

Healthy Aging

Nutrition and Healthy Aging

*Our mission is to help the people of Canada
maintain and improve their health.*

Health Canada

To obtain more information on this report, please contact:

Division of Aging and Seniors
Health Canada
Address Locator: 1908 A1
Ottawa (Ontario)
K1A 1B4

Tel: (613) 952-7606
Fax: (613) 957-9938
E-mail: seniors@hc-sc.gc.ca
Internet: <http://www.hc-sc.gc.ca/seniors-aines/>

The opinions expressed in this document are those of the author and do not necessarily reflect the official views of Health Canada.

© Minister of Public Works and Government Services Canada, 2002
Cat.: H39-612/2002-3E
ISBN: 0-662-31954-0

Ce rapport est disponible en français sous le titre : *Vieillesse en santé : Alimentation saine et vieillissement en santé.*

Foreword

This document on the subject of Nutrition and Healthy Aging was developed as a background paper for the *Workshop on Healthy Aging: Aging and Health Practices*, organized by Health Canada's Division of Aging and Seniors in November 2001. Following a series of internal investigations, the Division identified four key determinants that play key roles in healthy aging: healthy eating, injury prevention, physical activity, and smoking cessation. The Division convened a workshop to solicit the advice of experts and stakeholders on the development of an action plan on healthy aging, with a specific focus on the four areas noted above. Prior to the workshop, participants were provided with a series of background papers viewing the four key determinants through a healthy aging lens. This document is a revised version of the document on nutrition, incorporating comments from experts and stakeholders.

A. Overview of the Issue

Significance of the Issue

Nutrition is a fundamental element of healthy human development and a vital contributor to the overall health of seniors. Healthy eating provides essential energy and nutrients for general well-being, maintenance of health and functional autonomy, and prevention of chronic diseases at older ages. Combined with physical activity, good nutritional status is a key element for seniors to remain independent, maintain their quality of life and avoid progression of chronic conditions.

This presentation will focus on adults 65 years of age or over, since studies on aging generally consider this segment of the population as seniors. Moreover, when considering nutrition-related issues, people 65 years of age or over are quite different from younger adults with respect to: 1) energy and nutritional needs, as well as food choices, attitudes and consumption practices, 2) determinants of nutritional status, 3) vulnerability to energy and nutritional deficiencies, and 4) prevalence of nutritional problems.

Magnitude of the Problem

Energy needs are believed to decline with age because of decreased basal metabolism hormonal functions, reduction in lean body mass and a more sedentary lifestyle. Still, energy requirements could be higher than those set out in current recommendations in the face of impaired regulation of food intake in old age. A recent study using the doubly-labelled water method to assess energy expenditure among women 50 to 80 years of age or older and reporting light exercise activity showed that Canadian recommendations systematically underestimated energy needs for all age groups. Nonetheless, sufficient energy intakes (at least 1500 kcals or 6.3 MJ) distributed among appropriate food choices are essential for adequate nutrient intakes.

Although the protein needs of seniors are still subject to controversy, it has been suggested that their protein requirements exceed those of younger adults (1.0 to 1.25 g/kg vs. 0.8 g/kg body weight, respectively). Indeed, results from a recent study suggest that long-term daily consumption of the protein recommendation (0.8g/kg body weight) may lead to subtle but significant loss of muscle in older people.

While those with no risk factors (e.g smoking, hypertension, diabetes, hyperlipidemia) may experience minimal alteration in organ function with aging, older adults generally have distinct requirements for a range of nutrients to compensate for age-related changes in absorption, utilization and excretion. Specific dietary recommendations for several essential nutrients have not yet been determined because of insufficient information: longitudinal studies are necessary to identify factors related to diminished organ and metabolic function.

Determinants of Nutritional Status

Health, functional and behavioural determinants

Food consumption is a complex phenomenon with multiple, interrelated determinants having individual and collective components. The individual components encompass health, functional and behavioural attributes. In seniors, appetite, which is a decisive factor of food intake, is strongly influenced by medication, presence of physical (e.g. hypertension, chronic infection) or psychological (e.g. depression) disease, and some physiological sensory functions such as taste and smell. Daily energy intake is also partly determined by the level of physical activity. Exercise activates a series of immune and hormonal reactions which lead to increased skeletal muscle protein metabolism, higher energy requirements and, consequently, higher energy, protein and other nutrient intakes. Furthermore, chewing or swallowing difficulties greatly influence the quantity and quality of food consumed. The majority of studies in this area reported an adverse effect of poor dental status, chewing difficulties or dry mouth on appetite, weight, protein and nutrient (especially B vitamins) intakes.

On the other hand, idiosyncratic food beliefs and practices have not been sufficiently investigated in the very old. It has been suggested that foods which reinforce self-esteem and have symbolic and/or traditional content may be of particular importance to the old-old. In home-dwelling Québécois 55 to 74 years of age, better diet quality among women was found to be related to affirmative health and dietary concerns, while better diets in men were driven mainly by fat and cholesterol concerns. While these analyses were conducted in a relatively young sector of the older population, stated attitudes in relation to reported dietary practices could have implications for nutrition-based health promotion directed at older people. A recent study on predictors of dietary intakes in free-living seniors from the Ontario Health Survey (OHS) found that better perceived health status, belief in the relationship between nutrition and health, good autonomy and vision were positive predictors of diet quality among both men and women. Functional limitations in food intake-related activities (i.e. shopping, cooking, eating) negatively affect energy and nutrient intake. Among senior home care clients, arthritis, poor vision and appetite, and high levels of stress have a negative impact on energy intake leading to a poor quality diet.

Physiological factors affecting absorptive capacities, metabolism and bioavailability

The bioavailability of many nutrients can be disrupted at the point of absorption or by enzymatic activity. For example, the prevalence of atrophic gastritis varies from 20% to 50% in the senior population; this condition results in a decrease in the pH of the gastrointestinal tract leading to a marked reduction in the absorption of pH-dependent nutrients such as vitamins C, B₁₂, B₆ and folic acid. Bioavailability is further impaired by the age-related decreased parietal cell secretion of a glycoprotein called intrinsic factor which binds vitamin B₁₂ and permits its efficient absorption. Inflammation increases urinary loss of zinc, and intestinal absorption of calcium decreases with age and is further exacerbated by gastrointestinal problems. As people age, metabolic efficacy decreases for some nutrients, such as protein and glucose. Changes observed in energy metabolism in older people could be related to hormonal status as well as levels of inflammatory cytokines such as interleukin 1b (IL-1b) and 6 (IL-6) and physical activity level. Finally, the risk of drug-nutrient interactions increases with age, as seniors are prescribed more drugs than any other population sector. Interactions are complex and can alter nutrient digestion and absorption, metabolism, utilization or excretion. Also, little is known about interactions between energy metabolism, hormonal status and body composition.

Environmental determinants

Social support (e.g. frequency and quality of social contacts vs. isolation), living arrangements (i.e. living alone vs. with a family member or other person) and access to community food services have been shown to be related to dietary quantity and quality in community-dwelling senior populations along with socio-economic factors (e.g. education, occupational history, income). It is instructive to consider environmental determinants of nutrition from the perspective of change along a gradient of decreasing autonomy, while examining the dynamic interaction of resources needed and used to meet dietary needs, as well as adaptive dietary strategies which often follow changes in living arrangements.

Prevalence of Malnutrition

Poor nutrition status or malnutrition is defined as decrease in nutrient reserves measured by chronically low dietary intake, low body weight, weight loss or below normal biochemical indicators. Prevalent rates of disease and nutrition-related problems are greatly affected by the living arrangement and characteristics of the older population because living arrangements illustrate health and functional status. Therefore, differential aging associated with physical and mental health status is reflected in the nutritional status and the level of nutritional risk among different sub-groups of the senior population.

Among autonomous and ambulatory seniors, such as those participating in large-scale nutrition surveys, the prevalence is very low. However, as health and functional capacities deteriorate, the prevalence of malnutrition increases dramatically, reaching 60% in nursing homes or hospital settings. Among community-living seniors, high prevalence of malnutrition, illustrated by very low energy and nutrient intakes and weight loss, is observed among functionally dependent free-living seniors compared to those who are autonomous and independent.

Consequences of Malnutrition

Inadequate intake of energy and some nutrients have been associated with decreased body strength, lower resistance to infection and poorer indicators of quality of life. Both an inadequate body weight for height, and weight loss are associated with hip fractures, reduced autonomy, early institutionalization and increased mortality rates.

Body weight

Optimal weight in old age is a matter of considerable debate. There is some controversy as to whether body weight guidelines for younger adults are fully applicable to persons 70 years of age or over. Risk of mortality associated with greater body mass index [BMI=weight (kg)/height (m)²] declines with age. Furthermore, a number of population studies have shown a U-shaped relationship of BMI with mortality and have associated surprisingly high body weights with the lowest mortality and preserved functional autonomy. Indeed, studies of weight and mortality risk across the spectrum of age show that the nadir of mortality risk occurs at a higher body mass index in older adults than younger adults. A number of well-designed prospective studies have shown that elevated BMI was not associated with increased mortality at advanced ages. For instance, a recent study showed significant excess mortality in thin (BMI 19.4 kg/m²) seniors

while reduced mortality was observed in obese (BMI > 28.5kg/m²) after controlling for covariates such as smoking, functional status and serious medical conditions.

Weight loss

Weight loss is a precise nutritional marker and represents an imbalance between energy intake and expenditure. Prevalence estimates of involuntary weight loss range from 13% to 38% according to the level of autonomy of populations studied and occurs even in the absence of disease. Indeed, weight change may represent the most useful measurement in seniors since it signals loss of muscle and bone as well as fat tissue. Indeed, lean body mass loss is strongly associated with weight loss while higher fat mass appeared to protect against sarcopenia.

Weight loss leads to functional decline, increased risk of hip fracture, early institutionalization and mortality even after controlling for co-existing diseases and other potential confounders. These relationships have been demonstrated in prospective studies of generally healthy senior populations, geriatric patients and functionally dependent free-living seniors. Prospective epidemiologic studies have also shown that weight maintained after menopause is a significant factor in preventing fractures.

These results emphasize the magnitude of weight loss as the public health issue of seniors. Even modest decline in body weight is an important marker of risk for mortality in older adults. There is little evidence supporting the need for weight loss for seniors. Even in those who are obese, weight loss is accompanied by loss of muscle mass, which may explain the relationship of weight loss to disability and mortality.

Effectiveness of Interventions

Development and evaluation of targeted strategies to maintain or restore health, functional autonomy and quality of life in the aging population are still to be undertaken. Very limited Canadian data are available that demonstrate the effectiveness of nutrition-related interventions in senior populations. Nutrition education interventions directly targeted to seniors are scarce, and their evaluation even more so. In this area of nutrition education, we need to adapt public health messages on current knowledge of energy and nutrients needs, as well as food choices, attitudes and consumption practices of seniors. According to specific determinants of nutritional status, we need to target specific sub-groups of the population presumed to be at higher risk.

Over the last few years, some screening programs have been undertaken in institutions and at the community level. For example, in Quebec, a Nutrition Screening Program was developed, validated, evaluated and implemented in CLSCs, day hospitals, day centres and other seniors community organizations. In Ontario, a project entitled Bringing Nutrition Screening to Seniors in Canada, involving Dietitians of Canada, professor Heather Keller and Health Canada, is presently being carried out. Screening and preventive strategies should be population-specific, integrating evidence-based strategies incorporated into health professionals' routine and community organizations. They should aim to increase availability of foods to support "healthy eating" and their efficacy and effectiveness evaluated.

Intervention, including nutritional supplementation or dietary modification in undernourished seniors, has been carried out mainly in institutional settings. Intensive nutritional intervention has the potential to reverse weight loss and even leads to weight gain which has been associated with decreased mortality in a retrospective study of chronic care senior patients. Nevertheless, results are still controversial, especially in community-living frail seniors, and no clear conclusion can be drawn from available data. It is important to know if frail seniors with suboptimal nutritional status, who are managing to remain in their homes, can benefit from nutritional supplementation in terms of improved functional status. The few studies undertaken among this population showed that providing nutritional supplementation, along with dietary follow-up, is feasible and results in significant improvement in nutritional status. Consumption of the liquid supplement significantly increased total energy and nutrient intake in study subjects and resulted in significant weight gain. Even the individuals who were actively losing weight benefited from the intervention by stopping and, in some cases, reversing weight loss. However, improved nutritional status did not translate into significant clinical improvement in muscle strength or other functional indicators. This suggests two avenues of intervention: 1) prevent undernutrition through promotion of optimal nutrition or screening in populations at risk to prevent or retard loss in muscle mass and strength; and 2) target undernourished seniors and seek to increase muscle mass through nutrition supplementation, along with progressive increase in physical activity through a home-based exercise program. It is also crucial to document the events, transitions and changes in the biological parameters which precede weight loss so that true “preventive” interventions can be undertaken.

B. Support for Action

Key Stakeholders

The potential for significant investment by major stakeholders in the area of healthy eating is very good. An extensive system exists in Canada to address nutrition and healthy eating, including the public health network, non-governmental organizations (NGOs), community-based coalitions, the media and a federal, provincial and territorial group on nutrition. The corporate sector has demonstrated some interest in supporting selected initiatives, such as food labelling and related education.

A national nutrition framework developed by an intersectoral committee, *Nutrition for Health: An Agenda for Action*, outlines key strategies and actions to advance the nutritional health of Canadians and serves as a national plan for stakeholders in the nutrition field. Public health departments and the not-for-profit sector also provide support through their delivery networks for the development of policies and programs based on national dietary guidelines. However, there is no national network gathering together researchers, key stakeholders, governmental and NGO organizations and community-based coalitions.

Current Federal Government Strategies

Supporting healthy eating among seniors is possible by addressing such factors as awareness, knowledge and skills relating to food consumption, creating supportive environments and improving the food supply. Health Canada is a recognized leader in the promotion of healthy eating. Health Canada's most important levers to affect change are knowledge development, leadership and policy development, capacity building, and public information and education.

Research and knowledge development

A substantial deficiency in the area of nutrition and healthy eating is the lack of an ongoing monitoring system to assess changes in the food intakes and nutritional status of the general population and specific sub-populations, determinants of eating behaviour, and links to health outcomes. Monitoring of dietary intake patterns, nutritional status and their determinants are essential for policy making and the implementation of appropriate interventions and strategies aimed at chronic disease prevention and improved quality of life. Similarly, there is a great need for research and syntheses of effective interventions and best practices.

Until now, there has been no definite dietary, anthropometric or biochemical standards with respect to optimal nutrition during aging. A "healthy eating" concept needs to be developed using research linking dietary intakes and anthropometric indices to health outcomes. Only longitudinal observations will contribute to substantially clarify and improve the concept of optimal nutrition.

Main barriers to research and knowledge development include: 1) lack of substantial financial support; 2) lack of Canadian researchers in the area of nutritional epidemiology, physiology and sociology; and 3) deficient coordination/collaboration between researchers, public and private partners. This lack of partnership leads to inefficient knowledge translation and uptake.

Leadership and policy development

There is considerable opportunity to integrate the promotion of healthy eating with other Health Canada programs and strategies. As an important factor in the prevention of major chronic diseases, the promotion of healthy eating has been integrated into such initiatives as Heart Health, the Canadian Diabetes Strategy, and Vitality – an integrated approach to healthy living. Collaborations will have to be intensified with the Office of Nutrition Policy and Promotion.

Health Canada is currently collaborating with the United States in the scientific review of nutrient requirements. With the release of the new Dietary Reference Intake (DRI) reports, there is the need to re-evaluate the current nutrition recommendations and dietary guidelines for Canadians, with a particular focus on older adults. As Health Canada explores the promotion of healthy weights, it should consider appropriate benchmarks for seniors, as standards do not currently exist for this population. These revisions will likely have important implications for action, including modified "healthy eating" messages, modifications to food fortification policies, etc.

Capacity building

Health Canada policies and guidelines form the basis for the development of policies and programs to support healthy eating through many different national and community-level

delivery systems. By supporting and working through an extensive system of partners, including provincial, territorial and local governments, other federal government departments, the public health network, NGOs, community-based coalitions and the media, Health Canada's updated nutrition and healthy eating policies and guidelines have tremendous potential to have an impact on the health of Canadian seniors.

Public education and information

Building on the Division of Aging and Seniors' public education mechanisms, there is an opportunity to develop client-targeted educational material to inform health professionals, home care workers, nursing home personnel, community educators and seniors about the nutritional risk factors and nutrition requirements specific to seniors.

References

- ADA. (2000). "Position of the American Dietetic Association: Nutrition, aging, and the continuum of care". *J Am Diet Assoc*, 100, 580–595.
- Allison, D.B., D. Gallagher, M. Heo, F.X. Pi-Sunyer, & S.B. Heymsfield. (1997). "Body mass index and all-cause mortality among people age 70 and over: The Longitudinal Study of Aging". *Int J Obesity*, 21, 424–431.
- Amorim Cruz, J.A., O. Moreiras, Brzozowska & SENECA investigators. (1996). "Longitudinal changes in the intake of vitamins and minerals of seniors in Europe". *Eur J Clin Nutr*, 50 (Suppl 2), S77–S85.
- Andres, R., D. Elahi, J.D. Tobin, D.C. Muller, & L. Brant. (1985). "Impact of age on weight goals". *Ann Intern Med*, 103, 1030–1033.
- Ausman, L.M., & R.M. Russell. Nutrition in the elderly. In M.E. Shils, J.A. Olson, M. Shike, & A.C. Ross (Eds.). "Modern nutrition in health and disease" (pp. 869–881). (9th ed.). Baltimore, MD: Williams & Wilkins.
- Baltes, M.M., & F.R. Lang. (1997). "Everyday functioning and successful aging: The impact of resources". *Psychol & Aging*, 12, 433–443.
- Bianchetti, A., R. Rozzini, C. Carabellese, O. Zanetti, & M. Trabucchi. (1990). "Nutritional intake, socioeconomic conditions, and health status in a large elderly population". *J Am Geriatr Soc*, 38, 521–526.
- Blumberg, J. (1994). "Nutrient requirements of the healthy elderly. Should there be specific RDAs?" *Nutr Rev*, 52(8), S15–S18.
- Blumberg, J., & J. Mayer. (1997). "Nutritional needs of seniors". *J Am Coll Nutr*, 16(6), 517–523.
- Bucht, G., & P.-O. Sandman. (1990). "Nutritional aspects of dementia, especially Alzheimer's disease". *Age Ageing*, 19, S32–S36.
- Campbell, W.W., M.C. Crim, V.R. Young, & W.J. Evans. (1994). "Increased energy requirements and changes in body composition with resistance training in older adults". *Am J Clin Nutr*, 60, 167–175.
- Campbell, W.W., D.W.J.A. Cyr-Campbell, & W.J. Evans. (1997). "Energy requirement for long-term body weight maintenance in older women". *Metab*, 46(8), 884–889.

Campbell, W.W., T.A. Trappe, R.R. Wolfe, & W.J. Evans. (2001). "The Recommended Dietary Allowance for protein may not be adequate for older people to maintain skeletal muscle". *J Gerontol Med Sci*, 56A(6), M373–M380.

Chandra, R.K. (1992). "Effect of vitamin and trace element supplementation on immune response and infection in elderly subjects". *Lancet*, 340, 1124–1127.

Cornoni-Huntley, J.C., T.B. Harris, D.F. Everett et al. (1991). "An overview of body weight of older persons, including the impact on mortality. The National Health and Nutrition Examination Survey I – Epidemiologic Follow-up Study". *J Clin Epidemiol*, 44, 743–753.

Cummings, S.R., M.C. Nevitt, W.S. Browner et al. "Risk factors for hip fracture in white women". *New Engl J Med*, 1995, 332, 767–773.

Davies, L., & K. Carr-Knutson. (1991). "Warning signals for malnutrition in the elderly". *J Am Diet Assoc*, 91, 1413–1417.

Davis, M.A., S.P. Murphy, J.M. Neuhaus, & D. Lein. (1990). "Living arrangements and dietary quality of older U.S. adults". *J Am Diet Assoc*, 90, 1667–1672.

De Castro, J.M. (1993). "Age-related changes in spontaneous food intake and hunger in humans". *Appetite*, 21(3), 255–272.

De Groot, C.P.G.M., W.A. van Staveren, H. Dirren, & J.G.A.J. Hautvast. (1996). "The state of dentition in relation to nutrition in elderly Europeans in the SENECA study of 1993". *Eur J Clin Nutr* 50(Suppl 2), S117–S122.

De Groot, L., W.A. van Staveren, & J. Hautvast. (1991). "Euronut-Seneca-Nutrition and the elderly in Europe". *Eur J Clin Nutr*, 45(Suppl 3), 196.

De Jong, N., I. Mulder, C. de Graaf, & W.A. van Staveren. (1999). "Impaired sensory functioning in elders: The relation with its potential determinants and nutritional intake". *J Gerontol Biol Sci Med Sci*, 54(8), B324–B331.

DeFronzo, R.A., R.C. Bonadona, & E. Ferrannini. (1992). "Pathogenesis of NIDDM – A balanced overview". *Diabetes Care*, 15, 318–368.

Desjardins, I. (1991). "Nutrition et veuvage chez les hommes âgés". *Diététique en action*, 5(2), 38–39.

Dormenval, V., P. Mojon, & E. Budtz-Jorgensen. (1999). "Associations between self-assessed masticatory ability, nutritional status, prosthetic status and salivary flow rate in hospitalized elders". *Oral Dis*, 5(1), 32–38.

Dubois, L., L. Labrecque, M. Girard, R. Grignon, & N. Damestoy. (1999). "Déterminants des

difficultés reliées à l'alimentation dans un groupe de personnes âgées non-institutionnalisées du Québec”. *L'Année gérontologique*, (Suppl), 21–52.

Efthimiou, J., J. Fleming, C. Gomes, & S.G. Spiro. (1988). “The effect of supplementary oral nutrition in poorly nourished patients with chronic obstructive pulmonary disease”. *Am Rev Respir Dis*, 137, 1075–1082.

Ensrud, K.E., J. Cauley, R. Lipschutz, & S.R. Cummings. (1997). “Weight change and fractures in older women”. *Arch Intern Med*, 157, 857–863.

Fereday, A., N.R. Gibson, M. Cox, P.J. Pacy, & D.J. Millward. (1997). “Protein requirements and ageing: Metabolic demand and efficiency of utilization”. *Br J Nutr*, 77, 685–702.

Fielding, R.A., & W.J. Evans. (1997). “Aging and the acute phase response to exercise: Implications for the role of systemic factors on skeletal muscle protein turnover”. *Int J Sports Med*, 18(Suppl 1), S22–S27.

Fine, J.T., G.A. Colditz, E.H. Boakley et al. (1999). “A prospective study of weight change and health-related quality of life in women”. *JAMA*, 282, 2136–2142.

Finkelstein, J.A., & S.S. Schiffman. (1999). “Workshop on taste and smell in the elderly: An overview”. *Physiol Behav*, 66(2), 173–176.

Forbes, G.B. (1999). “Longitudinal changes in adult fat-free mass: Influence of body weight”. *Am J Clin Nutr*, 70, 1025–1031.

Franzoni, S., G.B. Frisoni, S. Boffelli, R. Rozzini, & M. Trabuchi. (1996). “Good nutritional oral intake is associated with equal survival in demented and nondemented very old patients”. *J Am Geriatr*, 44, 1366–1370.

Galanos, A., C. Pieper, J. Cornoni-Huntley, C. Bales, & G. Fillenbaum. “Nutrition and function: Is there a relationship between body mass index and the functional capabilities of community-dwelling elderly?” *J Am Geriatr Soc*, 42, 368–373.

Garry, P.J., & B.C. Vellas. (1996). “Aging and nutrition. In E.E. Ziegler, & L.J. Filer, jr. (Eds.), *Present knowledge of nutrition* (pp. 414–419). (7th ed.). Washington, DC: ILSI Press.

Grabowski, D.C., & J.E. Ellis. (2001). “High body mass index does not predict mortality in older people: Analysis of the Longitudinal Study of Aging”. *J Am Geriatr Soc*, 49, 968–979.

Gray-Donald, K. (1995). “The frail elderly: Meeting the nutritional challenges”. *J Am Diet Assoc*, 95(5), 538–540.

Gray-Donald, K., L. Gibbons, S.H. Shapiro, P.T. Macklem, & J.G. Martin. (1996). “Nutritional status and mortality in chronic obstructive pulmonary disease”. *Am J Resp Crit Care Med*, 153, 961–966.

Gray-Donald, K., H. Payette, & V. Boutier. (1995). "Randomized clinical trial of nutritional supplementation shows little effect on functional status among free-living frail elderly". *J Nutr*, 125, 2965–2971.

Greenspan, S.L., E.R. Myers, L.A. Maitland, N.M. Resnick, & W.C. Hayes. (1994). "Fall severity and bone mineral density as risk factors for hip fracture in ambulatory elderly". *JAMA*, 271, 128–133.

Griep, M.I., G. Verleye, A.H. Franck, K. Collys, T.F. Mets, & D.L. Massart. (1996). "Variation in nutrient intake with dental status, age and odour perception". *Eur J Clin Nutr*, 50(12), 816–825.

Grotowski, M.L., & L.S. Sims. (1978). "Nutritional knowledge, attitudes, and dietary practices of the elderly". *J Am Diet Assoc*, 72, 499–506.

Hama, M.Y., & W.S. Chern. (1988). "Food expenditure and nutrient availability in elderly households". *J Consumer Affairs*, 22(1), 3–19.

Harris, T., E.F. Cook, R. Garrison, M. Higgins, W. Kannel, & L. Goldman. (1988). "Body mass index and mortality among nonsmoking elder persons". The Framingham Heart Study". *JAMA*, 259, 1520–1524.

Harris, T., A.C. Looker, J. Madans, & E.C. Bacon. (1992). "Weight loss and risk of hip fracture in postmenopausal white women aged 60–74. The NHANES-I Epidemiologic Follow-up Study". *J Am Geriatr Soc*, 40, SA5.

International Food Information Council Foundation (IFIC). Accessed Dec. 2000. <http://www.ificinfo.health.org/infosn.htm>.

Jackson, R.A. (1989). Mechanisms of age-related glucose intolerance". *Diabetes Care*, 13 (Suppl 2), S9–S19.

Kaczkowski, C.H., P.J.H. Jones, J.Y. Feng, & S. Bayley. (2000). "Canadian recommendations underestimate energy needs of women over fifty years as determined by doubly-labelled water".

Can J Physiol Pharmacol, 78, 631–635.

Keller, H.H. (1995). "Weight gain impacts morbidity and mortality in institutionalized older persons". *J Am Geriatr Soc*, 43, 165–169.

Keller, H.H., T. Ostbye, & E. Bright-See. (1997). "Predictors of dietary intake in Ontario seniors". *Can J Pub Health*, 88, 305–309.

Krasinski, S.D., R.M. Russell, I.M. Samloff et al. (1986). "Fundic atrophic gastritis in an elderly population. Effect on hemoglobin and several serum nutritional indicators". *J Am Geriatr Soc*,

34, 800–806.

Lamy, P.P. (1994). “Drug–nutrient interactions in the aged”. In R.R. Watson (Ed.), *Handbook of Nutrition in the Aged*. (2nd ed.). Boca Raton, FL: CRC Press Inc.

Langlois, J.A., M. Visser, L.S. Davidovic, S. Maggi, G. Li, & T.B. Harris. (1998). “Hip fracture risk in older white men is associated with change in body weight from age 50 years to old age”. *Arch Intern Med*, 158(9), 990–996.

Launer, L.J., T. Harris, C. Rumpel, & J. Madans. (1994). “Body mass index, weight change and risk of mobility disability in middle-aged and older women”. *JAMA*, 271, 1093–1098.

Lipschitz, D.A., Mitchell, C.O., Russell, R.D., Steele, R.W. & Milton, K.Y. (1985). “Nutritional evaluation and supplementation of elderly subjects participating in a “Meals on Wheels” program”. *J Parent Ent Nutr* 9, 343–347.

Lowenstein, F. (1982). “Nutritional status of the elderly in the United States of America, 1971–1974”. *J Am Coll Nutr*, 1, 165–167.

McGandy, R.B., C.H. Barrows, A. Spanias et al. (1966). “Nutrient intakes and energy expenditure in men of different ages”. *J Gerontol*, 21(4), 581–587.

McIntosh, C., J.E. Morley, & I.M. Chapman. (2000). “The anorexia of aging”. *Nutrition*, 16, 983–995.

McIntosh, W.A., K.S. Kubena, J. Walker, D. Smith, & W.A. Landmann. (1990). “The relationship between beliefs about nutrition and dietary practices of the elderly”. *J Am Diet Assoc*, 90, 671–676.

McIntosh, W.A., P.A. Shifflett, & J.S. Picou. (1989). “Social support, stressful events, strain, dietary intake, and the elderly”. *Med Care*, 27(2), 140–153.

Meneilly, G.S., K. Dawson, & D. Tessier. (1993). “Alterations in glucose metabolism in the elderly patient with diabetes”. *Diabetes Care*, 16, 1241–1248.

Menotti, A., D. Kromhout, A. Nissinen, S. Giampaoli, F. Seccareccia, E. Feskens, J. Pekkanen, & M. Tervahauta. (1996). “Short-term all-cause mortality and its determinants in elderly male populations in Finland, the Netherlands, and Italy: The FINE Study”. *Prevent Med*, 25, 319–326.

Millward, D.J. & S.B. Roberts. (1996). “Protein requirements of older individuals”. *Nutr Res Rev*, 9, 67–87. Notes: (review)

Mojon, P., E. Budtz-Jorgensen, & C.H. Rapin. (1999). “Relationship between oral health and nutrition in very old people”. *Age Ageing*, 28(5), 463–468.

Morais, J.A., & S. Chevalier. (1999). “Le besoin protéique et le métabolisme des protéines chez la personne âgée”. *L'Année Gériatologique*, Suppl., 113–130.

Morais, J.A., R. Ross, R. Gougeon, P.B. Pencharz, P.J.H. Jones, & E.B. Marliss. (1997). “Aging and protein turnover: Altered contribution of muscle vs non-muscle tissues assessed by whole-body MRI”. *Am J Clin Nutr*, 66(1), 210.

Mowé, M., T. Bohmer, & E. Kindt. (1994). “Reduced nutritional status in an elderly population (>70 y) is probable before disease and possibly contributes to the development of disease”. *Am J Clin Nutr*, 59, 317–324.

Murphy, S.P., M.A. Davis, J.M. Neuhaus, & D. Lein. (1990). “Factors influencing the dietary adequacy and energy intake of older Americans”. *J Nutr Educ*, 22, 284–291.

Newman, A.B., D. Yanez, T. Harris, A. Duxbury, P.L. Enright, & L.P. Fried. (2001). “Weight change in old age and its association with mortality”. *J Am Geriatr Soc*, 49, 1309–1318.

Pannemans, D.L.E., D Halliday, K. Westerterp, & A.D.M. Kester. (1995). “Effects of variable protein intake on whole-body protein turnover in young men and women”. *Am J Clin Nutr*, 61, 69–74.

Payette, H., & G. Ferland. (1999). “La malnutrition chez les personnes âgées démentes: Étiologie, évolution et efficacité des interventions”. Dans *La collection l'Année gériatologique* (pp. 131–145). Paris: Maison Serdi.

Payette, H., V. Boutier, C. Coulombe, & K. Gray-Donald. (Accepted). “Benefits of nutritional supplementation in the free-living frail undernourished elderly: A prospective randomized community trial”. *J Am Diet Assoc*.

Payette, H., C. Coulombe, V. Boutier, & K. Gray-Donald. (1999). “Weight loss and mortality among the free-living frail elderly: A prospective study”. *J Gerontol Med Sci* 54A, M440–M445.

Payette, H., & K. Gray-Donald. (1994). “Risk of malnutrition in an elderly population receiving home care services”. *Facts Res Gerontol*, (Suppl), 71–85.

Payette, H., K. Gray-Donald, C. Coulombe, & V. Boutier. (2000). “Risk factors for institutionalization in a free-living functionally dependent elderly population”. *J Clin Epidemiol* 53(6), 579–587.

Payette, H., K. Gray-Donald, R. Cyr, & V. Boutier, V. (1995). “Predictors of dietary intake in a functionally dependent elderly population in the community”. *Am J Public Health*, 85, 677–683.

Poehlman, E.T., & M.J. Toth. (1996). “Energy dysregulation in menopause”. *Menopause Manage*, 5, 18–21.

- Poehlman, E.T. (1998). "Effect of exercise on daily energy needs in older individuals". *Am J Clin Nutr*, 68, 997–998.
- Prothro, J.W., & C.A. Rosenbloom. (1999). Description of a mixed ethnic, elderly population. II. Food group behavior and related nonfood characteristics". *J Gerontol Biol Sci Med Sci*, 54, M325–M328.
- Roberts, S.B. (2000). "Energy regulation and aging: Recent findings and their implications". *Nutrition Rev*, 58(4), 91–97.
- Roberts, S.B., & G. Dallal. (1998). "Effects of age on energy balance". *Am J Clin Nutr*, 68S, 975S–979S.
- Rosenberg, I.H., & J.W. Miller. (1992). "Nutritional factors in physical and cognitive functions of elderly people". *Am J Clin Nutr*, 55, S1237–S1243.
- Russell, R.M. (2000). "The aging process as a modifier of metabolism". *Am J Clin Nutr*, 72 (Suppl), 529S–532S.
- Russell, R.M. (1997). "New views on the RDAs for older adults". *J Am Diet Assoc*, 97, 515–518.
- Russell, R.M., R.A. Jacob, I.M. Samloff, & S.D. Krasinski. (1983). "The effect of atrophic gastritis on serum vitamin levels in an elderly population". *Gastroenterol*, 84(5 (Part II)), 1291.
- Sandman, P-O., R. Adolfsson, C. Nygren, G. Hallmans, & B. Winblad. (1987). "Nutritional status and dietary intake in institutionalized patients with Alzheimer's disease and multiinfarct dementia". *J Am Geriatr Soc*, 35, 31–38.
- Schiffman, S.S. (1999). "Chemosensory impairment and appetite commentary on "Impaired sensory functioning in elders: The relation with its potential determinants and nutritional intake" [comment]". *J Gerontol (Series A), Biol Sci Med Sci*, 54(8), B332–B3325.
- Schlettwein-Gsell, D. (1992). "Nutrition and the quality of life: A measure for the outcome of nutritional intervention?" *Am J Clin Nutr* 55, 1263S–1266S.
- Seeman, T.E., P.A. Charpentier, L.F. Berkman et al. (1994). "Predicting changes in physical performance in a high-functioning elderly cohort. MacArthur studies of successful aging". *J Gerontol Med Sci*, 49, M97–M108.
- Selhub, J., L.C. Bagley, J. Miller, & J.H. Rosenberg. (2000). "B vitamins, homocysteine, and neurocognitive function in the elderly". *Am J Clin Nutr* 71, 614S–620S.
- Sem, S.W., M. Nes, K. Engedal, J.I. Pedersen, & K. Trygg. (1988). "An attempt to identify and describe a group of non-institutionalised elderly with the lowest nutrient score". *Compr Gerontol*, 2, 60–66.

- Shatenstein, B., & G. Ferland. (2000). "Absence of nutritional or clinical consequences of decentralised bulk food portioning in elderly nursing home residents with dementia in Montréal". *J Am Diet Assoc*, 100(11), 1354–1360.
- Stevens, J. (2000). "Impact of age on associations between weight and mortality". *Nutrition Reviews*, 58(5), 129–137.
- Stipanuk, M.H. *Biochemical and physiological aspects of human nutrition*. Philadelphia: WB Saunders Company, 2000.
- Sullivan, D.H., W. Martin, N. Flaxman, & J.E. Hagen. (1993). "Oral health problems and involuntary weight loss in a population of frail elderly". *J Am Geriatr Soc*, 41, 725–731.
- Sullivan, D.H., G.A. Patch, R.C. Walls, & D.A. Lipschitz. (1990). "Impact of nutrition status on morbidity and mortality in a select population of geriatric rehabilitation patients". *Am J Clin Nutr*, 51, 749–758.
- Sullivan, D.H., R.C. Walls, & M.M. Bopp. (1995). "Protein-energy undernutrition and the risk of mortality within one year of hospital discharge: A follow-up study". *J Am Geriatr Soc*, 43, 507–512.
- Toth, M.J., C.K. Sites, & E.T. Poehlman. (1999). "Hormonal and physiological correlates of energy expenditure and substrate oxidation in middle-aged, premenopausal women". *J Clin Endocrinol Metab* 84, 771–774.
- Tucker, K.L., G.E. Dallal, & D. Rush. (1992). "Dietary patterns of elderly Boston-area residents defined by cluster analysis". *J Am Diet Assoc*, 92, 1487–1491.
- Tully, C.L., & D.A. Snowdon. (1995). "Weight change and physical function in older women: Findings from the Nun Study". *J Am Geriatr Soc*, 43, 1394–1397.
- Van der Wielen, R.P.J., G.M. de Wild, L.D. de Groot, W.H.L. Hoefnagels, & W.A. van Staveren. (1996). "Dietary intakes of energy and water-soluble vitamins in different categories of aging". *J Gerontol Biol Sci Med Sci* 51(1), B100–107.
- Walker, D., & R.E. Beauchene. (1991). "The relationship of loneliness, social isolation, and physical health to dietary adequacy of independently living elderly". *J Am Diet Assoc*, 91, 300–304.
- Wallace, J.I., R.S. Schwartz, A.Z. LaCroix, R.F. Uhlmann, & R.A. Pearlman. (1995). "Involuntary weight loss in older outpatients: Incidence and clinical significance". *J Am Geriatr Soc*, 43, 329–337.
- Welle, S., C. Thornton, R. Jozefowicz, & M. Statt. (1993). "Myofibrillar protein synthesis in young and old men". *Am J Physiol*, 264, E693–E698.

Whitney, E.N., & S.R. Rolfes. *Understanding nutrition*. (7th ed.). Minneapolis/St. Paul: West Publishing Co., 1996.

Woo, J., S. Ho, J. Lau, & Y.K.Y.M. Phil. (1994). "Chewing difficulties and nutritional status in elderly". *Nutr Res*, 14(11), 1649–1654.

Woo, J., S. Ho, & A. Sham. (2001). "Longitudinal changes in body mass index and body composition over 3 years and relationship to health outcomes in Hong Kong Chinese aged 70 and older". *J Am Geriatr Soc*, 49(6), 737–746.

Yeh, S.S., & M.W. Schuster. (1999). "Geriatric cachexia: The role cytokines". *Am J Clin Nutr*, 70, 183.

Young, V.R. (1990). "Amino acids and proteins in relation to the nutrition of elderly people". *Age Ageing*, 19, S10–S24.