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Clinical Assessment and Management of 6 Common At-risk Nutrients in the Older Person

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Older people in Western communities are the single largest demographic group at risk from inadequate diet and malnutrition. Their nutritional status is associated with increased hospital admissions, and it is an important determinant of morbidity. This risk is disproportionate in comparison to other age groups and needs to be a primary consideration in determining the appropriate management of the older person.

Acknowledging the subject's importance, this article is an adaptation from one previously published in *Integrative Medicine: A Clinician's Journal (IMCJ* 2003;2.1:28-33). Updates have been made from the Recommended Dietary Allowances to the Dietary Reference Intakes. We trust that all the information will be as vital and useful now as it was then.

Chronic illness, heavy use of medication, and periods of lengthy hospitalization are often underlying causes of nutritional deficiency. In addition lifestyle factors, immobilization, isolation, and physiological factors associated with aging compound the risks and affect the ability of the older person to meet nutritional needs or to digest, absorb, utilize, or excrete nutrients that are ingested.

Improvements in healthcare, nutritional status, and living standards have resulted in more Americans living to an older age. In order for the gains in life expectancy to be viewed as a positive demographic feature, the additional years need to be quality years with attention focussed on approaches that can retard the losses associated with aging. Of specific interest is the role nutrition may play in attenuating these losses and promoting functional independence and optimal wellness in an aging population.

It is widely recognized that physiological changes associated with aging can compromise the nutritional status of the older person and influence nutritional requirements.[1-4] Without an understanding of these changes, clinicians risk failing to deliver appropriate nutritional recommendations.

The objective of this review is to examine the influence of aging on nutritional requirements in the older person and to identify common at-risk nutrients, in this population. Although several nutrients are at-risk in this population, this review will concentrate on 6 particular nutrients, namely, protein, calcium, B-vitamins (including vitamin B_{12}, vitamin B_6 and folate) and vitamin D. There is general agreement in the literature that these are the most common nutrient inadequacies among older people, but these are not the only potentially at-risk nutrients. Studies have shown that among older individuals poor dietary intake leads to inadequate levels of other nutrients, such as zinc, selenium, and vitamin E.[5-8] Clearly the potential exists for widespread nutrient deficiencies to occur in the older person. Primary care physicians need to play a leading role in the nutritional management of the older person and simple dietary recommendations will be outlined for use in clinical practice.

Body Compositional Changes

Aging is associated with distinct changes in body composition, which over time confound the issue of accurately assessing the nutritional status of the older person.[2,6]

The major age-related physiological change in the older person is a decline in skeletal muscle mass, called sarcopenia.[2,6,9] Some decline in skeletal muscle mass is considered an inevitable consequence of the normal aging process, although it is clearly accelerated by physical inactivity and disuse of muscles. Lean body mass (muscle) declines progressively throughout adult life and is associated with a reduction in performance, loss of strength, decreased protein reserves, increased disability, and increased risk of falls and injury.[10]

Physical inactivity and inadequate dietary protein and/or impaired protein utilization have been implicated as factors that indirectly contribute to the progression of sarcopenia. According to Gariballa and Sinclair, protein synthesis, turnover, and breakdown all decrease with advancing age.[3]

Protein

The estimates for protein requirements for both young and healthy elderly adults generally have been based on nitrogen balance studies rather than on the maintenance of muscle mass.[9,11] A number of reports have suggested that in order to maintain positive nitrogen balance, protein requirements for the older person should be increased.[2,11,12] Increased dietary protein intake is recommended as a means of compensating for inefficient protein utilization leading to loss of muscle mass in the aged.

The nutritional consequence of a reduced lean body is a proportional decline in total energy requirements. According to Blumberg, a critical risk factor for under-nutrition in older adults is their declining need for energy due to a reduction in the amount of lean body mass and a more sedentary lifestyle.[13] This leads to a compensatory decrease in macronutrient and micronutrient intake of approximately 30% by the age of 80 years.[6] Decreasing energy intake associated with aging has important implications for the diet in terms of the adequacy of protein and micronutrient intake.[13]

Changes in Gastrointestinal Tract

Aging is associated with impairment of the gastrointestinal tract. Such impairment includes loss of dentition, impaired

gastrointestinal motility, atrophic gastritis, and hypochlorhydria.[14] Changes to the gastrointestinal tract may affect nutrient ingestion, absorption, metabolism, and elimination.

Changes in the oral cavity such as loss of teeth, ill-fitting dentures, decreased production of saliva, and gingivitis can profoundly affect the ability of the older person to chew and/or swallow with subsequent avoidance of many foods.[15]

Atrophic gastritis, a prevalent condition associated with advancing age, represents the greatest change in gastrointestinal physiology affecting nutrient bioavailability.[4] Characterized by a partial loss of fundic glands and a corresponding decrease in the parietal cell mass, the physiologic consequences of atrophic gastritis are decreased acid-pepsin digestion in the stomach, decreased secretion of intrinsic factor, bacterial overgrowth of the stomach and proximal small intestine, and elevated pH in the proximal small intestine.[1,4] The prevalence of atrophic gastritis affects between 20% to 50% of the older population, placing them at-risk of impaired absorption of folic acid, vitamin B_{12}, calcium, iron, and beta-carotene.[1,4,6] Optimal absorption of these particular nutrients is pH dependent and adversely affected by the low stomach acid conditions in atrophic gastritis.

Calcium

Optimizing calcium intake is an integral part of dietary recommendations aimed at reducing the incidence of osteoporosis, maintaining mobility, and enhancing functional independence. A number of factors associated with aging may adversely affect calcium absorption and metabolism, particularly among older women. In this group, lowered circulating levels of estrogen and serum vitamin D are thought to impair calcium absorption and metabolism, resulting in accelerated bone loss and increased incidence of fracture.[16] Lack of gastric acid in atrophic gastritis and a decline in active intestinal transport of calcium can also impair calcium absorption.[4,9] All men and women aged 50 years and over in the third National Health and Nutrition Examination Survey failed to meet the Dietary Reference Intake for calcium.[8] The discrepancy between recommended and actual intakes were greatest for women aged 70 years and older whose average calcium intakes were approximately half the requirement, for example, 600 mg daily instead of 1200 mg daily.

B Vitamins

Beyond their role in staving off classic deficiency disorders such as beri-beri and pellagra, and the concomitant neurological impairment, the role that B vitamins might play in modulating cognitive function in nondeficiency states has been poorly understood. Only recently has the importance of B vitamins in cognitive function and the mechanisms that might explain such a role been elucidated.

Emerging evidence suggests that folic acid, vitamin B_{12}, and vitamin B_6 might impact cognitive function via a reduction in serum homocysteine levels. This conclusion was reached by Nicolas and colleagues and is based on several studies showing inverse associations between clinically diagnosed Alzheimer's disease and folate, vitamin B_{12}, and homocysteine levels. Although there is no single hypothesis explaining the link between elevated serum homocysteine and cognitive function, some theories exist.[12]

For example, elevated serum homocysteine may bring about cerebrovascular changes or directly lead to neurological damage resulting in cognitive impairment.[12] Until data from intervention studies are available, it appears fair to assume that the relation between elevated serum homocysteine and cognitive impairment is one of association, rather than cause. Given the association between homocysteine levels and cardiovascular disease it is prudent to ensure that adequate nutritional protection is undertaken. Biochemical assessment of the older person has demonstrated that dietary intakes of less than 400 mcg of folate correlates with elevated serum homocysteine levels. Supplemental amounts of folic acid (0.5-5 mg) and vitamin B_{12} (0.5 mg) have been shown to reduce homocysteine levels found in typical western populations by approximately 30%.[12]

Vitamin D

For some nutrients, aging is associated with altered micronutrient absorption, metabolism, and utilization. Decreased sun exposure, reduced dietary intake, and impaired skin synthesis of vitamin D contribute to lower circulating levels of serum 1,25-dihydroxycholecalciferol (ie, the biologically active form of vitamin D) in the older person. Aging is not only associated with a decline in the epidermal concentration of 7-dehydrocholesterol but also with a decrease in the renal conversion of vitamin D into its biologically active form. Lowered circulating vitamin D leads to higher serum levels of parathyroid hormone concentrations in the older person, resulting in increased bone turnover.[13]

Bone and mineral metabolism are profoundly affected by these changes in vitamin D nutrition. Several lifestyle, environmental, and dietary factors are known to modify vitamin D status. Older populations at-risk for poor vitamin D include those with poor dietary vitamin D sources who are housebound, institutionalized, and sedentary. Vitamin D deficiency can also occur in association with high dietary intake of phytate; intestinal malabsorption; and steatorrhea caused by biliary obstruction, pancreatic exocrine deficiency, or surgical resection bypass of the bowel.[17] Low vitamin D intake in the older person has been reported in a number of studies.[13,17-19]

Clinical Assessment and Management

Step 1—Recognition of nutritional risk factors

Risk factors are defined as characteristics indicating that someone is at risk of or is already in a poor nutritional state and include inappropriate food intake, poverty, social isolation, dependency/disability, acute/chronic conditions, chronic medication use, and advanced age (ie, greater than 80 years.) According to an assessment by Charles, the majority of individuals over the age of 65 years display some degree of risk of nutritional compromise.[20]

It is important that clinicians recognize the scope of nutritional risk factors and consider the extent to which these factors influence the dietary habits of individual patients. The causes of nutritional deficiency in the elderly are likely to be multifactorial

Table 1. Nutritional Risk Factors Checklist

Risk Factors	Lower dietary intake	Impaired nutrient absorption	Increased nutrient utilization	Responsive to nutritional intervention
Physical and Physiological Risk Factors				
Reduced energy requirements	✓			✓
Reduced amount of lean body mass	✓			✓
Sedentary lifestyle	✓			✓
Increased morbidity	✓			✓
Neurological disease, eg, Parkinson's disease	✓		✓	
Diminished sense of taste	✓			✓
Diminished sense of smell	✓			✓
Oral health problems	✓			✓
Changes to appetite	✓			✓
Loss of dexterity	✓			✓
Reduced gastrointestinal motility	✓	✓		✓
Medication effects	✓	✓	✓	✓
Metabolically active pathological processes, eg, cancer	✓	✓	✓	✓
Psychological, Social, and Cultural Risk Factors				
Dementia, depression, and delirium	✓			✓
Food anxieties	✓			✓
Financial restraints	✓			
Poverty	✓			
Lack of career	✓			
Widowhood and bereavement	✓			
Loneliness	✓			
Culturally determined habits and beliefs about food	✓			

and are subject to physical, physiological, psychological, social, and cultural factors. Recognizing exactly what these risk factors are is the first step in planning a nutrition intervention strategy for the older person.

Table 1 presents a nutritional risk factor checklist as well as highlights the fact that the majority of the risk factors that influence the nutritional status of the older person are directly related to reduced dietary intake and are likely to respond to targeted nutritional management. The ways in which these risk factors can be addressed will be considered in Step 3.

Step 2—Nutritional assessment

Nutritional assessment is the determination of nutritional status and usually incorporates aspects of clinical, anthropometric, dietary, and laboratory data. A judgement regarding the nutritional status of the older person can be made on the basis of several clinically validated techniques and instruments, including a comprehensive food history; anthropometric measures such as height, weight, body mass index, mid-arm circumference, and measurement of biochemical values relevant to specific nutrients.

Obtaining information regarding dietary practices can be achieved using a range of methods such as 24-hour dietary recall, 3-day diet history, food frequency, and weighed food measures. A number of factors need to be considered when deciding on the most suitable method for the older person: cognitive ability (eg, memory impairment, dementia), visual acuity (eg, ability to accurately read scales), physical dexterity (eg, ability to record information on a chart), and the individual's general level of motivation to participate in such an exercise.

It is important to point out that accurate nutritional assessment requires a thorough understanding of the strengths and limitations of the various assessment and analysis methods. For an accurate assessment of the nutritional status of an older individual, referral to a dietician or other appropriately trained health professional may be necessary. It is beyond the scope of this article to outline the principles of nutritional assessment in any detail. Gibson offers a comprehensive guide to the topic of nutritional assessment.[21]

Once data about usual or typical food intake has been obtained, the next step is to assess the nutritional adequacy of the diet. Particular attention needs to be given to the evaluation of the dietary intake of the at-risk nutrients, eg, protein, vitamin D, calcium, folate, vitamin B_{12}, and vitamin B_6. Exact measures of the dietary intake of these nutrients can be determined by entering the information into a computer nutritional analysis software application. Alternatively, a clinician can form some opinion about the nutritional adequacy of the diet by approximating the intake of selected foods that provide these nutrients (Tables 2-7).

Step 3—Management of at-risk nutrients

Dietary guidelines aimed at meeting the nutritional needs of an aging population should emphasize the value of high-quality, nutrient-dense foods. Tables 2 to 7 provide the clinician with information about the nutrient content of selected foods to target at-risk nutrients[22-24] Dietary Reference Intakes (DRIs) are

provided for these nutrients for men and women aged 51 to 70 years and 71 years and older. Upper Tolerable Intake Levels (UL) for these nutrients are also provided. The ULs are not recommended amounts but suggested ceilings of intake and represent the maximum intake of a nutrient below which adverse health effects are not likely to be observed.[25]

Protein

The daily protein recommendation for older Americans is currently set at 0.8g/kg. Body weight studies have demonstrated that this is amount is inadequate to maintain nitrogen equilibrium in older individuals. Protein intakes in the range of 1 g to 1.5 g/kg body weight are required to maintain positive nitrogen balance in the older adult population.[2,24,26]

Appropriate dietary sources of protein include beef, lamb, pork, veal, chicken, salmon, liver, dairy products, soy, nuts and legumes, eggs, and whole wheat bread (Table 2).

Calcium

The DRI for all males and females aged 51 years and over is 1200 mg per day (compared to 1000 mg for males and females aged 19 to 50 years of age). The UL has been set at 2500 mg per day.[24]

According to Koehler and Garry, metabolic studies suggest that premenopausal women may require 1000 mg/day of calcium and 1500 mg/day after menopause to maintain calcium balance.[18] Calcium nutrition is dependent on a number of variables, including dietary intake of protein, fiber (particularly phytate) and phosphate; and vitamin D status.

Appropriate dietary sources include dairy products, calcium-enriched soy beverages, canned fish with bones, figs, molasses, and green leafy vegetables. (Table 3).

Table 2. Protein Content of Selected Foods

Food item	Protein (g)
Beef/lamb/pork/veal cooked (3/4 c diced, 145 g)	40.0
Fish, steamed (1 fillet, 120 g)	30.0
Chicken, baked, lean with skin (breast, 95 g)	25.0
Salmon/tuna, canned, drained (100 g)	23.0
Liver, lamb's fry, fried (1 slice, 9cm x 5cm, 40 g)	10.0
Milk, skimmed (250 mL)	10.0
Soy beverage (250 mL)	9.0
Milk, whole (250 mL)	8.5
Yogurt (1 tub, 200 g)	8.5
Legumes, baked beans, kidney beans (1/2 c)	8.0
Nuts (15-20 shelled, 35 g)	8.0
Tofu (6 cm x 7 cm x 3 cm, 100 g)	8.0
Cheese, processed cheddar (1 slice, 30 g)	7.0
Peanut butter (1 tbs)	6.5
Egg, boiled (1 medium, 48 g)	6.0
Bread, whole wheat (1 slice, 30 g)	3.0

Table 3. Calcium Content of Selected Foods

Food item	Calcium (mg)
Milk, evaporated (250 mL)	650
Milk, skim and whole (250 mL)	310
Soy beverage, calcium fortified (250 mL)	290
Sardines, canned (5 sardines, 75 g)	285
Salmon, canned, drained (105 g)	280
Yogurt, fruit (1 tub, 200 g)	255
Tofu (1 c)	200
Cottage cheese (1 c, 200 g)	160
Figs, dried (5 figs, 75 g)	150
Cheese, cheddar (1 cube, 2.5 cm, 16 g)	120
Black strap molasses (1 tbs)	115
Kale, cooked (1 c)	100
Almond, dry roasted (1/4 c, 45 g)	95
Tahini paste (1 tbs)	70
Baked beans (1/2 c)	60
Soy beans, cooked (1 c, 200 g)	55
Broccoli, cooked (1 c, 100 g)	40

Folate

The DRI for all men and women aged 19 years and over is 400 mcg. The Institute of Medicine, Food and Nutrition Board has not considered higher levels of folate necessary for those aged 51 years and over. The UL has been set at 1000 mcg per day (from supplements and fortified foods) for those aged 19 years and over.[24]

Appropriate dietary sources include fortified cereals, liver, legumes, dark-green leafy vegetables such as kale and spinach, oranges, and avocados (Table 4).

Vitamin B_{12}

The DRI for all men and women aged 19 years and over is 2.4 mcg. The Institute of Medicine, Food, and Nutrition Board have not considered higher levels of vitamin B_{12} necessary for those aged 51 years and over. The UL has not yet been established.[24]

Appropriate dietary sources include fortified foods, beef, liver, fish, and most dairy products (Table 5).

Vitamin B_6

The DRI for men and women aged 51 years and over is 1.7 mg and 1.5 mg, respectively. Adults 19 to 50 years of age require 1.3 mg of vitamin B_6. The UL has been set at 100 mg per day for those aged 19 years and over.[24]

Appropriate dietary sources include liver, meats, vegetables, cereals, and nuts (Table 6).

Table 4. Folate Content of Selected Foods

Food item	Folate (mcg)
Chicken liver, cooked (100 g)	500
Lentils, cooked (1 c, 200 g)	340
Black-eyed peas, cooked (1 c, 200 g)	200
Spinach, cooked (1 c, 200 g)	250
Kidney beans, cooked (1 c, 200 g)	220
Avocado (1 medium size fruit)	125
Peas, cooked (1 c, 200 g)	100
Asparagus cooked (4 spears)	90
Orange juice (250mL)	70
Collards (1/2 c)	64
Papaya (1 c, cubed)	50
Brussel sprouts, (1/2 c)	45
Peanuts (2 tbs)	35
Broccoli (1/2 c, cooked)	38

Vitamin D

The DRI for men and women aged 51 to 70 years is 10 mcg, and it is 15 mcg for those over 70. The UL has been set at 50 mcg per day.[23]

Dietary assessments of the older person confirm that mean intakes of 2.5 mcg of vitamin D are not uncommon.[13] Risk of osteomalacia and fractures is particularly increased in these individuals. Correction for vitamin D deficiency can be achieved through appropriate age-adjusted amounts.

Appropriate dietary sources include fish liver oils; oily fish including salmon, sardines, oysters, and mackerel; and some diary products (Table 7). Dairy foods such as milk and yogurt are often fortified with vitamin D and are a convenient source of the vitamin for older Americans.

Key Foods

Certain foods provide multiple nutrients in the at-risk category for the older individuals that consume them and are key foods to emphasize in providing effective patient advice. Table 8 provides a summary of the key foods particularly beneficial for addressing at-risk nutrients in older individuals.

In 1978, the US Senate Select Committee on Nutrition and Human Needs established dietary goals for the general American population, including older individuals, that have since been revised.[27] These general guidelines provide a firm basis on which to make specific recommendations and include the following:

1. Eat a variety of foods.
2. Maintain ideal body weight.
3. Avoid too much fat, especially saturated fat and cholesterol.
4. Eat foods with adequate amounts of starch and fiber.
5. Avoid too much sugar.
6. Avoid too much sodium and salt.
7. If you drink alcohol, do so in moderation.

Step 4—General recommendations

Integrative medicine fosters the notion that effective treatment is best achieved by addressing the needs of the individual holistically. This approach recognizes that in order to improve the nutritional status of the older person, aspects other than diet alone need to be considered. The functional capacity and energy expenditure of the older person appears to be critically linked to the strength and mass of skeletal muscle. Any physical activity that can retard the loss of muscle mass has a valuable role to play in preserving independence in old age.

Suitable forms of exercise for older individuals include walking, tai chi, low-impact exercise classes, and supervised weight training. Physical activity can enhance nutritional status by increasing appetite, and therefore nutrient intake, and by delaying the progressive loss of muscle mass.

Digestion can be improved by stimulating the appetite with

Table 5. Vitamin B_{12} Content of Selected Foods

Food item	Vitamin B_{12} (mcg)
Beef liver, cooked (85 g)	95.0
Trout, cooked (1 fillet)	4.60
Tuna, canned (1 c, 200 g)	4.50
Beef, steak, grilled (100 g)	2.10
Cottage cheese (1 c, 200 g)	1.40
Clams (3/4 c)	1.05
Oysters (6 oysters)	1.02
Skim milk (1 c, 250 mL)	0.90
Whole, plain yogurt (1 tub, 200 g)	0.90
Whole milk (250 mL)	0.80
Eggs, hard boiled (1 large)	0.60
Cheese, cheddar (30 g)	0.20

Table 6. Vitamin B_6 Content of Selected Foods

Food item	Vitamin B_6 (mcg)
Beef liver (85 g)	1.20
Banana (1 medium)	0.70
Chicken, roast (1 c, chopped)	0.60
Avocado (1 medium)	0.60
Tuna, canned (1 c, 200 g)	0.50
Spinach, cooked (1 c)	0.40
Soybeans, cooked (1 c)	0.38
Raisins (1 c)	0.34
Green peas, cooked (1 c)	0.33
Brown rice, cooked (1 c)	0.27
White rice, cooked (1 c)	0.14

Table 7. Vitamin D Content of Selected Foods

Food item	Vitamin D (mcg)
Cod liver oil (1 tbs)	56.0
Salmon, pink, canned, drained (100 g)	16.0
Sardines, canned (100 g)	7.0
Oysters (6)	6.7
Mackerel, canned in oil (100 g)	6.3
Whole milk, fortified (250 mL)	2.5
Skim milk, fortified (250 mL)	2.5
Beef salami (1 slice, 23 g)	2.0
Egg yolk	0.6

Table 8. Key Foods for Older Individuals

Food item	Selected Nutrients
Lean meat—beef, lamb, chicken	Protein, folate, vitamin B_{12}, and vitamin B_6
Fish—sardines, tuna, mackerel, salmon (canned with bones)	Protein, calcium, vitamin B_{12}, vitamin B_6, and vitamin D
Shellfish—oysters	Protein, vitamin B_{12}, and vitamin D
Soy—milk (fortified with calcium)	Protein, calcium, and vitamin B_6
Cow's milk—skim and whole (fortified with vitamin D)	Protein, calcium, vitamin B_{12}, and vitamin D
Eggs	Protein, vitamin B_{12}, vitamin B_6, and vitamin D (egg yolk)
Green leafy vegetables—broccoli, kale	Calcium and folate

herbal bitters (such as Swedish bitters) and by eating bitter greens (such as kale and dandelion leaves). Elderly individuals living by themselves often lose interest in food and food preparation. Clinical attention to mood dysphoria, depression, and signs of social isolation as components of holistic management of the individual can have a marked effect on an individual's nutritional intake. Above all, food is an essential part of life, and the older individual needs to be encouraged to continue to engage in exploration and innovation around food as part of an active lifestyle.

Conclusion

In this new millennium, the challenge for healthcare professionals in the developed countries is to reduce the morbidity associated with nutritional deficiencies so that the additional years an older person has are enjoyable. Appropriate recognition and assessment of nutritional needs of the older individual may contribute significantly to ensuring healthy aging and may reduce the demands on existing health services.

The incorporation of methods to improve digestion and enhance nutrient bioavailability is considered an essential component of successful nutritional intervention for older Americans. Primary care clinicians are well placed to provide an important role in the recognition, assessment, and management of nutritional deficiencies in the elderly, and the 4-step approach outlined in this article provides a simple method to incorporate these activities into clinical practice.

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References

1. Krasinski SD, Russell RM, Samloff M, et al. Fundic atrophic gastritis in an elderly population. *J Am Soc Geriatr Dent.* 1986;34:800-806.
2. Evans WJ. Exercise, nutrition, and aging. *Clin Geriatr Med.* 1995;11(4):725-734.
3. Gariballa SE, Sinclair AJ. Nutrition, ageing and ill health. *Br J Nutr.* 1998;80:7-23.
4. Russell RM. Factors in aging that effect the bioavailability of nutrients. *J Nutr.* 2001;1313:1359S-1361S.
5. Ryan AS, Craig LD, Finn SC. Nutrient intakes and dietary patterns of older Americans: a national study. *J Gerontol.* 1992;47(5): M145-M150.
6. Haller J. The vitamin status and its adequacy in the elderly: an international review. *Intern J Nutr Res.* 1999;69:160-168.
7. Richard MJ, Roussel AM. Micronutrients and ageing: intakes and requirements. *Proc Nutr Soc.* 1997;58:573-578.
8. Drewnowski A and Shultz. Impact of aging on eating behaviors, food choices, nutrition, and health status. *J Nutr Health Aging.* 2001;5(2):75-79.
9. Jensen GL, McGee M. Nutrition in the elderly. *Gastroenterol Clin North Am.* 2001;30(2):313-334.
10. Roubenoff R. Sarcopenia and its implications for the elderly. *Eur J Clin Nutr.* 2000;54(suppl 3):S40-S47.
11. Kurpad AV, Vaz M. Protein and amino acid requirements in the elderly. *Eur J Clin Nutr.* 2000;54(suppl 3):2000;S131-S142.
12. Nicolas AS, Andrieu S, Nourhashemi F, Rolland Y, Vellas B. Successful aging and nutrition. *Nutr Rev.* 2001;59(8):S88-S92.
13. Blumberg J. Nutritional needs of seniors. *J Am Coll Nutr.* 1997;16(6):517-523.
14. Clarke DM, Wahlqvist ML, Boyd J, Strauss G. Undereating and undernutrition in old age: integrating bio-psychosocial aspects. *Age Ageing.* 1998;27:527-534.
15. Curran J. Overview of geriatric nutrition. *Dysphagia.* 1990;5:72-76.
16. Drewnowski A, Warren-Mears VA. Does aging change nutrition requirements? *J Nutr Health Aging.* 2001;5(2):70-74.
17. Young VR. Macronutrient needs in the elderly. *Nutr Rev.* 1992;50(12):454-462.
18. Koehler KM, Garry PJ. Nutrition and aging. *Clin Lab Med.* 1993;13(2):433-453. Review.
19. Foote JA, Giuliano AR, Harris RB.Older adults need guidance to meet nutritional recommendations. *J Am Coll Nutr.* 2000;19(5):628-640.
20. Charles RP. Nutrition assessment methods for the older Irish adult in the clinical and community settings. *Proc Nutr Soc.* 1998;57(4):599-602. Review.
21. Gibson RS. *Principles of Nutritional Assessment.* New York, NY: Oxford University Press;1990.
22. English R, Lewis J. Australian New Zealand Food Authority. *Food for Health.* Canberra: Australian Government Publishing Service;1997.
23. Reavley N. *Vitamins Etc.* Melbourne, Australia: Bookman Press; 1998.
24. Mahan L, Escott-Stump S, eds. *Krause's Food, Nutrition, and Diet Therapy.* 10th ed.W.B. Saunders Company;2000.
25. Monsen ER. Dietary Reference Intakes for the antioxidant nutrients: vitamin C, vitamin E, selenium and carotenoids. *J Am Diet Assoc.* 2000;100(6):637-640.
26. Campbell WW. Dietary protein requirements of older people: is the RDA adequate? *Nutr Today.* 1996;31(5):192-197.
27. Ebersole P, Hess B, eds. *Toward Healthy Aging.* 5th ed. London, England: Mosby; 1998.