PAWŁOWSKI, Bartosz, MADEJ, Aleksandra, HACZKUR-PAWŁOWSKA, Karolina, JASIŃSKI, Kacper, KOWAL, Alicja, MALCZEWSKA, Julia, FISZER, Kornelia, ŁOMŻA-ŁABA, Aleksandra, DZIURDA, Stanisław and JAMA, Grzegorz. The role of physical activity, diet, and stress management in maternal and infant health during pregnancy. Quality in Sport. 2024;27:55224 eISSN 2450-3118.
https://dx.doi.org/10.12775/QS.2024.27.55224
https://apcz.umk.pl/QS/article/view/55224

The journal has had 20 points in Ministry of Higher Education and Science of Poland parametric evaluation. Annex to the announcement of the Minister of Higher Education and Science of 05.01.2024. No. 32553.
Has a Journal's Unique Identifier: 201398. Scientific disciplines assigned: Economics and finance (Field of social sciences); Management and Quality Sciences (Field of social sciences).
Punkty Ministerialne z 2019 - aktualny rok 20 punktów. Załącznik do komunikatu Ministra Szkolnictwa Wyższego i Nauki z dnia 05.01.2024 r. Lp. 32553. Posiada Unikatowy Identyfikator Czasopisma: 201398.
Przypisane dyscypliny naukowe: Ekonomia i finanse (Dziedzina nauk społecznych); Nauki o zarządzaniu i jakości (Dziedzina nauk społecznych).

The authors declare that there is no conflict of interests regarding the publication of this paper.
Received: 15.09.2024. Revised: 08.10.2024. Accepted: 19.10.2024. Published: 23.10.2024.

The role of physical activity, diet, and stress management in maternal and infant health during pregnancy

Bartosz Pawłowski, Aleksandra Madej, Karolina Haczkur-Pawłowska, Kacper Jasiński, Alicja Kowal, Julia Malczewska, Kornelia Fiszer, Aleksandra Łomża-Łaba, Stanisław Dziurda, Grzegorz Jama

Bartosz Pawłowski
University Clinical Hospital No. 4 in Lublin Doktora Kazimierza Jaczewskiego Street 8, 20-954 Lublin
Email: bartek4245@gmail.com
ORCID: https://orcid.org/0009-0009-3515-1777

Aleksandra Madej
Department of Clinical Physiotherapy, Medical University of Lublin
Email: aleksandramadej09@gmail.com
ORCID: https://orcid.org/0009-0001-8818-2886

Karolina Haczkur-Pawłowska
University Clinical Hospital No. 4 in Lublin Doktora Kazimierza Jaczewskiego Street 8, 20-954 Lublin
Email: karolinahaczkur@gmail.com
ORCID: https://orcid.org/0009-0009-0120-1780

Kacper Jasiński
Department of Epidemiology and Methodology of Clinical Research, Medical University of Lublin
Email: kacperjasinski433@gmail.com
ORCID: https://orcid.org/0009-0003-3345-2337

Alicja Kowal
Department of Clinical Physiotherapy, Medical University of Lublin
Email: alicjakowal2000@gmail.com
ORCID: https://orcid.org/0000-0003-0203-1743

Julia Malczewska
Department of Internal Medicine, Endocrinology and Diabetology, Stefan Cardinal Wyszyński Provincial Specialist Hospital Independent Public Health Care Institution in Lublin
Email: studialek2127@gmail.com
ORCID: https://orcid.org/0009-0009-8559-0372

Kornelia Fiszer
Department of Rehabilitation and Orthopaedics, Medical University of Lublin
Email: kornelafisz1@wp.pl
ORCID: https://orcid.org/0009-0005-3879-2853

Aleksandra Łomża-Łaba
Provincial Specialist Hospital in Lublin
Al. Kraśnicka 100
Email: aleksandra.lomza98@gmail.com
ORCID: https://orcid.org/0009-0007-0225-8100

Stanisław Dziurda
Independent Public Complex of Health Care Facilities in Wyszków
Email: dzstasio@gmail.com
ORCID: https://orcid.org/0000-0003-3884-9264

Grzegorz Jama
Clinical Regional Hospital No. 2 named after St. Hedwig of Anjou in Rzeszów Lwowska Street 60, 35-301 Rzeszów
Email: grzegorzjama@gmail.com
ORCID: https://orcid.org/0009-0004-8108-5428

ABSTRACT

Introduction and aim of the study: During pregnancy, significant physiological, hormonal and circulatory changes occur that affect both the health of the mother and the child. Therefore, it is important for the mother to maintain physical activity, a healthy diet, and reduce stress to prevent complications and health problems for the mother and the child.

Material and Methods: The Pubmed database was searched. The criteria for qualifying the article for the review were the following keywords: pregnancy, exercise, rehabilitation, nutrition during pregnancy, postpartum depression, atopy, stress, asthma. 30 articles from 2002-2023 were analyzed.

Description of the state of knowledge: Regular physical activity during pregnancy brings many benefits such as reducing the risk of complications during childbirth, postpartum depression and helps to maintain a healthy body weight. Diet also has an impact on the health of both mother and baby. It should be balanced, providing the necessary nutrients and taking into account the mother's caloric needs. It is very important to reduce stress due to its negative impact on the mother and child.

Summary: Physical activity and a healthy diet directly affect the course of pregnancy and the health of the fetus and baby. Exercise prevents pregnancy complications and other diseases, and maternal nutritional status is critical for fetal growth. During pregnancy, women are exposed to stress, which can be the cause of chronic mental disorders. Depression is the most common mental illness that occurs during pregnancy, which is influenced by various factors.

In addition, maternal stress has a negative impact on the child's health, potentially increasing the risk of a number of atopic and non-atopic diseases.

Key words: pregnancy, exercise, rehabilitation, nutrition during pregnancy, postpartum depression, atopy, stress, asthma.

INTRODUCTION

Pregnancy is characterized by significant physiological, social, and emotional changes that can have a multifaceted impact on maternal and fetal health. [8]

The first change observed during pregnancy is weight gain in the pregnant woman. According to the recommendations, in the case of a woman with a normal body weight (Body Mass Index (BMI) of 19 to 24 kg/m2), the weight gain during pregnancy (GWG - Gestational Weight Gain) should be between 11 and 16 kg. Physiological GWG is mainly due to the weight of the fetus, placenta, uterus, amniotic fluid, mammary gland, blood and adipose tissue. [12]

In addition, hormonal changes are important during pregnancy. On the one hand, there is an increase in the production of pre-existing hormones – mainly estrogens, progesterone and prolactin – and the main producing tissues are also changing. These hormones play an essential role in ensuring that pregnancy runs smoothly, and their levels evolve throughout pregnancy. [12]

Other changes that are observed in pregnant women concern the circulatory system and consist in a gradual increase in plasma volume by more than 40%, with a simultaneous slight increase in the mass of red blood cells. This results in a decrease in haemoglobin, haematocrit and red blood cell count in relation to plasma volume. In the face of these changes, the pregnant woman's body adapts the cardiovascular system by dilating peripheral vessels while reducing systemic vascular resistance and increasing cardiac output by about 40%. [12]

Other ailments that are often observed in pregnant women include the occurrence of swelling of the lower limbs, which is caused by an increase in venous pressure in the lower limbs, appearing as a result of the pregnant woman pressing on the inferior vena cava when lying down for a long time, and a decrease in venous flow to the heart and hypotension.

In addition, the expectant mother's oxygen demand increases by up to 20-30%, and increased levels of progesterone lead to increased respiratory rate and lung ventilation.
This condition is also often accompanied by quite common lower back pain (PLBP - Pregnancy-Related Low Back Pain) and pelvic pain (PP - Pelvic Pain). It can affect everyday activities such as walking, working, sleeping, mood, etc. Although most women recover within a month after giving birth, a significant percentage (5–8.5%) continue to complain of these complaints, even within 2 years after giving birth. Current research suggests that pregnancy-related PLBP and PP may be caused by mechanical factors, mainly related to weight gain and postural changes and shifts in the body's center of gravity forward. [5,12]

Aim of the study

The aim of the study was to analyze the current state of knowledge about the impact of physical activity during pregnancy on the health of the mother and child, the importance of diet and aspects related to the mental health of pregnant women.

Material and methods

A non-systematic review of the scientific literature was carried out, according to the keywords: pregnancy, exercises, rehabilitation, pregnancy nutrition, postpartum depression. The PubMed database was searched and 20 articles from 2018-2023 were analyzed. Review, quantitative and qualitative studies were qualified for the analysis. The criteria for qualifying records for the review were: title, abstract content and topics related to physical activity, nutrition and mental health in pregnant women and the negative impact of stress on the child.

State of the art description

Pregnancy and physical activity

Exercise is defined as a planned, structured activity performed to improve one or more elements of physical fitness. They are a key element of a healthy lifestyle, contributing to the prevention and treatment of many diseases. Pregnancy is a great time to start exercising, as it is associated with motivation to maintain or start a healthy lifestyle and an increased frequency of medical visits, which makes it easier to monitor the effects of physical exercise. [1]

Increased activity is recommended to women during pregnancy as a way to reduce the negative effects on the body that may take place and to optimize well-being by increasing beta-endorphins in the body, improving mood and sleep, as well as improving the quality of life,

which the World Health Organization has defined as "the subjective perception by an individual of his or her position in life in the context of culture and value systems, in which it lives, and in relation to its objectives, expectations, standards and concerns'. It is a concept that is complexly influenced by a person's physical health, mental state, personal beliefs, social relationships, and relationship with the essential characteristics of their environment. [4]

Exercise during pregnancy is also associated with other benefits, such as: reducing the incidence of hypertensive disorders, surgical deliveries, fetal macrosomia, prematurity, postpartum depression, promotes the maintenance of a healthy body weight during pregnancy and also after childbirth. [1] The literature indicates that just 140 minutes of moderate exercise per week can reduce the risk of gestational diabetes by 25%, and 180 minutes per week by up to 35%. [6] Exercise can also help prevent serious pregnancy-related disorders, such as preeclampsia (PE). Conditions that affect the quality of life of the mother, such as anxiety and prenatal depression, are also prevented. There was no association of exercise with an increased risk of miscarriage, preterm birth (PTB) or abnormal fetal growth (SGA - Small-for-gestational-age and LBW - Low Birth Weight). In the absence of contraindications, exercise during pregnancy is not associated with any particular risk. Given the exercise recommendation, most of the benefits described can be achieved by following current international guidelines. [1,6] Lack of adequate advice to pregnant women on this issue and concerns about the potential risks associated with exercise often contribute to the abandonment or refusal to exercise during this period. [1]

When deciding on the intensity of exercise, you should always take into account the previous fitness level of the individuals. Women who had an active lifestyle before pregnancy may be advised to exercise at a moderate intensity, while women who have previously been sedentary should start their exercise program with low-intensity exercise and then gradually increase it. [1]

There are many sports and types of physical activity that are recommended for pregnant women. These include both calmer exercises, such as stretching, walking, swimming, as well as sports that require more effort. Indoor cycling, aerobic dance, resistance exercise with light weights, and water aerobics are recommended. With the above-mentioned disciplines, it is important to remember to avoid contact classes, which have an increased risk of injury. It is important to approach exercises in a supine position carefully, avoiding long training periods, especially in the first trimester of pregnancy. [1]

Yoga is a frequently used element of therapy. It is a practice of mind, body and spirit, combining physical postures, relaxation and breathing techniques. It has been adapted to the

needs of the pregnant woman's body and is a common form of physical activity used by pregnant women and recommended by health professionals. Research suggests that yoga during pregnancy is safe, feasible, and acceptable, and may be more beneficial than walking and standard exercise, for both physical and mental health. It is also believed to provide pregnant women with an opportunity to improve their well-being and connect with their baby. Two randomized control studies on yoga during pregnancy report that it reduces levels of pain, stress, anxiety, and depression. It was found that yoga classes during pregnancy resulted in improvements in stress levels, quality of life (QoL), autonomic nervous system function, and birth parameters such as comfort, pain, and duration. **[8]**

Another type of exercise that is worth paying attention to is Pilates. Internationally, Pilates is considered an activity that improves physical, mental and motor functions. Such training involves a series of calm exercises that build strength and flexibility of the whole body. During the class, it is very important to adopt the correct breathing technique, which helps to activate the deep stabilizing muscles, especially the transverse abdominal muscles. [3]

Diet during pregnancy

In recent years, there has been a global increase in the number of obese people, which has many serious health consequences. Nutrition and maternal lifestyle before and during pregnancy, lactation, infancy and early childhood have been shown to have a long-term impact on the child's later health. Maternal nutrition can contribute to the onset of common non-communicable diseases such as diabetes, obesity and cardiovascular disease in the baby, and to insufficient gestational weight gain (GCD). This is associated with an increased risk of newborns being born with low birth weight and infants small in relation to gestational age and the appearance of cardiovascular and metabolic disorders in the future of the child's life. On the other hand, excessive GWG increases the likelihood of fetal macrosomia. [7, 9, 10, 14]

It is also assumed that focusing on health and taking care of a balanced diet should take place even before conception. Thanks to this, there is a good chance of creating the right conditions for the development of the embryo and fetus in the woman's body. Many women and adolescent girls are poorly nourished due to an improper or unbalanced diet, leading to underweight, overweight/obesity, and micronutrient deficiencies. In their research, K. Ługowska and W. Kolanowski described the eating behavior of pregnant women in Poland. The study included 815 women in their first pregnancy. They found that the subjects ate

excessive amounts of sweets and white bread and consumed insufficient amounts of fish, milk and fermented milk drinks. It is worth noting, however, that women with higher education were slightly more likely to use good eating practices. [11]

Numerous studies also show that a large proportion of women consume caffeine during pregnancy - in the USA it is about 70% of pregnant women, which confirms that it is the most widely consumed psychoactive substance in the world. It has also been proven that some women consume more than 300–500 mg of caffeine per day during pregnancy, which is equivalent to about three to five cups of 240 ml coffee per day. Although caffeine intake in adults has beneficial effects on e.g. neurological diseases (e.g. Parkinson's and Alzheimer's disease), cardiovascular disease (e.g. ischemic heart disease, stroke), certain cancers (e.g. prostate cancer, melanoma, liver cancer, breast cancer) and type 2 diabetes, there are also studies confirming that maternal caffeine consumption during pregnancy increases the risk of pregnancy failure or complications. However, it is important to note that the effects of caffeine on fertility and reproductive performance vary from person to person, due to individual health, genetics, and environmental factors. [16]

However, if nutrition before pregnancy is optimal, the balance of macronutrients in the diet does not have to change during pregnancy. At the beginning of pregnancy, the energy demand does not differ much from that before pregnancy. The focus should be on a healthy diet consisting of foods rich in essential nutrients, rather than increasing the amount of energy provided in the form of food. The concept of "eating for two" is a misconception that has no correct justification. For women with a normal BMI (<25 kg/m2), an increase in energy intake is only required later in pregnancy to cover the metabolic demand of the mother and the energy requirements of the growing fetus. International recommendations suggest that pregnant women increase their energy intake by about 85 kcal per day in the first trimester, 285 kcal per day in the second trimester, and 475 kcal per day in the third trimester. [9]

During pregnancy, the reference intake of certain micronutrients increases much more than the energy intake. Therefore, special attention should be paid to an adequate supply of micronutrients. Supplementation should mainly apply to people who avoid eating certain products, especially on a plant-based diet, and are more likely to be deficient. [9,13] Statistics say that about 20% to 30% of pregnant women worldwide suffer from deficiencies of vitamins A, E, C, B2, B1, calcium and zinc. [7, 15]

Pregnancy and mental health

Stress can be defined as the body's natural response to adverse situations that disrupt its homeostasis and balance. Expectant mothers must face many stressors, which often combined with insomnia, nausea, weight gain, can lead to mood and well-being disorders. [19] Motherhood for women is a breakthrough period in their lives, which often requires the acceptance of changes in their everyday life and lifestyle, directly affecting their psyche and body. [19, 20] Unfortunately, one in five women experience mental health problems before or after childbirth, which sometimes take the form of a chronic disorder. [18]

One of the most common mental disorders in expectant mothers is depression, which is diagnosed in up to 10% of pregnant women. It usually occurs in the first trimester, and the risk of its occurrence increases if the patient has experienced antenatal depression, miscarriages, family conflicts, as well as in the case of unwanted or unplanned pregnancies, a negative reaction from the partner or a lack of support from loved ones. [2, 18] Another important factor that can be aggravating for pregnant women is the socioeconomic context: low income, domestic violence, drug and alcohol use. [12] Depression most often affects women from high-income countries and is often the cause of suicide among expectant mothers. [17]

The impact of stress on the child

Not only the mother is exposed to stress during pregnancy. It is also worth mentioning the increased risk of premature birth, low birth weight and negative impact on the period after birth. [21, 22] More and more attention is paid to the relationship between stress in the prenatal period and the risk of atopy and asthma in childhood. [23, 24, 25] It is also important to have an impact on the occurrence of non-atopic diseases - respiratory, digestive, skin diseases, and even an increase in the frequency of indications for antibiotic therapy [26]. It is suspected that the above-mentioned negative effects of stress arise as a result of excessive activation of the hypothalamic-pituitary-adrenal (HPA) axis, which leads to changes in the intrauterine environment. Ultimately, these changes disrupt the child's HPA, autonomic system and immune system development. [27, 28, 29, 30]

Summary

1. Physical activity is highly effective in preventing pregnancy complications and other diseases.
2. Physical exercise does not increase the risk of miscarriages and pregnancy complications.
3. The intensity of exercise during pregnancy depends on the degree of physical activity of women before pregnancy.
4. There are many sports and types of physical activity that are suitable for pregnant women.
5. The mother's nutrition directly affects the development of the fetus and the risk of disease in the child after birth.
6. The health of the child is influenced by a woman's diet even before conception. Improperly balanced nutrition has a negative impact on the course of pregnancy.
7. Despite the adverse effects of caffeine in pregnant women, coffee consumption during pregnancy is still common.
8. During pregnancy, you should follow a balanced and wholesome diet.
9. The caloric demand increases gradually. It reaches its highest value only in the third trimester of pregnancy.
10. During pregnancy, women are exposed to stress, which can be the cause of chronic mental disorders.
11. The most common mental disorder in pregnant women is depression, which is influenced by a variety of factors.
12. Stress also has a negative impact on the child in the prenatal and postnatal period
13. This impact can be seen in the form of an increased risk of various diseases in the child.

Disclosure

Authors do not report any disclosures.

Author's contribution

All authors contributed to the article.

Conceptualization: Pawłowski B, Madej A, Kowal A;

Methodology: Madej A, Haczkur-Pawłowska K, Jasiński K, Jama G, Malczewska J;

Software: Pawłowski B, Haczkur-Pawłowska K, Łomża-Łaba A , Jama G, Fiszer K;
Formal analysis: Madej A, Haczkur-Pawłowska K, Kowal A;
Investigation: Pawłowski B, Madej A, Haczkur-Pawłowska K, Łomża-Łaba A;
Resources: Pawłowski B, Madej A, Łomża-Łaba A, Jama G, Malczewska J;
Data curation: Madej A, Dziurda S, Jama G , Malczewska J;
Writing - rough preparation: Pawłowski B, Madej A, Dziurda S, Kowal A, Fiszer K;
Writing - review and editing: Jama G, Madej A, Haczkur-Pawłowska K, Jasiński K, Dziurda S, Jama G;
Visualization: Pawłowski B, Madej A, Haczkur-Pawłowska K, Jasiński K, Łomża-Łaba A, Fiszer K;
Supervision: Pawłowski B, Madej A, Dziurda S, Łomża-Łaba A, Malczewska J, Fiszer K;
Project administration: Pawłowski B, Haczkur-Pawłowska K, Kowal A, Jama G, Fiszer K;
All authors have read and agreed with the published version of the manuscript.

Funding statement
The study did not receive any external funding.

Institutional Review Board Statement
Not applicable.

Informed Consent Statement
Not applicable.

Data Availability Statement
Not applicable.

Acknowledgments
Not applicable.

Conflict of Interest Statement
The authors declare no conflict of interest

References:

1. Ribeiro MM, Andrade A, Nunes I. Physical exercise in pregnancy: benefits, risks and prescription. J Perinat Med. 2021 Sep 6;50(1):4-17. doi: 10.1515/jpm-2021-0315. PMID: 34478617.
2. Coll CVN, Domingues MR, Stein A, da Silva BGC, Bassani DG, Hartwig FP, da Silva ICM, da Silveira MF, da Silva SG, Bertoldi AD. Efficacy of Regular Exercise During

Pregnancy on the Prevention of Postpartum Depression: The PAMELA Randomized Clinical Trial. JAMA Netw Open. 2019 Jan 4;2(1):e186861. doi: 10.1001/jamanetworkopen.2018.6861. PMID: 30646198; PMCID: PMC6324311.

3. Ghandali NY, Iravani M, Habibi A, Cheraghian B. The effectiveness of a Pilates exercise program during pregnancy on childbirth outcomes: a randomised controlled clinical trial. BMC Pregnancy Childbirth. 2021 Jul 2;21(1):480. doi: 10.1186/s12884-021-03922-2. PMID: 34215198; PMCID: PMC8253242.
4. Rodríguez-Blanque R, Aguilar-Cordero MJ, Marín-Jiménez AE, Menor-Rodríguez MJ, Montiel-Troya M, Sánchez-García JC. Water Exercise and Quality of Life in Pregnancy: A Randomised Clinical Trial. Int J Environ Res Public Health. 2020 Feb 17;17(4):1288. doi: 10.3390/ijerph17041288. PMID: 32079342; PMCID: PMC7068410.
5. Hu X, Ma M, Zhao X, Sun W, Liu Y, Zheng Z, Xu L. Effects of exercise therapy for pregnancy-related low back pain and pelvic pain: A protocol for systematic review and meta-analysis. Medicine (Baltimore). 2020 Jan;99(3):e17318. doi: 10.1097/MD.0000000000017318. PMID: 32011431; PMCID: PMC7220333.
6. Herzberger V, Bäz E, Kunze M, Markfeld-Erol F, Juhasz-Böss I. Exercise During Pregnancy. Dtsch Arztebl Int. 2022 Nov 18;119(46):793-797. doi: 10.3238/arztebl.m2022.0305. PMID: 36045499; PMCID: PMC9902891.
7. Martínez García RM, Jiménez Ortega AI, Peral Suárez Á, Bermejo López LM, Rodríguez-Rodríguez E. Importancia de la nutrición durante el embarazo. Impacto en la composición de la leche materna [Importance of nutrition during pregnancy. Impact on the composition of breast milk]. Nutr Hosp. 2021 Jan 13;37(Spec No2):38-42. Spanish. doi: 10.20960/nh.03355. PMID: 32993313.
8. Corrigan L, Moran P, McGrath N, Eustace-Cook J, Daly D. The characteristics and effectiveness of pregnancy yoga interventions: a systematic review and meta-analysis. BMC Pregnancy Childbirth. 2022 Mar 25;22(1):250. doi: 10.1186/s12884-022-04474-9. PMID: 35337282; PMCID: PMC8957136.
9. Koletzko B, Godfrey KM, Poston L, Szajewska H, van Goudoever JB, de Waard M, Brands B, Grivell RM, Deussen AR, Dodd JM, Patro-Golab B, Zalewski BM; EarlyNutrition Project Systematic Review Group. Nutrition During Pregnancy, Lactation and Early Childhood and its Implications for Maternal and Long-Term Child Health: The Early Nutrition Project Recommendations. Ann Nutr Metab.

2019;74(2):93-106. doi: 10.1159/000496471. Epub 2019 Jan 23. PMID: 30673669; PMCID: PMC6397768.

10. Aoyama T, Li D, Bay JL. Weight Gain and Nutrition during Pregnancy: An Analysis of Clinical Practice Guidelines in the Asia-Pacific Region. Nutrients. 2022 Mar 18;14(6):1288. doi: 10.3390/nu14061288. PMID: 35334946; PMCID: PMC8949332.
11. Huang LT. Maternal and Early-Life Nutrition and Health. Int J Environ Res Public Health. 2020 Oct 30;17(21):7982. doi: 10.3390/ijerph17217982. PMID: 33143058; PMCID: PMC7663172.
12. Jouanne M, Oddoux S, Noël A, Voisin-Chiret AS. Nutrient Requirements during Pregnancy and Lactation. Nutrients. 2021 Feb 21;13(2):692. doi: 10.3390/nu13020692. PMID: 33670026; PMCID: PMC7926714.
13. Brown B, Wright C. Safety and efficacy of supplements in pregnancy. Nutr Rev. 2020 Oct 1;78(10):813-826. doi: 10.1093/nutrit/nuz101. Erratum in: Nutr Rev. 2020 Sep 1;78(9):782. PMID: 31925443; PMCID: PMC7558284.
14. Moreno-Fernandez J, Ochoa JJ, Lopez-Frias M, Diaz-Castro J. Impact of Early Nutrition, Physical Activity and Sleep on the Fetal Programming of Disease in the Pregnancy: A Narrative Review. Nutrients. 2020 Dec 20;12(12):3900. doi: 10.3390/nu12123900. PMID: 33419354; PMCID: PMC7766505.
15. Mousa A, Naqash A, Lim S. Macronutrient and Micronutrient Intake during Pregnancy: An Overview of Recent Evidence. Nutrients. 2019 Feb 20;11(2):443. doi: 10.3390/nu11020443. PMID: 30791647; PMCID: PMC6413112.
16. Qian J, Chen Q, Ward SM, Duan E, Zhang Y. Impacts of Caffeine during Pregnancy. Trends Endocrinol Metab. 2020 Mar;31(3):218-227. doi: 10.1016/j.tem.2019.11.004. Epub 2019 Dec 6. PMID: 31818639; PMCID: PMC7035149.
17. Yelverton CA, Rafferty AA, Moore RL, Byrne DF, Mehegan J, Cotter PD, Van Sinderen D, Murphy EF, Killeen SL, McAuliffe FM. Diet and mental health in pregnancy: Nutrients of importance based on large observational cohort data. Nutrition. 2022 Apr;96:111582. doi: 10.1016/j.nut.2021.111582. Epub 2022 Jan 5. PMID: 35149320.
18. Perkovic R, Tustonja M, Devic K, Kristo B. Music Therapy and Mental Health in Pregnancy. Psychiatr Danub. 2021 Spring-Summer;33(Suppl 4):786-789. PMID: 34718319.
19. Alves AC, Cecatti JG, Souza RT. Resilience and Stress during Pregnancy: A Comprehensive Multidimensional Approach in Maternal and Perinatal Health.

ScientificWorldJournal. 2021 Aug 13;2021:9512854. doi: 10.1155/2021/9512854. PMID: 34434079; PMCID: PMC8382548.

20. Bush NR, Savitz J, Coccia M, Jones-Mason K, Adler N, Boyce WT, Laraia B, Epel E. Maternal Stress During Pregnancy Predicts Infant Infectious and Noninfectious Illness. J Pediatr. 2021 Jan;228:117-125.e2. doi: 10.1016/j.jpeds.2020.08.041. Epub 2020 Aug 19. PMID: 32827529; PMCID: PMC7752845.

21. Lima SAM, El Dib RP, Rodrigues MRK, Ferraz GAR, Molina AC, Neto CAP, et al. Is the risk of low birth weight or preterm labor greater when maternal stress is experienced during pregnancy? A systematic review and meta-analysis of cohort studies. PLoS One 2018;13:e0200594. [PMC free article] [PubMed] [Google Scholar]

22. Medsker B, Forno E, Simhan H, Celedon JC. Prenatal stress, prematurity, and asthma. Obstet Gynecol Surv 2015;70:773–9. [PMC free article] [PubMed] [Google Scholar]

23. van de Loo KF, van Gelder MM, Roukema J, Roeleveld N, Merkus PJ, Verhaak CM. Prenatal maternal psychological stress and childhood asthma and wheezing: a meta-analysis. Eur Respir J 2016;47:133–46. [PubMed] [Google Scholar]

24. Andersson NW, Hansen MV, Larsen AD, Hougaard KS, Kolstad HA, Schlunssen V. Prenatal maternal stress and atopic diseases in the child: a systematic review of observational human studies. *Allergy* 2016;71: 15–26. [PMC free article][PubMed] [Google Scholar]

25. Chan CWH, Law BMH, Liu YH, Ambrocio ARB, Au N, Jiang M, et al. The association between maternal stress and childhood eczema: a systematic review. Int J Environ Res Public Health 2018;15:395. [PMC free article] [PubMed] [Google Scholar]

26. Beijers R, Jansen J, Riksen-Walraven M, de Weerth C. Maternal prenatal anxiety and stress predict infant illnesses and health complaints. Pediatrics 2010;126:e401–9. [PubMed] [Google Scholar] [Ref list]

27. Merlot E, Couret D, Otten W. Prenatal stress, fetal imprinting and immunity. Brain Behav Immun 2008;22:42–51. [PubMed] [Google Scholar]

28. Van den Bergh BRH, van den Heuvel MI, Lahti M, Braeken M, de Rooij SR, Entringer S, et al. Prenatal developmental origins of behavior and mental health: The influence of maternal stress in pregnancy. Neurosci Biobehav Rev 2017. July 28 [Epub ahead of print]. [PubMed] [Google Scholar]

29. von Hertzen LC. Maternal stress and T-cell differentiation of the developing immune system: possible implications for the development of asthma and atopy. J Allergy Clin Immunol 2002;109:923–8. [PubMed] [Google Scholar]

30. Andersson NW, Li Q, Mills CW, Ly J, Nomura Y, Chen J. Influence of prenatal maternal stress on umbilical cord blood cytokine levels. Arch Womens Ment Health 2016;19:761–7. [PMC free article] [PubMed] [Google Scholar]