



# Hormonal Changes Across the Lifespan: Endocrine Shifts and Their Role in Aging Biology

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## DESCRIPTION

Hormones act as chemical messengers that regulate growth, metabolism, reproduction and stress responses throughout life. As humans age, the endocrine system undergoes profound shifts that alter the balance of these signaling molecules. These hormonal changes affect nearly every organ system, contributing to physical decline, metabolic alterations and vulnerability to chronic disease. Studying the relationship between aging and hormonal function provides insights into how the body adapts or fails to adapt to advancing years.

One of the most well-documented changes occurs in the Growth Hormone (GH) and Insulin-like Growth Factor 1 (IGF-1) axis. GH secretion peaks during adolescence and gradually declines with age, a process known as somatopause. Reduced GH and IGF-1 levels lead to decreased protein synthesis, reduced bone density and loss of muscle mass, contributing to frailty and sarcopenia. While GH replacement therapy has been explored, concerns about potential side effects, including increased cancer risk, limit its widespread use in older adults.

The thyroid gland, which regulates metabolism through hormones such as Thyroxine (T4) and Triiodothyronine (T3), also exhibits age-related changes. Although thyroid hormone production remains relatively stable, tissue responsiveness may decline, leading to subtle metabolic slowdown. Hypothyroidism becomes more common with age, contributing to fatigue, weight gain and cognitive difficulties. On the other hand, excessive thyroid activity in older individuals increases the risk of atrial fibrillation and osteoporosis, highlighting the need for careful balance in thyroid management.

Sex hormones undergo particularly striking changes with age. In women, menopause marks the end of reproductive capacity, accompanied by a sharp decline in estrogen and progesterone. These changes affect bone density, lipid metabolism and vascular function, contributing to osteoporosis and cardiovascular disease. The loss of estrogen also influences mood, sleep and

cognitive performance. Hormone Replacement Therapy (HRT) has been used to mitigate these effects, but its association with breast cancer and cardiovascular risks has led to more cautious application, typically tailored to individual risk profiles.

In men, testosterone levels decline more gradually in a process sometimes referred to as andropause. Lower testosterone is associated with reduced muscle mass, decreased libido, diminished energy and mood changes. Testosterone replacement therapy has shown benefits in selected individuals but must be monitored closely due to risks of prostate complications and cardiovascular effects. The debate continues over when and for whom testosterone supplementation is appropriate.

Another key hormonal system affected by aging is the adrenal gland, which regulates stress response through cortisol production. Cortisol rhythms may become blunted with age, leading to impaired stress resilience and increased inflammation. Elevated cortisol levels over time contribute to insulin resistance, central obesity and cognitive decline. In contrast, reduced production of adrenal androgens, such as Dehydroepiandrosterone (DHEA), has been linked with frailty, reduced immune function and decreased well-being. Supplementation with DHEA has been investigated, but evidence remains inconsistent regarding its benefits.

The insulin signaling pathway is central to aging and age-related disease. As individuals age, many develop insulin resistance, leading to impaired glucose metabolism and increased risk of type 2 diabetes. Insulin resistance also contributes to cardiovascular disease, fatty liver and cognitive impairment. Caloric restriction and exercise improve insulin sensitivity, highlighting the strong influence of lifestyle on hormonal balance. Research into drugs such as metformin has shown potential benefits for improving insulin sensitivity and extending healthspan.

Hormonal regulation of appetite and satiety also shifts with age. Levels of leptin, ghrelin and other gut-derived peptides change,

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often resulting in altered hunger cues and changes in body weight. Some older individuals experience unintentional weight loss and malnutrition, while others develop obesity due to metabolic inefficiency. These changes complicate nutritional management in aging populations, requiring individualized dietary interventions.

The interplay between hormones and the immune system is another critical area. Declining sex hormones and adrenal changes affect immune cell activity, contributing to immunosenescence. Estrogen, for example, modulates immune responses and its decline after menopause is linked with increased susceptibility to infections and autoimmune conditions. Cortisol dysregulation also alters immune signaling, further influencing disease risk.

## CONCLUSION

Hormonal changes represent a defining feature of the aging process, influencing metabolism, bone health, muscle strength, immunity and overall vitality. Shifts in growth hormone, thyroid hormones, sex hormones, adrenal hormones and insulin signaling collectively contribute to the decline in physiological function and increased susceptibility to chronic conditions. While hormone replacement therapies offer potential benefits, their risks require careful evaluation and individualized use. More promising are lifestyle interventions, including exercise, balanced nutrition and stress management, which naturally support healthier hormonal profiles. Emerging pharmacological strategies targeting insulin resistance and hormonal pathways further highlight the potential for extending healthspan.