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Review Article

Gut Microbiome and Impact on Women Health

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Abstract

The intestine is a delicate ecosystem housing trillions of microbes (10^{13}–10^{14} bacterial cells) which includes the commensal, pathogenic and symbiotic microorganisms [1]. These have been described, as a solid organ that play an essential role in the healthy development of the human body, and the onset of various diseases through the life span of an individual. There is evidence that they impact not only cardiovascular disease, metabolic disorders, neurologic conditions and cancer but even reproductive health.

Keywords: Gut Microbiome; Lifestyle; Breastfeeding

Researchers are now exploring what a crucial yet under-explored role gut microbiome play in female reproductive health. Interestingly, the microbiota undergo significant and dynamic shifts across all stages of life of women, possible due to a combination of factors, like hormonal changes, diet, environment, and lifestyle, that vary across the various life stages of a lady.

Gut bacteria and immunity

The interaction between gut microbiota and host immune system ensures that commensal bacteria are tolerated alongwith the antigens ingested with food, while maintaining the ability to identify and attack potential pathogens and prevent invasion and infection [2]. The gut microbiota also contribute to innate and adaptive immunity, because of the role of commensal bacteria and their products. Play in preventing colonisation by opportunistic pathogens.

Gut genital axis

While the upper reproductive tract (uterine cavity) was largely considered sterile [3], the lower reproductive tract (cervicovaginal region) harbors trillions of bacteria [2]. The physiologic vagina microbiota contains about 10^6–10^8 bacterial cells/ml [4]. The predominant species observed in healthy women are *Lactobacillus* (i.e., *Lactobacillus crispatus, Lactobacillus gasseri, Lactobacillus iners*, and *Lactobacillus jensenii* [5].

The gut and genital tract microbiome, are complex ecosystems, that are constantly communicating, and this crosstalk impacts the physiological, immunological and metabolic homeostasis of the host. These microorganisms have been traced to the rectum, which also serves as a reservoir [6]. The gut bacteria thus, are related directly to the vaginal microbioma.

Microbiome dysbiosis and diseases

Emerging evidence suggests that changes in microbiota community composition (dysbiosis) can cause diseases.

States of dysbiosis can adversely affect host health by promoting enrichment of pathogenic species, compromising the permeability of the intestinal barrier, and contributing to localized or generalized inflammatory states [7] which contribute to development of various diseases.

Dysbiosis has been associated with both extra-intestinal disorders (such as obesity, metabolic syndrome, type 2 diabetes, allergy, and asthma); and intestinal disorders such as colorectal cancer, inflammatory bowel disease (IBD), irritable bowel syndrome, and celiac disease [8]. In addition, some central nervous system-related disorders including Alzheimer's disease, Parkinson's disease, autism spectrum disorders and hepatic encephalopathy have been related to gut microbiota dysbiosis.

Women with reproductive disorders, like endometriosis, polycystic ovarian syndrome, primary ovarian insufficiency, and recurrent pregnancy loss, harbor distinct microbial signatures.

Key stages of life and microbiome impact

Early Life (Birth to Age 3)

The initial colonization of the microbiome is critical, as it lays the foundation for lifelong health and immune system development.

- **Birth:** The mode of delivery significantly impacts initial colonization in the neonate Vaginally born infants acquire gut microbiota similar to their mothers' vaginal microbiota (rich in *Lactobacillus* and *Bifidobacterium*), while C-section babies are colonized by maternal skin and environmental bacteria, deficient in microbial richness and diversity. Vertical mother-to-infant transmission of microbiota is important for neonatal. Metabolism and immune development. Babies born by caesarean section thus are at risk of numerous diseases [9].
- **Infancy and Weaning:** Breastfeeding fosters the growth of beneficial bacteria, particularly *Bifidobacterium* species. Bifidobacteria, which are among the first colonizers of the human gut, comprise up to 90% of the total colon microbiota in vaginally delivered breast-fed infants in the first year of life [10]. The introduction of solid foods leads to a major shift toward a more diverse, adult-like microbiome.
- **Critical Window:** The first two to three years of life are considered a «window of opportunity» where the microbiome is highly plastic and susceptible to long-lasting environmental imprints (e.g., antibiotic exposure, diet, stress) that can affect later health outcomes like asthma, obesity, and allergies.

Childhood and adolescence

During this phase, the microbiome becomes more stable, though sex-related differences begin to emerge with the onset of puberty due to fluctuating sex hormones. Elevated estrogen and testosterone levels are associated with differences in gut microbiota composition and diversity, contributing to the concept of a "microgenderome".

Adulthood and reproductive years

In adulthood, the microbiome is generally stable but still influenced by environment, stress, diet, exercise, and lifestyle.

- **Menstrual Cycle:** Fluctuations in estrogen and progesterone during the monthly cycle can affect gut motility (causing bloating, constipation, or diarrhea) and alter the vaginal microbiome, which ideally remains dominated by protective *Lactobacillus* species.
- **Pregnancy:** Pregnancy is a very complicated process, during which women undergo great changes in hormones, microbiome, metabolites, and immune responses. Healthy habits and the microbiome before and during pregnancy impact the maternal and fetal outcome in pregnancy. During pregnancy, the proportion of *Lactobacillus* spp. further increases, reducing the microbial diversity in the vagina. Increase in microbial diversity can increase risk of complications like miscarriage and preterm labour. Women with a dominance of *Lactobacillus* spp. experience less infection and lower levels of inflammation [11].

Menopause and older age

Menopause marks another major transition, characterized by a sharp decline in sex hormones.

- **Microbial Shifts:** The reduction in estrogen leads to decreased *Lactobacillus* dominance and increased microbial diversity in the vagina, raising the risk of infections like bacterial vaginosis and urinary tract infections.

- **Aging Gut:** The gut microbiome in older age typically shows reduced diversity and altered composition (e.g., lower *Firmicutes*, higher *Bacteroides*, increased pathobionts), which is associated with chronic low-grade inflammation ("inflammaging"), increased frailty, and age-related diseases like cardiovascular issues and cognitive decline. Healthier, long-lived individuals tend to maintain a more diverse microbiome similar to younger adults.

Role of diet

Dietary changes can improve fertility and reproductive outcomes, by directly affecting the gut microbiota [12]. Studies have highlighted that plant-based diet rich in fibre, eliminating ultra-processed foods, can positively impact gut microbiota within 4 days reducing pro- inflammatory taxa, when compared to a calorie-matched control diet [13]. These shifts led to not only led to reduced inflammatory markers, LDL Cholesterol but the resulting weight loss even improved glucose control [3]. These effects were reversed as the participants returned to their pre-intervention dietary habits [13], highlighting the importance of continued compliance, to sustain microbiota-driven improvements in reproductive and metabolic health.

Conclusion

The human body is a balanced ecosystem of various microbiota. Due to their complexity and dynamism, there is no ideal composition of a healthy gut microbiome [14].

The gut microbiome represents a mechanistic link connecting environmental influences on human health including reproductive health. Lifestyle factors including sedentary lifestyle, lack of exercise, obesity among others can adversely impact the microbiome. Changes in the microbiome before and after conception can influence both maternal and fetal health.

Antibiotic exposure is a significant disruptor of the microbiota. Broad-spectrum antibiotics can result in decreased microbial diversity, and related dysbiosis can have damaging effects on host immune and metabolic processes [15].

Further studies aimed at proving the relationship between the microbiome and various diseases are necessary before adopting microbiome-based interventions and therapies, to prevent many diseases including pregnancy complications and childhood disorders.

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