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NEUROBIOLOGICAL BASIS OF GENDERED BEHAVIOR ACROSS THE LIFE COURSE

Victoria Githenya *

School of Psychology, Daystar University, Nairobi, Kenya.

* Corresponding Author

ORCID Details

Victoria Githenya: <https://orcid.org/0009-0005-2329-1132>

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ABSTRACT

Societal expectations shape behavioral and psychological patterns regarding what it means to be either male or female. However, it is sex differentiation that helps to lay the foundation for gendered behavior in the future. Another critical period for gender socialization is puberty. The changes that occur during puberty are not only physical but also hormonal and psychological. This article also reviews pregnancy and postnatal period, menopause and andropause, and aging, and how these periods contribute to gendered behavior. The clinical implication is that there is need for mental health practitioners to adopt gender-sensitive approaches in treatment that are sensitive to the unique needs of each gender and offer holistic care.

Keywords: Aging, Andropause, Gendered Behavior, Menopause, Neurobiology, Pregnancy, Puberty, Sex Differentiation

1 INTRODUCTION

Gender, an important aspect of human experiences, combines social and psychological components, affecting how people interact with the world and shaping social norms regarding acceptable actions for people of a specific gender (Domingue et al., 2019). Societal expectations shape behavioral and psychological patterns regarding what it means to be either male or female. A person's social environment plays a significant role in shaping gendered behavior. However, the biological underpinnings are key factors and play an important role and they unfold across the lifespan.

2 SEX DIFFERENTIATION AND NEUROENDOCRINE REGULATION

According to Ray and Racine (2025), an embryo's chromosomal sex is determined as soon as fertilization takes place but the sex differentiation involves a series of steps where the sexually indifferent embryo starts to acquire either male or female characteristics in the gonads and genitalia. The genetic sex is the driver of primitive gonad differentiation into either testes or ovaries. When specific testicular hormones are present, that is androgens and anti-Mullerian hormone (AMH), the internal and external genitalia follow male pathway, while in the absence of these hormones, they follow the

female pathway (Ray & Racine, 2025). The sex differentiation helps to lay the foundation for gendered behavior in the future.

During fertilization, a sperm contributes either the X or the Y chromosome while an oocyte contributes only the X chromosome, which means that XY is a chromosomal male while XX is a female (Aatsha et al., 2023). However, in the initial six weeks post fertilization, there are no observable sex differences in the bipotential gonads. The gonads of chromosomally male embryos then differentiate into testes due to the influence of the SRY gene (sex determining region Y protein), also called the testis determining factor (TDF). The SRY gene helps to direct differentiation of male gonads and helps Sertoli cells to differentiate and the production of anti-Müllerian hormone (AMH) or Müllerian inhibiting substance.

It is the existence of the testes that determines the fate of the internal and external genitalia, with the presence of testes leading to the male pathway and the absence of testes leading to the female pathway (Ray & Racine, 2025). The presence of ovaries has no effect in the determination of genitalia differentiation. In the absence of an active SRY gene, for example mutation, the result is varying degrees of gonadal dysgenesis, but usually not sufficient to allow for ovarian differentiation. Testosterone production in gonadal male usually begins around the ninth week.

According to Arisaka et al. (2021), the testosterone that is secreted by the fetal testis from eight to 24 weeks of gestation, peaking at eight to 14 weeks, helps not only in the differentiation of internal and external genitalia but also in brain's sexual differentiation, though the effects on the brain occur later. It is thought that prenatal testosterone exposure permanently affects gender identity. For example, chromosomally male people with mutations that lead to complete androgen insensitivity are phenotypically female and usually identify as female and are mostly androphilic (Arisaka et al., 2021).

Pre-natal brain exposure to sex hormones plays a vital role in shaping gendered behavior. Male testosterone production tends to surge in mid-gestation and shortly after birth, with females being exposed to significantly lower quantities of gonadal hormones in early development, something that permanently organizes brain's sex differences (Quiñones-Labernik et al., 2025). The testosterone exposure in males helps to masculinize their biology, morphology, and behavior. The low exposure to gonadal hormones on the female brain on the other hand allows development of nurturing and bonding areas and feminine behavior.

Postnatally, between one to five months in male, there is another surge of testosterone, known as mini-puberty, which influences physiological development, including penile growth, though this surge does not seem to be critical for men's psychosexual development (Arisaka et al., 2021). Girls with congenital adrenal hyperplasia who are exposed to high levels of androgens beginning prenatally usually identify as female though with reduced female identification and are usually more interested in boy toys and in competitive sports. This shows that androgens may have much smaller effects on gender identity than they have on gender roles, but are main determinants of male gender identity.

Testosterone is an important hormone, with levels being much higher in males than females. It helps to regulate libido, maintain body density, regulate muscle mass and strength, maintain vascular health, and has an impact on mental health (Rojas-Zambrano et al., 2025). Low testosterone has been linked to depressive symptoms, and testosterone replacement can have antidepressant effects in people with hypogonadism, including the elderly. Testosterone in males is a marker of aggression, dominance, and determines male social behaviors like assertiveness.

Estrogen, although it is known as a female hormone, is also present in the male through aromatization of androgen, and plays a key role in social behavior including parenting and mating (Lawal et al., 2025). The high levels of estrogen in females help them to be empathetic, bond socially, take care of their young ones, and be sensitive emotionally, qualities that are usually described as feminine.

3 PUBERTY

Puberty is a complex process that marks the maturation of the reproductive system and transition from childhood to young adulthood and is influenced by multiple factors such as genetics, metabolic, and socio-environmental factors (Yan et al., 2025). The pubertal changes are not only physical but also hormonal and psychological. Physical changes include secondary sexual characteristics maturation, puberty growth spurt, and body composition changes.

Pubertal testosterone rise is steeper and more prolonged in males than females, and the high testosterone has been linked to behaviors such as risk taking (Laube et al., 2020). Puberty changes in males lead to behavioral shifts and males become more aggressive and have increased sexual interest. Puberty in females on the other is marked by increase in the levels of estrogen and progesterone and physical changes like breast development and menstruation begin to manifest (Li, 2024). However, chronic stress in females can postpone puberty or lead to irregular menstrual cycle, while

disorders like hypothyroidism can also delay puberty. Because the prefrontal cortex is still developing, people in puberty tend to be impulsive, engage in social comparison, and can develop inferiority feelings. Due to the cyclic changes in estrogen and progesterone in females, they are prone to emotional volatility and internalizing disorders like depression while boys are prone to externalizing disorders.

Pubertal period is also a critical time for gender socialization. According to Amin et al. (2018), adolescent males tend to endorse masculinity norms such as physical toughness, autonomy, emotional stoicism, heterosexual prowess and tend to get more freedom compared to girls. On the other hand, the boys who display feminine qualities like feminine behaviors or who engage in tasks linked to girls such as house chores tend to face social barriers like ridicule and stigmatization. Such societal expectations shape gender identity and relationships.

Gender-related attitudes and experiences in adolescence are predictors of a person's health and wellbeing, with perceived gender typical attitudes and behaviors linked to high self-esteem, high social competence, and lower risk of depression (Al Atoom et al., 2024). On the other hand, experiences of gender atypicality and sexist beliefs have been linked to more aggression and increased rate of depression. Efforts to transform restrictive social norms and to increase on gender equality have been a key area of focus in the field of global health.

4 PREGNANCY AND THE POSTPARTUM PERIOD

Pregnancy is a period that is marked by many physiological changes aimed at supporting the developing fetus. According to Siad et al. (2025), virtually every body system increases its function by about 30% to 50% during pregnancy. In the endocrine system, human chorionic gonadotropin (HCG), which promotes increased production of progesterone and estrogen, starts rising early. Later, estrogen from the placenta leads to increased levels of thyroid binding globulin (TBG) which binds free T3 and T4. Prolactin also rises progressively peaking at term, levels of cortisol rise and peak in labor, and there is increase in insulin resistance which increases the risk for gestational diabetes (Siad et al., 2025). All these changes help to prepare a woman for childbirth and maternal behavior.

The hormone oxytocin has been shown to modulate parenting behavior, with maternal peripheral oxytocin being linked to sensitive parenting (Hiraoka et al., 2020). However, of note is that the interactions between a parent and their infant are complex and influenced by multidimensional factors such as a child's behavior. Socio-cultural factors like social support, stigma linked to teenage pregnancy, and economic factors can also affect such interactions.

The peripartum period is a period of increased physiological and psychological stress, which can predispose such women to mental health conditions. Ekelöf et al. (2025) state that a study done showed that about 7% of pregnant women at first antenatal visit screened positive for a mental health illness with 85% of them having at least one mental health disorder or a risk factor for disorders like anxiety, depression, and fear of childbirth. Studies show a link between untreated antenatal depression with adverse infant outcomes like small for gestation weight. There is therefore need to screen and treat pregnant women appropriately.

Globally, about 25% of women have perinatal depression with socio-economic factors like intimate partner violence and living in low to middle income countries being some of the predictors (Fusar-Poli et al., 2025). Other women, about two in a thousand, experience peripartum psychosis, with its prevalence being higher among those with history of mood disorders. These disorders usually peak a few weeks after delivery and postpartum psychosis is a psychiatric emergency. All these highlight the need for screening women and initiating preventative measures. Psychosocial support is especially important for peripartum women.

5 MENOPAUSE AND ANDROPAUSE

Muralikrishna et al. (2025) state that menopause usually starts at 50 years, with the range being 40 to 60 years, and it is a natural phase in the life of a woman that marks the end of fertility as nearly all ovarian oocytes are lost. The decline in estrogen levels leads to symptoms such as mood swings, hot flushes, insomnia, mental and physical fatigue. During the postmenopausal period, women experience urinary problems, vaginal atrophy, and a higher risk of osteoporosis, and have a higher rate of morbidity and mortality.

Socio-cultural factors affect women's view and navigation of menopause. Some women lack adequate knowledge about menopause needed to address their symptoms, some go through it silently due to fear of stigma, while others view it as an age of hopelessness and think they may be perceived as less attractive, all of which lowers their quality of life (AlSwayied et al., 2024). Such views can also exacerbate mental health challenges in this group of women. There is therefore need for education and sensitization programs targeting perimenopausal women in order to equip them with knowledge and skills needed to navigate this period and help them know the options available like hormone replacement and psychotherapy. Social support and self-care is especially important for these women.

Andropause on the other hand is a phenomenon that occurs in men. Andropause, also known as male menopause, is a condition characterized by a gradual decline in testosterone levels at a rate of about 1% to 2% per year, starting at around 30 to 40 years, and affecting middle age to older men (Ajayi et al., 2024). The declining testosterone levels lead to reduction in muscle mass and bone density, reduction in sexual function and libido, fertility issues and impotence, and an overall reduced quality of life. Men have a general reluctance in seeking medical care, which has led to andropause being on the sidelines.

Societal expectations of masculinity can lead to psychological problems for men going through andropause. Men with rigid masculine ideals may prefer to suppress emotions and avoid seeking help especially due to stigma associated with vulnerability among men (Young et al., 2025). Therefore, men going through andropause and its associated symptoms like reduced sexual function may suffer in silence due to fear of vulnerability and stigma. The area of andropause seems neglected and therefore there is need for sensitization programs on this area and support for men who are affected.

6 AGING

Aging comes with many challenges. According to Gonmah and Parmar (2025), aging leads to a progressive decline in physiological functions, changes in cognition and emotional regulation, and an evolution of social roles and relationships. Physiologically, changes like cellular damage and slowed metabolism lead to susceptibility to diseases and decreased resilience. Psychologically, they may experience memory loss and declining processing speed, things that might impair self-care and increase dependence. Socially, they may experience isolation and loneliness, things that can increase susceptibility to psychological and physical health problems.

As people age, they face challenges like discrimination, stigmatization at both structural and individual level, being cast in a subordinate role and excluded, or being perceived as a burden, attitudes that lead to adverse health outcomes (Bratt & Fagerström, 2023). Cultures that value youth and beauty may perceive older women as having less social value, something that can predispose these women to disorders like depression. Declining strength in older men on the other hand may affect their self-concept and lead to social isolation. There is therefore need for targeted mental health interventions for the aging population.

7 CLINICAL IMPLICATIONS AND TRANSLATION CHALLENGES

Gendered behavior is affected by both biological and socio-cultural factors. Mental health practitioners therefore need to adopt gender-sensitive approaches in treatment that are sensitive to the unique needs of each gender and offer holistic care. According to Hartnett et al. (2025), sex and gender are important determinants of mental health and therefore overlooking these factors in healthcare would lead to gender blindness and ignoring the specific needs of men and women. Additionally, mental health disorders may present differently in men and women. Therefore, gender aware approaches can help to promote effective and equitable mental health care.

People's psychological experiences are complex and are shaped not only by gender but by other factors like socio-economic status, spiritual beliefs, and culture. Adoption of holistic approaches like the biopsychosocial model is therefore important in treatment. Meneses et al. (2024) posit that the biopsychosocial model helps to integrate psychological and social factors to understand health and emphasizes considering the full spectrum of people's experiences and their environment in the diagnosis and treatment of mental health conditions. Health care practitioners should therefore strive to offer holistic and gender-sensitive care in order to improve mental health outcomes.

Integrative approaches would help to reduce biological reductionism in clinical practice. Traditional reductionist approaches tend to oversimplify psychiatric disorders into linear relationships of cause and effect which leads to overlooking their complexity and interconnectedness (Öngür & Paulus, 2025). Such approaches overlook the multifaceted and dynamic nature of mental health conditions that involve interactions among biological, psychological, social, and environmental factors. Therefore, complex systems approaches would help in providing a comprehensive treatment framework.

Additionally, mental health treatment should be culturally sensitive. It is important to endeavor to understand gendered behaviors within their cultural contexts. For example, some African cultures promote male dominance. Nartey et al. (2023) states that gendered norms that normalize male dominance and obedience or submission among the women often lead to gender disparities and negative health outcomes among women such as violence against women and more health problems. Therefore, mental health interventions should be sensitive of such cultural dynamics in order to be effective.

8 CONCLUSION

The biological basis of gendered behavior is shaped and affected by sex differentiation and neuroendocrine regulation and manifests differently across the various stages of life such as puberty, pregnancy and postpartum period, menopause and andropause, and the old age. Biology intersects with gendered social experiences to shape behavioral trajectories and mental health outcomes. Gendered behavior is thus influenced by biological sex, social environment, roles, and expectations.

Beginning in childhood, people are socialized to social roles that affect their behavior and psychological wellbeing. While biological sex serves as the foundation for gender identity and gendered behavior, other factors like social and cultural norms are equally important, with girls and boys being expected to adhere to societal norms on femininity and masculinity respectively. Socio-cultural experiences and gender affect how people perceive and deal with mental health problems.

Clinical practice needs to adopt gender-sensitive interventions with due sensitivity to the unique needs of each gender. There is need to acknowledge how the biological sex is intricately related to gendered social experiences, which highlights the need to use integrative and holistic approaches like the biopsychosocial model that considers the biological, psychological, and social factors that affect mental health, which would help to discourage reductionism. Such measures would help to promote effective treatment and psychological wellbeing across the genders.

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