and physical performance in elderly persons: the Invecchiari in Chianti (InChianti) study. Am J Clin Nutr 2004;79:289-94.
19. Thomas DR. In: Morley JE, Thomas DR, eds. Nutritional requirements in older adults. In: Geriatric Nutrition, CRC Press, Boca Raton, 2007.p.103-21.
20. Schunemann HJ, Sperati F, Barba M, Santesso N, Melegari C, Elie AA, et al. An instrument to assess quality of life in relation to nutrition: item generation, item reduction and initial validation. Health Qual Life Outcomes 2010;8:26:1-13.
21. Koochek A, Johansson SE, Kocturk TO, Sundquist J, Sundquist K. Physical activity and body mass index in elderly Iranians in Sweden: a population-based study. Eur J Clin Nutr 2008;62: 1326–32.
22. Chapman IM. Obesity in old age. Obes Metabol 2008;36:97–106.
23. Drewnowski A, Evans WJ. Nutrition, physical activity, and quality of life in older adults. J Gerontol 2001;56A:89-94.
24. Kubota A, Ishikawa-Takata K, Ohta T. Effect of daily physical activity on mobility maintenance in the elderly. Int J J Sport Health Sci 2005;3:83-90.
25. Evans WJ. Protein nutrition, exercise and aging. J Am Coll Nutr 2004;23:S601–9.