Review Article

Hormonal Underpinnings of Emotional Regulation: Bridging Endocrinology and Psychology

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Abstract

This review explores the intricate relationship between hormonal fluctuations and emotional regulation, emphasizing the critical role of hormones in mood, stress responses, and psychological well-being. By examining key hormones involved in emotional regulation—such as those from the Hypothalamic-Pituitary-Adrenal (HPA) axis, gonadal hormones (estrogen and testosterone), thyroid hormones, oxytocin, and metabolic hormones like insulin, leptin, and ghrelin—we uncover how these biochemical messengers impact emotional states and contribute to mood disorders. The paper discusses methodological challenges and future research directions, highlighting the necessity for interdisciplinary approaches to deepen our understanding of hormonal influences on emotional regulation.

The review underscores the importance of considering hormonal mechanisms in developing targeted treatments for mood disorders, advocating for a holistic perspective that bridges endocrinology and psychology. By integrating current research findings with clinical implications, our objective is to enhance the biological foundation of emotional regulation, paving the way for innovative therapeutic strategies and improved mental health care. This comprehensive overview aims not only to consolidate existing knowledge but also to identify gaps in research, encouraging further exploration into the hormonal underpinnings of emotional states. Through this endeavor, we aspire to contribute to a broader understanding of emotional regulation, offering new perspectives on treating mood disorders and enhancing overall emotional well-being.

Keywords: Hormonal Regulation, Emotional Regulation, Mood Disorders, HPA Axis.

Introduction

Emotional regulation encompasses the myriad strategies individuals deploy to manage and modify their emotional experiences and expressions [1]. This regulatory process is essential for social adaptation[2] psychological well-being [3], and overall mental health [4]. It involves a complex interplay between awareness [5], understanding [6], acceptance [7], and the modulation of emotional responses [8] to meet situational demands and personal goals. While the cognitive and behavioral aspects of emotional regulation have been extensively explored, emerging research underscores a critical yet often overlooked dimension: the biological and hormonal foundations of emotional states and their regulation.

Hormones, as the biochemical messengers of the body [9], play a central role in regulating not only physical processes but also emotional and psychological states [10]. These substances, produced and secreted by various glands within the endocrine system [11], travel through the bloodstream to target organs, exerting their effects on mood, energy levels, and stress responses [12]. The influence of hormones on emotions can be profound, with fluctuations or imbalances in hormonal levels being linked to significant changes in emotional regulation, mood disorders, and overall mental health [13].

The interaction between hormones and emotional regulation is complex and bidirectional [14]. On one hand, emotional states can influence hormonal secretion [15]; for instance, stress triggers the release of cortisol, a hormone that prepares the body to respond to perceived threats. On the other hand, hormones can modulate the intensity and quality of emotional experiences [16]; for example, variations in estrogen and progesterone levels across the menstrual cycle are associated with changes in mood and emotional sensitivity in many women.

This dual influence underscores the need for a comprehensive understanding of the hormonal mechanisms underlying emotional regulation [17]. Several key hormones have been identified as major players in this process, including:

- **Cortisol:** Often referred to as the "stress hormone," cortisol plays a critical role in the body's stress response and has been linked to emotional regulation and mood disorders [18].
- **Estrogen and Testosterone:** These sex hormones are known to influence mood and emotional states, with imbalances being associated with depression and mood

How to cite this article: Yılmazer E. Hormonal Underpinnings of Emotional Regulation: Bridging Endocrinology and Psychology. J Neurobehav Sci 2024; 11:60-75.

Ethics committee approval: There is no need for ethics committee approval.

Received : 14.04.2024
Revised : 16.05.2024
Accepted : 26.06.2024
Published : 30.08.2024

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Access this article online

Website: https://dergipark.org.tr/tr/journal/4383/issue/86769/1539123

DOI: 10.32739/uha.jnbs.11.1539123

Quick Response Code:

swings [19].

- **Thyroid Hormones:** Thyroxine (T4) and Triiodothyronine (T3) regulate metabolism and energy levels, and their dysregulation can lead to mood disorders such as depression [20].
- **Oxytocin:** Dubbed the "love hormone," oxytocin is involved in social bonding, trust, and the modulation of social behaviors and emotional responses [21].

Understanding how these and other hormones influence emotional regulation offers a more holistic view of mental health, bridging the gap between biological sciences and psychology. By exploring the hormonal catalysts of emotional regulation, we aim to provide insights into the underlying biological mechanisms that shape our emotional experiences and offer new perspectives on treating mood disorders and improving emotional well-being [22].

The Role of Hormones in Emotional Regulation

Hormones, the biochemical messengers of the body, serve as critical components of the endocrine system, a network of glands that coordinates and regulates a myriad of physiological processes. These substances are secreted directly into the bloodstream and transported to various organs and tissues, where they exert their effects [23]. Beyond their well-known roles in growth, metabolism, reproduction, and homeostasis, hormones are instrumental in the complex domain of emotional regulation [14]. They act at the intersection of physiology and psychology, embodying the connection between the body's internal state and its external expressions of mood and emotion [24].

The endocrine system's interaction with the brain, particularly through the hypothalamus and pituitary gland, underscores the sophisticated level of coordination required to regulate emotional states [25].

The hypothalamus, often considered the endocrine system's master regulator, plays a pivotal role in maintaining homeostasis. It responds to a variety of signals from the brain and body, adjusting hormone production and secretion in response. The pituitary gland, under the influence of the hypothalamus, secretes hormones that regulate other glands in the endocrine system, further influencing emotional regulation [26].

This hormonal influence on emotions is mediated through various pathways and mechanisms:

1. **Neurotransmitter Modulation:** Many hormones interact with neurotransmitters, the chemical messengers of the nervous system, influencing mood, stress responses, and emotional resilience. For instance, cortisol affects neurotransmitter levels such as serotonin and dopamine, which are directly linked to mood and pleasure, respectively [27].
2. **Brain Structure and Function:** Hormones can impact the structure and function of brain regions involved in emotional processing. Estrogen, for example, has neuroprotective effects and influences the activity of the amygdala and prefrontal cortex, areas critical for emotional response and regulation [28].
3. **Stress Response:** HPA axis, a key player in the stress response, demonstrates the direct impact of hormones on emotional regulation. Activation of the HPA axis leads to the release of cortisol, preparing the body for a "fight or flight" response and influencing emotional states [29].
4. **Social and Bonding Hormones:** Oxytocin and vasopressin are hormones that play crucial roles in social bonding, trust, and empathy, directly affecting social behavior and emotional experiences in group settings [30].

Understanding the role of hormones in emotional regulation not only requires a grasp of these biochemical mechanisms but also an appreciation of the individual variability in hormonal responses. Factors such as genetic predispositions, environmental influences, and lifestyle choices can affect hormone levels and their impact on emotional regulation, contributing to the complexity of this dynamic interplay.

Melatonin

Reflecting on the hormonal catalysts of emotional regulation, it becomes evident that understanding, while extensive, remains poised for deeper exploration. Emerging research, particularly on the role of melatonin in synchronizing circadian rhythms and its implications for mood and anxiety disorders, exemplifies the dynamic nature of this field [31]. Such studies not only broaden the perspective on hormonal influences beyond the traditional realms but also illuminate potential pathways for innovative therapeutic interventions. The exploration of melatonin's impact on emotional regulation underscores the necessity for interdisciplinary research approaches that encompass the full spectrum of hormonal activity. As advancements continue, incorporating a broader array of hormonal interactions will be crucial in developing a more comprehensive understanding of their role in emotional well-being and mental health [32].

By exploring the multifaceted roles that hormones play in regulating emotions, we gain insights into the biological underpinnings of psychological states and behaviors. This knowledge is instrumental in developing more nuanced approaches to mental health care, emphasizing the importance of considering hormonal balance in therapeutic interventions for mood disorders and emotional dysregulation [33].

Objective of the Review

The overarching objective of this review is to synthesize and critically evaluate current research on the hormonal mechanisms underlying emotional regulation. In the intricate interplay between the endocrine system and psychological states, hormones emerge as pivotal regulators of mood, stress responses, and overall emotional well-being. Despite the significant advances in our understanding of this relationship, there remain gaps in my knowledge regarding the precise mechanisms through which hormones influence emotional regulation and how these processes contribute to mental health disorders.

To address this, the review seeks to accomplish the following specific aims:

1. **Comprehensive Synthesis:** Provide a comprehensive overview of the current state of research on the hormonal regulation of emotions, summarizing key findings from empirical studies, clinical trials, and meta-analyses. This includes examining the role of major hormones such as cortisol, estrogen, testosterone, thyroid hormones, and oxytocin

in emotional regulation.

2. **Mechanistic Insights:** Delve into the biological and neurochemical pathways through which hormones exert their influence on emotional regulation, highlighting the complex interactions between the endocrine system and the brain.
3. **Psychological and Behavioral Correlations:** Explore the psychological and behavioral implications of hormonal effects on emotional regulation, including the impact on mood disorders, stress-related conditions, and overall mental health.
4. **Identify Research Gaps:** Identify gaps in the current literature where further investigation is needed. This involves pinpointing areas where our understanding of hormonal influences on emotional regulation is limited, contradictory, or evolving.
5. **Future Directions:** Offer recommendations for future research, suggesting potential studies that could address the identified gaps and contribute to a more nuanced understanding of how hormonal regulation intersects with psychological health. This includes advocating for interdisciplinary research approaches that integrate endocrinology, neuroscience, and psychology.
6. **Clinical Implications:** Discuss the potential clinical implications of understanding hormonal mechanisms in emotional regulation. This includes considering how insights into hormonal influences on emotions could inform therapeutic strategies, improve diagnosis and treatment of mood disorders, and lead to the development of personalized medicine approaches.

By achieving these aims, this review intends to bridge the gap between endocrinology and psychology, providing a holistic perspective on the hormonal catalysts of emotional regulation. We aspire to contribute to a deeper understanding of the biological underpinnings of emotional states, offering a foundation for future research and clinical practices aimed at enhancing emotional well-being and mental health.

Hormonal Systems Involved in Emotional Regulation

Cortisol and Emotional Regulation: Hypothalamic-Pituitary-Adrenal (HPA) Axis

The HPA axis represents a major part of the body's neuroendocrine system responsible for regulating stress responses, metabolism, immune function, and emotions. Activation of this axis is a prime example of the body's effort to maintain homeostasis in the face of stress [34]. The process begins in the hypothalamus, which releases corticotropin-releasing hormone (CRH) in response to a stress signal. CRH then stimulates the pituitary gland to secrete adrenocorticotropic hormone (ACTH), which in turn prompts the adrenal glands to produce cortisol. Once released into the bloodstream, cortisol prepares the body to handle stress by increasing glucose availability, enhancing the brain's use of glucose, and suppressing nonessential functions in a fight-or-flight response [35].

Cortisol's Role in Stress Response

Cortisol plays a pivotal role in the body's response to stress, serving both to mobilize resources necessary to deal with stressors and to restore equilibrium afterward. It affects various bodily functions to increase alertness, energy levels, and the ability to respond to environmental demands [36]. However, cortisol's influence extends beyond the physical, impacting emotional and psychological states as well. It modulates areas of the brain involved in emotional regulation, such as the amygdala and prefrontal cortex, affecting mood, motivation, and fear [37].

Impact on Emotional Regulation

While cortisol is essential for survival, its dysregulation can lead to emotional and psychological disturbances. Chronic activation of the HPA axis and prolonged exposure to high levels of cortisol have been linked to a range of mental health issues, including anxiety, depression, and post-traumatic stress disorder (PTSD) [38]. Such conditions often arise from or result in impaired emotional regulation, where individuals struggle to manage and respond to their emotional experiences effectively [39].

Excessive cortisol can impair the function of the hippocampus, a brain region vital for memory and emotional regulation, leading to difficulties in forming and retrieving memories and in managing emotional responses [40]. This can exacerbate the symptoms of stress-related disorders, creating a feedback loop that further hinders emotional regulation [41].

Furthermore, variations in cortisol levels throughout the day, known as the diurnal rhythm, are associated with mood fluctuations. Disruptions in this rhythm, such as those seen in shift workers or individuals with irregular sleep patterns, can negatively affect emotional well-being [42].

Therapeutic Implications

Understanding the role of the HPA axis and cortisol in emotional regulation opens pathways for therapeutic interventions. Treatments that target HPA axis dysregulation, such as pharmacological agents that modulate cortisol levels or psychological interventions that reduce perceived stress, hold promise for improving emotional regulation and mental health [43].

Additionally, lifestyle interventions, including stress management techniques, regular physical activity, and sleep hygiene, can help normalize HPA axis function and enhance emotional well-being [44].

Gonadal Hormones: Estrogen and Testosterone in Emotional Regulation

Gonadal hormones, estrogen, and testosterone, produced by the ovaries and testes respectively, play critical roles beyond their reproductive functions. They are pivotal in modulating mood, aggression, and emotional well-being, demonstrating the intricate relationship between hormonal levels and psychological states [45].

Estrogen and Mood

Estrogen is often termed a "mood enhancer" due to its positive effects on brain function and mood. It interacts with serotonin and other neurotransmitters involved in mood regulation, enhancing their availability and the sensitivity of their receptors [46]. Estrogen's neuroprotective properties also support cognitive functions, including memory and attention, which can indirectly

influence emotional regulation and mood stability [47].

Fluctuations in estrogen levels, such as those occurring during the menstrual cycle, pregnancy, or menopause, can significantly affect emotional well-being [48]. For example, periods of rapid estrogen decline are associated with mood swings, irritability, and increased susceptibility to depression and anxiety. This underscores the hormone's complex role in modulating mood and highlights the potential for hormonal interventions in treating mood disorders, particularly those that manifest or worsen in relation to menstrual cycle phases or menopausal transition [13].

Testosterone and Aggression

Testosterone is often associated with aggression, risk-taking behaviors, and dominance. While it is simplistic to draw a direct line between testosterone levels and aggressive behavior, research suggests a correlation, particularly in males. High testosterone levels have been linked to increased irritability, impulsivity, and aggression, potentially exacerbating conflict in social interactions and impacting emotional well-being [49].

However, the relationship between testosterone and aggression is nuanced and influenced by environmental and social factors. For instance, social challenges or threats can elevate testosterone levels, suggesting that its role in aggression may also be a response to external stimuli rather than a direct cause [50].

Testosterone and Mood

Apart from its links to aggression, testosterone plays a vital role in mood regulation for both men and women. Low levels of testosterone (a condition known as hypogonadism) are associated with depression, fatigue, and a decreased sense of well-being [51].

Testosterone replacement therapy has been shown to improve mood and energy levels in men with hypogonadism, indicating the hormone's importance in maintaining emotional equilibrium [52].

Age-related changes

Furthermore, the critical examination of gonadal hormones in emotional regulation invites attention to age-related hormonal changes and their profound impacts on mood and well-being. Particularly noteworthy is the concept of andropause, akin to menopause in women, where men experience a gradual decline in testosterone levels, potentially affecting emotional stability, mood, and cognitive functions [53]. This parallel underscores a broader spectrum of hormonal influences across different stages of life, highlighting the intricate balance between estrogen and testosterone and their pivotal roles in maintaining emotional regulation [54]. The exploration of andropause, alongside menopause, accentuates the need for a gender-inclusive understanding of hormonal transitions and their psychological implications. It beckons further research into these age-related hormonal shifts, aiming to unravel their complex relationship with mood disorders and emotional well-being, thereby fostering a more holistic approach to mental health across the lifespan [55].

Therapeutic Implications

Understanding the effects of estrogen and testosterone on emotional regulation offers valuable insights for developing gender-sensitive approaches to treating mood disorders and emotional dysregulation. Hormonal therapies, such as estrogen replacement therapy during menopause or testosterone replacement therapy for hypogonadal men, may provide effective strategies for improving mood and emotional well-being when carefully managed [56].

Thyroid Hormones and Emotional Regulation

The thyroid gland plays a vital role in maintaining the body's metabolic rate, energy production, and overall homeostasis. The hormones it secretes, T4 and T3, influence nearly every organ system, including the brain, where they impact neurotransmitter activity, neurogenesis, and the overall health of neural tissue. Given this extensive reach, it's perhaps unsurprising that thyroid hormone imbalances can profoundly affect mental health [57].

Hyperthyroidism and Mood Disorders

Hyperthyroidism, characterized by elevated levels of thyroid hormones, can lead to symptoms that mimic anxiety and other mood disorders. Individuals with hyperthyroidism often experience increased nervousness, restlessness, irritability, and mood swings. The physiological state induced by excess thyroid hormones can mimic a chronic stress response, leading to an enhanced sense of vigilance or agitation, which can exacerbate or mimic the symptoms of anxiety disorders [58].

Additionally, hyperthyroidism can cause difficulty sleeping, rapid heart rate, and other physical symptoms that further contribute to emotional distress and dysregulation. The overlap of these symptoms with anxiety and mood disorders makes accurate diagnosis and treatment crucial [59].

Hypothyroidism and Depression

Conversely, hypothyroidism, or insufficient thyroid hormone production, is often associated with depression. Symptoms of hypothyroidism, such as fatigue, lethargy, weight gain, and decreased concentration, closely parallel those of depressive disorders, leading to challenges in distinguishing between the two conditions. The reduced metabolic rate and energy production in hypothyroidism can contribute to a lowered mood, diminished motivation, and overall decreased sense of well-being [60].

Studies have shown that individuals with hypothyroidism have a higher prevalence of depression than the general population. Furthermore, even subclinical hypothyroidism, where hormone levels are borderline low, has been linked to increased risk of depression and cognitive dysfunction [61].

Interactions between thyroid disorders and autoimmune diseases

The intersection of thyroid disorders and autoimmune diseases represents a complex layer in understanding hormonal influences on emotional regulation. Notably, autoimmune thyroiditis, such as Hashimoto's disease, exemplifies this complexity by being intricately linked with an increased prevalence of mood disorders [62]. The autoimmune attack on thyroid tissue not only disrupts hormonal balance but also introduces an inflammatory response that may further exacerbate emotional dysregulation [63]. This association underscores the challenges faced in diagnosing and treating mood disorders within the context of concurrent autoimmune conditions. The bidirectional nature of thyroid function and immune system activity invites a more

nuanced approach to treatment, necessitating considerations beyond standard hormonal replacement therapies. It highlights the importance of an integrated care model that addresses the autoimmune component as a critical factor in restoring emotional equilibrium and overall mental health [64].

Therapeutic Implications

The bidirectional relationship between thyroid function and emotional well-being underscores the importance of screening for thyroid dysfunction in patients presenting with mood disorders. Proper diagnosis and treatment of thyroid conditions can lead to significant improvements in mood and cognitive function. For example, thyroid hormone replacement therapy in hypothyroidism often alleviates depressive symptoms, while treatments that normalize thyroid hormone levels in hyperthyroidism can reduce anxiety and agitation [65].

Understanding the role of thyroid hormones in emotional regulation and mood disorders highlights the necessity of a holistic approach to mental health, considering the potential contributions of endocrine factors to psychological conditions. It also points to the importance of interdisciplinary collaboration in the diagnosis and treatment of mood disorders, ensuring that patients receive comprehensive care that addresses both the psychological and physiological aspects of their condition [66].

Oxytocin: Bonding, Trust, and Emotional Regulation

Facilitation of Social Bonds

Oxytocin is integral to forming social bonds, including maternal behaviors, pair bonding, and group cohesion. Its release during childbirth and breastfeeding helps establish the initial mother-infant bond, a critical aspect of human development [67]. Beyond maternal behaviors, oxytocin facilitates social bonding by enhancing the rewarding aspects of social interactions and reducing social anxieties, promoting feelings of contentment and security in relationships [68].

Enhancement of Trust

Oxytocin's role in trust is one of its most fascinating aspects. Studies have shown that oxytocin increases individuals' trust in others in social and economic exchanges, even in the absence of personal familiarity or when the risk of betrayal is high [69]. This effect suggests that oxytocin acts on the brain's reward and fear systems, lowering defenses and inhibiting the fear responses associated with social betrayal, thus facilitating cooperative behaviors and trust [70].

Regulation of Emotional Responses

Oxytocin also plays a significant role in regulating emotional responses, particularly in the context of social interactions. It can diminish the stress response, reducing levels of cortisol and mitigating the fight-or-flight reaction in socially threatening situations. By doing so, oxytocin promotes calmness and reduces anxiety, enhancing individuals' ability to navigate social complexities and maintain emotional balance [67].

Furthermore, oxytocin has been implicated in enhancing empathy and the ability to read emotional cues in others, crucial components of effective social communication and emotional regulation. By facilitating a better understanding of others' emotional states, oxytocin strengthens social connections and promotes prosocial behavior [71].

Genetic factors influencing oxytocin receptor function

Incorporating the nuanced role of genetic factors into the discourse on oxytocin and its impact on emotional regulation unveils a fascinating layer of complexity. Variations in the OXTR gene, which encodes the oxytocin receptor, have been implicated in modulating individual differences in social behavior, emotional regulation, and susceptibility to mood disorders [72]. Studies suggest that certain polymorphisms within the OXTR gene may influence the efficacy of oxytocin receptor signaling, potentially affecting an individual's capacity for social bonding, empathy, and processing of social cues [73]. These genetic variations could explain the wide range of responses to social stressors and predispositions to conditions such as anxiety or depression. Recognizing the influence of OXTR gene polymorphisms not only enriches our understanding of the biological underpinnings of emotional and social regulation but also opens the door to personalized medical approaches. Tailoring interventions that consider an individual's genetic makeup, particularly in the context of oxytocin signaling, may enhance therapeutic outcomes for mood disorders and improve strategies for enhancing social functioning and emotional well-being. This genetic perspective underscores the importance of integrating genomics with neuroendocrinology to pave the way for precision medicine in psychiatry and behavioral health [74].

Therapeutic Implications

Given its profound effects on social behavior and emotional regulation, oxytocin has been investigated as a potential therapeutic agent for a range of conditions characterized by social deficits and emotional dysregulation, such as autism spectrum disorders, social anxiety, and certain forms of depression [75]. While the therapeutic application of oxytocin is still under investigation, preliminary studies suggest that oxytocin administration can enhance social cognition, improve emotional recognition, and reduce social anxiety in some individuals [76].

However, the complexity of oxytocin's effects and its varied influence depending on individual and contextual factors necessitate further research to understand its potential as a therapeutic tool fully. The promise of oxytocin lies not only in its capacity to enhance social bonding and trust but also in its potential to illuminate the neurochemical pathways that underlie these fundamental human experiences [77].

Other Hormones: Linking Metabolic States to Emotional Regulation

Insulin and Mood Regulation

Insulin, a hormone produced by the pancreas, plays a critical role in glucose metabolism, allowing cells to absorb glucose from the blood for energy. Beyond its metabolic functions, insulin has been implicated in brain function and mood regulation [78]. Insulin receptors are widely distributed in the brain, particularly in regions involved in mood and cognition, such as

the hippocampus and prefrontal cortex. Dysregulation of insulin signaling in the brain can lead to cognitive impairments and has been associated with mood disorders [79].

Studies have suggested a link between insulin resistance—a condition in which cells become less responsive to insulin—and depression. Insulin resistance can disrupt the balance of neurotransmitters and impair neuronal growth and survival, potentially contributing to depressive symptoms. Moreover, the physiological stress of managing chronic conditions like diabetes, which involves insulin management, can also affect emotional well-being, underscoring the complex relationship between insulin regulation and mood [80].

Leptin, Satiety, and Emotional Well-being

Leptin is a hormone produced by adipose (fat) tissue that signals satiety to the brain, helping to regulate energy balance and body weight. Interestingly, leptin receptors are found in brain areas involved in emotion and reward processing, suggesting that leptin may influence mood and emotional responses. Low levels of leptin have been associated with increased appetite and reduced motivation, which can contribute to the development of obesity [81]

Emerging research indicates that leptin may play a role in modulating mood and cognitive functions, with leptin resistance (a condition often seen in obesity) being linked to depressive-like behaviors in animal models. Furthermore, leptin has been investigated for its potential antidepressant properties, with some studies suggesting that leptin administration can produce antidepressant-like effects in certain contexts [82].

Ghrelin, Hunger, and Mood

Ghrelin, often referred to as the "hunger hormone," is produced in the stomach and signals the brain to stimulate appetite. Like leptin, ghrelin's influence extends beyond metabolic regulation to affect mood and emotional states [83]. High levels of ghrelin have been associated with stress-induced eating and may enhance the rewarding aspects of food, linking hunger directly with emotional states [84].

Interestingly, ghrelin has been shown to have anxiolytic and antidepressant effects in animal models, suggesting that it plays a complex role in emotional regulation [85]. The hormone appears to promote stress resilience and may have protective effects against stress-induced depression. This relationship between ghrelin and mood underscores the potential therapeutic implications of understanding and modulating ghrelin levels in treating mood disorders and emotional dysregulation [86].

Role of Vitamin D

Exploring the role of vitamin D in emotional regulation adds a compelling dimension to the hormonal influences on mood and mental health. Vitamin D, often referred to as the "sunshine vitamin," exerts hormone-like actions, with its receptors widely distributed throughout the brain, indicating its potential impact on neurological and emotional processes. Emerging evidence has drawn a correlation between vitamin D deficiency and an increased risk of mood disorders, including depression and anxiety, as well as cognitive impairments. The neuroprotective properties of vitamin D, along with its influence on neurotransmitter synthesis and brain plasticity, suggest a significant role in maintaining emotional balance and cognitive function.[87]

Consequently, the potential for vitamin D supplementation as an adjunctive treatment in mood disorders represents an area ripe for further investigation. Research exploring optimal vitamin D levels for emotional regulation and the efficacy of supplementation in improving mood disorder symptoms could provide valuable insights into non-traditional approaches to mental health treatment. This burgeoning field underscores the necessity of broadening our perspective on the hormonal underpinnings of emotional well-being, integrating nutritional and hormonal therapies into holistic psychiatric care [88].

Mood Disorders: Hormonal Imbalances and Their Impact

Depression and Hormonal Imbalances

Depression is a multifaceted mood disorder characterized by persistent feelings of sadness, loss of interest, and a range of emotional and physical symptoms. Research has identified several hormonal systems implicated in depression, highlighting the role of cortisol, thyroid hormones, and sex hormones in its pathophysiology [89].

- **Cortisol:** Elevated cortisol levels, indicative of HPA axis dysregulation, have been frequently observed in individuals with depression. The chronic stress response associated with increased cortisol can exacerbate depressive symptoms, impairing emotional regulation and contributing to the neurobiological changes seen in depression [90].
- **Thyroid Hormones:** Both hyperthyroidism and hypothyroidism have been linked to depressive symptoms. Thyroid hormone imbalances can affect neurotransmitter levels and brain function, influencing mood and cognitive processes central to depression [91].
- **Sex Hormones:** Fluctuations in estrogen and testosterone levels have also been associated with depression. For example, postpartum depression has been linked to rapid hormonal changes after childbirth, and testosterone deficiency in men can contribute to depressive symptoms [92].

Bipolar Disorder and Hormonal Fluctuations

Bipolar disorder, characterized by mood swings between manic/hypomanic episodes and depressive episodes, has also been associated with hormonal imbalances [93]. Research suggests that the HPA axis may be overactive during manic phases and underactive during depressive phases, indicating a complex relationship between cortisol levels and bipolar symptomatology. Additionally, thyroid dysfunction has been observed at a higher rate in individuals with bipolar disorder, with some studies suggesting that thyroid hormone supplementation may stabilize mood in certain cases [94].

Anxiety Disorders and Hormonal Dysregulation

Anxiety disorders, encompassing conditions like generalized anxiety disorder, panic disorder, and social anxiety disorder, have been linked to dysregulation in several hormonal systems. The HPA axis is particularly relevant, as heightened and prolonged cortisol release in response to stress can increase susceptibility to anxiety disorders [95]. Furthermore, sex hormones like

estrogen and progesterone have been implicated in anxiety, with fluctuations during the menstrual cycle, pregnancy, and menopause potentially affecting anxiety levels [96].

In the exploration of hormonal influences on mood disorders, the literature presents a landscape marked by both concordance and contention. Notably, while a substantial body of research underscores the link between cortisol levels and depression, findings are not universally consistent. Some studies report elevated cortisol levels in depressed individuals, suggesting a hyperactive HPA axis, whereas others document normal or even reduced cortisol levels, particularly in cases of chronic depression. This discrepancy may stem from factors such as the stage of depression, individual variability in stress response, and the presence of comorbid conditions, which can obscure the relationship between cortisol and mood [97].

Furthermore, the role of gonadal hormones in mood disorders, particularly depression, illustrates the field's complexity. While the decline in estrogen levels during menopause is often correlated with an increased risk of depression, the preventive and therapeutic efficacy of estrogen replacement therapy (ERT) remains a subject of debate [98]. Some clinical trials suggest that ERT can mitigate depressive symptoms in perimenopausal women, yet other studies caution against potential risks and the lack of long-term benefits, highlighting the need for personalized treatment approaches [99].

These examples of conflicting findings in the literature on mood disorders underscore the challenges inherent in delineating the hormonal underpinnings of emotional regulation. They reflect the multifactorial nature of mood disorders, where hormonal dysregulation interacts with genetic, environmental, and psychosocial factors in complex ways. This complexity necessitates a cautious interpretation of research findings and a critical consideration of individual differences in hormonal sensitivity and response mechanisms. [100]

Research Gaps and Future Directions

While significant advances have been made in understanding the hormonal underpinnings of mood disorders, several research gaps remain. The precise mechanisms by which hormonal imbalances contribute to mood disorders, the role of individual variability, and the effects of hormonal interventions on these conditions are areas requiring further investigation. Future research should also explore the interplay between hormonal systems and other biological, psychological, and environmental factors in the development and treatment of mood disorders.

Stress-Related Disorders: The Role of HPA Axis Dysregulation

Post-Traumatic Stress Disorder (PTSD)

PTSD is a condition characterized by persistent mental and emotional stress following the experience or witnessing of a traumatic event. Individuals with PTSD often exhibit a hyperactive or hypoactive stress response, indicating dysregulation of the HPA axis [101]. Research has shown that cortisol levels in PTSD patients may be lower than average, contrary to what might be expected in chronic stress conditions. This paradoxical response suggests a complex alteration in the feedback mechanisms regulating the HPA axis, possibly as an adaptive response to prolonged exposure to stress hormones [102].

Furthermore, the sensitivity of glucocorticoid receptors within the HPA axis may be increased in individuals with PTSD, leading to an enhanced feedback inhibition of cortisol production. This altered feedback sensitivity can contribute to the symptoms of PTSD, including heightened reactivity to stress, flashbacks, and difficulty in extinguishing fear-related memories [103].

Other Stress-Related Disorders

Beyond PTSD, dysregulation of the HPA axis has been implicated in various stress-related disorders, including generalized anxiety disorder (GAD), acute stress disorder, and adjustment disorders. In these conditions, chronic activation of the HPA axis can lead to persistently elevated cortisol levels, which, over time, may contribute to a range of physiological and psychological effects. For example, chronic stress and elevated cortisol levels can impair cognitive functions, such as memory and attention, exacerbate mood disturbances, and increase vulnerability to anxiety and depressive disorders [104].

HPA Axis and Resilience to Stress

It's important to note that the relationship between HPA axis functioning and stress-related disorders is not solely one of pathology. Variability in HPA axis reactivity among individuals can influence resilience to stress and susceptibility to stress-related disorders [105]. Factors such as genetic predisposition, early life experiences, and environmental exposures can affect HPA axis regulation, potentially moderating the impact of traumatic events or chronic stress on psychological health [106].

Therapeutic Implications

Understanding the role of HPA axis dysregulation in stress-related disorders offers potential avenues for treatment. Interventions aimed at normalizing HPA axis function, such as psychotherapy, pharmacotherapy, and stress management techniques, can be effective in reducing symptoms and improving outcomes in individuals with PTSD and other stress-related conditions. Additionally, research into HPA axis modulation presents opportunities for developing novel therapeutic strategies targeting the biological underpinnings of stress resilience and vulnerability [107].

Impact of Life Stages on Emotional Regulation

Puberty

Puberty marks a period of rapid physical and psychological development, driven by surges in sex hormones including estrogen in females and testosterone in males. These hormonal changes can significantly impact emotional regulation during adolescence, contributing to mood swings, increased emotional sensitivity, and heightened vulnerability to stress [108]. The neurodevelopmental changes occurring during puberty, influenced by these hormonal fluctuations, can also affect risk-taking behavior and social dynamics, further complicating emotional regulation during this critical period [109].

Menstruation

The menstrual cycle involves cyclical changes in hormone levels, notably fluctuations in estrogen and progesterone, which can affect emotional well-being. Many women experience pre-

menstrual syndrome (PMS), characterized by mood swings, irritability, and increased emotional sensitivity, in the days leading up to menstruation [110]. For some, these symptoms escalate to premenstrual dysphoric disorder (PMDD), a more severe condition that significantly impairs emotional regulation and quality of life. Understanding the hormonal basis of these conditions is crucial for developing effective treatments and support mechanisms [111].

Pregnancy

Pregnancy is associated with substantial hormonal shifts, primarily increases in estrogen and progesterone, which support fetal development but can also influence maternal mood and emotional regulation. While many women experience heightened emotions and mood swings, some may develop antenatal depression or anxiety, underscoring the need for attention to emotional well-being during pregnancy [112]. Postpartum, the rapid hormonal withdrawal, particularly of estrogen and progesterone, can contribute to the development of postpartum depression in susceptible individuals [113].

Menopause

Menopause, the cessation of menstruation, involves significant hormonal changes, most notably a decrease in estrogen levels. These changes can lead to a range of physical and psychological symptoms, including hot flashes, sleep disturbances, and mood swings [114]. The transition through perimenopause to menopause can be particularly challenging for emotional regulation, with an increased risk of developing depression or anxiety disorders during this time. Perimenopausal women may experience physical and psychological changes that can affect their psychological well-being. To successfully adapt to these changes, particular coping emotional regulation strategies are necessary. A better *emotion regulation* was found to predict lower levels of psychological disorders such as depression and anxiety during the menopausal transition [115].

Therapeutic Implications and Support

Recognizing the impact of life stages and associated hormonal changes on emotional regulation is crucial for providing appropriate support and interventions. This may include hormonal therapies, such as contraceptive pills to manage PMS/PMDD symptoms [116] or hormone replacement therapy (HRT) during menopause, as well as psychological support and lifestyle interventions to enhance emotional well-being. Tailoring support and treatment to the individual's needs and life stage can significantly improve quality of life and emotional regulation [117].

Methodological Considerations

Research Challenges in Studying Hormonal Influences on Emotional Regulation

Complex Interactions

One of the foremost challenges in this research area is the complexity of hormonal interactions within the human body. Hormones operate within an intricate system of feedback loops and networks that influence a wide range of bodily functions, including mood and emotional regulation. The endocrine system's interconnected nature means that a change in one hormone can cascade through the system, affecting others in unpredictable ways. This complexity makes isolating the specific effects of individual hormones on emotional regulation a formidable task.

Moreover, hormones interact not just with each other but also with neurotransmitters and other biological systems, further complicating their study. For instance, cortisol, the stress hormone, interacts with neurotransmitters such as serotonin and dopamine, which are directly linked to mood and emotion. The dual roles of many hormones, affecting both physical and psychological states, add another layer of complexity to their study [118].

Individual Variability

Another significant challenge is the high degree of individual variability in hormonal responses and their psychological impacts. Factors such as age, sex, genetic background, lifestyle, and even the time of day can influence hormone levels and their effects on mood and behavior. For example, the menstrual cycle can dramatically affect hormonal balance in women, influencing mood and emotional regulation [119]. Similarly, stress levels, diet, and exercise can modulate hormonal responses differently across individuals [120,121].

This variability poses challenges for researchers attempting to draw broad conclusions from study findings. It necessitates large sample sizes and careful consideration of participant characteristics to ensure that results are not unduly influenced by individual differences [122]. [

Subjective Measures of Emotion

Emotions are subjective experiences, often assessed through self-report measures in research. While self-report instruments can provide valuable insights into an individual's emotional state and regulatory strategies, they are also subject to biases and inaccuracies. Participants may struggle to accurately recall or articulate their emotional experiences, leading to potential discrepancies in data collection.

Furthermore, the subjective nature of emotional experience complicates the task of establishing clear, objective criteria for emotional regulation and its dysregulation. This has led researchers to explore alternative, more objective measures of emotional regulation, such as physiological indicators (e.g., heart rate variability) and neuroimaging techniques, to complement self-reported data [123].

Measurement Techniques in Studying Hormonal Influences on Emotional Regulation

Blood, Saliva, and Urine Testing

The quantification of hormone levels often relies on biological samples such as blood, saliva, and urine. Each of these sampling methods has its own set of advantages and challenges:

- **Blood Testing:** Considered the gold standard for hormone measurement, blood testing provides accurate and comprehensive hormone profiles. However, it is relatively invasive and requires professional handling, making it less ideal for frequent sampling or studies with large sample sizes [124].

- **Saliva Testing:** Saliva testing offers a non-invasive alternative for measuring certain hormones, including cortisol and testosterone. It is particularly useful for studies requiring multiple daily measurements or those focusing on the stress response. Nevertheless, salivary hormone levels can be influenced by various factors such as food intake and oral health, potentially affecting accuracy [125].
- **Urine Testing:** Urine testing allows for the assessment of hormone metabolites over extended periods, providing a cumulative measure of hormonal output. This method can be useful for evaluating overall hormonal balance but lacks the specificity and temporal resolution needed for studying acute hormonal responses to emotional stimuli [126,127].

Functional Neuroimaging

Functional neuroimaging techniques, such as functional magnetic resonance imaging (fMRI) and positron emission tomography (PET), have become invaluable in studying the brain's role in emotional regulation and the effects of hormones on brain activity. These methods enable researchers to observe changes in brain regions associated with emotional processing and regulation in response to hormonal fluctuations or manipulations. While powerful, these techniques require substantial resources and expertise and are subject to limitations related to interpretation and the artificial nature of experimental conditions [128].

Psychophysiological Measures

Psychophysiological measures, including heart rate variability (HRV), skin conductance response (SCR), and electroencephalography (EEG), offer objective insights into the body's emotional responses. These measures can provide indirect evidence of hormonal effects on emotional regulation by capturing the physiological correlates of emotional arousal and regulation processes. However, they require careful interpretation as they can be influenced by a variety of non-emotional factors [129].

Ecological Momentary Assessment (EMA)

EMA involves the real-time assessment of emotions and behaviors in participants' natural environments, often using digital diaries or smartphone apps. This approach can capture the dynamic interplay between hormonal fluctuations and emotional regulation in everyday life, offering high ecological validity. The challenge lies in ensuring compliance and managing the extensive data generated [130].

Future Directions

Gaps in Research

Identifying gaps in the current research landscape on the hormonal influences on emotional regulation is essential for guiding future investigations. This endeavor reveals areas that are understudied or present conflicting findings, offering opportunities for new discoveries and advancements. Here are several notable gaps that we have identified, which require further exploration.

Long-term Effects of Hormone Therapy

One significant area that necessitates more research is the long-term effects of hormone therapy on emotional regulation. While hormone therapy is commonly prescribed for conditions like menopause, hypogonadism, and gender transition, the enduring impacts of these treatments on mood, emotional resilience, and psychological well-being remain poorly understood. Studies that track individuals over extended periods post-therapy could provide valuable insights into these effects, informing clinical practices and patient guidance [131].

Hormonal Interactions with the Microbiome

The interaction between hormonal systems and the gut microbiome presents an intriguing yet underexplored area. Emerging research suggests a bidirectional relationship between gut bacteria and hormones, which could significantly impact emotional regulation. Delving into how hormonal fluctuations influence the microbiome and vice versa could unveil novel mechanisms of emotional regulation and potential therapeutic targets [132].

Impact of Environmental Disruptors on Hormonal Balance

The influence of environmental disruptors, such as chemicals that mimic or interfere with the action of hormones, on emotional regulation is another area requiring more attention. These substances, found in plastics, pesticides, and personal care products, could have profound implications for hormonal health and, consequently, emotional and psychological well-being. Non-chemical factors, such as artificial light, radiation, temperature, and stress exposure, have not been thoroughly studied, despite their potential to significantly impact the endocrine system through the modification of hormone function. Understanding the extent of these impacts is crucial for public health measures and regulatory policies [133].

Hormonal Influences Across Diverse Populations

Much of the existing research on hormonal influences on emotional regulation has focused on relatively homogenous populations. There is a need for more studies that examine these dynamics across diverse populations, including different ethnicities, ages, and socioeconomic statuses [134]. Such research could uncover important variations in how hormonal changes affect emotional regulation, leading to more inclusive and effective treatment approaches.

Technological Innovations in Hormone Measurement

Another gap lies in the need for technological innovations that enable more accurate, non-invasive, and real-time monitoring of hormone levels. Current methods, while effective, often require invasive procedures or do not provide immediate results. Advances in wearable technology or biosensors could revolutionize the way hormones are studied, allowing for more dynamic assessments of their impact on emotional regulation in real-life settings [135].

Genetic and Epigenetic Factors in Hormonal Emotional Regulation

Finally, the role of genetic and epigenetic factors in determining individual sensitivity to hormonal fluctuations and their impact on emotional regulation is an area ripe for exploration [123]. Understanding the genetic underpinnings and how life experiences alter gene expression related to hormonal responses could lead to personalized treatment strategies and preventive measures for

mood disorders and emotional dysregulation [136].

Potential Therapeutic Approaches

Understanding the hormonal basis of emotional regulation opens promising avenues for developing new and more effective treatments for mood disorders. By delineating how hormonal imbalances contribute to conditions such as depression, anxiety, and bipolar disorder, researchers and clinicians can tailor therapeutic approaches that directly address these underlying biological mechanisms. Here are several potential therapeutic approaches that could emerge from a deeper understanding of the hormonal influences on emotional regulation:

Hormone Replacement Therapy (HRT)

For mood disorders linked to hormonal deficiencies or imbalances, such as those experienced during menopause or thyroid dysfunction, hormone replacement therapy could offer relief. By restoring hormonal balance, HRT has the potential to alleviate mood disorder symptoms. However, its application must be carefully considered, taking into account the individual's health profile and the risks associated with long-term hormone supplementation [137].

Selective Hormone Modulator Treatments

Developing treatments that selectively modulate hormone receptors could provide targeted relief from mood disorders without the broader effects of hormone replacement. For instance, selective estrogen receptor modulators (SERMs) have been explored for their potential to relieve symptoms of depression and anxiety in postmenopausal women, offering a more nuanced approach to hormone therapy [138].

Pharmacological Agents Influencing Hormonal Pathways

Pharmacological agents that influence hormonal pathways, such as those affecting the HPA axis or the synthesis and metabolism of sex hormones, could offer new ways to treat mood disorders. Medications that modulate cortisol levels or the sensitivity of cortisol receptors, for example, could be beneficial for stress-related mood disorders and those with a significant stress component, like PTSD [139].

Lifestyle Interventions and Behavioral Therapies

A hormonal understanding of emotional regulation can also inform non-pharmacological treatments. Lifestyle interventions that naturally balance hormone levels, such as diet, exercise, and stress management techniques, could serve as preventive measures or adjunctive therapies for mood disorders. Additionally, behavioral therapies that effectively reduce stress and improve emotional regulation might indirectly influence hormonal balance, contributing to mood stabilization [140,141].

Personalized Medicine Approaches

Insights into the hormonal underpinnings of mood disorders could lead to personalized medicine approaches, where treatments are tailored to the individual's specific hormonal profile and genetic predispositions. This could involve genetic testing to identify vulnerabilities to hormonal imbalances and customizing treatment plans that address these unique factors, potentially increasing treatment efficacy and reducing side effects.

The prospect of personalized medicine in the realm of emotional regulation and mood disorders represents a frontier of immense potential, guided by the nuanced understanding of hormonal influences. Tailoring treatments to individual genetic profiles, hormonal states, and environmental contexts holds the promise of revolutionizing mental health care. For instance, genetic variations affecting hormone receptor sensitivity or neurotransmitter function could inform customized treatment strategies, optimizing the efficacy of hormone-based therapies, psychotropic medications, and even lifestyle interventions. This approach necessitates a comprehensive integration of genomic data, endocrine assessments, and psychosocial evaluations, paving the way for treatments that are not only more effective but also minimize adverse effects. The move towards personalized medicine, rooted in the hormonal basis of emotional regulation, underscores the importance of interdisciplinary research, combining insights from endocrinology, genetics, and psychology to address the complexities of mood disorders [142].

Combination Therapies

Finally, understanding the multifaceted role of hormones in mood disorders suggests that combination therapies that address both hormonal and non-hormonal aspects of these conditions could be most effective. This might involve combining hormone therapy with antidepressants, psychotherapy, and lifestyle changes to tackle mood disorders from multiple angles.

Conclusion

This review has traversed the intricate landscape of hormonal influences on emotional regulation, shedding light on the complex interplay between various hormonal systems and their impact on mood, stress responses, and overall psychological well-being. Through an exploration from the foundational roles of the HPA axis and gonadal hormones to the nuanced effects of thyroid hormones, oxytocin, and metabolic hormones, the significant interconnectedness of endocrine and emotional systems has been underscored.

The challenges and methodological considerations delineated within this text reveal the intricate variables researchers face in elucidating the hormonal mechanisms underpinning emotional regulation. Despite these obstacles, the identification of potential therapeutic avenues offers promising directions for developing more effective, personalized treatments for mood disorders, rooted deeply in an understanding of hormonal regulation.

Highlighting gaps in current research, such as the long-term effects of hormone therapy on emotional regulation and the interplay between hormonal systems and the gut microbiome, sets a clear roadmap for future investigations. These domains promise to unlock further insights into how hormonal imbalances contribute to emotional dysregulation and mood disorders, paving the way for innovative treatments and interventions.

This examination into the hormonal catalysts of emotional regulation is not merely academic; it holds key implications for enhancing mental health care, offering new perspectives on treating mood disorders, and improving emotional well-being. As

the field continues to unravel the complex relationships between hormones and emotions, it moves closer to holistic, integrated approaches to mental health that recognize the inseparable ties between physical and psychological health.

Moreover, the dialogue surrounding hormonal therapy, particularly in addressing mood disorders, invites a nuanced consideration of its long-term implications on emotional regulation and overall health. The potential of hormonal therapy to offer relief for conditions characterized by hormonal imbalance underscores the necessity of rigorous, longitudinal research to fully comprehend its benefits and risks. Such investigations are pivotal in establishing safe, effective protocols that consider the complexities of hormonal interactions and their systemic effects.

The global implications of advancing our understanding of hormonal influences on emotional regulation extend far beyond the realms of academic interest, holding promise for transformative public health outcomes. As mental health disorders continue to pose significant challenges worldwide, elucidating the hormonal underpinnings of emotional dysregulation offers a pathway to more effective, holistic treatment approaches. Enhanced hormonal insights can inform public health strategies aimed at early detection, prevention, and intervention, potentially reducing the burden of mood disorders on individuals, families, and healthcare systems globally. Integrating hormonal health into mental health care and public health initiatives could foster a more resilient, emotionally well-regulated population, highlighting the broader societal and health-related benefits of this research.

This review's exploration emphasizes the indispensable need for a multidisciplinary approach in advancing our understanding and treatment of mood disorders influenced by hormonal regulation. Collaborations across endocrinology, psychology, neurology, and genetics promise to illuminate the intricate mechanisms at play, paving the way for innovative therapeutic strategies. By embracing a holistic perspective that integrates diverse scientific insights, the field can move towards personalized, comprehensive care strategies that address the multifaceted nature of mood disorders.

While comprehensive, this review represents a snapshot of a dynamic, evolving field. It invites further exploration, interdisciplinary collaboration, and innovative thinking to fully leverage this knowledge for improving mental health outcomes. The future of research in hormonal influences on emotional regulation is rich with possibilities, challenging the scientific community to expand understanding and to envision a future where emotional well-being is accessible to all, guided by the intricate dance of hormones that orchestrates our emotional lives.

Patient informed consent: There is no need for patient informed consent.

Ethics committee approval: There is no need for ethics committee approval.

Financial support and sponsorship: No funding was received.

Conflict of interest: There is no conflict of interest to declare.

Author Contributions subject and rate:

Eda Yılmazer (100%): Design, draft, write and submit

References

1. Kneeland ET, Goodman FR, Dovidio JF. Emotion Beliefs, Emotion Regulation, and Emotional Experiences in Daily Life. Behav Ther [Internet]. 2020;51(5):728–38. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0005789419301297
2. Martínez-González AE, Cervin M, Piqueras JA. Relationships Between Emotion Regulation, Social Communication and Repetitive Behaviors in Autism Spectrum Disorder. J Autism Dev Disord [Internet]. 2022;52(10):4519–27. Available from: https://link.springer.com/10.1007/s10803-021-05340-x
3. Greenier V, Derakhshan A, Fathi J. Emotion regulation and psychological well-being in teacher work engagement: A case of British and Iranian English language teachers. System [Internet]. 2021;97:102446. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0346251X2030806X
4. Kraiss JT, ten Klooster PM, Moskowitz JT, Bohlmeijer ET. The relationship between emotion regulation and well-being in patients with mental disorders: A meta-analysis. Compr Psychiatry [Internet]. 2020;102:152189. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0010440X20300316
5. Panayiotou G, Panteli M, Leonidou C. Coping with the invisible enemy: The role of emotion regulation and awareness in quality of life during the COVID-19 pandemic. J Context Behav Sci [Internet]. 2021;19:17–27. Available from: https://linkinghub.elsevier.com/retrieve/pii/S2212144720302076
6. Çınaroğlu M. Hormonal Catalysts in the Addiction Cycle of Muscle Dysmorphia: A Neuroendocrine Perspective. J Neurobehav Sci [Internet]. 2024;11(1):1–9. Available from: https://journals.lww.com/10.4103/jnbs.jnbs_19_23
7. Dixon ML, Moodie CA, Goldin PR, Farb N, Heimberg RG, Gross JJ. Emotion Regulation in Social Anxiety Disorder: Reappraisal and Acceptance of Negative Self-beliefs. Biol Psychiatry Cogn Neurosci Neuroimaging [Internet]. 2020;5(1):119–29. Available from: https://linkinghub.elsevier.com/retrieve/pii/S2451902219302022
8. Chang ML, Taxer J. Teacher emotion regulation strategies in response to classroom misbehavior. Teach Teach [Internet]. 2021;27(5):353–69. Available from: https://www.tandfonline.com/doi/full/10.1080/13540602.2020.1740198
9. Litwack G. Hormones. 4th Editio. Elsevier; 2022.
10. Ahrorbek N, Medicine G, Myungjae L, Medicine G, Jungjae L, Medicine G, et al. Hormonal Regulation. Texas J Multidiscip Stud. 2023;25:6–10.
11. Rosol TJ, Brändli-Baiocco A, Hoenerhoff MJ, Vahle JL. Endocrine System. In: Haschek and Rousseaux' s Handbook of Toxicologic Pathology [Internet]. Elsevier; 2024. p. 517–631. Available from: https://linkinghub.elsevier.com/retrieve/pii/B9780128210468000025
12. Lombardo G, Mondelli V, Dazzan P, Pariante CM. Sex hormones and immune system: A possible interplay in affective disorders? A systematic review. J Affect Disord [Internet]. 2021;290:1–14. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0165032721003670
13. Hsu CMK, Ney LJ, Honan C, Felmingham KL. Gonadal steroid hormones and emotional memory consolidation: A systematic review and meta-analysis. Neurosci Biobehav Rev [Internet]. 2021;130:529–42. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0149763421003936
14. Mikkelsen MB, Tramm G, Zachariae R, Gravholt CH, O'Toole MS. A systematic review and meta-analysis of the effect of emotion regulation on cortisol. Compr Psychoneuroendocrinology [Internet]. 2021;5:100020. Available from: https://linkinghub.elsevier.com/retrieve/pii/S2666497620300205
15. Meng C, Wang W, Hao Z, Liu H. Investigation on the influence of isolated environment on human psychological and physiological health. Sci Total Environ [Internet]. 2020;716:136972. Available from:

https://linkinghub.elsevier.com/retrieve/pii/S0048969720304824

16. Gamsakhurdashvili D, Antov MI, Stockhorst U. Facial Emotion Recognition and Emotional Memory From the Ovarian-Hormone Perspective: A Systematic Review. Front Psychol [Internet]. 2021;12:641250. Available from: https://www.frontiersin.org/articles/10.3389/fpsyg.2021.641250/full

17. Battaglia S, Di Fazio C, Mazzà M, Tamietto M, Avenanti A. Targeting Human Glucocorticoid Receptors in Fear Learning: A Multiscale Integrated Approach to Study Functional Connectivity. Int J Mol Sci [Internet]. 2024;25(2):864–70. Available from: https://www.mdpi.com/1422-0067/25/2/864

18. Dedovic K, Duchesne A, Andrews J, Engert V, Pruessner JC. The brain and the stress axis: The neural correlates of cortisol regulation in response to stress. Neuroimage [Internet]. 2009;47(3):864–71. Available from: https://linkinghub.elsevier.com/retrieve/pii/S1053811909005837

19. Rohr UD. The impact of testosterone imbalance on depression and women's health. Maturitas [Internet]. 2002;41:25–46. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0378512202000130

20. Duval F. Thyroid Hormone Treatment of Mood Disorders. Curr Treat Options Psychiatry [Internet]. 2018;5(4):363–76. Available from: http://link.springer.com/10.1007/s40501-018-0155-z

21. Magon N, Kalra S. The orgasmic history of oxytocin: Love, lust, and labor. Indian J Endocrinol Metab [Internet]. 2011;15(7):156–61. Available from: https://journals.lww.com/10.4103/2230-8210.84851

22. Sadiq NM, Tadi P. Physiology, Pituitary Hormones. StatPearls Publishing LLC.; 2020.

23. Campbell M, Jialal I. Physiology, Endocrine Hormones. StatPearls Publishing; 2022.

24. Drigas A, Mitsea E. Metacognition, Stress – Relaxation Balance & Related Hormones. Int J Recent Contrib from Eng Sci IT [Internet]. 2021;9(1):4–16. Available from: https://online-journals.org/index.php/i-jes/article/view/19623

25. Hiller-Sturmhöfel S, Bartke A. The endocrine system: an overview. Alcohol Health Res World. 1998;22(3):153–64.

26. Zefferino R, Di Gioia S, Conese M. Molecular links between endocrine, nervous and immune system during chronic stress. Brain Behav [Internet]. 2021;11(2):e01960. Available from: https://onlinelibrary.wiley.com/doi/10.1002/brb3.1960

27. Jiang Y, Zou D, Li Y, Gu S, Dong J, Ma X, et al. Monoamine Neurotransmitters Control Basic Emotions and Affect Major Depressive Disorders. Pharmaceuticals [Internet]. 2022;15(10):1203. Available from: https://www.mdpi.com/1424-8247/15/10/1203

28. Brønnick MK, Økland I, Graugaard C, Brønnick KK. The Effects of Hormonal Contraceptives on the Brain: A Systematic Review of Neuroimaging Studies. Front Psychol [Internet]. 2020;11:556577. Available from: https://www.frontiersin.org/articles/10.3389/fpsyg.2020.556577/full

29. Jentsch VL, Wolf OT. The impact of emotion regulation on cardiovascular, neuroendocrine and psychological stress responses. Biol Psychol [Internet]. 2020;154:107893. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0301051120300533

30. Bowling DL, Gahr J, Ancochea PG, Hoeschele M, Canoine V, Fusani L, et al. Endogenous oxytocin, cortisol, and testosterone in response to group singing. Horm Behav [Internet]. 2022;139:105105. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0018506X21001847

31. De Berardis D, Marini S, Fornaro M, Srinivasan V, Iasevoli F, Tomasetti C, et al. The Melatonergic System in Mood and Anxiety Disorders and the Role of Agomelatine: Implications for Clinical Practice. Int J Mol Sci [Internet]. 2013;14(6):12458–83. Available from: https://www.mdpi.com/1422-0067/14/6/12458

32. De Berardis D, Orsolini L, Serroni N, Girinelli G, Iasevoli F, Tomasetti C, et al. The role of melatonin in mood disorders. ChronoPhysiology Ther [Internet]. 2015;5:65–75. Available from: https://www.dovepress.com/the-role-of-melatonin-in-mood-disorders-peer-reviewed-article-CPT

33. Samanta S. Physiological and pharmacological perspectives of melatonin. Arch Physiol Biochem [Internet]. 2022;128(5):1346–67. Available from: https://www.tandfonline.com/doi/full/10.1080/13813455.2020.1770799

34. Smith SM, Vale WW. The role of the hypothalamic-pituitary-adrenal axis in neuroendocrine responses to stress. Dialogues Clin Neurosci [Internet]. 2006;8(4):383–95. Available from: https://www.tandfonline.com/doi/full/10.31887/DCNS.2006.8.4/ssmith

35. Juruena MF, Bourne M, Young AH, Cleare AJ. Hypothalamic-Pituitary-Adrenal axis dysfunction by early life stress. Neurosci Lett [Internet]. 2021;759:136037. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0304394021004158

36. Thau L, Gandhi J, Sharma S. Physiology, Cortisol. Treasure Island (FL): StatPearls Publishing; 2024.

37. Pulopulos MM, Baeken C, De Raedt R. Cortisol response to stress: The role of expectancy and anticipatory stress regulation. Horm Behav [Internet]. 2020;117:104587. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0018506X18304860

38. Sherin JE, Nemeroff CB. Post-traumatic stress disorder: the neurobiological impact of psychological trauma. Dialogues Clin Neurosci [Internet]. 2011;13(3):263–78. Available from: https://www.tandfonline.com/doi/full/10.31887/DCNS.2011.13.2/jsherin

39. Dziurkowska E, Wesolowski M. Cortisol as a Biomarker of Mental Disorder Severity. J Clin Med [Internet]. 2021;10(21):5204. Available from: https://www.mdpi.com/2077-0383/10/21/5204

40. Kim EJ, Pellman B, Kim JJ. Stress effects on the hippocampus: a critical review. Learn Mem [Internet]. 2015;22(9):411–6. Available from: http://learnmem.cshlp.org/lookup/doi/10.1101/lm.037291.114

41. Ouanes S, Popp J. High Cortisol and the Risk of Dementia and Alzheimer's Disease: A Review of the Literature. Front Aging Neurosci [Internet]. 2019;11:43–51. Available from: https://www.frontiersin.org/article/10.3389/fnagi.2019.00043/full

42. O'Byrne NA, Yuen F, Butt WZ, Liu PY. Sleep and circadian regulation of cortisol: A short review. Curr Opin Endocr Metab Res [Internet]. 2021;18:178–86. Available from: https://linkinghub.elsevier.com/retrieve/pii/S2451965021000363

43. Tafet GE, Nemeroff CB. Pharmacological Treatment of Anxiety Disorders: The Role of the HPA Axis. Front Psychiatry [Internet]. 2020;11:443–50. Available from: https://www.frontiersin.org/article/10.3389/fpsyt.2020.00443/full

44. Hinds JA, Sanchez ER. The Role of the Hypothalamus–Pituitary–Adrenal (HPA) Axis in Test-Induced Anxiety: Assessments, Physiological Responses, and Molecular Details. Stresses [Internet]. 2022;2(1):146–55. Available from: https://www.mdpi.com/2673-7140/2/1/11

45. van Wingen GA, Ossewaarde L, Bäckström T, Hermans EJ, Fernández G. Gonadal hormone regulation of the emotion circuitry in humans. Neuroscience [Internet]. 2011;191:38–45. Available from: https://linkinghub.elsevier.com/retrieve/pii/S030645221100460X

46. Wharton W, E. Gleason C, Sandra O, M. Carlsson C, Asthana S. Neurobiological Underpinnings of the Estrogen - Mood Relationship. Curr Psychiatry Rev [Internet]. 2012;8(3):247–56. Available from: http://www.eurekaselect.com/openurl/content.php?genre=article&issn=1573-4005&volume=8&issue=3&spage=247

47. Gettler LT, Mcdade TW, Agustin SS, Kuzawa CW. Progesterone and estrogen responsiveness to father-toddler interaction. Am J Hum Biol [Internet]. 2013;25(4):491–8. Available from: https://onlinelibrary.wiley.com/doi/10.1002/ajhb.22396

48. Albert KM, Newhouse PA. Estrogen, Stress, and Depression: Cogni-

tive and Biological Interactions. Annu Rev Clin Psychol [Internet]. 2019;15(1):399–423. Available from: https://www.annualreviews.org/doi/10.1146/annurev-clinpsy-050718-095557

49. Dekkers TJ, van Rentergem JAA, Meijer B, Popma A, Wagemaker E, Huizenga HM. A meta-analytical evaluation of the dual-hormone hypothesis: Does cortisol moderate the relationship between testosterone and status, dominance, risk taking, aggression, and psychopathy? Neurosci Biobehav Rev [Internet]. 2019;96:250–71. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0149763417306784

50. Nan Y, Li H, Wu Y. Testosterone and human aggression. Adv Psychol Sci [Internet]. 2020;28(10):1697–712. Available from: https://engine.scichina.com/doi/10.3724/SP.J.1042.2020.01697

51. Zito S, Nosari G, Pigoni A, Moltrasio C, Delvecchio G. Association between testosterone levels and mood disorders: A minireview. J Affect Disord [Internet]. 2023;330:48–56. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0165032723002768

52. Barbonetti A, D'Andrea S, Francavilla S. Testosterone replacement therapy. Andrology [Internet]. 2020;8(6):1551–66. Available from: https://onlinelibrary.wiley.com/doi/10.1111/andr.12774

53. Singh P. Andropause: Current concepts. Indian J Endocrinol Metab [Internet]. 2013;17(Suppl 3):621–9. Available from: https://journals.lww.com/10.4103/2230-8210.123552

54. Chen CY, Lee, Jiang, Chen, Chu, Chen CL. The correlation between emotional distress and aging males' symptoms at a psychiatric outpatient clinic: sexual dysfunction as a distinguishing characteristic between andropause and anxiety/depression in aging men. Clin Interv Aging [Internet]. 2013;8:635–40. Available from: http://www.dovepress.com/the-correlation-between-emotional-distress-and-aging-malesrsquo-sympto-peer-reviewed-article-CIA

55. Delhez M, Hansenne M, Legros JJ. Andropause and psychopathology: minor symptoms rather than pathological ones. Psychoneuroendocrinology [Internet]. 2003;28(7):863–74. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0306453002001026

56. Schmidt PJ, Rubinow DR. Reproductive hormonal treatments for mood disorders in women. Dialogues Clin Neurosci [Internet]. 2002;4(2):211–23. Available from: https://www.tandfonline.com/doi/full/10.31887/DCNS.2002.4.2/pschmidt

57. Burkauskas J, Pranckeviciene A, Bunevicius A. Thyroid Hormones, Brain, and Heart. In: Thyroid and Heart [Internet]. Cham: Springer International Publishing; 2020. p. 339–60. Available from: http://link.springer.com/10.1007/978-3-030-36871-5_25

58. Ittermann T, Völzke H, Baumeister SE, Appel K, Grabe HJ. Diagnosed thyroid disorders are associated with depression and anxiety. Soc Psychiatry Psychiatr Epidemiol [Internet]. 2015;50(9):1417–25. Available from: http://link.springer.com/10.1007/s00127-015-1043-0

59. Bode H, Ivens B, Bschor T, Schwarzer G, Henssler J, Baethge C. Hyperthyroidism and clinical depression: a systematic review and meta-analysis. Transl Psychiatry [Internet]. 2022;12(1):362–71. Available from: https://www.nature.com/articles/s41398-022-02121-7

60. Nuguru SP, Rachakonda S, Sripathi S, Khan MI, Patel N, Meda RT. Hypothyroidism and Depression: A Narrative Review. Cureus [Internet]. 2022;14(8):e28201. Available from: https://www.cureus.com/articles/108113-hypothyroidism-and-depression-a-narrative-review

61. Dayan CM, Panicker V. Hypothyroidism and Depression. Eur Thyroid J [Internet]. 2013;2(3):168–79. Available from: https://etj.bioscientifica.com/doi/10.1159/000353777

62. Carta MG, Hardoy MC, Carpiniello B, Murru A, Marci AR, Carbone F, et al. A case control study on psychiatric disorders in Hashimoto disease and Euthyroid Goitre: not only depressive but also anxiety disorders are associated with thyroid autoimmunity. Clin Pract Epidemiol Ment Heal. 2005;1(23):1–5.

63. Kotkowska Z, Strzelecki D. Depression and Autoimmune Hypothyroidism—Their Relationship and the Effects of Treating Psychiatric and Thyroid Disorders on Changes in Clinical and Biochemical Parameters Including BDNF and Other Cytokines—A Systematic Review. Pharmaceuticals [Internet]. 2022;15(4):391–6. Available from: https://www.mdpi.com/1424-8247/15/4/391

64. Siegmann EM, Müller HHO, Luecke C, Philipsen A, Kornhuber J, Grömer TW. Association of Depression and Anxiety Disorders With Autoimmune Thyroiditis. JAMA Psychiatry [Internet]. 2018;75(6):577–84. Available from: http://archpsyc.jamanetwork.com/article.aspx?doi=10.1001/jamapsychiatry.2018.0190

65. LeFevre ML. Screening for Thyroid Dysfunction: U.S. Preventive Services Task Force Recommendation Statement. Ann Intern Med [Internet]. 2015;162(9):641–50. Available from: https://www.acpjournals.org/doi/10.7326/M15-0483

66. Perros P, Hegedus L. Enhanced Well-Being Associated with Thyrotoxicosis: A Neglected Effect of Thyroid Hormones? Int J Endocrinol Metab [Internet]. 2022;20(2):1–18. Available from: https://brieflands.com/articles/ijem-127230.html

67. Olff M, Frijling JL, Kubzansky LD, Bradley B, Ellenbogen MA, Cardoso C, et al. The role of oxytocin in social bonding, stress regulation and mental health: An update on the moderating effects of context and interindividual differences. Psychoneuroendocrinology [Internet]. 2013;38(9):1883–94. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0306453013002369

68. Marsh N, Marsh AA, Lee MR, Hurlemann R. Oxytocin and the Neurobiology of Prosocial Behavior. Neurosci [Internet]. 2021;27(6):604–19. Available from: http://journals.sagepub.com/doi/10.1177/1073858420960111

69. Shou Q, Yamada J, Nishina K, Matsunaga M, Kiyonari T, Takagishi H. Is oxytocin a trust hormone? Salivary oxytocin is associated with caution but not with general trust. Yamasue H, editor. PLoS One [Internet]. 2022;17(5):e0267988. Available from: https://dx.plos.org/10.1371/journal.pone.0267988

70. Declerck CH, Boone C, Pauwels L, Vogt B, Fehr E. A registered replication study on oxytocin and trust. Nat Hum Behav [Internet]. 2020;4(6):646–55. Available from: https://www.nature.com/articles/s41562-020-0878-x

71. Romero-Martínez Á, Sarrate-Costa C, Moya-Albiol L. A Systematic Review of the Role of Oxytocin, Cortisol, and Testosterone in Facial Emotional Processing. Biology (Basel) [Internet]. 2021;10(12):1334–40. Available from: https://www.mdpi.com/2079-7737/10/12/1334

72. King LB, Walum H, Inoue K, Eyrich NW, Young LJ. Variation in the Oxytocin Receptor Gene Predicts Brain Region–Specific Expression and Social Attachment. Biol Psychiatry [Internet]. 2016;80(2):160–9. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0006322315010446

73. Triana-Del Rio R, Ranade S, Guardado J, LeDoux J, Klann E, Shrestha P. The modulation of emotional and social behaviors by oxytocin signaling in limbic network. Front Mol Neurosci [Internet]. 2022;15:1002846. Available from: https://www.frontiersin.org/articles/10.3389/fnmol.2022.1002846/full

74. Danoff JS, Wroblewski KL, Graves AJ, Quinn GC, Perkeybile AM, Kenkel WM, et al. Genetic, epigenetic, and environmental factors controlling oxytocin receptor gene expression. Clin Epigenetics [Internet]. 2021;13(1):23–8. Available from: https://clinicalepigeneticsjournal.biomedcentral.com/articles/10.1186/s13148-021-01017-5

75. Jin Y, Song D, Yan Y, Quan Z, Qing H. The Role of Oxytocin in Early-Life-Stress-Related Neuropsychiatric Disorders. Int J Mol Sci [Internet]. 2023;24(13):10430. Available from: https://www.mdpi.com/1422-0067/24/13/10430

76. Cochran DM, Fallon D, Hill M, Frazier JA. The Role of Oxytocin in Psychiatric Disorders. Harv Rev Psychiatry [Internet]. 2013;21(5):219–47. Available from: https://journals.lww.com/00023727-201309000-00001

77. Rodrigues SM, Saslow LR, Garcia N, John OP, Keltner D. Oxyto-

cin receptor genetic variation relates to empathy and stress reactivity in humans. Proc Natl Acad Sci [Internet]. 2009;106(50):21437–41. Available from: https://pnas.org/doi/full/10.1073/pnas.0909579106

78. Zou XH, Sun LH, Yang W, Li BJ, Cui RJ. Potential role of insulin on the pathogenesis of depression. Cell Prolif [Internet]. 2020;53(5):e12806. Available from: https://onlinelibrary.wiley.com/doi/10.1111/cpr.12806

79. Qaid MM, Abdelrahman MM. Role of insulin and other related hormones in energy metabolism: A review. Cogent Food Agric [Internet]. 2016;2(1):1267691. Available from: https://www.cogentoa.com/article/10.1080/23311932.2016.1267691

80. Martin H, Bullich S, Guiard BP, Fioramonti X. The impact of insulin on the serotonergic system and consequences on diabetes-associated mood disorders. J Neuroendocrinol [Internet]. 2021;33(4):e12928. Available from: https://onlinelibrary.wiley.com/doi/10.1111/jne.12928

81. Jequier E. Leptin Signaling, Adiposity, and Energy Balance. Ann N Y Acad Sci [Internet]. 2002;967(1):379–88. Available from: https://nyaspubs.onlinelibrary.wiley.com/doi/10.1111/j.1749-6632.2002.tb04293.x

82. Milaneschi Y, Sutin AR, Terracciano A, Canepa M, Gravenstein KS, Egan JM, et al. The association between leptin and depressive symptoms is modulated by abdominal adiposity. Psychoneuroendocrinology [Internet]. 2014;42:1–10. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0306453013004514

83. Zarouna S. Mood disorders: A potential link between ghrelin and leptin on human body? World J Exp Med [Internet]. 2015;5(2):103–9. Available from: http://www.wjgnet.com/2220-315X/full/v5/i2/103.htm

84. Miller GD. Appetite Regulation: Hormones, Peptides, and Neurotransmitters and Their Role in Obesity. Am J Lifestyle Med [Internet]. 2019;13(6):586–601. Available from: http://journals.sagepub.com/doi/10.1177/1559827617716376

85. Chuang JC, Zigman JM. Ghrelin's Roles in Stress, Mood, and Anxiety Regulation. Int J Pept [Internet]. 2010;8:1–5. Available from: https://www.hindawi.com/journals/ijpep/2010/460549/

86. Fahed R, Schulz C, Klaus J, Ellinger S, Walter M, Kroemer NB. Ghrelin is associated with an elevated mood after an overnight fast in depression. J Psychiatr Res [Internet]. 2024;175:271–9. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0022395624002590

87. Guzek D, Kołota A, Lachowicz K, Skolmowska D, Stachoń M, Głąbska D. Association between Vitamin D Supplementation and Mental Health in Healthy Adults: A Systematic Review. J Clin Med [Internet]. 2021;10(21):5156. Available from: https://www.mdpi.com/2077-0383/10/21/5156

88. Cheng Y, Huang Y, Huang W. The effect of vitamin D supplement on negative emotions: A systematic review and meta-analysis. Depress Anxiety [Internet]. 2020;37(6):549–64. Available from: https://onlinelibrary.wiley.com/doi/10.1002/da.23025

89. Deecher D, Andree TH, Sloan D, Schechter LE. From menarche to menopause: Exploring the underlying biology of depression in women experiencing hormonal changes. Psychoneuroendocrinology [Internet]. 2008;33(1):3–17. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0306453007002235

90. Dwyer JB, Aftab A, Radhakrishnan R, Widge A, Rodriguez CI, Carpenter LL, et al. Hormonal Treatments for Major Depressive Disorder: State of the Art. Am J Psychiatry [Internet]. 2020;177(8):686–705. Available from: http://ajp.psychiatryonline.org/doi/10.1176/appi.ajp.2020.19080848

91. Hage MP, Azar ST. The Link between Thyroid Function and Depression. J Thyroid Res [Internet]. 2012;9:1–8. Available from: http://www.hindawi.com/journals/jtr/2012/590648/

92. Fruzzetti F, Fidecicchi T. Hormonal Contraception and Depression: Updated Evidence and Implications in Clinical Practice. Clin Drug Investig [Internet]. 2020;40(12):1097–106. Available from: https://link.springer.com/10.1007/s40261-020-00966-8

93. Sher L. Testosterone and Suicidal Behavior in Bipolar Disorder. Int J Environ Res Public Health [Internet]. 2023;20(3):2502. Available from: https://www.mdpi.com/1660-4601/20/3/2502

94. Lyu N, Zhao Q, Fu B, Li J, Wang H, Yang F, et al. Hormonal and inflammatory signatures of different mood episodes in bipolar disorder: a large-scale clinical study. BMC Psychiatry [Internet]. 2023;23(1):449–52. Available from: https://bmcpsychiatry.biomedcentral.com/articles/10.1186/s12888-023-04846-1

95. Schreiber W. Dysregulation of the Hypothalamic-Pituitary-Adrenocortical System in Panic Disorder. Neuropsychopharmacology [Internet]. 1996;15(1):7–15. Available from: https://www.nature.com/doifinder/10.1016/0893-133X(95)00146-5

96. Fischer S. The hypothalamus in anxiety disorders. In: Handbook of clinical neurology [Internet]. 2021. p. 149–60. Available from: https://linkinghub.elsevier.com/retrieve/pii/B9780128201077000094

97. Burke HM, Davis MC, Otte C, Mohr DC. Depression and cortisol responses to psychological stress: A meta-analysis. Psychoneuroendocrinology [Internet]. 2005;30(9):846–56. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0306453005000831

98. Alblooshi S, Taylor M, Gill N. Does menopause elevate the risk for developing depression and anxiety? Results from a systematic review. Australas Psychiatry [Internet]. 2023;31(2):165–73. Available from: http://journals.sagepub.com/doi/10.1177/10398562231165439

99. Fernández-Guasti A, Fiedler J, Herrera L, Handa R. Sex, Stress, and Mood Disorders: At the Intersection of Adrenal and Gonadal Hormones. Horm Metab Res [Internet]. 2012;44(08):607–18. Available from: http://www.thieme-connect.de/DOI/DOI?10.1055/s-0032-1312592

100. Łoś K, Waszkiewicz N. Biological Markers in Anxiety Disorders. J Clin Med [Internet]. 2021;10(8):1744–8. Available from: https://www.mdpi.com/2077-0383/10/8/1744

101. Schumacher S, Niemeyer H, Engel S, Cwik JC, Laufer S, Klusmann H, et al. HPA axis regulation in posttraumatic stress disorder: A meta-analysis focusing on potential moderators. Neurosci Biobehav Rev [Internet]. 2019;100:35–57. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0149763418304512

102. Bryant RA. Post-traumatic stress disorder: a state-of-the-art review of evidence and challenges. World Psychiatry [Internet]. 2019;18(3):259–69. Available from: https://onlinelibrary.wiley.com/doi/10.1002/wps.20656

103. Fischer S, Schumacher T, Knaevelsrud C, Ehlert U, Schumacher S. Genes and hormones of the hypothalamic–pituitary–adrenal axis in post-traumatic stress disorder. What is their role in symptom expression and treatment response? J Neural Transm [Internet]. 2021;128(9):1279–86. Available from: https://link.springer.com/10.1007/s00702-021-02330-2

104. Karin O, Raz M, Tendler A, Bar A, Korem Kohanim Y, Milo T, et al. A new model for the HPA axis explains dysregulation of stress hormones on the timescale of weeks. Mol Syst Biol [Internet]. 2020;16(7):e9510. Available from: https://www.embopress.org/doi/10.15252/msb.20209510

105. Maniam J, Antoniadis C, Morris MJ. Early-Life Stress, HPA Axis Adaptation, and Mechanisms Contributing to Later Health Outcomes. Front Endocrinol (Lausanne) [Internet]. 2014;5(73):1–8. Available from: http://journal.frontiersin.org/article/10.3389/fendo.2014.00073/abstract

106. Kinlein SA, Karatsoreos IN. The hypothalamic-pituitary-adrenal axis as a substrate for stress resilience: Interactions with the circadian clock. Front Neuroendocrinol [Internet]. 2020;56:100819. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0091302219300846

107. Stephens MA, Wand G. Stress and the HPA axis: role of glucocorticoids in alcohol dependence. Alcohol Res Curr Rev. 2012;34(4):468–

83.

108. Peper JS, Dahl RE. The Teenage Brain. Curr Dir Psychol Sci [Internet]. 2013;22(2):134–9. Available from: http://journals.sagepub.com/doi/10.1177/0963721412473755

109. Tammilehto J, Punamäki RL, Flykt M, Vänskä M, Heikkilä LM, Lipsanen J, et al. Developmental Stage-Specific Effects of Parenting on Adolescents' Emotion Regulation: A Longitudinal Study From Infancy to Late Adolescence. Front Psychol [Internet]. 2021;12:582770. Available from: https://www.frontiersin.org/articles/10.3389/fpsyg.2021.582770/full

110. Gonda X, Telek T, Juhász G, Lazary J, Vargha A, Bagdy G. Patterns of mood changes throughout the reproductive cycle in healthy women without premenstrual dysphoric disorders. Prog Neuro-Psychopharmacology Biol Psychiatry [Internet]. 2008;32(8):1782–8. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0278584608002327

111. Petersen N, London ED, Liang L, Ghahremani DG, Gerards R, Goldman L, et al. Emotion regulation in women with premenstrual dysphoric disorder. Arch Womens Ment Health [Internet]. 2016;19(5):891–8. Available from: http://link.springer.com/10.1007/s00737-016-0634-4

112. Altshuler LL, Hendrick V, Cohen LS. An Update on Mood and Anxiety Disorders During Pregnancy and the Postpartum Period. Prim Care Companion CNS Disord [Internet]. 2000;2(6):217–222. Available from: https://www.psychiatrist.com/pcc/update-mood-anxiety-disorders-during-pregnancy-postpartum

113. Trifu S. Neuroendocrine Aspects of Pregnancy and Postpartum Depression. Acta Endocrinol [Internet]. 2019;15(3):410–5. Available from: http://www.acta-endo.ro/Archive/Abstract?doi=2019.410

114. Santoro N, Epperson CN, Mathews SB. Menopausal Symptoms and Their Management. Endocrinol Metab Clin North Am [Internet]. 2015;44(3):497–515. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0889852915000420

115. Süss H, Willi J, Grub J, Ehlert U. Psychosocial factors promoting resilience during the menopausal transition. Arch Womens Ment Health [Internet]. 2021;24(2):231–41. Available from: https://link.springer.com/10.1007/s00737-020-01055-7

116. Pearlstein T, Steiner M. Premenstrual dysphoric disorder: Burden of illness and treatment update. J Psychiatry Neurosci. 2008;33(4):291–301.

117. Wachs TD, Georgieff M, Cusick S, McEwen BS. Issues in the timing of integrated early interventions: contributions from nutrition, neuroscience, and psychological research. Ann N Y Acad Sci [Internet]. 2014;1308(1):89–106. Available from: https://nyaspubs.onlinelibrary.wiley.com/doi/10.1111/nyas.12314

118. Gust K, Caccese C, Larosa A, Nguyen TV. Neuroendocrine Effects of Lactation and Hormone-Gene-Environment Interactions. Mol Neurobiol [Internet]. 2020;57(4):2074–84. Available from: http://link.springer.com/10.1007/s12035-019-01855-8

119. Handy AB, Greenfield SF, Yonkers KA, Payne LA. Psychiatric Symptoms Across the Menstrual Cycle in Adult Women: A Comprehensive Review. Harv Rev Psychiatry [Internet]. 2022;30(2):100–17. Available from: https://journals.lww.com/10.1097/HRP.0000000000000329

120. Kanaley JA, Weltman JY, Pieper KS, Weltman A, Hartman ML. Cortisol and Growth Hormone Responses to Exercise at Different Times of Day 1. J Clin Endocrinol Metab [Internet]. 2001;86(6):2881–9. Available from: https://academic.oup.com/jcem/article-lookup/doi/10.1210/jcem.86.6.7566

121. Stachowicz M, Lebiedzińska A. The effect of diet components on the level of cortisol. Eur Food Res Technol [Internet]. 2016;242(12):2001–9. Available from: http://link.springer.com/10.1007/s00217-016-2772-3

122. Weigard A, Loviska AM, Beltz AM. Little evidence for sex or ovarian hormone influences on affective variability. Sci Rep [Internet]. 2021;11(1):20925. Available from: https://www.nature.com/articles/s41598-021-00143-7

123. Brown CL, Van Doren N, Ford BQ, Mauss IB, Sze JW, Levenson RW. Coherence between subjective experience and physiology in emotion: Individual differences and implications for well-being. Emotion [Internet]. 2020;20(5):818–29. Available from: https://doi.apa.org/doi/10.1037/emo0000579

124. Haddad RA, Giacherio D, Barkan AL. Interpretation of common endocrine laboratory tests: technical pitfalls, their mechanisms and practical considerations. Clin Diabetes Endocrinol [Internet]. 2019;5(1):12–5. Available from: https://clindiabetesendo.biomedcentral.com/articles/10.1186/s40842-019-0086-7

125. Giacomello G, Scholten A, Parr MK. Current methods for stress marker detection in saliva. J Pharm Biomed Anal [Internet]. 2020;191:113604. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0731708520314904

126. Gildner TE. Reproductive hormone measurement from minimally invasive sample types: Methodological considerations and anthropological importance. Am J Hum Biol [Internet]. 2021;33(1):e23535. Available from: https://onlinelibrary.wiley.com/doi/10.1002/ajhb.23535

127. Manikandan S, Nillni YI, Zvolensky MJ, Rohan KJ, Carkeek KR, Leyro TM. The role of emotion regulation in the experience of menstrual symptoms and perceived control over anxiety-related events across the menstrual cycle. Arch Womens Ment Health [Internet]. 2016;19(6):1109–17. Available from: http://link.springer.com/10.1007/s00737-016-0661-1

128. Dubol M, Epperson CN, Sacher J, Pletzer B, Derntl B, Lanzenberger R, et al. Neuroimaging the menstrual cycle: A multimodal systematic review. Front Neuroendocrinol [Internet]. 2021;60:100878. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0091302220300698

129. Xu F, Huang L. Electrophysiological Measurement of Emotion and Somatic State Affecting Ambiguity Decision: Evidences From SCRs, ERPs, and HR. Front Psychol [Internet]. 2020;11:520922. Available from: https://www.frontiersin.org/article/10.3389/fpsyg.2020.00899/full

130. Shiffman S, Stone AA, Hufford MR. Ecological Momentary Assessment. Annu Rev Clin Psychol [Internet]. 2008;4(1):1–32. Available from: https://www.annualreviews.org/doi/10.1146/annurev.clinpsy.3.022806.091415

131. Fischer S, Peterson C. Dialectical behavior therapy for adolescent binge eating, purging, suicidal behavior, and non-suicidal self-injury: A pilot study. Psychotherapy. 2015;52(1):78–92.

132. Hampl R, Stárka L. Endocrine Disruptors and Gut Microbiome Interactions. Physiol Res [Internet]. 2020;69(Suppl 2):211–23. Available from: http://www.biomed.cas.cz/physiolres/pdf/2020/69_S211.pdf

133. Guarnotta V, Amodei R, Frasca F, Aversa A, Giordano C. Impact of Chemical Endocrine Disruptors and Hormone Modulators on the Endocrine System. Int J Mol Sci [Internet]. 2022;23(10):5710. Available from: https://www.mdpi.com/1422-0067/23/10/5710

134. Robinson M a., Brewster ME. Motivations for fatherhood: Examining internalized heterosexism and gender-role conflict with childless gay and bisexual men. Psychol Men Masc [Internet]. 2014;15(1):49–59. Available from: http://doi.apa.org/getdoi.cfm?doi=10.1037/a0031142

135. Seger C, Salzmann L. After another decade: LC–MS/MS became routine in clinical diagnostics. Clin Biochem [Internet]. 2020;82:2–11. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0009912020301053

136. Alshaya DS. Genetic and epigenetic factors associated with depression: An updated overview. Saudi J Biol Sci [Internet]. 2022;29(8):103311. Available from: https://linkinghub.elsevier.com/retrieve/pii/S1319562X22002273

137. Langer RD, Hodis HN, Lobo RA, Allison MA. Hormone replacement therapy – where are we now? Climacteric [Internet]. 2021;24(1):3–10.

Available from: https://www.tandfonline.com/doi/full/10.1080/13697137.2020.1851183

138. Christiansen AR, Lipshultz LI, Hotaling JM, Pastuszak AW. Selective androgen receptor modulators: the future of androgen therapy? Transl Androl Urol [Internet]. 2020;9(Suppl 2):135–48. Available from: http://tau.amegroups.com/article/view/32604/28654

139. Moyer AM, Matey ET, Miller VM. Individualized medicine: Sex, hormones, genetics, and adverse drug reactions. Pharmacol Res Perspect [Internet]. 2019;7(6):e00541. Available from: https://bpspubs.onlinelibrary.wiley.com/doi/10.1002/prp2.541

140. Kancheva Landolt N, Ivanov K. Short report: cognitive behavioral therapy - a primary mode for premenstrual syndrome management: systematic literature review. Psychol Health Med [Internet]. 2021;26(10):1282–93. Available from: https://www.tandfonline.com/doi/full/10.1080/13548506.2020.1810718

141. Lustyk MKB, Gerrish WG, Shaver S, Keys SL. Cognitive-behavioral therapy for premenstrual syndrome and premenstrual dysphoric disorder: a systematic review. Arch Womens Ment Health [Internet]. 2009;12(2):85–96. Available from: http://link.springer.com/10.1007/s00737-009-0052-y

142. Zhang W, Sweeney JA, Bishop JR, Gong Q, Lui S. Biological subtyping of psychiatric syndromes as a pathway for advances in drug discovery and personalized medicine. Nat Ment Heal [Internet]. 2023;1(2):88–99. Available from: https://www.nature.com/articles/s44220-023-00019-x