Geriatric Nutrition
The Health Professional's Handbook

FOURTH EDITION

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To my mother Lynn, who, at the age of 91 years, has set a high standard for successful and graceful aging, and to family, friends, and those I love, who celebrate the days of our lives together.

Contents

Preface

January 2006 marked the year in which the post–World War II baby boom generation started passing the threshold of age 60 years; January 2011 sent the first wave of this generation closer to the age of 65 years and onward toward becoming the retirement generation. The increased demand for healthcare resources of the 76 million individuals born between 1946 and 1964 who are now turning age 65 at the rate of 8000 a day is a harbinger of things to come. The baby boomers are unique in that they are very different from previous generations: they are better educated, have a more sophisticated awareness of health care, are more invested in wellness and physical activity, expect accessible and affordable health care, and want to be a partner with their healthcare providers in making healthcare decisions. Simultaneously, the healthcare delivery system in the United States is in a transitional period where both infrastructure and services are rapidly changing. To meet the needs and expectations of this large cohort of elderly people, there is an obvious need to train health professionals to meet the challenges of caring for this very large group of older adults.

One dimension of health care that is important throughout the human life span is nutrition. Dietary intake must meet needs for growth and development, support successful reproduction, minimize risk factors for the development of chronic disease, and provide adequate substrate to heal injuries and wounds, fight infection, repair fractures, and recuperate from illness. All of this must be addressed within the context of aging organ systems, age-related physiologic changes, and the existence of chronic disease.

Aging successfully depends on a variety of factors including genetic inheritance, health habits, lifestyle, environmental factors, chronic and acute disease, and access to health care. Relationships among these factors become clearer when ongoing research is integrated into present knowledge. New models of healthcare delivery systems are being explored and disseminated with an eye toward cost, benefit, and impact on the lives of consumers. With the goals of all who work with elderly individuals to promote healthy aging and maximize life span, *Geriatric Nutrition* was revised and updated to integrate new research and information with knowledge already known. The contributors are all noted experts in their fields and provide new and updated information for all who would expand their understanding of the role of nutrition in aging, nutritional needs of aging adults, and nutrition and disease. Every chapter has been updated for this *Fourth Edition*.

The first chapter addresses some of the issues that we can expect to encounter as the population ages and demographics shift with changes in the population profile, immigration, and disease management. Chapters on micronutrient, vitamin, mineral, and trace metal requirements have all been updated. Chapters on smell, taste and somatosensation, oral health, and swallowing disorders have been revised.

Chapters on the aging gastrointestinal tract and the cardiovascular, renal, hematopoietic, endocrine, and skeletal systems have been revised and enlarged. These chapters can contribute to a greater understanding of human aging and the interrelationships with nutrition. A revised chapter on drugs and nutrient interactions gives new information on drugs, supplements, and herbal products and discusses the impact of Medicare Part D.

Nutritional status and assessment, as well as aggressive nutrition support are explored in chapters on nutrition assessment; a new chapter on nutritional support includes some discussion of the ethical issues involved. Additionally, our understanding of health promotion and secondary and tertiary disease prevention and management are deepened in the revised chapters on exercise, on nutrition services for older adults, and in a revised and expanded chapter on health promotion and disease prevention in elderly adults.

The more knowledge gained with scientific advancement, the more information we would like to add with each revision, but limited by time, publisher guidelines, and production requirements, this volume represents the basis of a primer in geriatric nutrition for the health professional. The contents in this new and updated format can contribute to a greater understanding of aging and nutrition, to the reader's own successful aging, and to healthcare professionals' endeavors to enhance healthy aging for parents, patients, family, and friends.

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CHAPTER

1

Demographics of Aging

Ronni Chernoff, PhD, RD, FADA, FASPEN

INTRODUCTION

As they approach the end of their predestined life span, all living organisms experience the process of aging. Aging has been described as "intrinsic, deleterious, universal, progressive and irreversible."[1] It is likely that aging begins when growth and development cease, and this process occurs on an individual timetable, affected by many factors that might not be regulated by any conscious effort; the process of aging can be referred to as *senescence*. Senescence is considered to be the nonreversible, deteriorating changes that occur as cells and organisms age, increasing vulnerability to fatal disease, dysfunction, and, ultimately, death.[2]

Geriatrics experts cannot predict prospectively how an individual will age and at what rate the changes associated with advancing age will become obvious or significant. Many studies on aging are cross-sectional, making them hard to replicate.[3] Aging is a continuous process that occurs in the absence of disease. Aging cells do, however, become more susceptible to dysfunction or disease, and organisms might decrease in mass as a result of an inefficient replacement of cells.

Despite the process that occurs in all living organisms, the life expectancy of humans continues to lengthen.[4] At the beginning of the 20th century, it was not common for people to live much beyond the age of 50 years; average life expectancy in 1900 was approximately 42 years. Of children born in 2000, many will live to celebrate their 100th birthday because of the progress made in postponing mortality, contributing to a greater life span. In 1999, 24.7 million men and 30.6 million women were age 55 years or older.[5] In 2010, there were 40.2 million Americans age 65 and older, and the projection for 2050 is 88.5 million.[6]

Life expectancy nearly doubled in the 20th century, and life expectancy has come close to tripling over human history.[7] One factor contributing to the gains in life expectancy in industrialized countries is a reduction in death rates among elderly people.[8] Death rates resulting from heart disease and cancer declined in the latter decades of the 20th century because of early detection of disease, medical interventions, and other factors.[4] There is a consequence to this increased longevity: increases in health-care costs associated with the aging of the baby boomers.[8]

An interesting artifact that has existed since the early 20th century is that the age of 65 years is arbitrarily identified as a demarcation between middle age and old age, although no biological data support this threshold. Biological aging occurs as a continuous process that varies among individuals. The selection of 65 years as a marker of age was established in the late 19th century by Otto von Bismarck as the dividing line that, when crossed, allowed eligibility for retirement pensions; this was an interesting decision because so few people were expected to achieve this number of years of life at that time in history.[1]

The advances in disease prevention and treatment that have been achieved during the last century have contributed to extending the human life span and delaying debility.[4] Senescence is the result of an imbalance between cellular damage and cellular repair; damage can be reduced through health prevention efforts and repair can be enhanced by medical interventions.[4] Economically, making health care available to more people earlier in life can be a factor in delaying morbidity and mortality and extending life span.[4]

Factors that can affect individual aging rates include such diverse occurrences as genetic profile,[7] food supply, social circumstances, political events, exposure to disease, climate and natural disasters, and other environmental events.[9] The impact of these factors and other life events is impossible to quantify and hard to interpret, especially because it is quite challenging and very expensive to conduct prospective studies on aging for the entire life span of a large enough group of people to draw conclusions about cause and effect of any factor and life span.[3] It is noteworthy that individual aging and population aging, although related, are not the same.[10] For individuals, aging means surviving into advanced years; for population groups, aging is related to an increase in median age.[11] The premier study on aging in the United States is the Baltimore Longitudinal Study of Aging, which has been gathering data prospectively since 1958.

The most valuable information collected regarding human aging must be gathered prospectively so that events that occur throughout the life span of an individual can be linked to physiologic, physical, and psychological changes experienced in later life. It is certainly easier to conduct cross-sectional studies in which groups of individuals at various life stages and varying ages are examined and the differences among them at one point in time are measured; such studies do not yield much information about the events that preceded that point in time or what factors might have contributed to the differences observed.[3]

This area of study is further complicated by the fact that humans are subject to an uncontrolled genetic pool; medical knowledge and interventions that change from one generation to the next; advances in science that affect quality of life, such as food supply and security, refrigeration and climate control; transportation systems; and advances in, and access to new, medications. Adding to the challenge is the lack of biological markers that measure true physiologic age. Although this issue has demanded attention and research resources, there are still no biological markers of aging and little progress in linking the impact of disease to expected life span.[3] It is notable that the maximum human life span has been estimated at approximately 112 to 114 years, and this projection has not changed in 200 years.

DEMOGRAPHIC TRENDS

Until research provides us with a better definition of old age, people who have reached the age of 65 years and those who are older will remain the reference group when the elderly population is discussed. Between 1950 and 1980, the population of those older than age 65 more than doubled so that one in every eight people fell into this age group; by 1997, one in six fell into this age group. Projections indicate that by 2030, 70 million people will be age 60 years or older, and, by 2050, the population older than age 65 is projected to be 88.5 million.[6]

What is truly significant about this increase is not the total size of this group, but rather that the greatest increases occur among the "old" and the "oldest old." Between 1997 and 2025, the percentage of individuals 75 years and older will increase from 5.8% to 7.9%. During the 1990s, the population age 85 years and older increased from 3.1 million to 4.2 million, a 38% growth.[11] This 85+ population is anticipated to grow from 4.2 million to 6.6 million in 2020, and then to 8.9 million by 2030, and to 19 million by 2050.[6] The number of centenarians, people age 100 years or older, is projected to increase from 37,000 in 1990 to approximately 131,000 (middle estimate based on population projections) in 2020.[12] (See **Figure 1-1**.)

Death rates declined or remained constant throughout the 20th century; however, declines in mortality rates varied by age, race, and sex.[13] Women had a consistently greater decline in mortality rate, making the proportion of women in older age categories larger.[13] (See **Figure 1-2**.) Actually, more boys than girls are born, but because there is a higher death rate for males and an improvement in mortality rate for females, this ratio changes early in life. In 1980, there were 44 males to every 100 females older than age 85 years. In 1996, there were 20 million older women and 13.9 million older men. In 2010, there were 22.9 million women and 17.3 million men older than age 65 years. By 2050, the population of women older than age 65 years is projected at 48.6 million and the population of men older than age 65 years is projected at 39.9 million.[6] What is of equal significance is that, by 2050, the estimate of persons older than age 85 years is 11.6 million females and 7.46 million males.[6] The ratio of males to females declines with advancing age although the gap is expected to narrow in coming decades; this ratio is expected to change from 62 males for every 100 females older than age 85 by 2020[14] to 71 males for every 100 females by 2050.[6,11] In 2050, it is estimated that 4.3% of the United States population will be older than age 85 years. The result will be an increasingly large group of very old people in the very old age group, and this presents serious policy issues.[6]

The impact of this trend is yet to be determined. Increased incidence of disability and severity of disability are associated with lower socioeconomic status, age, and gender.[14]

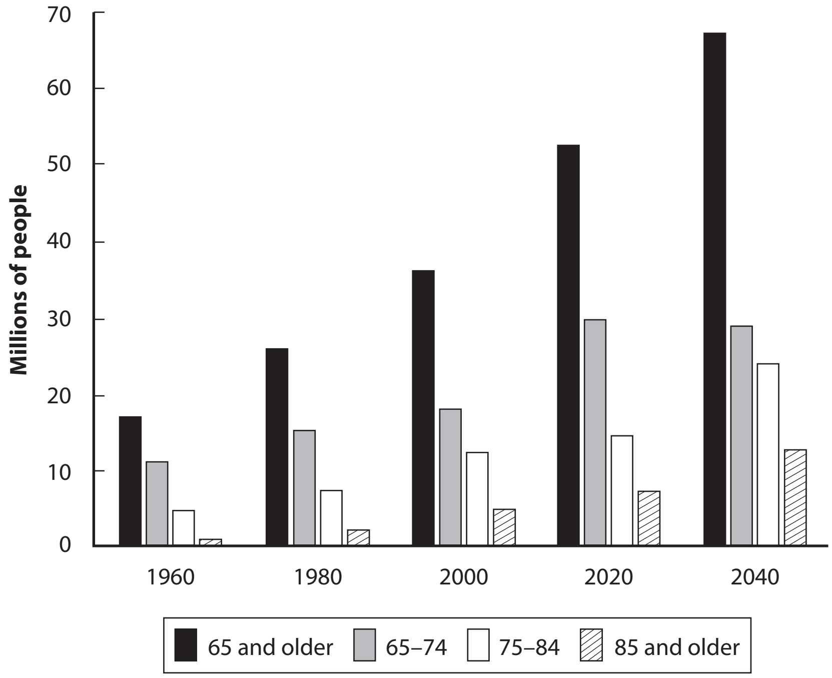

Figure 1-1 Population projections for various age groups from 1960 to 2040
Source: Based on U.S. Census Bureau data

Disability ranges along a continuum of decreasing independence.[15] The first level is *impairment*, which is characterized by a loss of physical or mental functioning. *Functional limitations* refers to the inability of the individual to perform physical or mental tasks needed for independent living. *Dependence* is defined as an inability to perform the activities of daily living (ADLs) such as dressing, bathing, and eating.[15]

In recent decades, disability rates in the United States have declined in older adults. It is hypothesized that this decline is the result of improved and/or more aggressive management of disabling conditions.[16,17] Women live longer, but they also have more disabilities than do elderly men. Disability in men is usually related to heart disease and stroke; in women, disability is related to osteoporosis and associated fractures, arthritis, and circulatory diseases. Women tend to live longer with disability than do men and tend to be more economically dependent.[18] However, men with lower education levels have a significantly greater loss of mobility than do women who have the same income, age, and chronic conditions.[15,16] Disability is linked with increased healthcare expenditures in later years.[16,19] There seems to be a decreasing trend in disability in older persons in recent years associated with a more educated elderly cohort.[16,20]

There are differences in population demographics by race as well as by age and sex. By 2030, individuals who are in minority groups are projected to be 25% of the total older population; by 2050, it is projected that the minority elderly population will be 42%.[6,11] In 2002, non-Hispanic whites accounted for 80% of the population older than age 65, 86% of those 75 to 84 years, and 87% of those 85 years and older.[21] By 2050, non-Hispanic whites older than age 65 will have fallen to 77%, with 12% being African Americans and 9% Asian.[6] American Indians and Alaska Natives represent 3.6%, Asians and Pacific Islanders are 2.9%, and Hispanics are 4.1% of the group 85 years old and older.[21] By 2050, of those 85 years and older, 81% are projected to be white, 10% will be African American, and 6% will be Asian.[6] Presently, there are many more elderly white people than there are elderly African Americans, despite a proportionately higher birth rate among African Americans. This discrepancy might be the result of a higher mortality rate at younger ages for African Americans as well as increased mortality from hypertension, less access to preventive healthcare services, and delays in seeing physicians until the later stages of disease.[22,23] Although the early mortality rate for African Americans is expected to decrease, it is not expected to compensate for the gap among the races in the near future. Between 1990 and 2030, the elderly African American population is expected to grow by 159%.

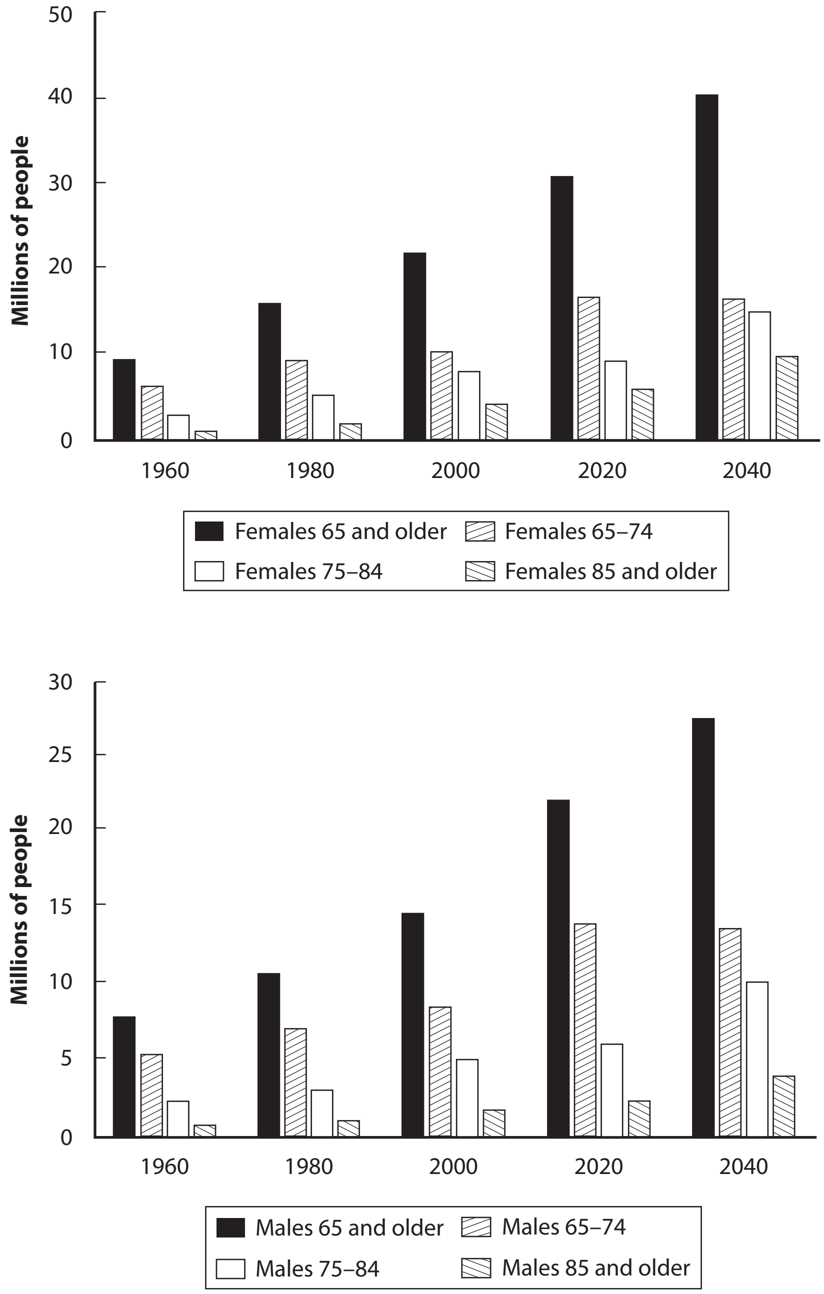

Figure 1-2 Comparison of population growth by age for women and men in the United States, 1960–2040
Source: Based on U.S. Census Bureau data

The ethnic diversity of the older population, as well as the working-age population, will increase as a result of the larger families and higher birth rates of both African Americans and Hispanic Americans.[24] It has been suggested that the two major factors driving the growth of the population are birth rates and net immigration. The number of Hispanic Americans is expected to increase by 570% between 1990 and 2030. Life expectancy is another factor that will drive policy decisions in the near and distant future; life expectancy will increase from 76 years in 1993 to 82.6 years in 2050 with a possibility of being closer to 87.5 years.[24]

It is accepted that the diversity of the population will continue and that by 2050, 60% of the American population will be other than white. The population of African Americans is projected to double in size to approximately 62 million by 2050. The fastest growing segment of the population is the Asian and Pacific Islander group, which is expected to increase by five times its present level to approximately 41 million by 2050.[24]

In 2009, about 3.4 million older adults were living below the poverty line.[11] In 2009, 6.6% of elderly whites, 19.5% of elderly African Americans, 15.8% of Asian elders, and 18.3% of elderly Hispanic were poor as defined by the poverty line. Another 2.1 million were considered “near poor,” defined as living on incomes between poverty and 125% of poverty.[11] Compared with elders in other ethnic groups, Hispanic American elders are 2.5 times more likely to live with incomes below the poverty line; in 1989, 27% of Hispanic American women and 20% of Hispanic American men were classified as poor.[11] However, Hispanic Americans tend to spend a larger proportion of their disposable income on health care, despite a lower likelihood of having health insurance than other groups of elderly people.[25] Health care tends to be accessed through emergency departments, and hospital admissions are usually through the emergency department.

Along with the socioeconomic barriers to accessing health care, Hispanic American elderly also have cultural and language barriers to overcome. There appears to be a link between having English language skills and having a primary care provider. This might reflect a higher socioeconomic status or more successful acculturation among English speakers than those who speak only Spanish.[25] Additionally, cultural traditions among older Hispanics/Latinos might impair independent decision making; the extended family might be more important than an individual and the patient might delay treatment until the family has had an opportunity to offer opinions.[26]

Asian and Pacific Islander elders have different cultural traditions than do other minority groups. They tend to form a more cohesive family group that offers support for elderly family members. Their cultural mores contribute to a unique approach to medical care, relying heavily on the customary view of mind and body linkages and the use of traditional medicines. Although this group of older adults represents a small proportion of the population, the number of elderly Asians and Pacific Islanders is expected to grow as the immigrants from the 1970s age.[27]

Life expectancy of Native Americans has increased dramatically during the past decade and is expected to increase by 294% by 2030. In recent years, innovative approaches to provide health care and health information have served to further reduce the gap in life expectancy compared with those not of American Indian or Alaska Native descent from 8 years to 5 years.[28] Data regarding the health status of elderly Native Americans are sparse, and their availability is highly variable among tribes. The Indian Health Service was elevated to agency status in the Public Health Service in 1988, and it can be anticipated that this will allow for greater awareness of the health needs of all Native Americans. It is well known that heart disease, diabetes mellitus, cancer, oral health, and nutrition problems exist among Native American groups.[29] Nutrition services and meals for Native Americans receiving care from the Indian Health Service have generally been provided through Title III of the Older Americans Act.

The income of today’s elderly populace is greater than that of similarly aged cohorts of previous generations. Social Security benefits represent the largest source of income for this group, followed by earnings and income from property, pensions, and investments. Although the current group of elderly people is less educated than are Americans of younger age groups, the gap is closing, is expected to change, and the indicators for this shift are beginning to show.[20] The next generation of older adults, the World War II baby boom generation, is much better educated and more affluent than the current age cohort.[30] This fact affects income levels of future groups of older people, who most likely will be more sophisticated and have greater expectations of social care systems and medical care options,[31] which might, therefore, lead to greater expenditures of healthcare resources. These factors contribute to the fact that more of the future elderly adult population will own their own homes and want to stay in them for as long as they can manage. New models of healthcare delivery are geared to keeping elderly, disabled, and terminally ill individuals at home or in a homelike setting.

Demographic trends are affected by many factors, including migration, immigration, and “new elderly births.” New elderly births are the number of people who are newly classified as elderly because they have passed their 60th birthday. This effect has shifted the elderly population in the United States so that it appears to grow faster than the total population; the first wave of the baby boom generation, people born between 1946 and 1964, are moving into this group. Elderly births are making a noticeable impact on African American, Hispanic, and Asian populations where immigration occurred in large numbers in the years prior to World War II. In the future, the impact of this phenomenon will continue to be greater than the effect of migration and immigration.[32]

Another demographic factor that distinguishes the present cohort of elderly people from future generations of older people is their mobility. Older people tend to move geographically less often, and less far, than do younger people; they tend to settle in the geographic region where they were born and raised or where they settled when they married.[31] This is likely to change as the next generation ages; younger retirees are moving to locales different from where they raised their families.[30]

As population demographics shift, population projections by the Census Bureau predict significant difference in rates of change in different regions of the United States. The regions that are growing most rapidly are the South and the West, while the north central region of the country will lose population.[18] Immigration per se has a minimal effect on the demographics of this age group except in four states: Hawaii, California, Florida, and New York. Internal migration has a more noticeable impact on states that tend to be magnets for retirees, led by Nevada, Florida, and Arizona.[32] These factors will influence the need for, and accessibility to, healthcare resources in the future.

IMPACT ON THE HEALTHCARE SYSTEM

One of the natural consequences that accompanies aging is an increase in the prevalence of disabilities and diseases. The incidence of concurrent illnesses and multiple disabilities rises sharply with age and is greatest in the very old segment of the population, those 85 years and older.[31] Perceptions of health status tends to be lower among older adults; 27% of older adults assessed their health as fair or poor compared to 9% for all other people. Older African Americans (42%) and older Hispanics (35%) were more likely to rate their health as fair or poor than were older Caucasians (26%).[11]

When an acute illness episode occurs, the consumption of healthcare resources is greater in this age group of patients because of the multiple chronic problems they might have that must be attended to along with their acute illnesses. Unfortunately, the healthcare system in the United States is becoming increasingly focused on the short-term delivery of acute care, allowing expensive and limited technologies to be used for the maximum number of patients. Complex, frail, very old patients require these expensive, lifesaving technologies, but concurrently they also require extended periods of skilled care for adequate recuperation and rehabilitation.[28] This increasingly large portion of the population will soon strain the resources of the existing healthcare system, if that has not already occurred. In the immediate future, the focus will be on noninstitutional care models that address chronic care in a cost-effective way. Life expectancy and health status at age 70 years predict healthcare expenditures in later years; elderly people in good health at age 70 years have similar health expenditures when compared to those whose health status at age 70 years is poor; however, individuals who are institutionalized by age 70 years have much greater healthcare expenditures.[8]

Chronic diseases, among them diabetes, cancer, and heart disease, account for nearly 70% of deaths in the United States every year.[33] Minority populations (African Americans, Hispanics, American Indians, and Alaska Natives) are twice as likely to have diabetes, death from heart disease, and double the incidence of coronary heart disease. It is postulated that the difference in long-term health and the burdens associated with chronic disease has to do with healthy behaviors, including a nutritious diet, exercise, smoking cessation (or not starting smoking), and avoidance of excessive alcohol consumption.[33] Another important factor is having providers appropriately trained to care for frail elders. Primary care physicians find caring for older patients somewhat difficult because of their medical complexity and their chronicity of care needs, among other challenges.[34]

According to U.S. Census Bureau projections, a substantial increase in the number of older people will occur during the 2010 to 2030 period; the first baby boomers turned 65 in 2011. The older population in 2030 is projected to be twice as large as in 2000, growing from 35 million to 72 million and representing nearly 20% of the total U.S. population at the latter date. On the basis of relatively recent statistics, the population segment older than 65 years is approximately 35 million, which represents slightly more than 12% of the total population.[21] These individuals account for more than 38% of all hospital stays,[11] use approximately 48% of acute care hospital bed days,[35,36] have longer in-hospital stays than do younger adults (6.4 days vs. 4.6 days),[11] buy 25% of all the prescription drugs, spend 30% of the healthcare dollars in the United States (about $53 billion/year), and account for more than 50% of the federal healthcare budget (about $20 billion).[36]

Researchers have found that people 65 years and older were consistently less likely than younger men and women to have a regular source of medical care. Women were more likely than men, and people with more education were more likely than the less educated to have a regular source of care. Among the reasons for delays in seeking care, people aged 75 years or older were most likely to report difficulties with getting to the doctor. Those aged 65 to 74 years were more likely than those 75 years and older to delay medical care and not have a regular doctor.[21] Older people were also more likely than those in younger age groups to visit emergency rooms. People 75 years and older had the highest rates; about 25% visited emergency departments at least once in 2000, and 10% made two or more visits. By 1993, the population older than 85 years of age represented 1.3% of the total population but accounted for 36% of all personal health expenditures, totaling approximately $162 billion.[37]

With national healthcare expenditures totaling an estimated $1.3 trillion in 2000, the United States spent more on health than any other industrialized country in the world.[38] Whereas 19% of the expenses were paid out of pocket and another 12% were paid by private insurance, about 65% were paid by public programs such as Medicare and Medicaid. With about 40 million enrollees in 2000, the Medicare program reported a cost of $222 billion. Medicare payments per enrollee varied among states, ranging from less than $4000 in Hawaii and the mountain states to more than $6200 in some of the East Coast states. Hospital costs accounted for 59% of Medicare expenditures, while expenditures for home healthcare agencies decreased from 14% of hospital insurance in 1995 to 3% in 2000. Researchers predict that increased longevity is likely to have implications for the financing of our healthcare systems.[21]

In 2009, older consumers averaged out-of-pocket healthcare expenditures of $4846, an increase of 61% since 1999. In contrast, the total population spent considerably less, averaging $3126 in out-of-pocket costs. Older Americans spent 12.9% of their total expenditures on health, more than twice the proportion spent by all consumers (6.4%). Health costs incurred on average by older consumers in 2009 consisted of $3027 (63%) for insurance, $821 (17%) for medical services, $828 (17%) for drugs, and $170 (3.5%) for medical supplies.[21]

The incidence of disability increases with advancing age, although there is evidence that the prevalence of disability in elderly adults is decreasing with the baby boom generation.[21] Approximately 74% of individuals age 80 years or older have at least one disability; almost 58% of those older than 80 years had one or more severe disabilities, and 35% required assistance associated with their disabilities.[21]

There is no doubt that healthcare managers and planners must assess the growth of the older segment of the population carefully and plan accordingly.[37] For example, although only 5% of elderly people are in nursing homes at any one time, 90% of those are older than 65 years and 42% of those older than 85 years have experienced a nursing home admission, making the availability of nursing home beds and services an increasingly important part of planning for and allocating healthcare resources in the future.[39] The heaviest users of nursing home beds are women age 85 years and older.[39] It is projected that the nursing home population will increase from 1.5 million in 1980 to 5.2 million in 2040. There is an increased shift in resources toward home health and community-based service providers; this will be a factor in future policy making and planning.[37]

When the baby boomers become the elderly generation between 2020 and 2040, a very large demand for resources and services will occur.[36] Other issues that will affect the utilization of and demand for services include the higher level of education of this generation compared to past generations, the level of medical sophistication they have, the slight downward trend in disability, and their expanded expectations of the healthcare system compared to those displayed by their parents. Baby boomers want the healthcare system to keep them well, not just to take care of them when they are sick. They have had better childhood health and medical care and are generally healthier than previous generations. The next generation of older adults expects accessible, local, convenient, available, and cost-effective services.[30]

The issue of how healthcare services for elderly Americans will be paid for is a major policy problem that needs to be addressed now. As the baby boomers reach retirement age, which started in 2006, it is expected that there will be a major stress on Social Security and Medicare resources.[39,40] Presently, Medicare pays for a notable percentage of the healthcare costs incurred by 41 million older adults when they reach the age of 65, disabled persons, and persons with end-stage renal disease; in fiscal year 2003, Medicare expenditures for older persons totaled $278 billion.[41] Medicare Part A covers in-hospital costs as well as skilled nursing and hospice care; as healthcare costs rise, the likelihood that the funds paid in to Medicare will cover the projected healthcare demands is rapidly decreasing.[39] Medicare Part B (referred to as Supplementary Medical Insurance, or SMI) covers physicians' and other practitioners' services, hospital outpatient department costs, and suppliers of medical equipment.[42]

Policy decisions to increase the retirement eligibility age will not address the problem with Medicare unless the eligibility age for Medicare changes too. Expenditures for acute and long-term care increase substantially with the increase in longevity. For individuals who die at age 65, approximately $31,000 is expended in healthcare costs; for those who turned 65 in 2005, it is projected that long-term healthcare costs will exceed $100,000. These costs might exceed

$200,000 for those who die at age 90, in part because of nursing home care of the very old.[43]

One approach to saving Medicare Part A funds is to shift costs to Medicare Part B, which covers less costly outpatient services. Reducing acute care hospital lengths of stay and shifting healthcare delivery to outpatient clinics, day hospitals, and home-delivered services are potential options for saving money.[41]

Healthcare utilization is a very complex issue. The major factor in this complicated matrix of resource utilization is health status, whether it is based on a medical diagnosis or an individual's perception.[44–47] Utilization has been described by a supply/demand model with some secondary factors that have a major effect on both supply and demand. These secondary factors are demographic (e.g., age, gender, socioeconomics), sociopsychological (e.g., attitudes, personality, health beliefs), sociocultural (e.g., religion, norms and values, ethnicity), and financial-economic (e.g., health insurance, disposable income).[45] On the demand side are age, sex, household composition, education, income, housing, social support system, medical technologies, and attitudes. On the supply side are health insurance and healthcare policy decisions, productivity of providers, efficiency, efficacy and technological developments, prescription drug costs, and suppliers' cooperation in the provision of services.

QUALITY OF LIFE AND HEALTH STATUS

It is well known that older people have more health problems than do younger individuals. However, a large percentage of the population older than age 65 years is relatively healthy and vigorous. Good health status contributes to vitality and quality of life.

Quality of life is a difficult term to define well. Objective indicators of quality of life show only a weak relationship to individuals' perceptions of quality of life.[48] Many subjective factors contribute to quality of life, only one of which is health status. For example, general health and functional status represent one dimension of perceived quality of life, along with socioeconomic status, general life satisfaction, and self-esteem.[48] One point of interest is that subjective estimates of health status by the individual do not correlate closely with objective assessment of health status as measured by laboratory tests and physical examinations.[48] The dimension that appears to correlate better when perceptions are compared with objective measures is functional status. *Functional status* is defined as that ability to perform activities related to self-care and daily living and can be measured by several instruments.[49] Frequently, poor health status and physical disability have an impact on functional ability; it is difficult to separate the two dimensions.[20,50,51]

Approximately 54% of all those older than age 65 years report having at least one disability and approximately one-third have at least one severe disability.[52,53] More than 4.4 million elders reported that their disability limits their ability to carry out ADLs, and 6.5 million reported difficulties in attending to fulfilling the instrumental ADLs. Seventy-two percent of those 85 years of age or older need assistance with ADLs.[20] As the population ages, there will be an increased need for assistive services to supplement family support.[54]

Quality of life takes on different meanings when applied to institutionalized elderly people. Because their health status is questionable, or they would not require institutionalization, factors that contribute to their perceptions of quality of life tend to relate to their immediate environment.[52,53] The quality of their food; the ability to make choices and control some parts of their lives; participation in events in the institution, such as self-feeding or exercise programs; and the attitudes of the care providers and other residents, all contribute to quality of life for chronically ill, elderly people cared for in institutions.[11] Certainly, satisfaction with one's life and surroundings contributes to perception of the overall quality of life. A positive outlook can contribute to better cooperation and compliance with healthcare regimens and perhaps help to maintain health status for a greater part of the latter years of life. All of these factors contribute to successful aging.

HEALTHCARE COSTS

As the elderly portion of the population expands, the consumption of healthcare resources might grow beyond their present availability. Efforts to curb expenditures have focused on acute care resources and have had an impact primarily on elderly, poor, and underprivileged patients. Many factors contribute to the large amounts of money spent on health care in the United States. Certainly, advances in medical technology, which result in the availability of expensive equipment needed to perform diagnostic tests and to provide technical treatment modalities, have contributed to rising costs. An unexpected contributing factor to healthcare costs is health inequalities and disparities. Racial and ethnic disparities occur in both direct and indirect costs. It is estimated that the costs of premature deaths related to minority healthcare disparities costs $230 billion in direct care expenditures and more than $1 trillion in indirect costs.[55] Another important contributing factor is that a large proportion of the population is living longer[21,56] since the management of chronic disease has become easier and since technological advances have made the diagnosis and treatment of serious illnesses more effective.

Data from the National Center for Health Statistics support the proposal that one of the reasons the elderly segment of the population is getting larger is that their death rates are decreasing.[57] Because older people tend to have more disabilities and more chronic conditions, they require and use more healthcare resources.[58] There is no doubt that people older than 65 years require more acute care hospital days than do younger people, and this need increases in even older groups; individuals older than 85 years use 8300 days of acute care hospital resources per 1000 persons; for chronic care resources, individuals older than age 85 years use 8640 days per year per 1000 persons.[58] Medicare hospitalization study data reveal that African Americans, Hispanics, and Native Americans have higher hospitalization rates than do whites, but Asian American Medicare beneficiaries are hospitalized less frequently.[22]

The need for healthcare services in the area of chronic care also requires an examination of the availability of appropriate providers. Models that analyze the requirements for physicians who are trained in geriatrics and are primary care providers indicate that there probably is an increasing compelling need for more physicians trained in geriatrics to work in collaboration with other providers to enhance and deliver quality care for both urban and rural elders[35,59]; in the absence of a trained geriatrician, the kind of health care and services needed can, and should, be provided by midlevel providers such as physician assistants (PAs) and advanced practice nurses (APNs).[60] It is estimated that if service delivery is shifted to ambulatory care practice with PAs and APNs, the number of patient visits can be increased by 12% to 37%, improving physician efficiency.[61]

The need for quality long-term care and the complexity of the issue are attracting the attention of policy makers. Few demographic data describe residents of long-term care facilities because they are often missed or overlooked in censuses or household surveys. However, as the population of frail, elderly people increases, interest in payment sources for their care has become greater. Currently, public or private insurance to help defray the costs of long-term care is limited, although more options are becoming available.[62–66] Skilled nursing services are expensive, and it is likely that in most cases public funds such as Medicare or Medicaid will not cover the costs of care.[67–71] Proprietary nursing homes are reluctant to accept patients who require skilled care; facilities that accept this type of patient might have staff inadequately skilled to care for ill patients. This limitation often creates a difficult situation when services are needed but are not affordable or available.[60]

Experimental and demonstration projects are exploring alternatives to nursing home care. Home health services are one option that can prove to be a viable alternative to nursing home care. Home care services have limitations, particularly the need for caregiver support required to make it work. In one model, a large portion of the care provided (about 72%) is delivered by family members, particularly if the patient's disabilities are not too great. Costs for home services increase with the level of patient disability.[6]

One alternative that has garnered some attention and that is becoming more popular among those who can afford it is assisted living facilities. This option enables older individuals to live independently in their own space until they require assistance such as skilled nursing care; then, they can move within a facility to living spaces that better meet their needs.[22,63]

Some physicians do not favor the home health care concept because they are concerned with malpractice issues, quality-of-care issues, loss of control over patient care, and loss of reimbursement because the home health agencies take over managerial responsibilities.[72] Physicians have a limited role in the delivery of health care when the home care agencies become the primary providers, although recent trends indicate an increase in "house call" programs. The physician is involved only in approving forms that allow home care professionals to be reimbursed or in providing telephone consultations to the primary care provider. To be paid for patients' home health care, physicians must see the patients in the office or visit them in their homes; these activities are very time-consuming and not very cost-effective. However, in recent years the reality of accommodating the needs of the next generation of elders has enhanced the perspective of home and community-based care; the system developments have made this a much more attractive option.[73]

Hospitals are becoming involved in developing home health services because they are a viable option for extending services and marketing other hospital programs. These have become prime objectives because hospital reimbursement systems have contributed to the limited income in many facilities.[11] In fact, hospital-based home healthcare programs have grown faster than independent home healthcare agencies have.[72]

Other models of home care have been developed by the Department of Veterans Affairs. For frail but medically stable elderly individuals who have able caregivers, the home-based primary care program is a successful alternative. The hospital-based staff members make home visits within a 50-mile radius of their base, and skilled health professionals (social workers, pharmacists, APNs, dietitians, and physicians) track patients on a regular schedule and assess their home situations. This program provides continuity of care, which is an important dimension of caring for frail elderly people. Regular contact by telephone enables problems to be dealt with early in their course and hospitalization to be arranged efficiently when needed.[74]

Another program alternative that might offer a feasible solution to the problems of providing health care to elderly patients is adult day health care.[75] Access to appropriate adult day healthcare facilities can enable frail elderly people to remain at home and maintain familiar surroundings and lifestyles. There are different types of adult day care models. The most common model is the social model. Social day care programs are designed to meet the needs of clients who might be disabled but who are medically stable. The primary purpose of these programs is to maintain social and physical capacities through recreational and other social programs and to prevent or delay institutionalization.[75]

Medical model day care programs are designed to provide rehabilitative and support services, with the goal being the restoration of physical and functional abilities. One type of medical model adult day care has been under study through a multicenter health services research study of the Department of Veterans Affairs (VA). In this program, elderly people can remain in their own homes yet receive health care through a day care center that provides therapeutic services. Family members, friends, or other support providers must arrange for transportation to the sites, or the program must provide transportation services. Patients can be enrolled in the program if they require rehabilitative care, such as physical or occupational therapy, medical treatment, or respite care. Patients can attend the center as needed, but usually they attend two or three times per week. They are brought in early in the morning and are picked up late in the afternoon, making it possible for care providers, spouses, or adult children to continue to participate in other activities, such as work, household, and child care responsibilities.[75]

Newer models include patient-centered medical homes and medical foster homes, both of which are viable and less costly alternatives.[76] Patient-centered medical homes have been instituted using several different models but seem to be following a trend in interdisciplinary care, involving physicians, APNs, social workers, pharmacists, dietitians, and others as well as support personnel. Medical foster homes, a program developed by the VA, build on a foster home model but are used for frail, dependent elderly people who do not otherwise have family to care for them. This model relies on a "foster home" that is certified by the VA, has access for persons with disabilities, and offers a home setting and privacy.

One of the technologic advances that make many more options viable is the growth of telemedicine, including telehealth models.[77–79] This applied technology makes access to quality medical care easier and less expensive, particularly among rural-dwelling elderly patients. Use of technologies will revolutionize how health care and medical care and consultation are provided to elderly patients who wish to remain at home and be monitored without traveling long distances to their primary care providers. The electronic medical record is contributing to information portability and greater information sharing among healthcare professionals.

Although ready-made answers to the problems of providing health care to older adults in the future might not exist, these and other options are being explored.[42] It is obvious that something must be done to provide quality health care for this segment of the population. However, to develop the services and find the resources to pay for them, a great deal must be learned about aging, diseases that are common in old age, and the maintenance of health in aging people.

CONCLUSION

No doubt the rapid expansion of the population segment older than 65 years forces healthcare providers to face problems associated with an aging society sooner than they might like. Many creative options have been proposed to provide appropriate quality health care to elderly people, but they need to be tested and evaluated before solutions can be found to the problems inherent in healthcare delivery to a large, distinct population of patients who have different income levels, unique medical problems and profiles, and diverse life experiences.

Within this context, healthcare providers must understand the role of nutrition in the maintenance of health, the management of chronic conditions, and the treatment of serious illness. The remainder of this text addresses the relationship among physiologic aging, nutrition, and disease. Comprehension of these important associations and the application of this knowledge will contribute to more effective health promotion, disease prevention, and disease management in elderly adults.

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CHAPTER

2

Protein Metabolism and Requirements

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INTRODUCTION

Adequate dietary protein intake is critical to maintain the integrity, function, and health of humans by providing amino acids that serve as precursors for essential molecules that are components of all cells in the body.[1] Human aging is a dynamic process that includes progressive changes in body composition, metabolism, physiologic functional capacities, physical activities, food intake, the frequency of disease, and the ability of the body to respond to these changes.[2] It is important to recognize that these changes are both progressive and integrated. For example, sarcopenia, the age-associated loss of skeletal muscle mass, muscle strength, and muscle efficiency,[3,4] has been linked to declines in physical activity, motor neuron numbers and function, protein synthesis, hormones such as insulin-like growth factors (IGF-1), testosterone, estrogen and growth hormones, and serum albumin concentration.[5]

Dietary protein and amino acids are also essential for the composition of the protein-dense bone structure.[6] The loss of bone has been associated with both excessive and inadequate dietary protein intakes.[7] The protein needs of an adult might be expected to change in concert with these metabolic and physiologic changes, and the Recommended Dietary Allowance (RDA) for protein should ideally be sufficient to preserve bodily function throughout adulthood.[2] Despite the recognized importance of knowing the protein needs of all adults, surprisingly few data firmly establish recommended protein intakes for elderly persons to maintain health.[1,8]

PROTEIN REQUIREMENTS

The average daily protein intake estimated to meet the requirement of one-half of healthy men and women age 19 years and older (i.e., the Estimated Average Requirement, EAR) is 0.66 g protein $\bullet kg^{-1} \bullet d^{-1}$.[1] The average daily protein intake estimated to be sufficient to meet the needs of nearly all (97.5%) healthy men and women age 19 years and older (i.e., the RDA) is 0.80 g protein$\bullet kg^{-1} \bullet d^{-1}$.[1] For the reference 77-kg adult male and 65-kg adult female, the RDA for protein is 63 g/d and 50 g/d, respectively.

Sarcopenia results in the apparent protein requirement of elderly persons being lower than for younger adults when expressed per kilogram body weight. However, the impact of sarcopenia on protein requirement is likely modest because muscle has a lower rate of protein turnover relative to most nonmuscle tissues; the rate of whole-body protein turnover is not reduced with advancing age when expressed per kilogram of fat-free mass.[1] Moreover, declines in physical activity levels and total energy intake and increases in frequency of disease might also contribute to a change in dietary protein needs for older adults.

STUDIES OF PROTEIN REQUIREMENT USING NITROGEN BALANCE IN OLDER ADULTS

The EAR and RDA of protein for adults are based primarily on a large meta-analysis of nitrogen balance data.[1,9] Nitrogen balance is an assessment of the difference between dietary nitrogen intake (primarily from dietary protein) and nitrogen excretion in urine, feces, and other miscellaneous losses including sweat and skin. There are a limited number of nitrogen balance studies in older persons.[10–16] The results and interpretations of these studies are mixed, with some supporting the adequacy of the RDA for protein,[13,15,16] and some suggesting that it is inadequate.[10,12,14,17] The inconsistent results and interpretation of these studies[10,18,19] severely limit confidence in the fact that the RDA is accurate and adequate for elderly persons.

Part of the confusion in interpreting these studies is that each one used a different nitrogen balance formula to calculate a mean protein requirement. To correct this inconsistency, Campbell and associates[10] recalculated the data from Cheng et al.,[15] Uauy et al.,[12] and Zanni et al.[13] using the nitrogen balance formula recommended by the 1985 World Health Organization (WHO) Consultation.[2] Combined, these data established a mean protein requirement of 0.91 g protein$\bullet$kg$^{-1}\bullet$d^{-1} for older people (a value that is 50% higher than the 0.6 g protein$\bullet$kg$^{-1}\bullet$d^{-1} established by the WHO, and they suggest that the RDA for protein is higher in older people).[2] Kurpad and Vaz have reaffirmed this interpretation, based on an independent evaluation of short-term nitrogen balance data.[20] Millward and associates have questioned the suitability of the available short-term nitrogen balance data to determine protein requirements of older people based on issues that include study length, protein and energy intakes, propagation of errors of the nitrogen balance technique, and the apparent health of the research subjects.[18,19] They have concluded that the RDA for protein is adequate for older people. The apparent differences in interpretation of the available short-term nitrogen balance data reemphasize the need for more data in older people.[1]

Most recently, Campbell and associates conducted a randomized 18-day nitrogen balance trial on younger and older adults.[16] Subjects were divided into four groups: younger men (n = 11), younger women (n = 12), older men (n = 8), older women (n = 11). Each subject completed, in random order, three 18-day trials with protein intake of 0.50, 0.75, and 1.00 g$\bullet$kg$^{-1}\bullet$d^{-1}. Protein requirement was estimated by using linear regression of nitrogen intake and nitrogen balance. Results showed that there was no significant effect of age or sex in terms of protein requirements. For all subjects combined, the adequate protein allowance was estimated to be 0.85 ± 0.21 g protein$\bullet$kg$^{-1}\bullet$d^{-1}.

Although the nitrogen balance method is the foundation of the current RDA and the only method with sufficient data to determine protein needs, there are several inherent limitations. For example, nitrogen balance is determined as the difference between nitrogen intake and nitrogen output; incomplete consumption of foods provided and incomplete sample collections can favor a positive nitrogen balance, which translates to a lower protein requirement. In addition, the current linear regression model used appears to underestimate protein requirements because of the assumption that with higher protein intake, nitrogen balance no longer follows a simple linear model.[21] An alternative biphase linear regression has been used on current available nitrogen balance data, and the authors concluded that protein requirement is 40% higher than the current RDA.[21] However, the validity of the conclusion is limited by the lack of nitrogen balance studies in which protein intakes were above the estimated breakpoint.

In 2005, the Institute of Medicine of the National Academies report on the DRI intakes of protein included the following research recommendation: "Currently protein data for elderly are sparse and more data are needed. Available data for the very elderly, namely those from 80 to 100 years of age, consists of only two or three adults in their early 80s, and thus studies conducted with this age group need to be done." And "New methods, other than nitrogen balance, need to be validated to determine protein requirements, particularly in regard to long-term health."[1]

INDICATOR AMINO ACID OXIDATION TECHNIQUE TO MEASURE PROTEIN REQUIREMENTS

The indicator amino acid oxidation technique (IAAO) is emerging as a possible alternative method to estimate protein requirements.[21] The IAAO method is based on the concept that if one or more indispensable amino acids is deficient for protein synthesis, the indicator amino acid (usually L-[1-^{13}C] phenylalanine) will be oxidized.[22] It has been used to estimate individual amino acid requirements since 1993.[23] In 2007, the first study using IAAO to estimate total protein requirement in adult men was conducted, and the mean protein requirement obtained using IAAO was 0.93 g$\bullet$kg$^{-1}\bullet$d^{-1}.

The IAAO method does not require an adaptation period or a complete urine and feces collection and therefore is more plausible to conduct in older adults. In addition, IAAO is minimally invasive because breath and urine samples are collected instead of blood samples. Although there are possible limitations of IAAO, including using an amino acid mixture to represent dietary protein, it is considered an alternative to nitrogen balance, especially in vulnerable groups such as older adults.

LONG-TERM CONTROLLED BALANCE STUDIES

Both the nitrogen balance and IAAO methods have one major limitation—they do not evaluate physiologic and functional outcomes of different protein intakes that span the range of adequacy. Studies designed to compare and contrast successful adaptations versus detrimental accommodations are important to support the 2002/2005 protein DRI Panel's recommendation to establish new methods of determining protein requirements based on health outcomes. Results from Castaneda and associates indicate that older women who consumed 56% of the RDA for protein for 10 weeks were in a profound negative nitrogen balance and experienced significant decreases in fat-free mass, muscle mass, muscle fiber area, and muscle strength.[11,24,25] These findings are consistent with physiologic accommodations, including losses in physical function.

In another longitudinal study, Campbell and associates assessed the adequacy of the RDA of protein for older people by examining the longer-term responses in urinary nitrogen excretion, whole-body protein metabolism, whole-body composition, and midthigh muscle area.[26,27] Twelve men and 17 women (ages 54–78 years) completed a 14-week controlled diet and exercise study. Throughout the 14-week study, each subject completely consumed daily energy-balanced menus that provided the RDA of 0.8 g protein•kg^{-1}•d^{-1} and either remained sedentary or performed whole-body resistance exercise 3 d/week. At week 14, muscle strength increased 10–36% in the subjects who performed resistance exercise training and was not changed in the sedentary subjects. Over time, whole-body muscle mass and protein–mineral mass were not changed, fat-free mass ($P = .004$) and total body water were decreased, and percentage body fat was increased in these weight-stable older people, independent of group assignment. Midthigh muscle area (from computed tomography scans) increased in the resistance exercise group (~2.15 cm^2), but the sedentary group lost muscle area (~ –1.7 cm^2). Over time, 24-h urinary total nitrogen excretion decreased, nitrogen balance increased from near equilibrium to positive, with no group differences in response. Collectively, most of the results are consistent with a successful adaptation to the RDA for protein.[26,27] However, the decrease in midthigh muscle area and the association with decreased urinary nitrogen excretion in the sedentary group and the decreases in fat-free mass and total body water observed in all subjects are consistent with metabolic and physiologic accommodations. In theory, if the RDA of 0.8 g•kg^{-1}•d^{-1} was adequate, the apparent loss of fat-free mass and skeletal muscle should not have been observed. These occurrences bring into question whether this level of protein intake contributes to the progression of sarcopenia and whether moderately higher protein intakes would be preferred. Future studies that evaluate this question need to include protein intakes that span the range of adequacy to strengthen our understanding of a preferred protein intake for older adults that does not contribute to sarcopenia.

DIETARY PROTEIN INTAKE

An important question to address is whether protein intakes change as we age. The influence of age on protein intake depends on how the dietary data are reported. Quantitatively, protein intakes are highest in young adults and progressively decline with advancing age.[28–30] For example, 2003–2004 National Health and Nutrition Examination Survey (NHANES) data indicate that mean protein intakes (grams per day) of men and women age 71 years and older were ~33% and ~19% lower than men and women age 19–30 years, respectively (See **Figure 2-1**).[28] The declines in protein intake are likely the result of reduced energy intake and not a change in the proportion of energy consumed as protein. Expressed as percentage of energy consumed, protein intake remains constant across the age range of 20 to 71 years and older, with both men and women consuming about 14–17% of energy as protein (**Figure 2-2**).[28–30] For men and women age 51 years and older, the 5th, 50th, and 95th percentiles for protein intake (percentage of energy) were 11.5–13.2%, 15.5–16.0%, and 18.9–20.8%, respectively, based on 2003–2004 NHANES.[28] These data indicate that although the acceptable macronutrient distribution range for protein is 10–35% of energy,[1] very few older adults customarily consume more than 20% of energy as protein.

With the amount of protein consumed by older persons progressively declining with advancing age, it is important to know how many older persons are consuming inadequate dietary protein. Using the RDA of 0.8 g protein•kg^{-1}•d^{-1} as the criterion for adequacy, results from the 1994–1996 U.S. Department of Agriculture Continuing Survey of Food Intakes by Individual indicate that 36% of men and 41% of

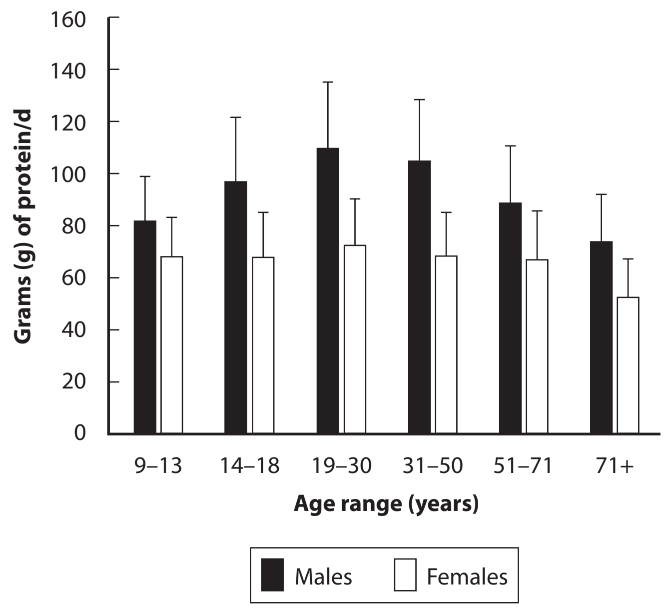

Figure 2-1 Habitual total protein intakes in the United States
Data from: VL Fulgoni. Current protein intake in America: analysis of the National Health and Nutrition Examination Survey, 2003-2004. *Am J Clin Nutr*. 2008;87:1554S–1557S.

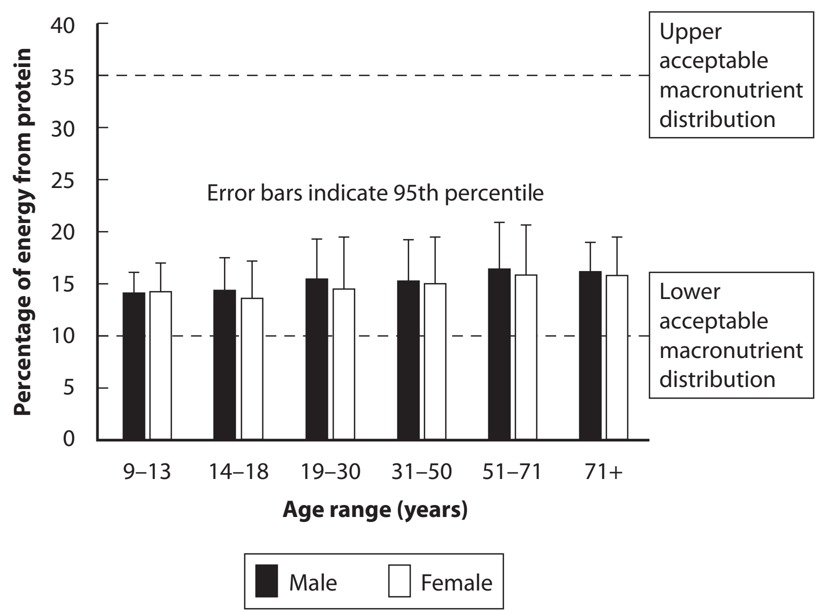

Figure 2-2 Habitual total protein intakes as a percentage of energy in the United States
Data from: VL Fulgoni. Current protein intake in America: analysis of the National Health and Nutrition Examination Survey, 2003-2004. *Am J Clin Nutr*. 2008;87:1554S–1557S.

women age 60 years and older did not habitually consume this minimum suggested intake, with 14% of men and 19% of women consuming less than 75% of the recommendation.[31] The Salisbury Eye Evaluation, a study of 2655 elderly men and women, aged 65 to 85 years from rural Maryland, reported the prevalence of inadequate protein intake as shown in **Table 2-1**.[32] For the age and race groups combined, the prevalence of inadequate protein intake was 24% for older men and 31% for older women. For the age and gender groups combined, blacks compared to whites had an 11% higher prevalence of inadequate protein

Table 2-1	Estimated Prevalence of Inadequate Protein Intake			
	White		Black	
Age	Male	Female	Male	Female
66–69 y	14.3%	18.7%	27.0%	31.1%
70–74 y	21.1%	26.1%	28.3%	38.2%
75–79 y	24.8%	28.8%	35.5%	36.8%
80–84 y	19.6%	25.4%	21.9%	43.4%

Adapted from: J Cid-Ruzafa, LE Caulfield, Barrón Y, et al. Nutrient intakes and adequacy among an older population on the eastern shore of Maryland: the Salisbury Eye Evaluation. *J Am Diet Assoc*. 1999;99:564–571.

intake. Based on data from all age groups combined, the prevalence of inadequate protein intake for white and black women and men were as follows: 25% for white women, 37% for black women, 20% for white men, and 28% for black men. In general, the proportion of persons who consumed inadequate protein increased with advancing age, with 80- to 84-year-old black women at greatest risk of inadequate protein intake (43% of this group). Survey data from 2003–2004 NHANES support these findings and collectively suggest that 25–40% of older adults are at risk of consuming less than the RDA for protein.[28]

In 2002, there were about 35.6 million persons age 65 years and older living in the United States (12.3% of the population), and the number of older persons is expected to double to about 70 million (20% of the population) by the year 2030.[33] Thus, the prevalence of inadequate protein intake among elderly persons currently can be estimated at 8.9–14.2 million and is projected to be 17.5–28.0 million in the year 2030.

DIETARY PROTEIN SOURCES

Older adults typically consume dietary protein from a variety of sources. The Third National Health and Nutrition Examination Survey reported that community-living adults age 60 years or older consume about 65% of their total protein from animal sources (**Table 2-2**).[29] These sources include ~40% from flesh foods (14% beef, 13% poultry, 8% pork, and 5% fish), ~20% from dairy (15% milk and yogurt, and 5% cheese), and ~5% from eggs. The predominant plant protein sources were grains (19%), fruits and vegetables (11%), and legumes, soy, nuts, and seeds (4%). The animal-to-plant protein intake ratio was 2.6. All of these intakes were comparable to adults aged 20–39 and 40–59 years, suggesting that sources of

Table 2-2	Sources of Dietary Protein in Adults 60 Years and Older			
		% of Total Protein Intake		
	Protein Source	Men	Women	
	Total animal	**65.9 ± 0.5**	**64.4 ± 0.6**	
Flesh:	Beef	16.0 ± 0.8	11.6 ± 0.8	~40%
	Pork	8.6 ± 0.7	7.1 ± 0.5	
	Poultry	10.4 ± 0.6	14.3 ± 0.8	
	Fish	5.3 ± 0.6	5.6 ± 0.5	
Dairy:	Milk/yogurt	15.2 ± 0.5	15.8 ± 0.5	~25%
	Cheese	4.5 ± 0.4	5.0 ± 0.3	
	Egg	5.1 ± 0.3	4.3 ± 0.2	
	Total plant	**34.1 ± 0.5**	**35.5 ± 0.6**	
	Grain	18.4 ± 0.4	18.6 ± 0.4	
	Fruits	1.9 ± 0.1	2.7 ± 0.1	
	Vegetables	8.2 ± 0.2	9.1 ± 0.2	
	Legumes/soy	2.4 ± 0.2	2.4 ± 0.1	
	Nuts/seeds	2.0 ± 0.2	1.6 ± 0.3	
	Other	1.2	1.2	

Mean ± SEM

Adapted from: E Smit, FJ Nieto, et al. Estimates of animal and plant protein intake in US adults: results from the Third National Health and Nutrition Examination Survey, 1988–1991. *J Am Diet Assoc*. 1999;99:813–820.

protein intakes are not different among younger, middle-aged, and older persons.

PATTERNS OF PROTEIN INTAKE

Whereas the RDA for protein is based on total protein intake on a daily basis, accumulating evidence suggests that the quantity of protein intake at each meal may be important.[34–36] Data from the Continuing Survey of Food Intakes by Individuals from 1994–1996 were evaluated to compare eating patterns and dietary composition in younger (age 20–59 years, n = 1792) and older (age 60–90 years, n = 893) adults.[37] Breakfast and lunch usually contain lower amounts of protein than dinner (~12% vs. ~19% of total daily energy), with snacks containing the lowest amount of protein in both younger and older adults. Therefore, breakfast and lunch can present important opportunities for older adults to increase protein intake and achieve multiple protein-related anabolic responses daily.[34–36]

In addition to increasing total protein intake, it is also important to increase the intake of essential amino acids because they are primarily responsible for stimulating muscle protein synthesis.[38,39] A 20-g serving of most animal or plant-based proteins typically contain 5–8 g of essential amino acids. In older adults, skeletal muscle is not able to respond to lower doses of essential amino acids (~7.5 g); however, higher doses of essential amino acids (10–15 g) can stimulate muscle protein synthesis to a similar extent as younger adults.[39,40] Interestingly, consuming more than 30 g of high-quality protein does not further increase muscle protein synthesis in younger or older adults, suggesting that 25–30 g of high-quality protein (~10 g of essential amino acids) is needed to maximally stimulate muscle protein synthesis.[34,41] Collectively, these findings suggest that ingestion of 25–30 g of high-quality protein at each meal can help older adults maintain muscle mass, although longitudinal research is needed to assess this notion.

EFFECTS OF WEIGHT LOSS AND EXERCISE ON PROTEIN REQUIREMENTS IN OLDER ADULTS

As stated earlier, the RDA for protein is 0.8 $g \bullet kg^{-1} \bullet d^{-1}$ for all healthy adults. It might be of interest to question whether circumstances would arise when a healthy older person might need more protein. This question can be appropriate for overweight and/or obese older persons who are in a negative energy balance (weight loss) or for the older person who exercises regularly.

WEIGHT LOSS

In normal aging, changes in body composition occur that result in a shift toward decreased muscle mass and increased fat mass.[42] The coexistence of diminished muscle mass and increased fat mass is referred to as sarcopenic obesity.[43] Sarcopenic obesity presents a complex challenge to healthcare professionals who need to prescribe an appropriate treatment that reduces the health risks associated with obesity, such as heart disease and diabetes, while preserving muscle mass to reduce the risk of disability. As a result, weight loss is cautiously recommended for overweight/obese older adults to improve their health and physical functioning.[44,45] Recommendations include reducing energy intake by 500–750 kcal/d and engaging in regular physical activity and exercise. A systematic review evaluating the separate and combined effects of energy restriction and exercise training on fat-free mass in older adults suggests that the addition of exercise to energy restriction reduces the amount of weight lost as fat-free mass from ~24% to ~11%,[46] which is similar to findings in younger adults.[47]

Protein intakes modestly above the RDA (1.0–1.2 $g \bullet kg^{-1} \bullet d^{-1}$) are also recommended based on research showing reduced lean body mass (LBM) losses when higher protein diets are consumed during weight loss with or without concurrent exercise.[48–52] Data from the Health ABC Study indicate adults age 70–79 years who consumed the highest quintile of protein intake (~1.2 g $protein \bullet kg^{-1} \bullet d^{-1}$) lost ~40% less appendicular LBM than those who consumed the lowest quintile (~0.7 g $protein \bullet kg^{-1} \bullet d^{-1}$) over a 3-year period.[50] Importantly, the impact of protein intake on the preservation of appendicular LBM depended on the energy balance of these older adults. The effect of dietary protein intake was only evident for subjects who were in negative energy balance and lost weight (**Table 2-3**). Also, the effect of protein on appendicular LBM changes over time in these energy-restricted subjects was only significant when intakes were below the RDA (quintiles 1 and 2), intakes that would never be recommended purposefully for apparently healthy older adults to consume.

Findings from a study by Leidy and associates further document the impact of protein intake on changes in LBM after weight loss.[52] Leidy et al. reported that middle-aged women who consumed a higher protein diet (30% of energy) during a 12-week energy deficit period (750 kcal/d below energy needs) lost less LBM (18% of weight loss) than women who consumed a normal protein (18% of energy) energy deficit diet (LBM loss 18% vs. 30% of weight loss, $p < .05$).[52]

Table 2-3 Protein Intake and Appendicular Lean Body Mass Changes Over 3 Years in Older Adults*

	All subjects	Weight losers	Weight stable	Weight gainers
Quintile 1 (0.7 g protein•kg-1•d^{-1})	−0.661 (0.057)	−1.550 (0.088)	−0.386 (0.065)	0.201 (0.112)
Quintile 2 (0.7 g protein•kg-1•d^{-1})	−0.540 (0.056)	−1.528 (0.096)	−0.410 (0.062)	0.310 (0.100)
Quintile 3 (0.8 g protein•kg-1•d^{-1})	−0.520 (0.056)	−1.306 (0.095)	−0.414 (0.062)	0.256 (0.106)
Quintile 4 (0.9 g protein•kg-1•d^{-1})	−0.463 (0.057)	−1.323 (0.104)	−0.394 (0.062)	0.326 (0.100)
Quintile 5 (1.1 g g protein•kg-1•d^{-1})	−0.400 (0.058)	−1.340 (0.102)	−0.350 (0.064)	0.512 (0.105)
P for trend	0.0003	0.03	0.60	0.02

*in kg; mean ± SEM.

Note: aLBM: appendicular lean body mass. Among weight losers, individuals that consumed the three highest quintiles or protein intake tended (*P* for trend <0.05) to lose less aLBM than those consuming the lowest quintile. Among weight gainers, individuals who consumed the highest quintile of protein intake gained significantly (*P* for trend <0.05) more aLBM than those consuming the lowest quintile.

Data from: DK Houston, BJ Nicklas, Ding J, et al. Dietary protein intake is associated with lean mass change in older, community-dwelling adults: the Health, Aging, and Body Composition (Health ABC) Study. *Am J Clin Nutr*. 2008;87:150–155.

In practical terms, consuming the higher protein diet while losing 10 kg of weight would help preserve 1.2 kg LBM (12%), an amount comparable to exercise noted earlier. We have observed similar results in middle-aged men who participated in a comparable protocol.[53] The men in the higher versus normal protein groups lost 21% versus 28% of weight as LBM ($P < .05$). Collectively, these data support the suggestion that the effects of protein intake and exercise on energy-restriction-induced changes in LBM are independent and additive, not synergistic.[51]

RESISTANCE TRAINING

In older adults who perform resistance training, consumption of protein intakes above the RDA might be needed to support muscle growth or maintenance, but data are conflicting. Higher protein intakes from high-quality food sources stimulate muscle protein synthesis in proportion to the essential amino acid content of the food.[41] Theoretically, this promotes the maintenance or accretion of muscle mass over time, especially when combined with an anabolic stimulus such as exercise training.[36,54,55]

In 2002, the Food and Nutrition Board Panel stated, "In view of the lack of compelling evidence to the contrary, no additional dietary protein is suggested for healthy adults undertaking resistance or endurance exercise."[1] This statement contrasts with the year 2000 conclusion from the American College of Sports Medicine (ACSM), American Dietetic Association (ADA), and Dietitians of Canada (DC) committee that the need for protein of highly physically active persons is higher than for sedentary persons.[56] Specifically, that strength-trained athletes might require as high as 1.6 to 1.7 g protein•kg^{-1}•d^{-1}, and that endurance athletes might require 1.2 to 1.4 g protein •kg^{-1}•d^{-1}. The higher protein requirement of athletes was recommended to offset the increased use of protein for energy during exercise, to provide substrate for muscle hypertrophy, and to provide adequate amino acids for the repair of exercise-induced muscle damage. It might be appropriate to view the ACSM, ADA, and DC recommendations as the maximum protein requirements of highly trained athletes who routinely exercise at high intensity and long duration, training routines that most people do not attempt or maintain. It might also be appropriate to consider that the RDA for protein can be adequate for an athlete to meet basal needs, but might be below that needed to enhance or optimize athletic performance, although more research is required to resolve this issue.[57] It is commonly thought that most athletes' customary diets provide enough protein to adequately meet need, especially when the diets contain sufficient energy and include complete sources of protein (e.g., dairy, meats, eggs, and fish).[56] The protein intakes of older athletes are largely unknown.

It is difficult to establish the protein needs of the older athlete. Consistent with the general view of the RDA, Reaburn suggested that older athletes might require less dietary protein than younger athletes because they have age-associated declines in fat-free and muscle masses and decreased volume and intensity of training.[1,58] Research by Campbell and associates suggest that the RDA for protein is a marginal intake, as evidenced by a significant decrease in midthigh muscle size of sedentary older persons who habitually consumed this amount of protein for 14 weeks.[27] Campbell and associates reported that older persons who performed strength training 3 days per week while consuming the RDA for protein achieved an offset of the muscle atrophy in the exercised muscle groups but did not prevent the apparent loss of whole-body fat-free mass.[26] In contrast, fat-free mass and skeletal muscle hypertrophy occurred in older men who performed the same 12-week resistive exercise training program and consumed 125% of the RDA for protein.[59] A retrospective reassessment of data from 106 men and women age 50–80 years who participated in diet and resistance training studies and consumed dietary protein intakes from about 0.4 to 1.7 g protein•kg^{-1}•d^{-1} revealed a modest but statistically significant positive relationship ($r = 0.202$, $P = .038$) between dietary protein intake and the change in whole-body fat-free mass.[54] Interestingly, the regression line crosses the line of neutrality (no change in fat-free mass) at a protein intake of about 1.0 g protein•kg^{-1}•d^{-1}. The apparent loss of fat-free mass by many of these older persons when they consumed the RDA for protein of 0.8 g protein•kg^{-1}•d^{-1}, despite the anabolic stimulus of resistance training, is consistent with this being a marginally inadequate amount of protein to consume habitually.

Collectively, these results continue to draw into question whether the RDA for protein is sufficient for older persons to maximally hypertrophy muscle using strength training. The older athlete should monitor protein intake and strive to consume about 1.2 to 1.4 g•kg^{-1}•d^{-1}. It is important to emphasize that there are currently no data that suggest protein intakes above this range are more beneficial, and that this recommendation does not extend to persons with acute or chronic diseases that require therapeutic diets.

EFFECT OF PROTEIN ON BONE MINERAL DENSITY

Higher protein diet is a popular approach for weight loss because it can help preserve LBM.[52] Weight loss has been found to be associated with bone mineral density (BMD) loss.[60] Dietary protein has been found to have both positive and negative effects on bone.[7,61] Data are limited on the potential impact of dietary protein on bone during weight loss and remain controversial. It has been observed that a higher protein consumption is associated with increased insulin-like growth factor 1 (IGF-1) concentration. IGF-1 can stimulate bone formation and preserve bone mass.[62] On the other hand, acid load increase caused by protein consumption can lead to bone resorption, which could contribute to bone loss.[63]

Skov and associates found that there was no effect of protein on BMD in premenopausal women and similarly aged men when consuming an energy-restricted diet with 25% versus 12% energy from protein (primarily dairy and meat) for 6 months.[64] Thorpe and associates suggested that achieving a higher protein intake (1.4 vs. 0.8 g•kg^{-1}•day^{-1}), mainly from dairy, attenuated BMD loss after a 4-month period of energy-restriction-induced weight loss in subjects aged 30–65 years.[65] In contrast, Campbell and Tang observed in two separate studies (12- and 9-week lengths) that total body BMD loss occurred in postmenopausal women consuming a higher protein diet (primarily meat) compared with a normal protein diet (nonmeat), with all subjects consuming adequate calcium.[66] A recent study looked at the effect of dietary protein on BMD during a 1-year period of energy restriction in postmenopausal women.[67] Results showed that a higher protein diet (24% energy from protein, mixed sources) attenuated BMD loss at various weight-bearing sites compared with a normal protein diet (18% of energy from protein). The various lengths of the studies, different ages and sexes of the population, and the different sources of protein studied might all contribute to the inconsistent findings among studies.

A recent systematic review and meta-analysis of dietary protein and bone health during weight maintainence found a positive correlation between dietary protein and lumbar spine BMD only, and protein sources (soy vs. milk basic protein) has no effect on lumbar BMD.[68] More research is needed to evaluate long-term effects of both quantity and sources of dietary protein on BMD during weight loss, especially in older adults, a high-risk population for osteoporosis.

CONCLUSION

The RDA for protein is set at 0.8 g•kg^{-1}•d^{-1} for apparently healthy adults of all ages. It is estimated that 25–40% of persons age 65 years and older consume less than this amount of protein. Chronological aging is associated with numerous changes that can affect dietary protein needs. These changes might include sarcopenia, increased body fat, decreased food intake, decreased physical activity, decreased physical functional capacity, and increased number and frequency of acute and chronic diseases. The loss of fat-free mass with advancing age theoretically results in a relatively lower protein requirement (per kilogram of body mass) compared to a younger adult. However, at present there is no consensus regarding the protein needs of elderly persons, with some research suggesting that the RDA should be higher than the current level. Short-term nitrogen balance studies are inconclusive, whereas the limited longer-term nitrogen balance studies suggest that the RDA is not sufficient to completely meet the metabolic and physiologic needs of elderly persons, especially persons who strive to offset sarcopenia and achieve muscle hypertrophy using strength training exercises. The indicator amino acid oxidation technique can provide a feasible means to estimate protein intake in vulnerable groups, such as older adults, but research is needed.

It is suggested that older weight-stable sedentary persons consume at least 1.0 g protein•kg^{-1}•d^{-1}, and that older persons who are in a negative energy balance consume 1.0–1.2 g protein•kg^{-1}•d^{-1}. In addition, older adults who habitually perform high-intensity exercise should consume 1.2–1.4 g protein•kg^{-1}•d^{-1}. Finally, dietary protein can affect bone loss during weight loss; however, results to date are inconclusive and more research is needed to look at the effects of both quantity and sources of protein on BMD during energy-restriction-induced weight loss.

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CHAPTER

3

Carbohydrate, Fat, and Fluid Requirements in Older Adults

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INTRODUCTION

One of the features of human aging is the change in body composition that occurs with advancing age. In general, there is a decrease in lean body mass, a reduction in total body water, a loss of bone density, and an increase in the proportion of body fat. These changes are experienced by all living organisms; this has been previously described as senescence, the nonreversible deterioration of cells.[1,2] Body composition changes are difficult to quantify in elderly people because of the variability in the rate of aging among individuals.[3,4] These body composition alterations, which occur independently of declines in physical activity,[5] contribute to changes in nutrient requirements, metabolism, and physiologic function.[6] When a meta-analysis of studies exploring the effects of exercise on body fatness was published, the authors could attribute very modest changes in body composition to physical exercise.[7]

ENERGY NEEDS IN OLD AGE

Most noticeable among the changes associated with body composition alterations is a decrease in energy required to maintain homeostasis including body weight and function.[8] Accordingly, to avoid excess weight gain, caloric intake must be reduced. The Baltimore Longitudinal Study of Aging demonstrated a decrease in energy intake from 2700 kilocalories at age 30 to 2100 kilocalories by age 80 in male subjects.[8] As basal energy needs decrease and activity levels slow, less energy substrate is required to maintain lean body mass and support energy expenditure. However, reducing total caloric intake can place the individual at risk for deficiencies of intake of other nutrients.

The reduction in lean body mass, including both skeletal and visceral tissue, as well as other protein compartments such as blood components, antigens and antibodies, platelets, leukocytes, hormones, enzymes, cytokines, and other compounds, contributes to the reduction in calorie requirements.[9] The onset of serious chronic disease is associated with functional disability related to diabetes, cardiovascular disease, chronic obstructive pulmonary disease, renal and hepatic dysfunction, cancer, bone and joint diseases, autoimmune conditions, and dementias. This is a factor in decreased energy expenditure associated with increasingly sedentary behavior, although this effect can vary among older adults.[10–15] There is good evidence that there is a decrease in consumption of calories as well as a decrease in energy expenditure.[15,16] However, actual energy consumption must be measured accurately for a better sense of individual variability in both energy expenditure and energy needs.[15,17,18] This is particularly important when estimating needs to heal, fight infection, make new tissue, address the demands of illness, and perform activities of daily living.

For older adults who do not reduce their caloric intake as they become more sedentary, which reduces their basal energy requirements, weight gain can result. Links between obesity in older adults and functional limitations have been found.[19] *Obesity* has been defined as body mass index equal to or greater than 30; although specific guidelines for older adults are not in place, the prevalence of notable overweight continues to grow.[20,21] Significant gain in weight can contribute to an additional reduction in activity level and other lifestyle changes that occur over time.[22]

Conversely, a decrease in physical activity associated with increasing disability can lead to a gain of weight, further exacerbating disabling conditions.

Most studies on energy requirements in adults include a very small sample of elderly subjects, making extrapolation of current research data to clinical application in older adults unreliable. There are reports that elderly men do not respond in the same way as young men do after periods of energy restriction or overconsumption;[23–25] requirements for energy to maintain weight are often linked to energy consumption, but research indicates that this might not be reasonable in estimating energy needs for elderly individuals. Under any circumstances, prediction equations for energy requirements also do not give reliable estimates of energy requirements in elderly people and indirect calorimetry should be employed when actual energy needs must be defined rather than grossly estimated.[26,27]

One approach that has been reported to estimate total energy expenditure is the use of doubly labeled water, although between-laboratory variability was substantial despite using shared standards.[28] When comparing results using doubly labeled water to measure total energy expenditure and resting energy expenditure, the total energy expenditure is slightly higher; this has been validated when direct measurements of energy expended are conducted.[29]

Using total body potassium, investigators have reported that this is the most accurate method to measure the decrease in lean body (fat-free) mass and it explains the reduction in resting energy expenditure with more accuracy than does doubly labeled water.[30] Regardless of the method used, it is clear that energy requirements decrease with advancing age. The clinical challenge is to continue to meet all nutrient requirements in a smaller caloric base of food consumed.

CARBOHYDRATE REQUIREMENTS

Carbohydrates are an essential component of a well-balanced diet. In its simplest form, glucose is an efficient energy substrate that can be used by all body tissues but is necessary for energy production in brain and red blood cells.[31,32] Requirements for dietary carbohydrate generally approximate 55–60% of total energy intake. The complexity of dietary carbohydrate can be as important as the percentage of calories contributed by carbohydrate-rich food.

Consumption of food that has had indigestible dietary fiber removed can contribute to gastrointestinal disorders commonly encountered in older adults, including constipation, diverticular disease, diabetes, and hyperlipidemia.[33] Dietary fiber is derived from structural components of plant cell walls and is mainly composed of plant polysaccharides and lignin, which are resistant to human digestive enzymes.[33] Hydroscopic particulate fiber with high pentosan content, such as wheat bran, increases fecal bulk and decreases gut transit time and intraluminal pressure within the colon.[33] These effects help to reduce the incidence of constipation and the formation of colonic diverticula. However, soluble fibers such as gums and pectins increase the viscosity of intestinal contents, increase gut transit time, and decrease the rate of small intestinal absorption.

Increased consumption of fibers such as guar, pectin, and tragacanth reduced insulin secretion following a test meal in normal subjects and increased carbohydrate tolerance in diabetics as evidenced by control of fasting glucose levels, improved lipid profiles, and reduced glycosylated hemoglobin (HbA1c).[34] The mechanism of the positive effect seems to be related to delayed gastric emptying and reduced rate of absorption of carbohydrate in the small intestine. Recommendations from the American Diabetes Association as well as other national nutrition and diabetes organizations advise increased consumption of high-fiber carbohydrate-containing foods in the management of diabetes mellitus.[33]

Inclusion of purified fibers such as guar, pectin, oat bran, and high-fiber foods, including cereals, starchy vegetables, and beans, have been reported to lower serum lipids.[35–37] Decreases in total cholesterol, low-density lipoprotein cholesterol, and triglycerides without changes in high-density lipoprotein cholesterol have been reported.[38] The mechanism appears to be related to the decrease in gastric emptying and reduced intestinal absorption of cholesterol and triglycerides. However, there are complex interactions among saturated fat, unsaturated fat, cholesterol, and carbohydrate intake and sorting these out can be challenging.[39]

For the reasons described, it seems prudent to have a daily dietary fiber intake of 25–35 g/day and to include a variety of fibers from fresh fruits, vegetables, legumes, and whole-grain products. Every effort should be made to encourage older adults to have a varied dietary intake of carbohydrate-containing foods daily.

FAT REQUIREMENTS

A desirable fat intake in elderly adults does not differ from that of younger adults. Fats and carbohydrates are the major macronutrient substrates that provide dietary energy, responsible for 85% to 95% of total caloric intake. Dietary fat is the most efficient source of energy, providing more than twice the energy per gram than do carbohydrate and protein. As with younger adults, a minimum of 10% of total energy intake should be derived from fat to ensure an adequate dietary intake of fat-soluble vitamins and essential fatty acids. Essential fatty acids are required for the synthesis of prostaglandins and cell membrane phosophlipids.[40]

Recommendations for dietary fat intake to be limited to 30% or less with saturated fats providing from 8% to 10%, polyunsaturated fats being approximately 10%, and monounsaturated fats making up the difference of 15% of total fat intake are the same for older versus younger adults.[41] Dietary cholesterol intake is recommended to be 300 mg/day or less. Although total cholesterol is generally considered an important risk factor for coronary heart disease, its impact in elderly people is unknown. In a 5-year prospective study that included 4066 men and women older than age 71 years, elevated total cholesterol levels were associated with a similar pattern of death from coronary heart disease as seen in younger adults (younger than age 70 years), but first adjustments for age, preexisting cardiovascular disease, risk factors, and general health status had to be made. Unexpectedly, the subject group with the lowest total cholesterol levels (<160 mg/dL) had the highest incidence of preexisting cardiovascular disease, the highest risk factors for cardiovascular disease, the highest indices of poor health, and the highest crude coronary heart disease mortality.[42] It appears that elevated total cholesterol levels remain a risk factor for death from coronary artery disease in elderly persons. High-density lipoprotein cholesterol values less than 35 mg/dL predict coronary heart disease mortality and occurrence of new events in individuals older than 70 years.[43]

However, some contradictory outcomes are associated with lowering dietary fat intake in older adults. In one study, a decrease in dietary fat intake was associated with an increased risk of ischemic stroke in middle-aged men[44] as well as women.[45] Not surprisingly, low cholesterol levels have been associated with short-term mortality after ischemic stroke in older patients.[46] However, in a 20-year follow-up study of men in the Framingham Heart Study, the risk of ischemic stroke declined as intake of saturated and monounsaturated, but not polyunsaturated, fat increased.[47] In another recent report, a high intake of polyunsaturated fat had a significant cardioprotective effect in adult women.[48] Specific recommendations for dietary fat modifications must be made on an individual basis based on a complete profile of cardiovascular and stroke risk factors.

Although this chronic condition develops over years, the prevention of coronary heart disease in older adults deserves consideration. One approach to reducing risk in older adults is to reduce the intake of saturated fat and simultaneously increase the intake of polyunsaturated and monounsaturated fat, keeping the total fat intake about the same.[49] In another trial, subjects who had previously suffered a myocardial infarction were put on a Mediterranean-style diet with more complex carbohydrate; fruit; green vegetables; fish with less beef, lamb, or pork; and monounsaturated cooking oils. The group on this type of diet had fewer cardiac events and deaths at 2-year follow-up than did a control group who made no dietary modifications.[50] Even on this modified diet, there was no change in total cholesterol or low-density lipoprotein cholesterol levels. The Mediterranean diet is recommended routinely as secondary prevention of coronary heart disease.[51]

In another study of obese, postmenopausal women, subjects were put on an American Heart Association (AHA) Step 1 diet followed by a weight loss diet. This combination of dietary modifications decreased triglyceride levels and total, low-density, and high-density lipoprotein levels in women who had hypercholesterolemia but had no effect in women who had normal cholesterol levels or who were mildly hypercholesterolemic. The authors concluded that this dietary regimen of an AHA Step 1 diet and weight loss would help obese, postmenopausal women with elevated lipid profiles but would have no impact on women with normal lipid profiles.[52,53] Nevertheless, reduction of dietary fat will reduce overall caloric intake and contribute to weight loss or the avoidance of obesity in older adults.

In addition to heart disease, risk of stroke or cerebral infarction has been associated with dietary fats, although the studies looking for linkages with specific lipid components are often complicated by the small study samples. In a large study (34,670 subjects) conducted in Sweden, the investigators found an inverse relationship between long-chain omega-3 polyunsaturated fats and risk of stroke. Total fat, saturated fat, monounsaturated fat, polyunsaturated fat, α-linoleic acid, and omega-6 polyunsaturated fatty acids were not associated with stroke risk in this population.[45]

Diet is a major factor, although not the only factor, that influences total cholesterol and low-density lipoprotein cholesterol. In younger adults, lifestyle changes including diet and exercise are often recommended. These recommendations can contribute to weight loss and a slight reduction in cardiovascular disease risk factors in adults older than age 70 years.[54,55]

Management of weight appears to be a significant factor in health status and cardiovascular health in older individuals.[56] The use of statins has been shown to reduce cardiovascular events in adults ages 65–80 years.[57] It is noteworthy that reduction of serum cholesterol levels in elderly institutionalized individuals might not be beneficial. There has been a higher mortality rate in older men when cholesterol levels were depressed.[58,59]

FLUID REQUIREMENTS

Water is an essential nutrient for older adults that often does not receive the attention it needs. Total body water decreases with age, shrinking from 75% body weight in infants to 55% body weight in elderly adults, and this parallels the decrease in total lean body mass.[60] In older adults, inadequate fluid intake can lead to rapid dehydration, which has its own potentially risky problems including hypotension, constipation, nausea and vomiting, mucosal dryness, decreased urinary output, elevated body temperature, and mental confusion.[61,62] Consequences of inadequate fluid intake can also include an inappropriate dosage of medications. The dose level of many medications is calculated on body weight and an assumption that the drug will be distributed through the body to reach its intended organ or tissue with water serving as a diluent; a decrease in body water can lead to a greater concentration of a drug than intended, which can prove toxic.[63]

Water also has a role as a thermal buffer to protect the individual from hypo- or hyperthermia. In older adults, there is a decrease in sweating and other thermoregulatory responses, making a physiologic adjustment to periods of environmental shifts in temperature difficult to accommodate. Insensible losses through the skin can range from 0.3 L/hour when sedentary to 2.0 L/hour with exercise, which would lead to as high as 6 L/day in extreme heat and with strenuous activity.[61,63] The poor response to dehydration associated with extreme environmental temperature can lead to decreased plasma volume and osmolality and can result in death during periods of extreme environmental heat.[64]

Adequate hydration in older adults affects ability to exercise, physical performance[63] and cognitive performance.[64] Concentration, alertness, and short-term memory are affected by mild dehydration.

In older adults, consuming adequate fluid intake, whether from water or other beverages, becomes a greater challenge than it is in younger adults. Thirst mechanisms and sensitivity are compromised in elderly people, and external factors might also affect adequate fluid intake.[60–62]

Thirst sensitivity decreases with age, and the aging kidney has a decreased urinary concentrating ability and a reduced ability to compensate for a high water load.[65] The decrease in fluid intake is the result of alterations in mechanisms that control thirst sensitivity, particularly a decrease in osmoreceptors and baroreceptors and secretion of vasopressin.[65,66] The primary stimulus of thirst is increased plasma osmolality; this contributes to an increase in osmotic pressure that stimulates vasopressin secretion and increased water intake.[65]

Another mechanism that stimulates thirst is hemodynamic factors, particularly hypovolemia and hypotension. The carotid artery and aortic arch are sites for baroreceptors that are responsive to changes in blood pressure. Increased blood pressure or blood volume excites baroreceptors, turns off vasopressin release, and decreases thirst.[65] Additionally, a variety of endocrine and environmental factors also affect thirst.[61] Endocrine factors include secretion of renal angiotensin and atrial natriuretic peptide. Environmental factors include climate, temperature, humidity, and availability of water and food.[65] Other factors that might be more important in elderly adults include medical problems, diuretic abuse, polypharmacy, low levels of hormone production, and a voluntary decrease of fluid intake to manage mild incontinence.

Dehydration can be a serious problem for older adults. Along with disordered thirst control mechanisms and inadequate intake of fluid for maintenance,[66,67] older adults who have fever, infection, institutionalization, immobility, dementia, coma, excess loss (hemorrhage, diarrhea, vomiting, diabetes insipidus), or acute illness can become chronically dehydrated.[61,62,68,69] With age, the kidneys' ability to concentrate urine or efficiently conserve water also can affect fluid balance.[60] Hypotonic dehydration results when sodium losses exceed water losses; this is usually diagnosed when serum sodium levels are less than 135 mmol/L and serum osmolality is less than 280 mmol/kg body weight.

A series of studies indicated that when compared to young men, older men who are water deprived for a period of time do not rehydrate to baseline levels when ad lib access to water is allowed, as younger men will.[69,70] There are indications that many elderly adults, particularly those who are institutionalized, are not consuming adequate amounts of fluid.[71,72] Although the usual stated requirement for fluid intake is eight 8-ounce glasses of fluid per day, data to support this recommendation are lacking. Actual need is probably in the range of six 8-ounce glasses of fluid per day. Fluid intake should be adequate to compensate for normal losses through kidneys, bowel, lungs, and skin as well as losses associated with fever, vomiting, diarrhea, or hemorrhage.

Diagnosis of dehydration is more difficult than it might seem because the signs of clinical dehydration can be confusing.[73,74] Dehydration is associated with increased morbidity and mortality; appropriate, aggressive rehydration can improve clinical outcomes. Dehydration might truly exist if serum osmolality is greater than 295 mOsm. Intravascular volume depletion is diagnosed with a BUN:creatinine ratio greater than 20 or serum sodium (Na) greater than 145 g/dL.[74] It is common for a clinical judgment of dehydration to be made without laboratory values to support the diagnosis.

Adequate fluid intake is often a problem in healthy, free-living older adults, but the challenge of adequate hydration in institutionalized elderly persons might be of greater concern. Chronically ill, functionally dependent elderly people might not meet their fluid needs voluntarily and might have to be strongly encouraged to drink sufficient fluids.[75,76] Individuals who are dependent on nutrition support, including both chronically and critically ill elderly people, can be underhydrated because they are receiving inadequate volumes of nutrient solutions or they are receiving hypertonic formulas without adequate solute-free water to compensate for the solid solute load of enteral feedings or the hypertonicity of parenteral solutions.[61]Conversely, the possibility of water intoxication in older adults presents a similar, and possibly more challenging, problem in this population. This condition is not well recognized; symptoms can include hyponatremia, depression, mental confusion, anorexia, and depression. When serum sodium concentrations are depressed (levels at 110 mEq/L or less) the individual might experience seizures, stupor, and central nervous system (CNS) damage.[61,62] Water intoxication can be the result of decreased renal capacity to excrete excess water or hyponatremia caused by oversecretion of arginine vasopressin associated with pulmonary and CNS disorders, stroke, pneumonia, tuberculosis, and other diagnoses. When decreased renal blood flow exists, treatment should focus on maximizing renal function, volume repletion if extracellular fluid depletion exists, and normalization of blood pressure.

Estimating actual fluid needs is challenging, and several methods can be used to gauge an individual's actual requirement. Methods commonly used to determine fluid needs in individuals include 30 mL/kg body weight with a minimum of 1500 mL/day; 1 mL per kilocalorie consumed; or 100 mL/kg for the first 10 kg of actual weight, 50 mL/kg of the next 10 kg actual body weight, and 15 mL/kg of remaining weight. The first method (30 mL/kg body weight) approximates fluid needs most accurately in institutionalized elderly persons; additional research needs to be conducted to better estimate actual needs of older adults.[76] For individuals who are tube feeding dependent, provision of free water at approximately 25% of the total formula volume is recommended.

To rehydrate individuals who are dehydrated, insensible losses of 600–1200 mL must be accounted for as baseline before adding fluid adequate to rehydrate. Intravenous fluid repletion with a physiologic solution will work most rapidly. For acute rehydration in someone losing fluid rapidly such as from vomiting or diarrhea, 2.5–4.0 L of fluid might be needed to replace acute losses and restore normal hydration status. Strong and chronic encouragement for oral fluid intake might be necessary to maintain hydration status.[77]

CONCLUSION

For older adults, macronutrient recommendations can be somewhat altered. Encouraging older adults to eat more complex carbohydrates rather than simple carbohydrates can contribute to adequate dietary fiber intake. Reduction of saturated fat, with an increased emphasis on consumption of poly- and monounsaturated fats, and decreased overall fat intake compensate for lower basal energy requirements and a decreased activity level often encountered in older adults. Meeting fluid needs in older adults is challenging because thirst mechanisms are not as sensitive in older adults as they are in younger individuals. Attention to overall fluid intake in healthy free-living, chronically ill, functionally dependent, or acutely ill elderly people is key to maintaining optimal health—in any person, but particularly important for this age group. Needs for these macronutrients (carbohydrate, fat, fluid) can be met with awareness of individual requirements, imagination, and attention to daily intake.

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CHAPTER

4

Vitamin Nutriture in Older Adults

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INTRODUCTION

In most areas of the world, aging of the population represents the major demographic shift with changes in morbidity and mortality patterns.[1] The population stratum of the 60-years-and-older group constitutes the fastest growing group in Western societies and will soon also be one of the fastest growing population strata in many other societies, including China and India.[2] These epidemiologic changes call for special approaches in research, especially in the fields of nutrition research, nutritional epidemiology, and prevention.[3–5] Demographic changes are paralleled by a rise in the prevalence and incidence of chronic diseases modulated and accelerated by the overweight and obesity pandemic as well micronutrient nutriture.[2]

Obviously, the aging process and genetic predisposition represent the major causes for the increase in chronic disease risk with advancing age; however, external factors such as nutrition (energy balance but also vitamin nutriture), exercise, and psychosocial factors represent major modulators that can be influenced by the individual. Evidence has accumulated that the roots of the development of chronic diseases of aging grow early in life and that vitamin nutriture might be of special importance.[6–8] During the last few years, many new functions of vitamins, especially at the level of signaling pathways, have been elucidated.[9] Also, interesting concepts regarding disease risk (e.g., homocysteine and cardiovascular diseases) have been dismissed, and the pathogenetic role has been reduced.[10–13]

In view of the aging of society, as well as the disappointing intervention trials with vitamin supplements, the maintenance of an adequate intake of all essential nutrients from food sources becomes more important than ever. Approximately 35–50% of the U.S. population regularly takes vitamin supplements and the use increases with aging.[14] The intake of the recommended amounts of vitamins is not always easily achievable from food alone, thus calling for additional educational efforts and also the consideration of selected supplements.[15] There is no evidence for a general recommendation for supplements with aging. However, with aging it seems to be crucial to eat at least one complete meal daily.[15–17] With increasing age, many older adults eat more snack foods, which are not suited to supply the needed micronutrients, rather than full meals.[18]

The aim of any medical strategy in relation to aging should not only be that more people live longer, but that they live well. This is a function of vitamin nutrition and overall nutrition and other lifestyle factors not directly related to nutrition (i.e., physical activity, smoking, body weight control, and psychological factors). Nevertheless, in formulating recommendations for the nutriture of older adults, it should be remembered that a 50- to 60-year-old person is very different from a70-year-old person or a person older than 70 years. The elderly population represents an extremely heterogeneous group as compared to younger population groups. The latest Dietary Reference Intakes (DRI) account for this heterogeneity by adding separate recommendations for the age group of those older than 70 years as compared to the "young old" (the age group 51–70 years).[19–23] This increasing heterogeneity with aging has important consequences for medical therapy, as well as for the formulation of dietary guidelines. The only common aspect in elderly people is that they share several factors that put them at increased risk for malnutrition and clinically manifesting, and sometimes difficult to treat, chronic diseases.

An adequate intake of the different vitamins is important for the prevention of deficiency as well as for the control of chronic disease risk. Vitamins might play a role in the prevention of the pathogenesis of most chronic diseases of aging, from cardiovascular disease to cognitive function and cancer. This chapter focuses on age-related metabolic effects of vitamins that might affect requirements. Effects of vitamins on chronic disease risk or specific diseases is not discussed in detail. Vitamin supplementation trials for most chronic disease conditions have been disappointing so far.

The nutritional status of elderly populations is very heterogeneous as a function of age, gender, geographical area, cultural aspects (including eating pattern), and especially associated disease conditions and overall health status. Up to 50% of the U.S. population consumes nutritional supplements daily. In view of the high prevalence of nutritional deficiencies as well as postulated putative effects of nutrients on the risk of chronic diseases, elderly persons consume nutritional supplements widely. Many nutrients have two-sided effects, and it is important to know whether supplements are effective in modulating chronic disease risk. Despite the widespread use of supplements, there is insufficient evidence to show that nutritional supplements reduce the risk of chronic diseases or cancer.[24–27] On the contrary, these supplements might increase the risk of, for instance, lung cancer in smokers.[26]

This chapter reviews and summarizes the major physiologic, pathophysiologic, and clinical features of the different vitamins. It should be remembered that people do not eat single nutrients but a complex mixture of essential and nonessential nutrients. This suggests that for a well-balanced vitamin nutriture in older adults, dietary patterns are crucial. Many studies support this; data from the European Prospective Investigation into Cancer and Nutrition (EPIC) confirmed a large variability in nutrient intakes across different populations, accounting for differences in biochemical status.[28]

VITAMIN A

The essentiality of vitamin A and the vitamin A precursors (different carotenoids) is well known. In modern Western society classical vitamin A deficiency signs are encountered only very rarely.[29] Vitamin A (retinol) plays an important role in growth, cell differentiation, vision, reproduction, and maintenance of immune function.[30] The discovery of new—so far unknown—functions of vitamin A, especially in the regulation of gene expression in the nuclear retinoid receptors, represents a revival of this vitamin or even a new "retinoid revolution."[31–33] The present Recommended Dietary Allowance (RDA) for those older than 51 years is 900 μg Retinol Activity Equivalents (RAE) for older men and 700 μg RAE for older women.[22] Vitamin A can also be obtained by the conversion of provitamin A carotenoids. Covering vitamin A needs by an increased ingestion of carotenoids might actually be a meaningful and safe strategy, especially in older adults.[34]

Others have recommended lower intakes of vitamin A for older adults in the range of 600 μg RAE for older men and 600 μg RAE in women.[35] Epidemiological studies support the lower figures of intake recommendations because the vitamin A intake of many elderly people is below the present recommendations, but their vitamin A plasma levels remain well within the limits of normality.[36,37] Suggestive evidence for lower dietary requirements in older adults comes from the Survey in Europe on Nutrition and the Elderly, a Concerted Action of the Third European Framework Programme (EURONUT SENECA study), where vitamin A intake decreased over an observation period of 4 to 5 years without the occurrence of low plasma levels.[38] Vitamin A intake varies widely, and up to 70% of elderly people, depending on age, income, sex, race, geographical location, and socioeconomic status, have vitamin intakes below 660 μg RAE (corresponding to two-thirds of the 1989 RDA). Nevertheless, these data must be interpreted with caution because vitamin A content in food varies widely and determining the vitamin A content in different food matrices is a challenging and difficult task.

Institutionalization is associated with an overall impairment of nutritional status, including lower vitamin A intake than in free-living elderly persons.[39] Sex differences in the plasma retinol and β-carotene levels might be in part caused by differences in the plasma lipid levels, as well as changes in the concentration of the retinol-binding protein (RBP).

The mostly adequate intake level of vitamin A in different age groups of the U.S. population is reflected in the rather high prevalence of elevated plasma retinyl ester concentration in National Health and Nutrition Examination Survey (NHANES).[40–41] The authors of this publication mention that in most population strata vitamin A intakes as well as biochemical status have reached a "luxus" level, that is, intakes in excess of physiologic need that can lead to potentially harmful accumulation of this vitamin and its metabolites.[40] Accordingly, it is not surprising that vitamin A liver stores are well maintained with the aging process.[42] The constellation of intakes lower than the recommendations, adequate liver stores, and well-maintained plasma vitamin A levels suggest alterations at the level of absorption and/or plasma clearance. Two elegant studies showed that vitamin A absorption (assessed by measuring plasma tolerance curves) in elderly adults is better and that vitamin A is cleared much faster in younger individuals than in older individuals.[43,44] These findings lend further support that vitamin A nutriture is generally not impaired in elderly people, as also recently reported in the European Nutrition and Health Report 2009.[45]

Much evidence underlined the relationship between vitamin A intake and bone health. In the Women's Health Study, vitamin A status was associated with an increased risk of hip fractures only in postmenopausal women with vitamin D deficiency.[46] This interaction is well known, and bone symptoms are a well-known feature of vitamin A toxicity.[47–48] For the time being, it is probably wise not to have high vitamin A intakes in older adults, especially in the setting of vitamin D deficiency.[49] A safe strategy is for older adults to get vitamin A from a higher intake of carotenoid-containing foods.

Plasma carotenoids are a heterogeneous group of chemical substances, including lycopene, α-carotene, β-carotene, zeaxanthin, lutein, and β-cryptoxanthim.[30,50–52] The importance of these carotenoids varies considerably, but they might be of great importance in the pathogenesis of age-related chronic conditions such as cardiovascular disease or macular degeneration and cataract. A recent study reported a direct association between lycopene status and functional capacity (including dependence in self-care) in women age 77 to 98 years.[53] Low-density lipoprotein (LDL) cholesterol is the major carrier of lycopene in the blood. The increased intake of carotenoids from fruits and vegetables was found to be associated with a decreased cardiovascular mortality in an elderly population of Massachusetts residents.[54] Others described a similar finding but reported only a small effect of carotenoid supplementation on the reduction of cardiovascular risk.[55] In the latter study, the lower mortality in subjects with plasma carotenoids above the median is probably caused by improved carotenoid status and by other nutrients and phytochemicals. A colinearity of nutrients is very important and must be considered in any interpretation of the association between a single nutrient and a specific disease. An increase of vitamin C, vitamin E, or carotenoids is usually associated with a greater plasma concentration of one or both of the other vitamins and is a marker of an overall healthier lifestyle, especially a higher fruit and vegetable intake.[56]

Vitamin A might have considerable toxicity.[22,30,35,57–58] In view of widespread vitamin A supplement use by older adults, it has been suggested that high intake in combination with increased absorption of vitamin A with age could contribute to toxicity in elderly individuals (especially those who have high vitamin A intakes from supplements and/or fortified foods). There are two forms of hypervitaminosis A: chronic and acute. Acute hypervitaminosis A is rare in elderly people, but chronic toxicity can be seen in this group.[59]

Chronic diseases of old age can influence vitamin A nutriture at the levels of intake, absorption, recycling, tissue utilization, and storage. Of special importance in elderly individuals are chronic liver diseases, often related to the chronic ingestion of alcohol, which impairs the storage of vitamin A in the liver as well as the ability of the liver to synthesize retinol-binding proteins.[58,60,61] In normal aging, defined as aging in the absence of any relevant disease, the liver hardly senesces, and constitutive liver functions are maintained, suggesting no alterations in vitamin A metabolism. Several drugs (including ethanol and barbiturates) are capable of affecting the metabolism of vitamin A by accelerating hepatic retinol breakdown. Chronic toxicity is mainly the result of long-term intake of vitamin A supplements and is rarely caused by excessive intakes of vitamin A from diet alone. Because over-the-counter vitamin A capsules containing up to 20,000 IU of vitamin A are available, the risk of toxicity can be high. Supplemental intake of vitamin A can be associated with greater levels of circulating retinyl esters in fasting blood. These high retinyl esters might be an indicator of vitamin A toxicity and liver damage.[44,59]

In a study using the relative dose response (RDR) for assessing vitamin A intake in older adults, the maximum plasma retinol response occurred in elderly subjects 60 to 120 minutes later than in younger subjects.[62] Therefore, the procedures of the RDR should be modified when used with elderly subjects. Unlike younger individuals, elderly people should have their fasting vitamin A levels measured for correct assessment of vitamin A intake.[63]

The increased ingestion of carotenoids from food and vegetables as a strategy to improve vitamin A status should be encouraged. The safety of β-carotene supplements is a matter of dispute; however, β-carotene from food sources alone does not bear any toxicity.[22] In view of current knowledge, a recommendation of β-carotene supplements is warranted only after a careful evaluation of the clinical constellation of the patient. Several large trials reported higher mortality in subjects receiving