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BREASTFEEDING AND PHYSICAL ACTIVITY, ITS IMPACT ON THE INCIDENCE OF OBESITY IN OFFSPRING IN THE FUTURE

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ABSTRACT

Childhood obesity represents a serious and steadily increasing global health problem, and early life feeding practices, particularly during infancy, may contribute to the subsequent development of obesity. Breastfeeding is regarded as the most appropriate method of infant feeding, and a growing body of evidence indicates that breastfeeding exerts a protective effect against overweight and obesity later in life.

This article is based on a narrative review of the literature. Medical databases, including PubMed and Google Scholar, were systematically searched using the keywords breastfeeding, physical activity, exercise, obesity and adolescence. Due to heterogeneity in study designs and outcome measures, a quantitative meta-analysis was not performed.

The available evidence suggests that engagement in physical activity during pregnancy and lactation does not adversely affect milk production, milk composition, or infant growth. A considerable body of research suggests that engagement in physical activity during lactation confers substantial health benefits to both the mother and the infant and may attenuate the risk of overweight and obesity in offspring later in life.

KEYWORDS

Breastfeeding, Physical Activity, Exercise, Obesity, Adolescence

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1. Introduction

Physical activity is one of the most effective tools for improving health and longevity. It provides benefits ranging from enhanced brain and cardiovascular function to a reduced risk of chronic diseases such as diabetes, cancer, and neurodegenerative disorders, as well as alleviation of menopausal symptoms in perimenopausal women. (Simmons et al., 2024; Warburton & Bredin, 2017) Regular engagement in any form of movement including aerobic, anaerobic, resistance, and balance training has a positive impact on metabolic health, immune system function, psychological well-being, and the aging process. (Warburton & Bredin, 2017)

Engaging in physical activity during pregnancy confers similarly beneficial effects for both the mother and her child. (Ferrari & Joisten, 2021; X. Yang et al., 2022)

Physiological pregnancy is a state in which numerous changes occur over a short period of time, potentially leading to alterations in hormone profiles, serum and urinary electrolyte concentrations, as well as in the morphology of endocrine glands as observed in imaging studies. The duration of pregnancy constitutes a challenge for the maternal immune system. To adapt to this condition, a pro-inflammatory state is generated, which enables the tolerance of the fetus within the uterus for a period of nine months. Increased inflammatory processes have been observed, among other conditions, in the obstetric complication of preterm birth. Studies have shown that women who experienced preterm delivery exhibited elevated pro-inflammatory markers in the serum, placenta, and amniotic membranes. (Couture et al., 2023) Physical activity during pregnancy can have a positive impact on the pregnancy itself and therefore benefit both the mother and her baby by reducing the occurrence of inflammation during pregnancy. Moreover, engagement in physical exercise during pregnancy alleviates symptoms of anxiety and depression by regulating maternal stress hormone levels. (Nakamura et al., 2019) (Morton & Teasdale, 2022)

Engaging in physical activity undoubtedly brings numerous benefits. The many metabolic changes that occur during exercise contribute to a reduced risk of developing various non-communicable diseases. Current recommendations indicate that undertaking approximately 150 minutes of moderate-intensity physical activity per week provides substantial health benefits. (Warburton & Bredin, 2017)

Physical activity should be individually adapted to the patient's clinical condition. In the context of pregnancy, particular emphasis should be placed on the established benefits of pelvic floor muscle training in the prevention of urinary incontinence both during gestation and in the postpartum period. (Kwiatkowska et al., 2024) It should further be emphasized that in women with pregnancy-related complications, such as those diagnosed with gestational diabetes mellitus, engagement in physical activity may constitute a significant clinical challenge due to the potential risk of exercise-induced hypoglycaemia. Accordingly, structured and comprehensive patient education delivered by the managing clinician is of critical importance to facilitate safe implementation of physical activity and to minimize the risk of preventable adverse outcomes during pregnancy. (Fernández et al., 2023)

During physical activity, muscle fibers secrete peptides known as myokines, which exhibit anti-inflammatory effects. (Alshahrani, 2025) Peptides classified within this group such as cathepsin B, myostatin, interleukin-6, brain-derived neurotrophic factor (BDNF), and irisin exert broad effects on multiple tissue types. In investigating the effects of myokines on the course of chronic and autoimmune diseases, Díaz and colleagues demonstrated that irisin released during physical activity contributes to clinical improvement in patients. Conversely, the lack of physical activity leads to the development of resistance to myokines and the induction of a pro-inflammatory state, which promotes sarcopenia and the accumulation of adipose tissue, thereby creating favorable conditions for the development of cardiovascular diseases, insulin resistance, and type 2 diabetes. (Díaz et al., 2018; Gascoigne et al., 2023)

Obesity is defined by the World Health Organization (WHO) as an excessive accumulation of adipose tissue that may be detrimental, and even hazardous, to health due to the increased risk of premature mortality associated with conditions such as diabetes, hypertension, musculoskeletal disorders, and cardiovascular diseases. Currently, obesity constitutes a growing public health concern not only among adults but, most notably, among children. (Nagore González et al., 2025) Childhood obesity represents a serious and steadily increasing global health problem. This condition leads to adverse health consequences in both the short and long term. According to data from the WHO, in 2022 overweight affected 37 million children under the age of five and 390 million children and adolescents aged 5–19 years, of whom 160 million were living with obesity. (World Health Organization, 2025) Obesity is a chronic, multifactorial disease resulting from the complex interplay of genetic predisposition and environmental factors. Dietary patterns constitute a key determinant, as sustained positive energy balance promotes the excessive accumulation of adipose tissue. The significance of nutritional factors appears to be such that early-life feeding practices, particularly during infancy, may contribute to the subsequent development of obesity.

Breastfeeding is regarded as the most appropriate method of infant feeding. Human milk constitutes the optimal source of nutrition, providing essential macronutrients, immunological components, and bioactive compounds that support growth and development and confer long-term health benefits. (G. Calcaterra et al., 2025) Breastfed children exhibit lower morbidity and mortality rates from infectious diseases over a prolonged period. Moreover, a growing body of evidence indicates that breastfeeding exerts a protective effect against overweight and obesity, allergies, diabetes, and other chronic diseases later in life. Breastfeeding may also be associated with a reduced prevalence of malocclusion and with higher intelligence scores compared with shorter durations of breastfeeding or its complete absence. (Froń & Orczyk-Pawłowicz, 2024) Furthermore, breastfeeding confers substantial health benefits for the mother. Evidence indicates that lactation is associated with a reduced risk of postpartum haemorrhage, lower incidence of infectious complications, and a decreased prevalence of mood and sleep disturbances. In addition, breastfeeding has been linked to a reduced risk of ovarian and breast cancer. (Filardi et al., 2025) Previous research has identified factors such as preconception body mass index and the consumption of meals containing adequate amounts of protein, fatty acids, carbohydrates, and vitamins as determinants influencing breast milk composition and, consequently, offspring outcomes. (Bravi et al., 2016) Breast milk is a dynamic and personalized nutrition source. It is known that compared of breast milk is influenced by many factors as: maternal diet, lifestyle and environmental factors. All of them have impact on infant health. However, it remains to be clarified to what extent maternal physical activity both in terms of its occurrence and type affects the course of the postpartum period and the composition of breast milk in lactating women.

2. Methodology

This article is based on a narrative review of the literature. To identify the most relevant evidence, medical databases, including PubMed and Google Scholar, were systematically searched between January 2025 and 2026. The following keywords were used: breastfeeding, physical activity, exercise, obesity and adolescence. Both randomized controlled trials and observational studies were included in the analysis. Articles were eligible for inclusion if they addressed outcomes related to lactation, physical activity, and overweight or obesity in children and adolescents. Very small case reports and studies lacking data on clinical outcomes were excluded. The review primarily included publications from 2000 to 2025 that examined the association between physical activity undertaken by breastfeeding women and the subsequent risk of obesity in their offspring. Study selection was conducted independently by the authors through sequential screening of titles, abstracts, and full-text articles. Any discrepancies were discussed collectively until consensus was reached. The extracted data were subsequently organized and compared in order to present the most reliable evidence regarding the risk of obesity among breastfed offspring. Due to heterogeneity in study designs, models, and outcome measures across the identified studies, a quantitative meta-analysis was not performed. Instead, a descriptive synthesis is provided, highlighting the principal trends, areas of consistency, and existing gaps in the current body of evidence.

3. How Maternal Exercise During Breastfeeding impact on Childhood Obesity

3.1 The Impact of Physical Activity on Breastfeeding

In accordance with the recommendations of the WHO, exclusive breastfeeding is recommended during the first six months of an infant's life. This practice has been demonstrated to exert beneficial effects in the prevention of childhood obesity, excessive adiposity, and non-communicable diseases (NCD) later in life. (World Health Organization, 2026) Moreover, breast milk supports the proper growth and development of the respiratory system. (Dieterich et al., 2013) Therefore, it is important to investigate how physical activity influences the composition of human milk and the breastfeeding process itself. According to the recommendations of the American College of Obstetricians and Gynecologists, engagement in regular aerobic exercise by breastfeeding women may have beneficial effects on the maternal cardiovascular system without adversely affecting milk production, milk composition, or infant growth. (Birsner & Gyamfi-Bannerman, 2015) (Jones et al., 2025) During engagement in physical activity, breastfeeding women should ensure adequate intake of food and fluids. In addition to energy expenditure associated with exercise, it is important to account for the approximately 450–500 kcal per day required to support lactation. (V. Calcaterra et al., 2025) Research indicates that engagement in physical activity during pregnancy, prior to the lactation period, positively influences the composition of breast milk. A study conducted by Aparicio et al. supports this hypothesis: the levels of pro- and anti-inflammatory cytokines in the colostrum of breastfeeding mothers who had engaged in physical activity before delivery were assessed. The findings demonstrated a reduction in the pro-inflammatory profile both in early milk and during later stages of lactation. (Aparicio et al., 2018) Additionally, it has been confirmed that the frequency and intensity of physical activity undertaken during pregnancy may influence the duration of breastfeeding. Data from a prospective cohort study involving 1,715 women demonstrated that after 12 months, as many as 71.8% of mothers who had engaged in physical activity during pregnancy were still breastfeeding. Furthermore, it was confirmed that mothers whose physical activity was of greater intensity exhibited higher levels of engagement in the breastfeeding process. (Nguyen et al., 2019) The results of a clinical study conducted by Be'er et al. indicate that engagement in moderate- to high-intensity physical activity does not significantly affect the macronutrient composition (fat, carbohydrates, and protein) of human milk, nor does it alter its energy content. In addition the volume of expressed milk remained unchanged. (Be'er et al., 2020) Adiponectin is one of the specific hormonal components of human milk and plays an important role in glucose and lipid metabolism. It is believed to support the metabolic development of infants and may protect against rapid weight gain in early childhood. (Young et al., 2018) An increase in adiponectin levels in human milk was confirmed in a randomized crossover study, which demonstrated higher hormone concentrations in women engaging in high-intensity interval training compared with those who remained inactive. (Holmen et al., 2023) Other components present in human milk that positively influence neonatal health are human milk oligosaccharides (HMOs). Although their concentrations are known to be affected by various maternal factors, research has shown that physical activity exerts a positive effect on their levels in breast milk. (Biddulph et al., 2023) Although interest in research on the microbiota is increasing, there remains a lack of studies that comprehensively describe the impact of physical activity on the gut microbiota of breastfeeding women and on the composition of their breast milk. However, several studies have documented a positive effect of physical activity on bacterial diversity and richness. (Cataldi et al., 2022) Furthermore, some evidence supports the theory of active migration of gut bacteria to the mammary glands

via an endogenous pathway. Consequently, the positive modulation of the microbiota through exercise may indirectly exert beneficial effects on the composition of human milk. (Bianco et al., 2024) Although the positive effects of physical activity on breastfeeding have been relatively well studied, it should be noted that activity levels often decline during lactation. In a study conducted by Cabrera-Domínguez et al., a significant reduction in daily physical activity was observed toward the end of pregnancy and during the lactation period. Importantly, the decline in overall physical activity was particularly associated with breastfeeding, and women in this group also reported lower levels of social support compared with the pregnancy period. (Cabrera-Domínguez et al., 2022a)

3.2 The Relationship Between Breastfeeding and Childhood Obesity

Undoubtedly, breastfeeding confers both short- and long-term benefits for both the infant and the mother. (Filardi et al., 2025) This practice is widely recognized as playing a key role in the optimal development of the newborn. The composition of human milk dynamically changes throughout lactation, adapting to the evolving needs of the infant. Breast milk provides adequate energy and delivers bioactive factors that promote somatic growth, regulate postnatal intestinal function, enhance immune protection, and support brain as well as metabolic development. (Martin et al., 2016; Nyquist et al., 2022) Moreover, compared with infant formula, human milk differs in its content of fat, protein, vitamins, and minerals. Infant formula contains higher levels of cholesterol and protein compared with human milk. (Z. Yang et al., 2022) Research indicates that higher protein intake during infancy is associated with an increased likelihood of excessive weight gain and the subsequent development of obesity, which does not support the feeding of infants with formula milk. (Koletzko et al., 2005) The recommendations of the WHO clearly state that exclusive breastfeeding for the first six months of life is the most optimal form of infant nutrition. Studies conducted on a Swedish group of children and adolescents confirm that breastfeeding for more than six months has no effect on the risk of overweight or obesity among those surveyed up to the age of 16. (Haahr Vad et al., 2025) However, statistical data indicate that only 44% of infants worldwide are exclusively breastfed. (Victora et al., 2016) According to conducted studies, breastfeeding during the first 1,000 days of life reduces the risk of childhood obesity by influencing the modulation of factors that are typically involved in this process. (Pietrobelli & Agosti, 2017) Additional studies confirm that breastfeeding is inversely correlated with the rate of weight gain and body mass index (BMI). A 13% reduction in the risk of overweight and obesity has been observed among breastfed children, and a breastfeeding duration exceeding four months may contribute to lower BMI values at six years of age. (V. Calcaterra et al., 2025)

The precise mechanisms by which breastfeeding may confer protection against the development of obesity in later life remain incompletely elucidated. Nevertheless, it is postulated that these effects may be mediated by bioactive constituents of human milk and their regulatory influence on gene expression. (Carr et al., 2021) Human milk is considered one of the most miRNA-rich human body fluids. Numerous studies indicate that miRNA molecules present in breast milk influence the regulation of adipogenesis and may protect against the premature commitment of the adipogenic lineage. (Golan-Gerstl et al., 2017) Additionally, human milk contains hormones involved in the regulation of appetite and energy homeostasis, which play a pivotal role in metabolic health, including adiponectin, leptin, and ghrelin. (Zheng et al., 2024) The protective effect of breastfeeding against the risk of developing obesity may be mediated through methylation of the LEP gene. Studies have demonstrated that expression of the LEP gene suppresses hunger and contributes to the prevention of obesity, and prolonged methylation enhancing the expression of this gene has been associated with longer durations of breastfeeding. (Sherwood et al., 2019) It is hypothesized that the epigenetic modifications induced by breastfeeding may be mediated through the modulation of genes associated with fat mass and obesity (FTO), the retinoid X receptor alpha (RXRA), and the peroxisome proliferator-activated receptor gamma (PPAR- γ). Studies have shown significantly lower expression levels of the FTO gene in breastfed infants compared to those fed with formula. The FTO gene is well recognized for its interindividual variability and its strong correlation with obesity. (Cheshmeh et al., 2020) Conversely, other studies aimed at investigating the effects of human milk and its bioactive compounds on the regulation of RXRA and PPAR- γ genes have shown that prolonged breastfeeding is favorably correlated with reduced activity of these genes, whose expression is associated with an increased risk of obesity. (V. Calcaterra et al., 2025) Furthermore, a cross-sectional study designed to investigate the hypothesis of an interaction between breastfeeding and a genetic risk score (GRS) for obesity demonstrated that breastfeeding for longer than four months was associated with lower BMI values among adolescents. (Baxevanis et al., 2025) Therefore, breastfeeding may exert a preventive effect against the development of obesity in children who possess a specific genetic profile conferring an increased risk for this condition.

However, the benefits of breastfeeding in preventing the future risk of obesity are not solely attributable to epigenetic modulation of obesity-related genes. They also include, for example, the opportunity for the

infant to learn self-regulation in milk intake during breastfeeding, as compared to bottle feeding. (Brown & Lee, 2012) Moreover, it has been observed that breastfed infants are more likely to consume fruits and vegetables and exhibit less selective eating behavior, resulting in an overall healthier diet compared to their peers who are fed with formula. (Kim & Shin, 2023) Furthermore, it has been shown that children breastfed for the first six months of life exhibited a lower preference for sugar-containing foods. (Yelverton et al., 2021) Another study indicates that breastfeeding may also contribute to the proper establishment of circadian rhythms in infants, which are not yet fully developed at birth. (Olejniczak et al., 2023) This may be attributed to the fact that human milk contains relatively high levels of tryptophan, which acts as a signalling molecule in the regulation of biological rhythms in breastfed infants. In addition researchers have observed that circadian rhythmicity of body temperature emerges earlier in breastfed infants, which may further facilitate the earlier establishment of stable circadian regulation. (Sánchez et al., 2013)

Finally, the impact of human milk on the infant microbiota constitutes an additional, yet highly significant, aspect requiring consideration. A substantial body of evidence indicates that breastfeeding represents a principal determinant in shaping the composition and development of the infant gut microbiota. Notably, higher abundances of *Bifidobacterium* species have consistently been reported in breastfed infants compared with those receiving formula. (Odiase et al., 2023) This observation may, in part, be attributed to the practice of early and sustained skin-to-skin contact, routinely implemented immediately after birth, during initial colostrum feedings, and throughout the course of breastfeeding. Moreover, human milk contains a diverse array of probiotic microorganisms that actively contribute to the colonization and maturation of the infant gastrointestinal tract. (Notarbartolo et al., 2022)

4. Summary and conclusions

The present review of the available literature unequivocally underscores the substantial role that breastfeeding may play in determining the long-term health outcomes of infants. Although the precise biological mechanisms through which the bioactive constituents of human milk exert their effects on the infant organism have not yet been fully elucidated, the current body of evidence supports the conclusion that breastfeeding is superior to formula feeding in terms of health benefits. An important consideration is that the diet of a lactating mother directly influences the composition of human milk and its bioactive constituents. Evidence suggests that a protein-rich maternal diet may increase both milk volume and lactose content, whereas carbohydrate intake appears to be associated with an increased presence of certain amino acids in human milk. (Öner Sayar & Köseoğlu, 2025) Future research should seek to examine these correlations in larger study populations and aim to elucidate the mechanisms through which modulation of the maternal diet during lactation might contribute to the prevention of non-communicable diseases in offspring later in life. In addition to diet, an adequate amount of rest and sleep constitutes an essential component of maintaining optimal health. Evidence clearly indicates that women during lactation engage in physical activity less frequently, primarily due to reduced sleep duration and limited social support. (Cabrera-Domínguez et al., 2022b) It is also noteworthy that maternal psychological well-being exerts a decisive influence on the duration of breastfeeding. Therefore, providing adequate psychological and social support to mothers during this period is of paramount importance. (Vargas-Pérez et al., 2025)

A considerable body of research suggests that engagement in physical activity during lactation confers substantial health benefits to both the mother and the infant, without adversely affecting either the composition or the availability of human milk. Although physical activity is highly important during postpartum recovery and the puerperium, it does not constitute an easily implemented component of daily life for breastfeeding mothers. Accordingly, the promotion of physical activity throughout the breastfeeding period appears to be of particular importance, as it may further potentiate the preventive effects of breastfeeding against the development of obesity in later life.

The evidence gathered so far clearly shows the benefits of physical activity for breastfeeding women and provides indirect insight into the mechanisms through which breastfeeding may attenuate the risk of overweight and obesity in offspring later in life. Nonetheless, further large-scale, well-designed studies are warranted to precisely delineate the optimal duration of breastfeeding, the most appropriate maternal dietary patterns during lactation, and the type, frequency, and intensity of maternal physical activity that would most effectively contribute to minimizing the risk of overweight, obesity, and other non-communicable diseases in offspring in the long term.

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