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Physical Activities as a Modulator of Cortisol Regulation and Stress Resilience in women

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ABSTRACT

Women experience stress through a complex interaction of biological, psychological, and social factors, making cortisol regulation a critical determinant of their overall health and resilience. Cortisol, a key glucocorticoid hormone regulated by the hypothalamicpituitaryadrenal (HPA) axis, plays an essential role in metabolism, immune function, and stress adaptation. However, chronic dysregulation of cortisoloften driven by hormonal fluctuations, occupational demands, and unpaid domestic responsibilitiescan negatively affect women's physical, reproductive, and mental health. This paper adopts a biopsychosocial approach to examine the impact of physical activity on cortisol regulation and stress resilience in women. It explores how moderate, well-structured physical activity positively influences cortisol dynamics by improving metabolic efficiency, enhancing mood and sleep quality, supporting cardiovascular and immune function, and strengthening adaptive stress responses. Conversely, excessive or poorly managed exercise is discussed as a potential stressor that may elevate cortisol levels, contributing to muscle catabolism, immune suppression, menstrual irregularities, reduced bone density, and mood disturbances. The review further highlights the influence of life stages such as the menstrual cycle, pregnancy, and menopause on cortisol responses to physical stress. Overall, the findings underscore the importance of personalized and balanced physical activity interventions to optimize cortisol regulation, enhance stress resilience, and promote holistic well-being in women. Physical fitness is presented not only as a means of individual health enhancement but also as a vital contributor to women's societal, economic, and familial roles.

INTRODUCTION

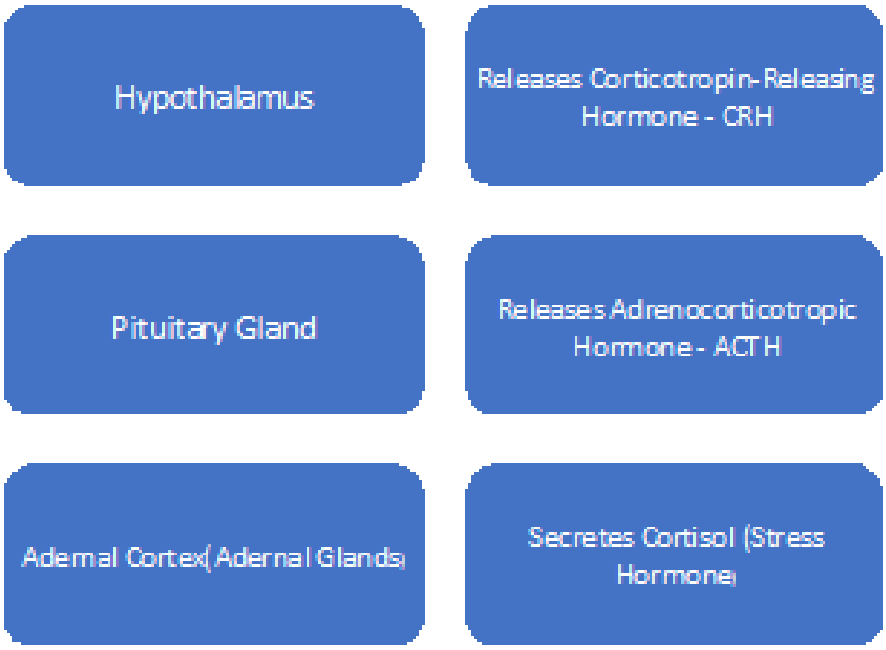
Women possess unique physical characteristics and face specific challenges in balancing their work schedules. Biologically, women have higher body fat percentages and lower muscle mass compared to men, which supports reproductive health but can influence physical strength and endurance. Hormonal fluctuations throughout the menstrual cycle affect mood, energy levels, and physical performance, making certain phases more physically demanding than others. Women are also more susceptible to conditions like iron-deficiency anemia, osteoporosis, and autoimmune diseases. Despite these physiological factors, women demonstrate strong endurance and adaptability when supported with proper nutrition, exercise, and rest.

As if we talk in terms of work schedules, modern women often juggle dual rolesmanaging both professional responsibilities and the unpaid domestic duties. **According to the International Labour Organization (ILO, 2024),** women perform nearly three times more unpaid care work than men globally. This "double burden" contributes to increased stress and fatigue, often affecting their mental and physical well-being. Many women are employed in healthcare, education, retail, and informal sectors, often with part-time or flexible roles to accommodate family needs. However, irregular hours or night shifts are common in certain professions which disrupt their sleep patterns and hormonal balance, leading to long-term health concerns.

Stress in women is inclined by a combination of biological, psychological, and social factors that make their experience of stress distinct from men. **Kajantie and Phillips (2006)** observed that women often exhibit a blunted cortisol response to stress compared to men, especially during the luteal phase of the menstrual cycle, suggesting hormonal mediation of stress reactivity. stress-related disorders like anxiety and depression are more prevalent among women. Kessler et al. (1993) found that women are nearly twice as likely to be diagnosed with major depressive disorder compared to men, largely due to both hormonal and psychosocial influences.

Cortisol is a steroid hormone produced by the adrenal cortex in the adrenal glands. It plays a critical role in the regulation of metabolism, immune response, and the body's response to stress. It is often referred to as the "stress hormone" because it is secreted in higher levels during the body's fight-or-flight response.

The "stress hormone,", often referred to as the " Cortisol," is a steroid hormone produced by the adrenal glands and plays a crucial role in maintaining homeostasis in the human body. It is part of the hypothalamic-pituitary-adrenal (HPA) axis and is primarily released in response to stress and low blood-glucose concentration.cortisol helps to regulate metabolism by increasing the glucose availability through gluconeogenesis, stimuluses blood pressure, lessens inflammation, aids in fat, protein, and carbohydrate metabolism, regulates sleep-wake cycles, suppresses the immune system and supports the body's fight-or-flight response. **According to Sapolsky, Romero, and Munck (2000)** in their study published in Endocrine Reviews, cortisol is essential for survival, but its chronic elevation can lead to negative effects such as immune suppression, insulin resistance, and mood disorders. In women, cortisol also interacts with reproductive hormones, influencing menstrual health, fertility, and emotional well-being. The hormone follows a diurnal rhythm—peaking in the early morning and declining throughout the day—which is influenced by factors like physical activity, sleep, and psychological stress. Thus, cortisol plays a dynamic and vital role in the body's ability to adapt to internal and external stressors, making it a key hormone in both health and disease management.



Influence of corticoid gland on inclusive health of women

The corticoid gland, more precisely known as the adrenal gland, has a substantialimpact on women's inclusive health by regulating hormone production that affects stress response, metabolism, mood, and reproductive function. One of its primehormones, i.e cortisol, plays a dominant role in managing stress. In women, elevated levels of cortisol due to chronic Stress that comes from physiological changes, professional responsibilities and the unpaid domestic duties disrupt the menstrual cycle, subsidize to premenstrual syndrome (PMS), affecting fertility, and increasing the risk of anxiety and depression. **Research by Kirschbaum and Hellhammer (1994)** showed that women, especially during certain phases of their menstrual cycle or while using oral contraceptives, exhibit heightened cortisol responses to stress. Furthermore, the adrenal glands produce androgens such as DHEA and testosterone in small amounts, which are essential for maintaining libido, energy levels, and muscle and bone strength. However, overproduction of these androgens can lead to conditions like polycystic ovary syndrome (PCOS), resulting in acne, excessive hair growth, and hormonal imbalance. During the phase of menopause, ovarian hormone levels decline as the adrenal glands partially compensate by producing limited sex hormones, which indeed helps to maintain hormonal balance. Weak adrenal function at this stage may contribute to symptoms like fatigue, hot flashes, and mood swings. Overall, the adrenal glands play a vital role in supporting women's physical and emotional well-being throughout different stages of life.

Physical activity has a direct and important relationship with cortisol hormone levels, especially in women. Cortisol, produced by the adrenal (corticoid) gland, is a key hormone involved in the body's response to stress, energy regulation, and metabolism. In women, the moderate amount of physical activity helps in regulating cortisol levels by reducing chronic stress, improving mood, and enhancing overall hormonal balance. However, excessive or intense physical training without adequate rest can lead to elevated cortisol, which may disrupt the menstrual cycle, weaken the immune system, and increase fatigue. Women are particularly sensitive to hormonal changes, and imbalanced cortisol levels can lead to symptoms such as anxiety, irregular periods, and reduced bone density. On the other hand, regular and balanced physical exercise—such as walking, yoga, or aerobic workouts—can help maintain healthy cortisol patterns, improve resilience to stress, and support reproductive and mental health. Thus, physical activity, when properly managed, serves as a powerful tool for women to maintain optimal cortisol function and overall well-being.

Positive Influence of Physical Activities:

1. Energy Mobilization

Cortisol promotes the process of gluconeogenesis converting non-carbohydrate sources (like protein and fat) into glucose, which inturn helps in sustaining energy during physical activity.**Sapolsky et.al, (2000)** emphasises on the cortisol's role in energy release under stress and physical activity

2. Supports Metabolism

Cortisol helps in mobilizing energy during workouts and post-exercise by regulating the metabolism of fats, proteins, and carbohydrates. Regular training adapts the body to manage cortisol spikes more efficiently by helping the body efficiently use energy during physical exertion. **Charmandari et.al, (2005)** explains cortisol's regulatory effects on metabolic systems during physical stress.

3. Enhances Focus and Alertness

While undergoing the moderate physical activity, cortisol helps to improve attention, motivation, and alertness, which are very crucial for athletic performance.**McEwen and B. S. (2007)** describes cortisol's cognitive and neurological benefits during acute stress and exercise.

4. Maintains Cardiovascular Function

Cortisol helps to regulate blood pressure and cardiovascular tone aiding in oxygen and nutrient delivery to active muscles during physical activities.**Walker and B. R. (2006)** discusses cortisol's effects on cardiovascular function and vascular tone during exertion.

5. Anti-inflammatory Effects

Cortisol has short-term anti-inflammatory effects on the body that help to reduce muscle inflammation and provides a support recovery after intense activity.**Rhen, T. and Cidlowski, J. A. (2005)** explains the role of glucocorticoids like cortisol in short-term inflammation control.

6. Adapts Body to Stress (Improved HPA Regulation)

Regular physical activity supports the regulation of the hypothalamic-pituitary-adrenal (HPA) axis, which helps to stabilize cortisol release, especially in women with hormonal imbalances such as PCOS or PMS, leading to more balanced cortisol release and improved resilience to stress. Regular moderate-intensity physical activity (like walking, yoga, or swimming) helps lower baseline cortisol levels over time, thereby reducing stress and anxiety in women.

Rimmele, U. et al. (2009) found that physically trained individuals (especially women) had a healthier cortisol response to stress.

7. Better Sleep and Mood: Lower cortisol levels associated with consistent exercise lead to improved sleep quality and mood by increasing serotonin and endorphin levels.

Negative Influence (When Exercise is Excessive or Intense):

While cortisol is essential for acute stress responses, chronically elevated cortisol due to overtraining or insufficient recovery can have serious negative impacts on women's muscle health, immunity, hormonal balance, bone density, and mental well-being during physical activity.

1. Chronic Elevated Cortisol Leads to Muscle Breakdown (Catabolism)

Prolonged high cortisol levels lead to the breakdown of muscle protein, impairing muscle growth and recovery in women.**Timmons, J. A., and Atherton, P. J. (2009)**discusses how elevated cortisol promotes muscle catabolism under chronic stress or overtraining.

2. Impaired Immune Function

Excess cortisol suppresses immune responses by increasing the risk of infections and delaying recovery from exercise-induced muscle damage.**Gleeson, M. (2007)** highlights cortisol's immunosuppressive effects, especially in athletes undergoing intense training.

3. Menstrual Irregularities and Hormonal Imbalance

High cortisol disrupts the hypothalamic-pituitary-gonadal axis, causing menstrual cycle irregularities or amenorrhea in physically active women.**Loucks, A. B. (2003)** demonstrates how stress and cortisol affect menstrual function in active women.

4. Increased Risk of Overtraining Syndrome

Chronically elevated cortisol is a marker of overtraining syndrome which is characterized by fatigue, decreased performance, and mood disturbances.**Meeusen, R., and De Meirleir, K. (1995)** describes cortisol's role in overtraining and its negative effects on physical and mental health.

5. Negative Impact on Bone Health
Excess cortisol can lead to reduced bone mineral density, increasing risk of osteoporosis and fractures in women athletes.**Friedl, K. E. (2001)** explains how elevated cortisol negatively affects bone metabolism in active women.

6. Impaired Cognitive Function and Mood Disorders
Prolonged cortisol elevation may contribute to anxiety, depression, and cognitive impairments, negatively affecting motivation and focus during training.**Lupien et. Al, (2009)** reviews cortisol's detrimental effects on brain function and mood.

ROLE
Physically fit women significantly enhance their contribution to society by performing multiple roles more efficiently and effectively whether it is professional, familial, or leadership domains. **According to a study by the World Health Organization (2020)**, women involved in regular physical activity not only reduces the risk of non-communicable diseases but also improves mental health, work productivity, and social participation. When women are physically fit and mentally sound, they exhibit higher energy levels, better emotional resilience, and improved cognitive functioning, which directly translates into increased confidence and leadership potential. This empowers them to exhibit their active roles in education, governance, healthcare, and entrepreneurship. Moreover, physically active mothers tend to influence the health behaviors of their children in a positive manner, promoting healthier families and communities **(Nelson et al., 2007, Journal of Women's Health)**. In socio-economic terms, fit women experience fewer work absences and contribute more consistently to the workforce. In developing countries, where women often engage in physically demanding labor, fitness becomes crucial for livelihood and self-reliance. Therefore, a physically fit woman is not only a symbol of personal well-being but also a catalyst for community health, economic growth, and social transformation.

CONCLUSION

The relationship between women, cortisol, and physical activity is very complex and deeply interconnected as balanced and appropriately timed physical activity is highly beneficial for managing cortisol levels in women. Physical activity can serve as both a stressor and a stress reliever, depending on its intensity, duration, and the individual's physical and hormonal condition. In women, moderate physical activity tends to regulate cortisol levels, promoting mental well-being, metabolic balance, and improved cardiovascular and muscular health. However, excessive or intense training—especially when combined with inadequate recovery or nutritional deficits can lead to elevated cortisol levels, disrupting menstrual cycles, impairing muscle recovery, and increasing fatigue or anxiety.

Hormonal fluctuations across the menstrual cycle, as well as life stages like pregnancy and menopause, also influence how women respond to physical stress and cortisol. Therefore, personalized exercise plans and stress management strategies are essential to ensure that cortisol supports rather than hinders women's physical and mental health.

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