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Dietary guidelines to combat complications during pregnancy

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Healthy diet during pregnancy not only guarantees growth and development of fetus but also maintains maternal health and facilitates lactation. Nutrition counseling and recommendation guidelines should be a fundamental part of prenatal care and it should continue during gestation. Maternal, fetal and neonatal complications are reduced because of these precautions and risk of short and long-term complications are reduced. Underweight or obese (malnourished) women that enter gestation in same state face adverse pregnancy outcomes as compared to healthy women with normal weight range. Numerous metabolic adaptations are met to fulfil the increased energy and nutritional needs during pregnancy. Evidence suggests that fetus will adapt the alternative metabolic competence if nutrient restrictions surpass the adaptive responses limit. The complication may emerge in adult life in form of hypertension, coronary heart disease, stroke, and diabetes type 2.

Keywords: nutrition, preconception, pregnancy, fetal growth, nutrient requirement, adequate intake, lactation, micronutrients

INTRODUCTION

In every woman's life, the most critical and nutritionally challenging period of life is pregnancy. The need of nutrients is increased because energy need to be deposited in the form of new tissues. Pregnant women are more susceptible to malnutrition because increased energy is obligatory for development of new tissues and growth of existing maternal tissues i.e uterus and breast (Goldberg, 2002).

To support physiological changes occurring in mother, development of fetus and optimal growth it is essential to make sure the intake of healthy and balanced diet. Achieving appropriate weight gain, consumption of foods having adequate amount of micro and macronutrients, avoiding ingestion of harmful substances and sticking to pregnancy specific food safety recommendations are fundamental aspects of healthy eating behavior (O'Connor et al. 2016). With reference to previous studies, pregnant women are at increased risk of adversative outcomes of pregnancy if they do not adopt these behaviors. The most common outcomes are pre-term birth (Han et al. 2011), low birth weight (Martin et al. 2015), neurodevelopmental problems (Brown et al. 2010) like fetal alcohol spectrum disorder and preeclampsia (Flick et al. 2010).

When compared to non-pregnant state, pregnant women are more motivated for intake of

healthy diet as they are well known with the impact of dietary patterns on fetus health, also women prepare themselves for motherhood (Copelton, 2007). Diet related behaviors are changed due to interaction of non-pregnant state eating behaviors (i.e time, personal preferences, money) with physical and physiological changes, personal beliefs and values regarding nutrition during pregnancy and health professional's advice (Gardner et al. 2012). Despite of being aware about the necessity of healthy dietary intake during pregnancy, women may not be skilled enough to improve their diet or they have lack of knowledge about dietary recommendations (Reyes et al. 2013). Some barriers i.e nausea, vomiting, aversions, hemorrhoids, constipation, cravings, heartburn and tiredness make it problematic for women to maintain healthy eating during pregnancy (Lammi et al. 2008). Women's choices during pregnancy are influenced by several sources such as peers, health professionals, and educational resources (Szwajcer et al. 2005).

Fetal Growth and Undernutrition

Placental supply of nutrients to fetus is the ultimate determinant of intrauterine fetal growth. This depends on blood supply, morphology and placental size (Fowden and Forhead, 2004). In experimental study, altered placental efficiency and reduced placental weight were the result of isocaloric low protein diet (Meyer et al. 2003) and food restriction (Denommeet et al. 2005), this resulted in intrauterine growth retardation (IUGR) and low birthweight. The time required for the nutrient delivery by placenta is also very important. Placental-fetal weight ratio was reduced in early pregnancy in global under nutrition (Makrides, 2009); increased placental size was observed in early- mid gestation in global under nutrition; and reduced fetal growth was observed in late gestation in global under nutrition. A diet low in protein in rats showed higher placental growth in early pregnancy and lower fetal growth in late pregnancy (Report of a Joint FAO/WHO/UNU, 2014). It can be summarized that system that regulate appetite, located in hypothalamus, faces impairment in programming, also structural disorganization was exhibited in offspring with reduced maternal nutrition (20-70% calorie intake i.e global food restriction and low protein isocaloric diet). Increased risk of potential obesity, due to increased white adipose tissue and changes in orexigenic pathways, is unavoidable. Fat mass and fetal adipocyte metabolism is influenced by maternal undernutrition during critical growth periods in humans. In later life it leads to obesity (Ruiz et al. 1992). When fetal nutrition supply is altered, growth and metabolism is influenced by driving developmental adaptations. Due to these alterations, baby is highly susceptible to diseases in later life along with postnatal outcomes. Proxy for maternal under nutrition is low birth weight (Vriese et al. 2002). Reduced fat mass and lean body mass (Donahue et al. 2009), high blood pressure in adulthood (Salem et al. 2001), poor cognition in childhood (Janssen and Kiliaan, 2014) and elevated risk of type 2 diabetes (Coti et al. 2006) are associated with low birth weight. Link between infant birth weight, maternal nutrition ad short and long term consequences is supported by these studies. However, impact of optimal maternal intake on optimal infant birth weight is suggested by limited number of epidemiological studies.

Table 1: Factors effecting nutrition during pregnancy

Preconception obesity/overweight-malnutrition
Maternal Age (>35 years, adolescents/ especially after first two years of menarche)
Chronic diseases
Nutritional intolerances and allergies
Sedentary lifestyle
Physical inactivity
Excessive or insufficient weight gain
Nutritional Disorders (bulimia, anorexia)
Multiple pregnancy
History of obstetric complications
Substance abuse
Social, religious, psychological and cultural factors that influence nutrition

Recommended weight gain and energy requirements in pregnancy

During pregnancy, weight gain is indicator of energy intake. Before conception, recommendations are given on the basis of BMI. Most recent and generally accepted recommendations on weight gain are from 2009 American Institute of Medicine (IOM). The recommendations on weight gain are extracted from recommendations that were issued in 1990. The only difference between both are that recent

ones have specific recommendations fir obese and overweight women for gestational weight gain and also these are based on BMI categories of World Health Organization (WHO). Insufficient weight gain during pregnancy causes common problem in women like impaired intrauterine development, premature labor and lactation initiation failure. Contrary to that, those women also face complications that gain excess weight than recommendation during their pregnancy. These complications include cesarean sections, macrosomic infants, higher prevalence of gestational hypertensive disorders and difficult weight reduction gained during postpartum period (Plecas, 2013).

According to British National Institute for Health and Clinical Excellence, individual monitoring of potential complications and fetal development should be focused instead of gestational weight gain routine follow up. The complications that should be focused are growth restriction induced insufficient weight gain or fluid retention induced excessive weight gain in preeclampsia (National Institute for Health and Clinical Excellence, 2008). A study also analyzed the pregnancy outcome among women who gained less weight (2.7-6.4 kg) than recommendation and were overweight (25-29.9 kg/m^2 BMI) (American College of Obstetricians and Gynecologists, 2013). This study concluded that additional benefit was seen for mother and fetal health if weight gain was not insisted according to recommendation of US Institute of Medicine 2009, if fetus have appropriate development and growth. Contrary results were provided in a study of pregnant women that were obese. The objective of recommendations for obese pregnant women was to eliminate the risk of large-for-gestational-age infants and also small-for-gestational age-infants, preterm births, obstetric complications and retention of postpartum weight. The relationship between weight gain during pregnancy and class of nutritional status of mother is assumed to be very complex. For obese and overweight women that gain less than recommended weight, case-to-case clinical judgement for management is required, so that risk of maternal and fetal adverse outcomes are balanced.

Additionally, weight gain should be assessed in relation to tissues that are extra deposited during pregnancy. A woman with appropriate weight (BMI= 18.5-24.9 kg/m^2) begins pregnancy and will gain average of 12.5 kg weight. This weight gain is segregated as placenta-650 g, amniotic fluid-800 g, uterus- 970 g, fetus- 3400 g, maternal fat deposits- 3345 g, increased fluids-1480 g, breasts-405 g and increased blood volume- 1450g (Hytten, 1991).

Energy metabolism of incomparable wider range undergo complex, numerous adaptations during gestation as compared to mechanisms involved in non-pregnant state. Under deprived maternal nutrition, metabolic capacity of humans and slow process of fetal growth secures and protect fetal growth. Irrespective of these adaptations, poor nutrition encountered in poor environment often leads to intrauterine growth retardation (Prentice & Goldberg, 2000).

For normal pregnancy, no accurate data is present on total energy costs. Generally, energy deposited as fat, deposited as new tissue and required for new tissue maintenance together constitute total costs. Soon after conception, basal metabolic rate in well-nourished woman rises and this increase continue until delivery. Contrary to that, suppression of metabolism is evident in an undernourished woman that persists till third trimester (Prentice & Goldberg, 2000).Although, woman carry her pregnancy to term with individual metabolic variations. Extensive range of nutritional conditions occurs under adaptive limits and nutritional deprivations exceeding these limits show consequences as well (Scientific Advisory Committee on Nutrition, 2011). A strong correlation was found between pre-pregnancy fatness, total costs of pregnancy and pregnancy weight gain. Energy costs of gestation can be modified by a key factor that is pre-pregnancy nutritional status. This can be done by a system supervising the maternal pre-pregnancy energy status and then fit the individual capacity of pregnant women by adopting economical metabolic mechanisms (Augustine et al. 2008).

For healthy pre conception weighing women who gained 1 kg during gestation, 80,000 kcals were additional energy requirement (Royal College of Obstetricians and Gynecologists, 2010). Multiple pregnancies account for greater energy needs. Well nourished, obese and overweight women with twin pregnancies should have recommended weight gain of 16.-24.5 kg, 14.1-22.7 kg and 11.3-19.1 kg (American College of Obstetricians and Gynecologists, 2013).

Protein

During pregnancy, among macronutrients protein is the most important and needs attention. Protein's demand increases during pregnancy due to protein synthesis for maternal tissue

maintenance and fetal growth.

Table 2: Energy Intake recommendation during pregnancy

Recommendations		Normal (kcal/day)	Pregnancy (+kcal/day)
WHO		1940	285
EUROPE		1950-2000	200**
USA		Upto 2200	300***
UK	19-50 years	1950	200**
Canada*	19-30 years	1900	+0- 1st trimester
			+340- 2nd trimester
			+452- 3rd trimester
	31-50 years	1800	+0- 1st trimester
			+340- 2nd trimester
			+452- 3rd trimester

*based on IOM recommendations, 2006
** Only in last trimester
***in the second and third trimester

This demand is mostly high during third trimester. Weight and length of baby at birth is affected negatively by excessively low intake of protein during pregnancy. However, development of fetus could also be affected by excessively increased intake of protein (Kramer & Kakuma, 2003).

Protein Digestibility Corrected Amino Acid Score (PDCAAS) measures the protein quality of foods. This is amino acid digestibility score (Schaafsma, 2000). Values of typical animal products are close to 1, these include all 9 essential amino acids. While, values of typical plant products are below 0.7. The overall protein component quality is improved when two or more vegetables, having amino acidic composition that is different, are consumed (Food and Agriculture Organization of the United Nations, 2016). International guidelines settle in the recommendation of increased protein intake during second and third trimester especially. This recommendation makes sure the provision of required protein for fetal and maternal tissues and placenta i.e 21 grams (Trumbo et al. 2002). According to population reference intake (PRI); the dietary need at 97.5th percentile, the RDA during first trimester of gestation should be increased by 1 g/day, in second trimester by 8g/day and in third trimester by 26 g/day (SINU, 2014).

During first trimester of exclusive breastfeeding, intake of protein should be 21 g/day along with habitual protein intake. If a child continue to breastfeed even after that and take substantial portion of diet from breastfeeding then protein intake should be 14 g/day along with habitual protein intake (SINU, 2014).

Carbohydrates

For both fetus and mother, carbohydrate serves as a source of energy. The recommendation during gestation is same as it is recommended for general population i.e 50-60% of energy. Blood glucose level is controlled and body is protected against ketosis by intake of optimal amount of suitable carbohydrates. Wholegrain and potatoes are recommended as a source of carbohydrate but they should not be fried or deep fried instead they should be bakes or boiled. Sugar intake should be > 5% of energy intake that is 25 g (5 tea spoonful). Additional sugar consumption should be limited. Risk of obesity is also increased due to excess sugar intake. Sweetened soft drinks increase the risk of premature birth and pre-eclampsia so it should be avoided by expectant mothers.

Fat

During pregnancy, for infant growth and development of fetus, quality of fat is of prime importance instead of quantity of fat. Due to this, the improvement of polyunsaturated fats relative portion instead of total fat intake increase, is necessary. DHA (docosahexaenoic acid) is disparagingly essential for the growth and development of retina and brain. So, the standard intake of DHA is of extreme importance. Breast milk fat content after delivery is less relevant to lifestyle and maternal diet (amount of dietary fat and energy intake) while it is dependent mainly on stage of feed, feeding period and number of pregnancies (Sauerwald et al. 2001). In actual, food intake over long term is imitated by the release of stored deposits in mother's storage compartments. Thus, overall fat intake is not needed to change during prenatal period and lactation (Koletzko et al. 2007).

DHA

The major polyunsaturated fatty acid is DHA-docosahexaenoic acid. During pregnancy DHA is essential for neural and retinal development of fetus because human brain and retinal rods

contain DHA. During first month of lactation, DHA is required in high amounts for psychomotor neurodevelopment of baby. This high amount is fulfilled by breast milk as it is not present in cow's milk (Koletzko et al. 2011).

Extensive literature supports the essential need of DHA for fetus as well as infant. The appropriate amount of omega-3 intake is important and essential for pregnant women (it reduces the premature birth and pots-partum depression risk), for the healthy content of breast milk and for health of infant (Mennitti et al. 2015).

DHA is the n-3 fatty acid that has highest degree of unsaturation and longest carbon chain. According to experimental evidence, despite of a proper enzymatic pathway for DHA synthesis from its metabolic precursor (ALA- alpha linolenic acid), adequate tissue levels are not attained from ALA to longer chain fatty acids conversion. Although ALA to DHA conversion is even lower then ALA to EPA conversion and is nil in male subjects virtually. ALA to EPA conversion is demonstrated as highly inconstant and is <10% (Brenna et al. 2009). In recent years, because of limited long polyunsaturated fatty acids synthesis by human body, concept of essentiality was shifted from ALA to EPA and DHA. Only fatty fish (salmon, mackerel, anchovies) in cold seas have high concentrations of EPA and DHA with EPA to DHA ratio variably high.

Fiber

Fiber's recommended intake is 30-35g. Major role of fiber is to prevent constipation which aids in haemorrhoidal vein disease risk reduction. Risk of preeclampsia and gestational diabetes is also reduced by fiber intake. Vitamins minerals and biologically active substances are present in fiber-rich food products. Fresh fruits, vegetables, whole grain products, legumes, nuts, seeds, and dried fruits are main sources of fiber. The most common and main sources of fiber are cereal products, rye bread being the most common among them. Additional bran uptake can lessen the minerals absorption, calcium and iron and may lead to intestinal obstruction. So high dosage of bran should be taken on professional advice (Meija and Rezeberga, 2017).

Folate/Folic Acid

Genetic material in the body is regulated and developed with folic acid. The RNA is expressed by this genetic material which in turn produces proteins. During pregnancy, changes like increased growth rates, cell division and production of DNA takes place. These activities increases the requirements of folic acid during pregnancy. According to several studies, development of neural tube defects (NTDs) has been linked to folic acid deficiency. Around the fourth week of pregnancy, when complete closure of neural tube end fails, NTDs occur. Anencephaly, Spina bifida and Encephalocele are the most common types of NTDs present till now (American College of Obstetricians and Gynecologists, 2013).

Folic acid is found in fortified food, nutritional supplements and is a synthetic form of folate. As compared to natural folate equivalent, folic acid is found to be two times mire available. In United Kingdom, folic acid recommendation is 400 mg per day. This intake should be started before conception and continue till the twelfth week of gestation. Risk of NTDs is reduced when folate rich diet is taken along with supplementation. Bioavailabity of folic acid is found to be increased when it is taken empty stomach. During pregnancy, 5 mg per day folic acid is recommended for women at risk of NTDs. Following conditions confirm if the women are at risk of NTDs:

1- Had previous NTD affected pregnancy?
2- Family history of NDT in either mother or father.
3- Manage diabetes by use of insulin.

Are on medications that could possibly affect folic acid metabolism.

Acne medications, antiepileptic drugs, insulin and infertility treatment may hinder folic acid metabolism. Deficiency of Vitamin B_{12} is masked by high levels of folic acid supplementation. Before prescription of high doses of folic acid, women's vitamin B_{12} status should be considered first, especially in vegans/ vegetarians because they are highly susceptible to B_{12} deficiency. 200 mg of folate from dietary sources should be taken throughout pregnancy along with the folic acid supplementation. Citrus fruits, legumes, leafy green vegetables, wholegrain breads and fortified foods are good source of natural form of folic acid i.e folate (Masood et al. 2020) (Masood et al. 2021). Folic acid supplementation is required because the recommended level of folic acid is difficult to achieve through diet alone (Seymour et al. 2019).

Vitamin A

Vitamin A is a fat-soluble vitamin. Vitamin A is derivative of provitamin carotenoids or retinoids that are performed. Retinal and retinoic acid are the forms of retinoids. It is mainly obtained from

animal sources like fish liver oil, liver, dairy, and eggs. Beta-carotene is a type of carotene and is mainly obtained from plant sources like yellow or dark vegetables including sweet potatoes, kale and carrots. Vitamin A is stored in liver and retinoids and carotenoids are transferred to vitamin A in liver (McCauley et al. 2015). Bone metabolism, antioxidant activities, immune function, vision, gene transcription and growth are the physiological functions are vitamin A. During pregnancy, additional vitamin A is mandatory for tissue maintenance and growth of fetus, fetal reserves and aid in maternal metabolism. When non-pregnant women have stores of vitamin A in liver, it is thought to be supplied during pregnancy to fulfil the basal requirement of 370 µg/day. Also daily recommended intake of vitamin A during pregnancy is 770 µg/day (Stipanuk & Caudill, 2013).

<0.7 µmol/L serum plasma retinol concentration and night blindness history determines hypovitaminosis A. Globally, 7.8%- 9.8 million pregnant women are affected by night blindness while serum retinol concentration based deficiency is 15.3% (19.1 million) (Black et al. 2013).Higher risks of low birth weight and infant mortality is is correlated with maternal night blindness in many studies, although these outcomes are not seen to be prevented by vitamin A supplementation. 19 trialsbased Cochrane meta-analysis with >310,000 women reported that during pregnancy, stillbirths, preterm birth, newborn death, low birthweight or anemia in newborn is not improved or effected by vitamin A supplementation. Although, risk of maternal infection, anemia and night blindness was reduced in vitamin A deficient mother (McCauley et al. 2015). Baseline deficiency status is likely to vary the effects of supplementation of vitamin A. Further studies are required to understand the reason of this variation, optimal duration of dose, infection preventing- potential benefits and optimal dose of vitamin A. 3000 µg/day (10,000 IU) is recommended upper limit of retinol because it has teratogenic effect. Beta-carotene is nontoxic form and is preferred during pregnancy. Vitamin A deficiency is rare in developed country, so with reference to current evidence, vitamin A supplementation is not recommended in these countries to improve pregnancy outcomes. In deficient women, current intake is is carefully assessed and supplementation is recommended on its basis and regular monitoring is done to prevent any toxicity.

The B Vitamins

B-vitamins are water soluble vitamins that include Thiamine (B_1), Riboflavin (B_2), Niacin (B_3), Pyridoxine (B_6) and Cyanocobalamin (B_{12}). These vitamins play role in metabolism of macronutrients and energy production and release in cells. Blood cell formation and energy generation related intermediary metabolic pathways use B vitamins as coenzymes (Ang et al. 2008). A process of conversion of homocysteine to methionine is facilitated by vitamin B_{12} alongside folate. This process is essential for several many other components i.e methylation of neurotransmitters, proteins, phospholipids, DNA and RNA (Sukumar et al. 2016). Due to high energy demand of these vitamins, nerve tissue development and cellular growth have high impacts of deficiency of these vitamins. As metabolic role of individual B-vitamins are not well defined, so B-complex vitamins supplementation is recommended for prenatal period, except for vitamin B_{12}.

Most animal source food contain B-complex vitamins, these include dairy products, fish, meat, poultry. It is also found in fortified cereals, legumes, and leafy green vegetables. In pregnancy, increased protein and energy needs highlight the requirement of B vitamins. This requirement is high particularly during third trimester. Although, urinary excretion of B-vitamins particularly riboflavin is reduced by adaptive responses due to increasing need of them during pregnancy (Williamson, 2006). Vitamin B-complex deficiencies, except B_{12}, are unavailable for global estimations. However, 25% pregnancy are affected due to vitamin B_{12} insufficiency, worldwide (Gernand et al. 2016).

Fetal brain development is impaired by thiamine deficiency. It is suggested y studies because deficiency of thiamine disturbs the thiamine dependent enzyme metabolic processes that is important for synthesis of nucleotides and lipids in brain (Dias et al. 2013). Conditions like congenital heart defects, preeclampsia and low birth weight are correlated with riboflavin and niacin deficiencies. The evidence regarding extend of prevention of these condition after supplementation is sparse. It is found that risk of orofacial cleft and nausea in reduced with thiamine, pyridoxine and niacin increased preconception intakes. Stillbirths, low birthweight, placental abruption and preterm birth is observed when vitamin B_{12} levels are low because they increase the homocysteine levels. A meta-analysis of individual patient data (11,216 observations) consisting of 18 longitudinal studies

suggested that risk of preterm birth and low birth weight infant is increased when B_{12} concentrations were <148 pmol/L (Rogne et al. 2017). Neural tube defects i.e spina bifida is associated with B_{12} deficiency along with folate deficiency. However, confirmation of high levels of vitamin B supplementations and their potential health benefits need more sufficient evidences.

Vitamin C

Towards final stage of pregnancy, maintenance of maternal stores is ensured by increment of 10 mg/day vitamin C during last trimester, which makes a total of 50 mg/day vitamin C. the rapidly growing fetus is able to quintessence the vitamin and tissue stores are extra drained at the cost of maternal stores and circulating vitamin concentration.

The most important ability of vitamin C is to increase the absorption of non-heme iron. Therefore, pregnant women are recommended to eat iron rich food together with vitamin C containing drinks and foods as this helps in absorption of iron (FSA, 2005b).

Table 3: WHO recommended vitamins and minerals per day during pregnancy and lactation

Micronutrient	WHO recommendation
Vitamin A	800 µg
Vitamin B_1 (Thiamine)	1.4 mg
Vitamin B_2 (Riboflavin)	1.4 mg
Vitamin B_3 (Niacin)	18 mg
Vitamin B_6	1.9 mg
Vitamin B_{12}	2.6 µg
Vitamin C	55 mg
Vitamin D	5 µg
Vitamin E	15 mg
Folic acid	600 µg
Calcium	1.5-2 g
Iron	27 mg
Iodine	250 µg
Copper	1.15 mg
Zinc	10 mg
Selenium	30 µg

Maternal homeostasis of Calcium and Vitamin D

During pregnancy extra calcium is required. Increased absorption of intestinal calcium seems to be the chief mechanism for this requirement. During third trimester of pregnancy, fractional calcium absorption reaches ~60% from ~35% in no pregnant state. During second trimester, 50-100% 1,25(OH)D serum concentration is higher over non-pregnant state and during third trimester it is reached to 100% (Specker, 2004). However, vitamin D binding protein also have increased serum concentration during pregnancy. Concentration of free 1,25 (OH)D is increased during last trimester because it is unassociated whether binding protein concentrations is increased or not and 1,25(OH)D is continuously increased. During pregnancy, renal calcium is not conserved. In late human gestation, serum 1,25 (OH)D concentrations and absorption of calcium are positively associated. The underlying mechanism of increase in 1,25 (OH)D concentration is not clear. Stimulus for transformation of 25(OH)D to 1,25(OH)D by renal hydroxylation is PTH (parathyroid hormone). It is not seemed to be elevated during pregnancy. 1,25(OH)D concentration in maternal circulation is speculated to be from placental origin.

Vitamin D

For under 65 years adults, no vitamin D RNI is present, because in adult women, sunlight exposure maintain vitamin D status better as compared to diet. In foods like meat, eggs and oil-rich fish, vitamin D is naturally available. By law margarine fortification is done with vitamin D. some breakfast cereals and fat spreads are also fortified with vitamin D.

Calcium absorption and utilization is regulated by vitamin D. During later stages of pregnancy, fetal skeleton is calcified by using calcium so mother and fetus are both at risk because of reduced by vitamin D. In offspring, bone mass is reduced at age 9 due to poor vitamin D status during pregnancy, according to a recent study. In later life, risk of osteoporosis is also increased in such individuals (Javaid et al. 2006). A good vitamin D supply is needed for pregnant women. 10 µg/day is the current recommendation for vitamin D for pregnant women (FSA 2005b).

In UK, vitamin D deficiency is highly prevalent among pregnant women who are particularly Asian and vegetarian (Iqbal et al. 1994). It is thought that in Asians, need of supplemental and dietary Vitamin D is high because of slower vitamin D synthesis rate in the skin of Asian as compared to Caucasians. Women who keep their skin covered when outdoors little exposure to sunlight has and is more likely to have lower vitamin D status. Such women need supplementary vitamin D to maintain optimal vitamin D status during pregnancy.

Calcium

Calcium is a key intracellular and essential

nutrient that plays role in cell membrane maintenance and bone mineralization. Several other biological processes i.e nerve cell function, muscle contraction, neurotransmitter release, signal transduction and hormonal and enzymatic homeostasis, needs calcium (Buppasiri et al. 2015). The best sources of calcium are milk and dairy products, nuts, leafy green vegetables, fortified foods like dairy alternatives (soya products) and flour. Active transportation of calcium occurs across placenta during pregnancy. During last trimester, demand of maternal calcium increases. During pregnancy, physiological adaptations make calcium uptake and utilization more efficient. These adaptations include enhancement in calcium retention by kidney tubules and hormone stimulated increased calcium absorption/ these hormones are prolactin, estrogen, vitamin D and lactogen (Williamson, 2006). 1.2 g/day is recommended increased calcium need that can be fulfilled by diet alone. For women, whose dietary calcium intake is low i.e <1 g/day, 0.3-2 g/day supplementation is recommended rto maintain maternal bone density and calcium balance and support fetal growth (Buppasiri et al. 2015).

Paraesthesia, tremor, muscle cramps, osteopenia and tetanus is occur in mother who had low maternal calcium intake. Evidence related to conditions in fetus is inconclusive however it may cause low birth weight, delayed growth and poor fetal mineralization (Hofmeyr et al. 2014). According to recent evidence, during pregnancy, women are at high risk of having hypertensive disorders due to low calcium intake. Current supplemental recommendation of WHO suggests 1.5-2 g/day of calcium throughout pregnancy (WHO, 2013).

Iron

The foremost constituent of myoglobin, hemoglobin and various enzymes is iron and is involved in various enzymatic processes. Iron is important mineral as it supplies oxygen to tissues (Rehman at al. 2021). Anemia is worldwide a very common condition. Anemia is caused by the deficiency of iron. In Europe, 22% childbearing age women and 50% women in developing countries are affected with anemia (Stevens et al. 2013). Children of age 6-36 months are commonly iron deficient (Eussen et al. 2015). Main dietary sources of iron are green leafy vegetables, meat and meat products and legumes. Non-heme form of iron is usually found in dietary iron. The absorption of non-heme iron depends on overall diet composition and nutritional status of an individual. Ascorbic acid, meat and fish facilitates the absorption of non-heme iron while it is repressed by polyphenols and phytates. The human body's ability to absorb heme iron is 25% while for non-heme iron it is 2-13% (SINU, 2014).

When accumulation of iron in fetal tissue occurs in third month, iron requirement is increased progressively during third month of pregnancy. Complex mechanism of transport takes place to regulate the transport of iron from maternal compartment to fetus. In maternal liver iron is stored as ferritin. From maternal liver iron is released and circulates as Fe^{2+}, from circulation it is taken up by placenta and transferred to fetus with specific binding protein- transferrin. Here it is oxidized to Fe^{3+} and stored as ferritin (Cetin et al. 2011).

Risk of preterm delivery, low birth weight, and post-partum hemorrhages is increased and development and growth of fetus is affected when iron demand is increased during pregnancy yet intakes are inadequate. This increases the risk of iron deficiency (Khambalia et al. 2015). Some recent studies suggested that maternal inadequate intakes during pregnancy increase the cardiovascular diseases risk for offspring in adulthood.

Improvement in pregnancy and birth outcomes is the only motive of iron supplementation in pregnancy. However, impaired glucose metabolism, oxidative stress, gestational hypertension and lipid peroxidation can be caused to women whose iron intake is excessively high during pregnancy (Kres et al. 2015). According to WHO and Center for Disease Control and Prevention, the international recommended amount is 27mg/day to 30-60 mg for all pregnant women.

Iodine

Iodine is vital mineral during pregnancy. Maternal thyroid hormones are synthesized by iodine which play essential role in fetal central nervous system development. During preconception period, pregnancy and lactation an adequate intake of iodine must be guaranteed. Coordinated and programmed development of fetal central nervous system, behavioral and cognitive development is necessary for thyroid hormones. Therefore, mental and developmental disorders are prevented by iodine. Early stages of pregnancy is the most susceptible period of development of iodine deficiency (Gnady, 2014). If supplementation of iodine is given only after the

first antenatal visit (9th week), best possible outcome of pregnancy is too late to ensure.

Women of reproductive age should ensure adequate daily iodine intake to maintain optimal iodine level before conception. Vitamin formulations, having active ingredient of potassium iodide, are able to supple daily iodine requirement 150-250 µg before conception and during pregnancy and lactation.600 µg/day is the maximum allowed dose for lactating and pregnant women. > 1100 µg/day dosage is considered unsafe (Meija & Rezeberga, 2017). Dosage of women with thyroid disorder is adjusted in consultation with endocrinologist. Iodine level in soil and in food, iodine in disinfectants and fertilizers decides whether iodine supplementation along with food is required or not.

Seafood, dairy products and fish are the main iodine sources in diet. Addition of iodized salt in cooking at home is helpful. Dietary iodine alone does not fulfil the need of pregnant women. 100 µg/day iodine is consumed from dairy products, seafood twice a week and iodized salt. Additional 100-150 µg is provided by iodine supplementation (Konrade et al. 2015). During pregnancy planning, complex supplements of iodine and folic acid is beneficial. During pregnancy, additional iodine supplementation is not require if mother is taking multivitamin supplementation. If mother's intake is adequate, child get optimal iodine supple if he is exclusively breastfed.

Zinc

Zinc is a vital structural constituent of several hormones, proteins and nucleotides and catalytic component of more than 200 enzymes. Biochemical functions like cellular division, antioxidant defense, nucleic acid metabolism, wound healing, protein synthesis, vision and immune and neurological function and gene expression (Mousa et al. 2019).Many foods contain zinc but seafood, nuts, meat and milk have higher concentration of zinc. Bioavailabity of zinc is reduced when diet is rich in phytate and fiber. Zinc-dependent enzyme levels, serum or plasma zinc level and 24-hour urinary zinc excretion are indicators of zinc status in human. Physiological factors like infection or stress, sex, age and time of day can vary the zinc values (Mousa et al. 2019). Cut off points are difficult to assess due to this reason which causes the assessment of prevalence of zinc deficiency difficult. During the second and third trimester, recommended intake of zinc is 15 mg/day. However it is estimated that pregnant and lactating women consume ~9.6 mg/day of zinc which account for 82% women who have inadequate zinc intake during pregnancy (WHO, 2013).

In developed countries, half a million annual maternal and child deaths are proposed to be contributed by zinc deficiency (Black et al. 2008). Pregnancy induced hypertension, intrauterine growth retardation, prolonged labor, preterm and post term births, low birth weight and impaired immunity are some conditions associated with zinc deficiency in pregnancy (Ota et al. 2015). Inherited defects in zinc absorption-acrodermatitis enteropathica causes severe zinc deficiency that can lead to congenital malformations and loss of pregnancy.Although such situation is quite rare (Black et al. 2008). Chaffee & King reported that supplementation of zinc during pregnancy had no effect on hypertensive disorders, birth weight or neonatal mortality. However incidence of pre-term birth was reduced by 14% (Chaffee & King, 2012). Women from low socioeconomic status were seen to have reduction in preterm birth when supplemented with zinc. This reflects the need of improvement in poor baseline nutritional status (Black et al. 2008). Till date benefits of zinc supplementation is not demonstrated. The need of hour is to improve overall maternal health strategies as zinc deficiency is an image of poor diet.

Dietary restrictions and special recommendations during pregnancy

The recommendations for pregnant women are also based on general principles and 5 main food groups help in planning. These groups are fruits and vegetables, bread and cereals, meat and meat products, dairy and dairy products and substitutes; high fat and sugar beverages and food, egg, pulses and soya products. Additional to that, pregnant women are advised to: (Royal College of Obstetricians and Gynecologists, 2010) (Plecas, 2013) (Dietary Guidelines for Americans, 2010) (National Institute of Health and Clinical Excellence, 2008)

1-Potential teratogens food sources should be excluded such as retinoids containing medications and high concentrated vitamin A foods and supplements.

2- Bacteriologically unsafe foods should be excluded. Toxoplasmosis (Contaminated vegetables, undercooked meat), listeriosis (unpasteurized milk, immature soft cheese), salmonellosis (mayonnaise, soft cooked or raw egg, undercooked meat) are prominent sources of

infection.
3- Intake of iodized salt is necessary
Folic acid recommendation is 400 mg per day. This intake should be started prior to conception and continue till the twelfth week of gestation. Risk of NTDs is reduced when folate rich diet is taken along with supplementation as diet alone cannot fulfil the requirement.
4- Caffeine should be limited to 200 mg/day. (no more than cups of coffee)
5- Upon lactase deficiency diagnosis, lactose-free milk is recommended.
6- Good source of heme iron should be chosen i.e fish and meat
7- Avoid alcohol consumption, smoking, and passive smoking as it exposes to nicotine.
8-Swordfish, king mackerel, shark and tilefish are contaminated by methyl-mercury. These toxicants case fetal damage. So these should be avoided by pregnant and lactating women due to potential danger of contamination. Intake of oily fish (30% fat in tissues) like herring, sardines and salmon should be limited to two portions per week as they are low in mercury. White fish (1-4 % fat) is elusively deposited in liver. These include haddock, flatfish and cod.

Vegetarians are at verge of several deficiencies, this risk is eliminated through the appropriate choice of natural and enriched food and supplementation:
1-5-10 µg/ day (200-400 IU) vitamin D
2-48.6 mg/day iron; however recommendation after individual assessment is advisable.
3-400-800 µg folic acid
4-2.6 µg/day vitamin B_{12}
5-500 mg calcium supplementation, if required

15 mg zinc supplementation for vegans if dietary sources (nuts, whole grains and legumes) not present in diet.

CONCLUSION

The VBMI of expectant mother should be normal before conception. The diet should be balanced with healthy and comprehensive foods. 10-15% energy requirements are increased during pregnancy with highest increase in macronutrient requirements. Even distribution of meals should be regulated throughout the day. Number of meals per day vary according to condition but generally small frequent 6 meals are recommended. Protein requirement is high increased among macronutrients. Calcium intake should be high almost 1000 mg from food sources. Sufficient sources of minerals and vitamins should be added in diet. Diet should incorporate all food groups in it i.e wholegrain products, lean meat and oily fish, vegetables and fruits and dairy products with low fat. The diet should composed of moderate quantity of animal products ad high quantity of plant products. Adequate water intake should be ensured. Limited quantity and infrequent intake of high caloric sweets and snacks and large amount of saturated fats. Iodized salt intake is beneficial but not more than 5 g/day. The supplementation should be initiated only on individual needs. During pre-conceptional phase, gestation and breastfeeding drugs, tobacco, alcohol and electronic cigarettes should completely be avoided. Contaminants and toxins, that enter body from environment, food, water and food processing, should be taken care of. It is also advised to have moderate regular physical activity.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

TT, AF and HBUA originally came up with the idea of the article and wrote the manuscript. MUA, HS, IJ, KR, MJ, PK substantially contributed in literature review, drafting and formatting. TK, FI, MA gathered the literature and managed references. SM and MI has critically revised the manuscript and provided supervisory support.

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