Physiology of aging

Aging is inevitable, and as life expectancy increases it becomes more important to understand physiological mechanisms associated with the normal aging process so that quality of life can be sustained. Maintaining physiological function or “health” in an aging population will help to reduce the burden on the existing medical systems as older individuals consume medical services. Physiologists are in the ideal position to develop and test hypotheses of how genetic, molecular, and cellular mechanisms of aging affect human physiology. The October through December 2003 issues of the Journal of Applied Physiology will feature a Highlighted Topics series on the “Physiology of Aging” and will spotlight original research and invited mini-reviews on aging mechanisms in selected physiological systems. The invited mini-reviews will provide background knowledge necessary for development of novel integrated research initiatives.

One article on this topic has already appeared in the July 2003 issue of the Journal. In “Fluctuations in acceleration during voluntary contractions lead to greater impairment of movement accuracy in old adults” (J Appl Physiol 95: 373–384, 2003), Christou et al. discussed the effects of movement velocity on the relation between fluctuations in acceleration and the ability to achieve a target velocity during voluntary contractions performed by young and old adults. They found that these fluctuations had a more pronounced effect on movement accuracy for old compared with young adults.

The need for integrated thinking in approaches to questions of aging is emphasized in the first mini-review of this Highlighted Topics series, entitled “Theories of aging,” by Drs. B Weinert and P. Timiras. These investigators discuss how aging, as an extremely complex multifactorial process, has recently replaced the earlier search for a single cause, such as a single gene or the decline of a key body system. This mini-review keeps in mind the multiplicity of mechanisms regulating aging and examines them at molecular, cellular, and systemic levels. Although several theories are identified only briefly, a few are discussed in more detail (e.g., evolutionary, gene regulation, cellular senescence, free radical, and neuro-endocrine-immuno theories).

In another mini-review in this issue, Dr. T. Doherty characterizes age-associated losses of skeletal muscle mass, muscle quality, and strength, now commonly referred to as sarcopenia. In Doherty’s mini-review, entitled “Aging and sarcopenia,” etiological factors and functional consequences are examined in relation to the extent to which sarcopenia occurs in older men and women. Sarcopenia is associated with reduced functional capacity, increased risk of falls, and loss of independence. Research further elucidating the underlying mechanisms and potential countermeasures for sarcopenia is crucial so that the most effective prevention and rehabilitation strategies to optimize function and independence for the rapidly growing numbers of older adults in our population can be developed.

Related to sarcopenia is the change in energy balance associated with altered muscle metabolism and declines in activity. Also in this issue, in a mini-review entitled, “Aging and energy balance,” Drs. J. Morley and M. Wilson evaluate factors contributing to energy balance in older persons. It is well recognized that resting metabolic rate declines with aging due predominantly to loss of lean tissue and activity declines. However, whether there are also alterations in energy metabolism due to altered muscle metabolism or changes in adaptive thermogenesis remains to be determined. There is a clear decline in food intake over the life span. This has been described as the physiological anorexia of aging and may be due to altered hedonic qualities of food, early satiation because of changes in adaptive relaxation, and an excess satiating effect of cholecystokinin. These factors are discussed relative to hormonal and cytokine effects that may differ between male and female individuals. The physiological changes with aging place older men and women at risk of developing pathological weight loss when they develop disease states.

In the November issue, themes of aging and movement and strength are explored in three mini-reviews focusing on mechanophysiology of connective tissue, bone health, and exercise training. In the first mini-review of the November issue, entitled “Role of mechanophysiology in aging of ECM: effects of changes in mechanocellular transduction,” Silver et al. examine the relationship between mechanical loading and cellular events on aging of connective tissue. This mini-review discusses how growth factors and growth factor receptor-dependent processes, hormone and hormone receptor-dependent processes, and integrin-dependent and integrin-independent events are associated with downregulation of mechanocellular transduction and aging of connective tissue. Mechanical forces play a role in the development and evolution of extracellular matrices found in connective tissue. As body mass increases during development, musculoskeletal tissues and other extracellular matrixes are able to adapt their size to meet the increased mechanical requirements. These forces may be reduced with age as body composition changes.

In another mini-review in the November issue, entitled “Pathogenesis of osteoporosis,” Dr. E. Seeman discusses the early growth and later decay of the material and structural components that establish bone strength during growth. To understand the basis for bone loss and the emergence of bone fragility (e.g., osteoporosis) late in life, it is necessary to understand structure and not surrogate measures such as bone mineral density.
Combining factors such as muscle strength, energy balance, and bone health influence functional capacity or our ability to perform the physical tasks of daily life and the ease with which these tasks can be performed. Also in the November issue, in a mini-review entitled, “Dynamic exercise performance in Masters athletes: insight into the effects of primary human aging on physiological functional capacity,” Drs. H. Tanaka and D. Seals discuss and synthesize their findings on the effects of primary (healthy) adult human aging on functional capacity. The potential modulatory influences of gender and habitual aerobic exercise status on this process are evaluated through studies conducted on young adult and Masters athletes. With advancing age, even in healthy adults, the capacity to perform certain physical tasks is reduced. Eventually, this reduced capacity results in increased incidence of functional disability, increased use of health care services, loss of independence, and reduced quality of life.

In the December issue, the mini-reviews focus on cardiovascular aging and temperature regulation. Cardiovascular disease is the leading cause of death in the United States. Interactions of aging with other known risk factors for cardiovascular disease must be identified in order to reduce the burden of this disease. In the first mini-review of the December issue, entitled “Aging and the cardiovascular system,” Ferrari et al. examine structural and functional age-related alterations of the heart and blood vessels. Changes in the vascular system are diverse, as are age-related modifications of the arterial baroreceptor reflex. Changes in baroreceptor function have a greater effect on cardiac than on vascular control. A section in this mini-review is also devoted to cardiopulmonary reflex changes in aging. Homeostatic and clinical implications of age-related cardiovascular modifications are included in this mini-review.

In another mini-review in the December issue, entitled “Aging and human temperature regulation,” Drs. W. Kenney and T. Munce summarize the present knowledge of temperature regulation and aging in thermoneutral conditions, as well as during hypo- and hyperthermic challenges. Although epidemiological evidence of increased mortality among older adults from hypo- and hyperthermia exists, thermal tolerance appears to be minimally compromised by age when concurrent factors such as fitness level, body composition, and the effects of chronic disease are separated from the effects of chronological age.

Quality of life is becoming a valuable outcome measure in clinical trials and in the decision-making process for medical interventions. Although aging is inevitable, understanding the basic physiology of aging processes can contribute to decision making that can help to sustain quality of life in an aging population. The Associate Editors and I remain committed to the ongoing publication of articles exploring the physiology of aging and strongly encourage investigators working in this area to consider submitting their work to the Journal of Applied Physiology.

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