SYSTEMATIC DETAILS ABOUT NUTRITION SUPPLIMENTATION IN PREGNANT WOMEN

Shaik Asha Begum[1, 2*], Dr. T.Vinay Kumar[1], V. Sai Ramya[3], P.Bhanu[3], K.Sravya[3]

[1]Department of Pharmacy Practice, Nirmala College of Pharmacy, Atmakur, Mangalagiri, AP, India-522503

[2] Department of Pharmacy Practice, IPT, SPMVV, Tirupati.

[3]Pharm D students, Nirmala College of Pharmacy, Atmakur, Mangalagiri, AP, India-522503

Corresponding author:

Shaik Asha Begum

Assistant Professor

Nirmala college of Pharmacy

Atmakur, Mangalagiri, AP, India-522503

Email id: sk.asha86@gmail.com

ABSTRACT:

Nutrition is very important in the body since it aids in growth and development. Prenatal nutrition is critical for the baby's healthy growth and development. Both the mother and the foetus require high-quality meals, as well as micro and macro nutrients. Fruits, vegetables, a low-fat diet, and dairy are all important for a child's birth weight. Deficiencies arise as a result of the increased demand for energy and nutrients by both the mother and the child during pregnancy. Vitamins play an important role in the body, although hypovitamnosis is common among pregnant women. Vitamin D is crucial for the mother's health as well as the children's long-term health. Calcitrol is the active and hormonal metabolite of vitamin D. Low vitamin B12 levels during pregnancy put the offspring's metabolism at danger. In the first trimester, maternal consumption of milk, fresh fruits, and nuts acts as a protective factor, reducing neural tube abnormalities. Maternal nutrition also plays a role in the risk of future hypertension in the offspring. The provision of folic acid and docosahexaenoic acid (DHA) in micronutrient supplementation has been shown to improve pregnancy and newborn outcomes. Micronutrient supplementation improves the outcomes of pregnant women with preeclampsia, eclampsia, and anaemia. Iron supplementation increases a child's birth weight and aids in the growth and development of the baby's brain. Low birth weight is less likely when omega 3 fatty acids are consumed. Vitamin D, in conjunction with calcium, aids in the development of children's bones and teeth. Calcium supplementation during pregnancy can assist to minimise the risk of preeclampsia. For proper growth and development, sulphate is a necessary nutrient. Because the developing foetus has a lower capacity for sulphur generation, sulphataemia occurs in pregnant women. Sulphataemia is controlled by the maternal kidneys and supplies a sulphate reservoir for the developing foetal' gestational demands. Reduced sulphate levels in pregnant women cause sulphate deficiency in the foetus, which results in the foetus' mortality. Fish has various nutrients that aid in the development of a healthy foetus, and it is also crucial to consume seafood that are low in mercury because fish can be polluted with heavy metals.

Key words: Foetal development, Supplements, Pregnant Woman, Low birth weight

Introduction :

According to the developmental origins of fitness and disorder hypothesis, maximum situations that arise in maturity originate in foetal lifestyles.(1) Pregnancy is a especially Bhot period for the programming of destiny condition(2). The healthful consuming and bodily lively fashion of lifestyles is promoted to save you immoderate gestational weight gain (GWG).Micronutrients and macronutrients play a major function withinside the improvement of the foetus. Calcium facilitates to construct robust bones and teeth. Iron facilitates purple blood cells to supply oxygen to the baby. Vitamin A for healthful skin, eyesight, and bone growth. Vitamin C Promotes healthful gums, teeth, and bones, and facilitates your frame take in iron. Vitamin D facilitates withinside the absorption of calcium to assist construct your baby’s bones and teeth. Vitamin – B6 Helps to shape purple blood cells and facilitates your frame use protein, fat, and carbohydrates. Vitamin B12 Helps shape purple blood cells and continues your fearful system. Folic acid performs a chief function with

ISSN: 0975-3583, 0976-2833 VOL 12, ISSUE 04, 2021

inside the manufacturing of blood and protein and decreases the threat of neural tube defects. Fish may be a top notch supply of protein, omega-three fatty acids, and different healthful nutrients.(3)

Methods :

A complete assessment of the literature become undertaken through the digital databases PubMed, Cochrane Library, and Medline. The maximum current systematic opinions and meta-analyses have been used to seize records from epidemiological and RCTs, with any next research posted after the systematic opinions additionally blanketed. Reviews have been to begin with looked for the usage of the quest keywords "omega three fatty acids birth weight small for gestational age being pregnant"; "zinc birth weight small for gestational age being pregnant"; "iron birth weight small for gestational age being pregnant"; "folate birth weight small for gestational age being pregnant"; "calcium birth weight small for gestational age being pregnant"; "nutrition D birth weight small for gestational age being pregnant"; and "food plan birth weight small for gestational age being pregnant". Articles have been confined to human research posted in English, and articles have been blanketed in which they furnished records approximately food plan and nutrients throughout being pregnant and the birth weight consequences of the foetus. Outcomes focussed on low start weight (LBW: ninetieth percentile for gestational age); and macrosomia (>4000 g at start). Key mechanistic research have been blanketed to focus on the significance of various vitamins throughout being pregnant and switch thru the placenta. Supporting animal research have been blanketed in which there has been a loss of human research at the outcomes of maternal under over nutrition.

Role of sulphate in pregnancy:

The conjugation of sulphate (sulphonation) to sure endogenous molecules, inclusive of steroids (e.g., oestrogens) and thyroid hormone ends in their inactivation.(4,5).The ratio of sulphonated(Inactive) to unconjugated (active) harmones play a first-rate function in modulating endocrine feature, and consequently foetal and maternal body structure at some point of being pregnant(6) . Certain foods, inclusive of brassica veggies and industrial breads incorporate a excessive sulphate content material (>0.nine mg/g), while low sulphate ranges.(7) Oral dietary supplements of ferrous sulphate (a hundred mg $FeSO_4$ in line with tablet in line with day, ≈sixty three mg sulphate in line with tablet) are prescribed to deal with iron deficiency anaemia in being pregnant. However, ferrous sulphate may be annoying to the gastrointestinal tract(8). Magnesium sulphate is likewise used for seizure prevention in preeclampsia or eclampsia, in addition to a tocolytic agent, being administered i.v. to girls quickly earlier than preterm birth (nine).Protien consists of sulphate containing amino acids cysteine and methionine(10) . The day by day consumption of encouraged quantity of protein consumption in being pregnant is 0.8-1.2g/kg. The sulphate this is generated from the protein is about 1.7g/kg (11). In loose inorganic sulphate (SO_4^{2-}) is the fourth maximum ample anion in circulation (about three hundred μmol/L)(12). a twofold boom in plasma sulphate ranges in pregnant girls (13,14). Sulphonated proteoglycans are crucial componenets of extracellular matrices of the connective tissue at some point of the body.(15,16). The sulphate content material of proteoglycans affects mobileular signalling feature and the structural integrity of tissues.(17). Highly sulphonated glycoproteins, inclusive of chondroitin proteoglycan (CSPG), play critical roles withinside the growing skeleton, with hyperlinks to modulation of the Indian Hedgehog signalling pathway (18). A enough deliver of sulphate, both from the weight loss plan or from the sulphur-containing amino acids, desires to be provided from mom to foetus, in particular in past due gestation while foetal needs for sulphate are excessive.

ROLE OF POLY SATURATED ACIDS:

Polyunsaturated fatty acids are important vitamins throughout being pregnant and lactation, due to their position in mind and visible improvement. Docohexasoic acid is vital fatty acid consumption throughout being pregnant. Linoleic acid (LA) and Alpha linoleic acid (ALA) . AA and DHA are taken into consideration the maximum vital metabolic merchandise of LA and ALA (19). Arachionoic acid and docohexasoic acid are the structural additives of the phospholipids of moleular membrane (20). Docosahexaenoic acid (DHA) is nearly completely found in a excessive attention in membrane phospholipids of cells from the relevant apprehensive gadget (neurons and glial cells) (21). The better charge of AA and DHA accretion takes place throughout the 0.33 trimester of being pregnant and the primary years after delivery (22). Maternal DHA supplementation throughout being pregnant effects in better rankings on visible and neurocognitive exams in youngsters at 365 days of age (23). DHA improves the early improvement of the visible acuity and different neurodevelopmental indicies . (24) Fetal metabolic call for of DHA will increase throughout boom withinside the final trimester of being pregnant, being the duration wherein DHA accretion to the fetal mind and apprehensive gadget reaches its most speed (25). Maternal DHA necessities are extended in reaction to the enlargement of crimson mobileular mass and placenta and for the accomplishment of the DHA desires of pregnant women (26).

VITAMIN D SYNTHESIS AND METABOLISM:

UVB radiation from daylight initiates nutrition D (VD) biosynthesis withinside the pores and skin with the aid of using bioconverting 7-dehydrocholesterol to previtamin D3, that's thermally isomerized to VD3. The dietary varieties of VD consist of each VD3 (cholecalciferol) from animal starting place and VD2 (ergocalciferol) from fungi and plant starting place. Once fashioned withinside the pores and skin or absorbed withinside the intestine, VD is launched into the move and transported with the aid of using the VD-binding protein (DBP) to the liver, wherein it's far transformed with the aid of using the VD-25-hydroxylase (CYP2R1) into 25-hydroxyvitamin D (calcidiol, 25OHD). (27,28)During pregnancy, massive modifications in maternal serum calcitriol, DBP and placental VDR take area and engage to gather greater calcium for ok fetal bone mineralization (for a latest evaluation see Brannon PM and Picciano MF [29]). Indeed, the fetus can also additionally acquire as much as 30 g of calcium at term, and to meet this demand, VD metabolism is boosted with a purpose to growth calcium intestinal absorption [30]. During pregnancy, serum calcitriol rises from the primary trimester, doubling its attention as compared to non-gravid ladies with the aid of using the cease of the 0.33 trimester and returning to regular values after delivery [31,32,33.,34.,35,36].

FISH:

Fish is a supply of numerous vitamins which can be critical at some stage in being pregnant for healthful foetal improvement along with iodine, lengthy chain omega-three polyunsaturated fatty acids (LCn-3PUFAs), and nutrients A, D and B12.1. . Recent research imply that pregnant ladies lack enough know-how concerning the significance of iodine and LCn-three PUFAs vitamins which can be found in fish and seafood.(37,38).

Iron:

Dietary iron necessities throughout being pregnant boom because of the enlargement of pink mobileular mass to deal with fetal and placental growth, and to permit for the blood loss that happens at delivery. Increased nutritional iron necessities are hard to gain via weight-reduction plan alone, and starting being pregnant with already low intakes will increase the probability of effects which include preterm start and LBW [39,40]. Thus, the superiority of iron deficiency (with and with out anemia) is stated to boom throughout every trimester [41,42]. y amongst 1274 pregnant ladies elderly 18–forty five years from the UK, it turned into observed that for each 10 mg boom in nutritional iron intake, fetal birthweight turned into expected to boom with the aid of using 70 g (95% CI: 10, 130; $p = 0.02$). A latest overview of 25 observational research found out anemia (described as Hb < a hundred and ten g/L) throughout being pregnant expanded the chance for LBW (OR 1.25; 95% CI: 1.08, 1.25) in comparison to non-anemic ladies (Hb ≥ a hundred and ten g/L); however, while inclusive of simplest the 9 research with adjusted estimates, this turned into now not significant (aOR 1.13; 95% CI: 0.94, 1.35) [43]. Interestingly, there has been a 30% expanded chance for LBW while anemia befell throughout the primary trimesters of being pregnant in comparison to the very last trimester.Iron deficiency is the main cause for the . ron deficiency anaemia is the most common type of anaemia that arises during pregnancy.The apparent increased risk of anaemia during pregnancy is complicated by the expansion of plasma volume around six weeks into the pregnancy [44]. Even before it manifests as anaemia, iron deficiency affects both mother and child [44], with cognitive impairment, lower physical activity, impaired immunity, and probably more subtle abnormalities in the mother. This reduces the mother's ability to manufacture haemoglobin and transport oxygen due to an iron deficit. In pregnancy, iron shortage should be avoided; iron supplementation and increasing iron storage in the third trimester have been associated to maternal problems.

FOLATE:

Folate necessities are elevated in the course of being pregnant because of the call for of fetal growth [90d it's far presently encouraged that a four hundred µg/day folic acid supplementation is taken 3 months earlier than and early on in being pregnant [45,46,47] maternal RBC folate popularity regarded to be related to birthweight. Only 2 of 15 research said vast institutions among excessive or growing serum or plasma folate in the course of being pregnant and elevated birthweighT. whilst 1 take a look at confirmed a appreciably reduced danger of LBW with growing folate tiers withinside the 2nd trimester.

CALCIUM:

Calcium supplementation has been linked to a lower risk of pre-eclampsia, LBW, and pre-term birth [18]. The World Health Organization (WHO) now recommends 1.5 to 2.0 g of elemental calcium per day for pregnant women with low dietary calcium intakes because calcium supplementation during pregnancy reduces the incidence of gestational hypertension by 35%, pre-eclampsia by 52%–55%, and pre-term births by 24% (48). When compared to pre-conception or after delivery, calcium absorption and urine calcium excretion are roughly two-fold higher during pregnancy [49-51]. These alterations are visible at the conclusion of the first trimester and are available for the third trimester's peak foetal demands. Calcium is transferred across the placenta via an active transport process and is essential for skeletal development [52].

ZINC:

Zinc is required for optimal foetal development and growth [53]. In the United States, dietary zinc consumption should be increased from 8 mg per day in non-pregnant women to 11 mg per day during pregnancy [54]. The majority of the zinc is stored in the foetus and uterine muscle. Rather than increased rates of cellular oxidative damage, increased rates of apoptosis, or reduced binding of hormones and transcription factors dependent on zinc-finger regions, zinc deficiency is thought to affect embryonic and foetal development by reducing cell proliferation, protein synthesis, or tubulin polymerization rates [55,56]. The association of low plasma zinc concentrations in the first and third trimesters of pregnancy with respective increases in risk for deformities [57] and LBW [58] may support the idea that zinc deficiency is a teratogenic concern in humans. Increased maternal mortality, longer labour, preterm [59], and impaired foetal development [60] are all negative effects of maternal zinc insufficiency.(61)

CONCLUSION:

For proper growth and development, sulphate is an essential nutrient. Despite the fact that it is required for a variety of cellular and metabolic activities during foetal development. Decahexasonic acid is a essential fatty acid and it is the structural component of the membrane phospholipids and it helps in the development of the visual acuity and the neurodevelopmental indices.vitamin –d helps in the mineralization of the bones of the foetus. Fish consists of the nutrients like omega 3 poly unsaturated fatty acids which is essential for the development of the foetus. Iron is an essential element which is an important for the formation of the haemoglobin and its demand is increased during the pregnancy. Its deficiency leads to the risk of low birth weight. Folate is essential for the growth of the foetus. Zinc is essential for the normal growth and development its deficiency leads to tetragenocity and risk of the prolonged labour .calcium reduces the risk of pre-eclempsia and the low birth weight.

Conflicts Of Interest: The author expresses no conflict of interest.

REFERENCES:

1.Nash DM, Gilliland JA, Evers SE et al (2013) Determinants of diet quality in pregnancy: sociodemographic, pregnancy-specific, and food environment influences. J Nutr Educ Behav 45:627–634. https://doi.org/10.1016/j.jneb.2013.04.268.

2. Oken E, Ning Y, Rifas-Shiman SL et al (2007) Diet during pregnancy and risk of preeclampsia or gestatioEpidemiol 17:663–668. https://doi.org/10.1016/j.annepidem.2007. 03.003

3.https://www.johnmuirhealth.com/health-education/health-wellness/pregnancy breastfeeding/nutritional-needs-during-pregnancy.html

4. Darras, V.M.; Hume, R.; Visser, T.J. Regulation of thyroid hormone metabolism during fetal development. Mol. Cell. Endocrinol. 1999, 151, 37–47.

5. Richard, K.; Hume, R.; Kaptein, E.; Stanley, E.L.; Visser, T.J.; Coughtrie, M.W. Sulfation of thyroid hormone and dopamine during human development: Ontogeny of phenol sulfotransferases and arylsulfatase in liver, lung, and brain. J. Clin. Endocrinol. Metab. 2001, 86, 2734–2742.

6. Dawson, P.A. The biological roles of steroid sulfonation. In Steroids—From Physiology to Clinical Medicine; Ostojic, S.M., Ed.; Intech: Rijeka, Croatia, 2012; pp. 45–64.

7. Florin, T.H.J.; Neale, G.; Goretski, S.; Cummings, J.H. The sulfate content of foods and beverages. J. Food Compos. Anal. 1993, 6, 140–151.

8. . Panarelli, N.C. Drug-induced injury in the gastrointestinal tract. Semin. Diagn. Pathol. 2014, 31, 165–175.

9.Doyle, L.W.; Crowther, C.A.; Middleton, P.; Marret, S.; Rouse, D. Magnesium sulphate for women at risk of preterm birth for neuroprotection of the fetus. Cochrane Database Syst. Rev. 2007, 18, CD004661.

10. Brand, E. Amino acid composition of simple proteins. Ann. NY Acad. Sci. 1946, 47, 187–228.

11. Australian Government. Nutrient Reference Values for Australia and New Zealand; NHMRC: Canberra, Australia, 2014.

12. Cole, D.E.; Evrovski, J. The clinical chemistry of inorganic sulfate. Crit. Rev. Clin. Lab. Sci. 2000, 37, 299–344.

13. Morris, M.E.; Levy, G. Serum concentration and renal excretion by normal adults of inorganic sulfate after acetaminophen, ascorbic acid, or sodium sulfate. Clin. Pharmacol. Ther. 1983, 33, 529–536.

14. Tallgren, L.G. Inorganic sulphate in relation to the serum thyroxine level and in renal failure. Acta Med. Scand. 1980, 640, 1–100.

15. Habuchi, H.; Habuchi, O.; Kimata, K. Sulfation pattern in glycosaminoglycan: Does it have a code? Glycoconj. J. 2004, 21, 47–52.

16. Klüppel, M. The roles of chondroitin-4-sulfotransferase-1 in development and disease. Prog. Mol. Biol. Transl. Sci. 2010, 93, 113–132.

17. Mulder, G.J.; Jakoby, W.B. Sulfation. In Conjugation Reactions in Drug Metabolism: An Integrated Approach: Substrates, Co-substrates, Enzymes and Their Interactions in Vivo and in Vitro; Mulder, G.J., Ed.; Taylor and Francis: London, UK, 1990; pp. 107–161

18. Cortes, M.; Baria, A.T.; Schwartz, N.B. Sulfation of chondroitin sulfate proteoglycans is necessary for proper Indian hedgehog signaling in the developing growth plate. Development 2009, 136, 1697–1706.

19.Innis, S.M. Essential fatty acids in growth and development. Prog. Lipid Res. 1991, 30, 39–103

Youdim, K.A.; Martin, A.; Joseph, J.A. Essential fatty acids and the brain: Possible health implications. Int. J. Dev. Neurosci. 2000, 18, 383.

20. O'Brien, J.S.; Fillerup, D.L.; Mead, J.F. Quantification and fatty acid and fatty aldehyde composition of ethanolamine, choline, and serine glycerophosphatides in human cerebral grey and white matter. J. Lipid Res. 1964, 5, 329–338.

21. Crawford, M.A.; Hassam, A.G.; Stevens, P.A. Essential fatty acid requirements in pregnancy and lactation with special reference to brain development. Prog. Lipid Res. 1981, 20, 31–40.

22. Crawford, M.A.; Hassam, A.G.; Stevens, P.A. Essential fatty acid requirements in pregnancy and lactation with special reference to brain development. Prog. Lipid Res. 1981, 20, 31–40.

Clandinin, M.T.; Chappell, J.E.; Leong, S.; Heim, T.; Swyer, P.R.; Chance, G.W. Intrauterine fatty acid accretion rates in human brain: Implications for fatty acid requirements. Early Hum. Dev. 1980, 4, 121–129.

Martinez, M. Tissue levels of polyunsaturated fatty acids during early human development. J. Pediatr. 1992, 120, S129–S138

23. Dunstan, J.A.; Simmer, K.; Dixon, G.; Prescott, S.L. Cognitive assessment of children at age 2.5 years after maternal fish oil supplementation in pregnancy: A randomised controlled trial. Arch. Dis. Child. Fetal Neonatal Ed. 2008, 93, F45–F50.

24 Birch, E.E.; Carlson, S.E.; Hoffman, D.R.; Fitzgerald-Gustafson, K.M.; Fu, V.L.; Drover, J.R.; Castaneda, Y.S.; Minns, L.; Wheaton, D.K.; Mundy, D.; et al. The diamond (DHA intake and measurement of neural development) study: A double-masked, randomized controlled clinical trial of the maturation of infant visual acuity as a function of the dietary level of docosahexaenoic acid. Am. J. Clin. Nutr. 2010, 91, 848–859.

25. Brenna, J.T.; Carlson, S.E. Docosahexaenoic acid and human brain development: Evidence that a dietary supply is needed for optimal development. J. Hum. Evol. 2014, doi:10.1016/j.jhevol. 2014.02.017.

ISSN: 0975-3583, 0976-2833 VOL 12, ISSUE 04, 2021

Al, M.D.; van Houwelingen, A.C.; Kester, A.D.; Hasaart, T.H.; de Jong, A.E.; Hornstra, G. Maternal essential fatty acid patterns during normal pregnancy and their relationship to the neonatal essential fatty acid status. Br. J. Nutr. 1995, 74, 55–68.

26. Larque, E.; Gil-Sanchez, A.; Prieto-Sanchez, M.T.; Koletzko, B. Omega 3 fatty acids, gestation and pregnancy outcomes. Br. J. Nutr. 2012, 107, S77–S84.

27. Bikle, D. Highlights from the 16th vitamin D workshop, San Francisco, CA, June 11–14, 2013. J. Steroid Biochem. Mol. Biol. 2014, 144, 1–4

28. . Wacker, M.; Holick, M.F. Sunlight and vitamin D: A global perspective for health. Derm. Endocrinol. 2013, 5, 51–108.

29. Brannon, P.M.; Picciano, M.F. Vitamin D in pregnancy and lactation in humans. Ann. Rev. Nutr. 2011, 31, 89–115.

30. . Kumar, R.; Cohen, W.R.; Silva, P.; Epstein, F.H. Elevated 1,25-dihydroxyvitamin D plasma levels in normal human pregnancy and lactation. J. Clin. Invest. 1979, 63, 342–344

31. Seki, K.; Makimura, N.; Mitsui, C.; Hirata, J.; Nagata, I. Calcium-regulating hormones and osteocalcin levels during pregnancy: A longitudinal study. Am. J. Obstet. Gynecol. 1991, 164, 1248–1252.

32. Cross, N.A.; Hillman, L.S.; Allen, S.H.; Krause, G.F.; Vieira, N.E. Calcium homeostasis and bone metabolism during pregnancy, lactation, and postweaning: A longitudinal study. Am. J. Clin. Nutr. 1995, 61, 514–523.

33. Moller, U.K.; Streym, S.; Mosekilde, L.; Heickendorff, L.; Flyvbjerg, A.; Frystyk, J.; Jensen, L.T.; Rejnmark, L. Changes in calcitropic hormones, bone markers and insulin-like growth factor I (IGF-I) during pregnancy and postpartum: A controlled cohort study. Osteoporos. Int. 2013, 24, 1307–1320.

34. Ritchie, L.D.; Fung, E.B.; Halloran, B.P.; Turnlund, J.R.; Van Loan, M.D.; Cann, C.E.; King, J.C. A longitudinal study of calcium homeostasis during human pregnancy and lactation and after resumption of menses. Am. J. Clin. Nutr. 1998, 67, 693–701.

35. . Ardawi, M.S.; Nasrat, H.A.; HS, B.A.A. Calcium-regulating hormones and parathyroid hormone-related peptide in normal human pregnancy and postpartum: A longitudinal study. Eur. J. Endocrinol. 1997, 137, 402–409

36. Wilson, S.G.; Retallack, R.W.; Kent, J.C.; Worth, G.K.; Gutteridge, D.H. Serum free 1,25-dihydroxyvitamin D and the free 1,25-dihydroxyvitamin D index during a longitudinal study of human pregnancy and lactation. Clin. Endocrinol. (Oxf.) 1990, 32, 613–622

37. Charlton, K.E.; Yeatman, H.; Brock, E.; Lucas, C.; Gemming, L.; Goodfellow, A.; Ma, G. Improvement in iodine status of pregnant Australian women 3 years after introduction of a mandatory iodine fortification programme. Prev. Med. 2013, 57, 26–30.

38. Emmett, R.; Akkersdyk, S.; Yeatman, H.; Meyer, B.J. Expanding awareness of docosahexaenoic acid during pregnancy. Nutrients 2013, 5, 1098–1109

39.Masters, D.G.; Keen, C.L.; Lonnerdal, B.; Hurley, L.S. Release of zinc from maternal tissues during zinc deficiency or simultaneous zinc and calcium deficiency in the pregnant rat. J. Nutr. 1986, 116, 2148–2154.

40. Jankowski-Hennig, M.A.; Clegg, M.S.; Daston, G.P.; Rogers, J.M.; Keen, C.L. Zinc-deficient rat embryos have increased caspase 3-like activity and apoptosis. Biochem. Biophys. Res. Commun. 2000, 271, 250–256.

41.Scholl, T.O. Maternal iron status: Relation to fetal growth, length of gestation, and iron endowment of the neonate. Nutr. Rev. 2011, 69 (Suppl. 1), S23–S29.

42. Zhou, L.M.; Yang, W.W.; Hua, J.Z.; Deng, C.Q.; Tao, X.; Stoltzfus, R.J. Relation of hemoglobin measured at different times in pregnancy to preterm birth and low birth weight in Shanghai, China. Am. J. Epidemiol. 1998, 148, 998–1006.

43. B.A.; Olofin, I.; Wang, M.; Spiegelman, D.; Ezzati, M.; Fawzi, W.W. Anaemia, prenatal iron use, and risk of adverse pregnancy outcomes: Systematic review and meta-analysis. BMJ 2013, 346, f3443.

44. Lederman, S.A.; Rosso, P. Effects of food restriction on fetal and placental growth and maternal body composition. Growth 1980, 44, 77–88.

45. Institute of Medicine. Dietary Reference Intakes: Estimated Average Requirements; The National Acadamies Press: Washington, DC, USA, 2011

46. Czeizel, A.E.; Dudas, I. Prevention of the first occurrence of neural-tube defects by periconceptional vitamin supplementation. N. Engl. J. Med. 1992, 327, 1832–1835

47. National Health and Medical Research Council. Nutrient Reference Values for Australia and New Zealand Including Recommended Dietary Intakes; National Health and Medical Research Council: Canberra, Australia, 2005.

48. Baur, R. Morphometry of the placental exchange area. Adv. Anat. Embryol. Cell Biol. 1977, 53, 3–65

49. Han, Z.; Mulla, S.; Beyene, J.; Liao, G.; McDonald, S.D.; Knowledge Synthesis, G. Maternal underweight and the risk of preterm birth and low birth weight: A systematic review and meta-analyses. Int. J. Epidemiol. 2011, 40, 65–101

50. Cross, N.A.; Hillman, L.S.; Allen, S.H.; Krause, G.F.; Vieira, N.E. Calcium homeostasis and bone metabolism during pregnancy, lactation, and postweaning: A longitudinal study. Am. J. Clin. Nutr. 1995, 61, 514–523.

51. Gertner, J.M.; Coustan, D.R.; Kliger, A.S.; Mallette, L.E.; Ravin, N.; Broadus, A.E. Pregnancy as state of physiologic absorptive hypercalciuria. Am. J. Med. 1986, 81, 451–456.

52. Heaney, R.P.; Skillman, T.G. Calcium metabolism in normal human pregnancy. J. Clin. Endocrinol. Metab. 1971, 33, 661–670.

53. Kovacs, C.S. Bone metabolism in the fetus and neonate. Pediatr. Nephrol. 2013, 29, 793–803.

54. Fung, E.B.; Ritchie, L.D.; Woodhouse, L.R.; Roehl, R.; King, J.C. Zinc absorption in women during pregnancy and lactation: A longitudinal study. Am. J. Clin. Nutr. 1997, 66, 80–88

55. Institute of Medicine. Dietary Reference Intakes: Estimated Average Requirements; The National Acadamies Press: Washington, DC, USA, 2011.

56. Jankowski-Hennig, M.A.; Clegg, M.S.; Daston, G.P.; Rogers, J.M.; Keen, C.L. Zinc-deficient rat embryos have increased caspase 3-like activity and apoptosis. Biochem. Biophys. Res. Commun. 2000, 271, 250–256.

57. Mackenzie, G.G.; Zago, M.P.; Keen, C.L.; Oteiza, P.I. Low intracellular zinc impairs the translocation of activated nf-kappa b to the nuclei in human neuroblastoma imr-32 cells. J. Biol. Chem. 2002, 277, 34610–34617.

58. Jameson, S. Effects of zinc deficiency in human reproduction. Acta Med. Scand. Suppl. 1976, 593, 1–89.

59. Wells, J.L.; James, D.K.; Luxton, R.; Pennock, C.A. Maternal leucocyte zinc deficiency at start of third trimester as a predictor of fetal growth retardation. Br. Med. J. 1987, 294, 1054–1056

60. Shah, D.; Sachdev, H.P. Effect of gestational zinc deficiency on pregnancy outcomes: Summary of observation studies and zinc supplementation trials. Br. J. Nutr. 2001, 85 (Suppl. 2), S101–S108.

61. Merialdi, M.; Caulfield, L.E.; Zavaleta, N.; Figueroa, A.; DiPietro, J.A. Adding zinc to prenatal iron and folate tablets improves fetal neurobehavioral development. Am. J. Obstet. Gynecol. 1999, 180, 483–490.