Review Article

Biological and lifestyle determinants of menstrual health

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Abstract

The menstrual cycle is a reproductive process that prepares the uterus for a potential pregnancy, occurring regularly during a woman's reproductive years. Menstruation, marked by vaginal bleeding, is a part of this cycle and happens when pregnancy does not take place. While hormonal control, primarily involving the hypothalamic-pituitary-ovarian axis, plays a central role in orchestrating the menstrual cycle, the process itself is far more intricate. It is shaped not only by biological mechanisms but also by an array of psychological, environmental, and socio-cultural factors, all of which contribute to individual variability in menstrual experiences. This comprehensive review delves into the diverse internal and external factors that influence key aspects of menstruation, including the timing of onset (menarche), cycle regularity, duration, frequency, menstrual bleeding, and associated indicators. A deeper understanding of the contributing factors associated with menstruation may be useful as it enables more informed healthcare decision-making, supports the development of personalized approaches to menstrual health management, and contributes to broader efforts in education and public health policy related to reproductive well-being.

Keywords: Anovulation, endocrine disruptors, hormonal imbalance, lactational amenorrhea, menarche, menorrhagia, menstrual health**,** menstrual stress, PCOS.

Introduction

Menstruation or period is characterized by the cyclical shedding of the endometrium leading to the vaginal discharge of blood and mucosal tissue which take place during the reproductively active phase of a woman. The cyclical events associated with menstruation is referred to as menstrual cycle. The menstrual cycle is only one aspect of the cyclic reproductive activity in a woman's reproductive life and is closely synchronized with changes in the ovary, collectively known as the ovarian cycle.[1,2]

Ovarian cycle

The ovarian cycle refers to the recurring changes within the ovary, including the development of ovarian follicles, ovulation and the formation of the corpus luteum. These processes prepare the endometrium for the implantation of a fertilized ovum and support early pregnancy. The ovarian hormones, oestrogen and follicle-stimulating hormone (FSH) play key roles in the development and maturation of ovarian follicles. Luteinizing hormone (LH), secreted by the anterior pituitary gland, triggers ovulation through a surge in its levels. The ovarian cycle is divided into two phases: the follicular phase (before ovulation) and the luteal phase (after ovulation). In healthy women, ovulation typically occurs around day 14 of the cycle. The follicular phase is dominated by oestrogen and FSH, while the luteal phase is primarily influenced by progesterone secreted by the corpus luteum. If fertilization and pregnancy do

not occur, the corpus luteum degenerates and forms a scar-like structure called the corpus albicans.[1,2]

Menstruation and the uterine cycle

Menstruation is initiated primarily by the falling levels of progesterone, along with the release of prostaglandins.[2] These hormonal changes cause constriction of the spiral arteries and spasms in the endometrial tissue. As a result, the blood supply to the endometrium is cut off, leading to oxygen deprivation and tissue death. The upper layer of the endometrium then breaks down, capillaries rupture, and the discarded tissue along with blood flows out through the vagina. This process is known as menstruation. An enzyme called plasmin breaks down blood clots in the menstrual fluid, helping to ease the flow of blood and broken-down lining from the uterus. Menstrual discharge typically continues for 2–6 days. Approximately 30–60 ml of blood is lost during menstruation. Menstruation is a sign that pregnancy has not occurred.[1]

The next phase of the uterine cycle, known as the proliferative phase, follows menstruation. This phase is characterized by a gradual increase in oestrogen secretion, which stimulates the growth and regeneration of the uterine lining. The latter part of the follicular phase of the ovarian cycle corresponds to the proliferative phase. As ovarian follicles mature, they secrete increasing amounts of oestradiol, a form of oestrogen. This hormone initiates the formation of a new endometrial layer and the development of spiral arterioles within it.[1]

The final phase of the uterine cycle is the secretory phase, which overlaps with the luteal phase of the ovarian cycle. During this phase, the corpus luteum secretes progesterone, which causes further thickening of the endometrium and cervical mucus. These changes prepare the uterus for implantation of a fertilized egg, which by this stage has developed into a blastocyst. In early pregnancy, progesterone also increases blood flow to the endometrium and reduces uterine smooth muscle contractility to support successful implantation and maintain pregnancy. If pregnancy does not occur, both the ovarian and uterine cycles start over again.[2]

The menstrual cycle is a tightly regulated, cyclical process orchestrated by hormonal interactions within the hypothalamic–pituitary–ovarian (HPO) axis. It is the overt manifestation of a complex neuroendocrine dialogue. This interaction reflects a person's overall health, including metabolic, physiological, and environmental conditions. In the context of rapid urbanization and global health transitions, the menstrual cycle increasingly reflects the cumulative impact of modern life. The epidemiological shift from infectious to chronic disease, combined with significant lifestyle changes, has contributed to a rising prevalence of menstrual irregularities, dysmenorrhea, and amenorrhea. This review aims to interrogate the multifaceted influences that act upon the menstrual cycle ranging from hormonal imbalance to lifestyle factors. By synthesizing insights from reproductive physiology and behavioural science, this review discusses some of the common factors that can disrupt the normal reproductive cycle in human females.

Hormonal imbalance

Hormonal balance plays a crucial role in regulating the menstrual cycle, controlling follicle maturation, ovulation, and preparation of the uterine lining through a complex interplay of hormones like oestrogen, FSH and LH. Common imbalances include oestrogen dominance, which causes heavy periods, breast tenderness and mood swings; low progesterone levels, which lead to irregular periods and spotting, typically caused by chronic stress, age-related hormonal shifts, and PCOS (polycystic ovary syndrome) characterized by excess androgens which disrupts ovulation, causing irregular cycles and fertility issues. Additionally, thyroid hormone imbalances, such as hypothyroidism or hyperthyroidism can cause menstrual irregularities.[3] Factors that trigger the balance include lifestyle choices such as a poor diet, inadequate exercise, irregular sleep patterns, and exposure to endocrine-disrupting chemicals. Chronic stress can also disrupt hormone balance by elevating

cortisol levels and affecting secretion of reproductive hormones. Other factors such as excessive caffeine and high alcohol consumption can interfere with oestrogen and progesterone balance. Likewise, certain medications can alter natural hormone levels, causing changes in menstrual cycles. Women in their late 40s or early 50s may experience hormonal fluctuations during perimenopause and menopause, leading to irregular cycles and mood swings and other hormonal disorders. Menstrual disorders related to hormone imbalance include amenorrhea (absence of menstruation), dysmenorrhea (painful menstruation), menorrhagia (heavy or prolonged bleeding), oligomenorrhea (infrequent menstruation), premenstrual syndrome (PMS) and premenstrual dysphoric disorder (PMDD) characterized by emotional and physical symptoms before menstruation. The treatment depends on the cause and there are a variety of treatments used to balance hormone levels such as hormone therapy and medication. By understanding the impact of hormonal imbalances on menstrual cycles and making simple yet effective lifestyle changes, women can manage their reproductive health and alleviate symptoms. By prioritizing self-care, balanced diet, and stress management, it is possible to maintain hormonal balance and reproductive health, thereby improving menstrual cycle.[3]

Endocrine disruptors

Endocrine-disrupting chemicals (EDCs) are substances that can interfere with the body's endocrine system, which regulates hormones essential for various bodily functions. Due to its structural similarity with endogenous hormones, it can interfere hormone production and its function. So, they can mimic, block or alter production of certain hormones such as oestrogen, leading to a range of health issues.[4] Some of the common EDCs include bisphenol A (BPA), phthalates, polychlorinated biphenyls (PCBs), dioxins and heavy metals, which can be found in various everyday products. BPA, phthalates and parabens are found in food packaging, cosmetics and feminine hygiene products. It can disrupt female reproductive health, causing menstrual irregularities, hormonal imbalances, delayed puberty, breast cancer, infertility and potentially reducing fecundability.[5] High exposure poses significant health risks to women, particularly in relation to premenstrual syndrome (PMS). Exposure to these chemicals has been linked to menstrual irregularities, changes in cycle length, and potential fertility issues, highlighting the importance of understanding the effects of EDCs on women's health.[4,5]

Menstrual stress nexus

Stress can lead to many different changes in our body, that may affect mental as well physical health. The complex interplay between stress and hormones can disrupt menstrual cycle, leading to irregularities and changes in period duration and intensity. One may experience spotting, menorrhagia, dysmenorrhea, amenorrhea, PMS etc due to stress.[6] The hypothalamic-pituitary-adrenal (HPA) axis is responsible for adjusting the balance of hormones in response to stress. In a stressful situation, hypothalamus releases corticotropin-releasing hormone (CRH). It then triggers HPA axis stress response leading to the production of the stress hormone cortisol. A high level of stress leads to an increase in secretion of cortisol which, in turn, decreases gonadotropin-releasing hormone (GnRH) production, leading to changes in oestrogen and progesterone levels. Fluctuating progesterone levels can affect the luteal phase of the ovarian cycle, leading to variations in menstrual cycle length. Stress-induced delays in ovulation can also contribute to prolonged periods. The interplay between HPA axis and hypothalamic-pituitary-ovarian axis plays a crucial role in these changes, highlighting the complex relationship between stress and menstrual health. Understanding the impact of stress on menstrual cycles highlights the importance of stress management for reproductive health. Stress can be reduced to some extent through practices such as yoga, regular exercise, and maintaining a balanced diet.[7]

Weight fluctuations and nutrition

Obesity and high body mass index (BMI) are known risk factors for anovulation and infertility. Studies suggest that obesity may contribute to infertility by shortening the luteal phase, causing irregular periods, amenorrhea, and miscarriages. [8] Obesity during puberty is also linked to irregular periods and conditions like PCOS which can cause missed periods, heavy bleeding and higher levels of testosterone and insulin. [9] Leptin, a protein hormone primarily produced by fat cells (adipocytes), plays a regulatory role in maintaining long-term energy balance and body weight. Leptin regulates the gonadotropin surge, which initiates the development of pubertal stages.[10] [11] Kisspeptins are peptides that regulate the hypothalamic-pituitary-gonadal (HPG) axis and are involved in the onset of puberty, sex hormone-mediated gonadotropin secretion, and fertility. They stimulate gonadotropin-releasing hormone (GnRH) neurons, leading to the secretion of GnRH and the subsequent release of gonadotropins and sex steroid hormones. Insulin also has a crucial role in both childhood obesity and reproductive health. In children, insulin resistance can increase the risk of type 2 diabetes and contribute to obesity and impaired growth. In women, insulin resistance can lead to PCOS, which may affect menstrual cycles and fertility. Together, leptin, kisspeptin, and insulin influence childhood obesity and the early onset of puberty by acting through the hypothalamic-pituitary-ovarian (HPO) axis. Even if obese women have regular periods, they tend to have lower levels of certain reproductive hormones such as gonadotropins, oestradiol and inhibin during the first part of their cycle. This suggests that obesity itself may reduce hormone production.[12] Questionnaire data from 1,012 women (aged between 17 and 53) suggest that obese women are more than twice as likely to experience heavy menstrual bleeding compared to women of normal weight, while underweight women are less likely to experience heavy bleeding.[13] Women with a normal BMI, especially around 20 kg/m², have the lowest risk and better reproductive health.[14]

Excessive exercise

There is varying evidence that increased physical activity may help lower the risk of breast cancer in both premenopausal and postmenopausal women, as exercise can reduce oestrogen levels in the body.[15] However, exercise related menstrual dysfunction may include problems like short luteal phase, anovulation, oligomenorrhoea, amenorrhoea and delayed menarche. These issues have many causes, but its main reason is hypothalamic inhibition with suppression of gonadotrophin releasing hormone pulsatility i.e., the frequency at which pulses of the hormone are released by the hypothalamus.[16] During the luteal phase, women often perceive exercise as more difficult, even when performing their usual workout. Continuous high-intensity exercise during this phase can lead to increased physical stress and more negative psychological responses.[17]

Medical condition

Menstruation can be affected by various medical conditions that disrupt hormonal balance or damage reproductive organs. In the first few years after menarche, the most common cause of menstrual irregularities is anovulation resulting from the immaturity of the hypothalamic-pituitary-ovarian axis. Women with type 2 diabetes tend to have significantly longer menstrual cycles and the incidence of oligomenorrhea in their 20s is nearly twice as high compared to non-diabetic controls.[18] Thyroid dysfunction is a significant underlying cause of menstrual irregularities. Subclinical hypothyroidism has been linked to mild menstrual disturbances such as occult menorrhagia, while in women of reproductive age hyperthyroidism is most commonly associated with oligomenorrhea and amenorrhea.[19] Endometriosis is a common condition affecting about 10% of women. The most frequently reported symptom is dysmenorrhea which may be accompanied by nausea, vomiting, mood swings, lower back pain, and fatigue; over time, this can progress into chronic pain. Dyschezia (difficult or painful defecation), especially when it follows a cyclical pattern with menstruation, can also

indicate endometriosis.[20] Cushing's syndrome can cause menstrual disturbances due to hypogonadotropic hypogonadism and shares several features with PCOS, including amenorrhea or oligomenorrhea, obesity, hirsutism, an exaggerated response to GnRH, low levels of sex hormone-binding globulin, and elevated blood androgen levels.[21] Valproate, a widely used antiepileptic medication, may increase the risk of developing PCOS in girls with epilepsy or bipolar disorder, possibly due to the immaturity of the hypothalamic-pituitary-ovarian axis.[22]

Antipsychotics, which are widely used to treat adolescents with bipolar disorder, psychotic conditions, and behavioural disturbances, can cause hyperprolactinemia in some cases, potentially leading to oligomenorrhea or amenorrhea.[22] Antidepressants such as paroxetine, sertraline, venlafaxine, and their combination with mirtazapine are linked to a higher risk of menstrual disturbances in women of reproductive age.[23] Isotretinoin used for the treatment of severe acne, is found to have menstruation-related side effects such as amenorrhea, dysmenorrhea and oligomenorrhea.[24] Progestogen-only hormonal contraceptives such as progestin-only pills (POPs), Depo-Provera (DMPA), and implanon are commonly associated with disturbances in bleeding patterns among users. Progestogen-only pills can cause various bleeding irregularities, including amenorrhea, irregular spotting, or prolonged bleeding, with amenorrhea and unscheduled light bleeding being particularly common in Depo-Provera (DMPA) users. Irregular vaginal bleeding is the most common side effect of newer hormonal contraceptives.[25] Hormone therapies like the levonorgestrel intrauterine system, subdermal implant and other progesterone-based therapies can reduce blood loss and may cause amenorrhea. Drugs that inhibit prostaglandin synthesis, such as NSAIDs include aspirin, ibuprofen and naproxen sodium reduce uterine contractility in dysmenorrheic women. Oral progestins such as norethindrone acetate and dienogest, target the progesterone receptor. It is known that dienogest reduces dysmenorrhea in women with endometriosis. Abnormal vaginal bleeding was observed significantly more often in women of reproductive age treated with edoxaban compared to those receiving warfarin.[26] Certain cancer therapies can negatively impact the reproductive system, potentially leading to secondary amenorrhea. Individuals diagnosed at older ages are more likely to experience prolonged amenorrhea and early onset of menopause.[27]

Age and life changes

There is a significant effect of age on menstruation as it influences the menstrual cycle onset, pattern as well as eventual cessation. The average menstrual cycle length increases from age 15 to 23, decreases until around age 45, and then increases again. [28] During childhood because of the inactivity of hypothalamic-pituitary-ovarian axis, the hormone levels are low and no mature eggs are produced by the ovaries. Hence no menstruation occurs.[29] Following puberty there is an irregularity in menstrual cycles as the body adjusts to hormone changes. As a result, ovulation may not occur with every cycle initially.[30] The age of 15-40 is considered as the reproductive age during which period the menstrual cycle becomes regular and ovulation occurs monthly. Here the average cycle ranges up to 28 days. Fertility is at its peak between the ages of 20 and the late 30s.[31] Mid-late 40s are accompanied with hormonal fluctuations, shorter, longer or irregular cycle, heavier or lighter bleeding and increased PMS syndrome due to declining ovarian functions.[32] Menopause is defined as the permanent absence of menstrual periods (amenorrhea) for 12 consecutive months. It marks the end of reproductive years and is characterized by a drop in oestrogen and progesterone levels, cessation of ovulation, and symptoms such as hot flashes and sleep disturbances.[33] No menstrual bleeding should occur during post-menopausal stage. Any occurrence of post-menopausal bleeding is regarded as abnormal and must be diagnosed.[34]

Pregnancy

Menstruation halts entirely during the stage of pregnancy, mainly due to the increased levels

of oestrogen and progesterone which maintains the uterine lining to support the developing foetus. Human Chorionic Gonadotropin (hCG) produced during post-implantation assist corpus luteum, thereby ensuring continued progesterone production which in turn maintains the uterine lining. Oestrogen and progesterone levels steadily increase during pregnancy, which inhibits follicle development and ovulation by suppressing the hypothalamic-pituitary-ovarian axis.[35] During pregnancy, the placenta itself acts as an endocrine organ, secreting progesterone.[2] In fact, progesterone predominates during pregnancy and is often referred to as the pregnancy hormone. Postpartum menstrual changes are accompanied by a decline in pregnancy-associated hormone secretion, gradually creating conditions favourable for the resumption of the menstrual cycle.[1]

Lactational Amenorrhea

Lactational Amenorrhea is a natural infertility period caused especially by exclusive breast feeding.[1] This happens due to the release of prolactin, which in turn suppresses the GnRH secretion, leading to reduced LH and FSH levels, which inhibits ovulation and menstruation. The release of prolactin is stimulated by suckling. When the frequency of breast-feeding decreases or supplemental feeding is introduced, there will be a decline in prolactin levels and this causes resumption of menstrual cycle.[36]

Lifestyle factors

The endocrine system is interfered by nicotine and other chemicals in tobacco. Hence smoking causes fluctuations in oestrogen and progesterone levels, which are very essential for regulating the menstrual cycle. Heavy smoking is associated with shorter menstrual cycles, variability in cycle and menses lengths, and a higher risk of anovulation.[37]

Alcohol interferes with the metabolism of oestrogen and progesterone, leading to heavy menstrual bleeding and irregular cycles. Excessive alcohol consumption disrupts liver enzymes responsible for hormone breakdown, contributing to menstrual disturbances. It can also cause anovulation, which may result in infertility. Regular intake of large amounts of alcohol can elevate levels of reproductive hormones such as oestradiol and luteinising hormone (LH), further disrupting the menstrual cycle.[38]

Altogether stoppage of periods may occur due to poor nutrition or food habits. Maintenance of essential body fat is very important for the production of sex hormones. Menstrual regularity and flow are affected by the deficiency of dietary iron and zinc. Amenorrhea is common in underweight individuals. Skipping meals, particularly breakfast and consuming junk food are linked to increased menstrual cramps and mood instability.[39]

Conclusion

The menstrual cycle, traditionally defined by its endocrine foundations, is a complex biological process influenced by an interplay of physiological, psychological, environmental, and socio-cultural factors. These influences are multifaceted and interdependent, extending beyond the classical hypothalamic-pituitary-ovarian axis to include nutritional status, psychological stress, circadian rhythm disruptions, endocrine-disrupting exposures, and genetic predispositions. Raising awareness and promoting education can empower women to take a more proactive role in their reproductive health, while encouraging healthcare systems to adopt more personalized care approaches. As we move towards a more integrative model of medicine and women's health, it is essential to reframe menstrual health as a multidisciplinary concern; one that calls for collaborative insights from endocrinology, psychiatry, nutrition, public health and other fields. Adopting this holistic perspective is crucial not only for optimizing reproductive care but also for recognizing the menstrual cycle as a key indicator of overall health and resilience.

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