Chapter 2

Body Mass Index (BMI) and Anthropometric Measurement of the Developing Fetus

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Additional information is available at the end of the chapter

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Abstract

Medical and scientific study of the measurements and size of the human body is known as anthropometry. In anthropometry, body mass index (BMI) is one of the best indirect methods for the estimation of body fat and mass. Other methods of indirect methods include weight, stature, and abdominal circumference. Direct methods include total body water, total body counting, and criterion methods include body density. Other factors like the size and weight of the mother also influence the size and mass of the body. An earlier work was conducted by K.L. Mukherjee on the systemic anthropometric measurements of the aborted human fetus. The following chapter will deal with the importance of parental and fetal BMI and its influence on the development of the fetus at varying stages of development and their relationship with anthropometric measurements.

Keywords: anthropometric measurements, body mass index (BMI), fetal development

1. Introduction

Anthropometry is a technique implemented for the scientific study of the measurements of the human body. Over the years anthropometric measurements have become an important tool for clinicians and scientists in health assessment of the fetal development and growth [1]. One of the main parameters used in anthropometry to study the impact of the fetal growth through different phases of pregnancy includes that of the parental and the fetal body mass index (BMI), which is believed to affect the baby's growth, development, and birth weight [2].

Birth weight is also one of the important factors affecting the fetal anthropometric measurements, and any abnormality is strongly associated with the morbidity and even mortality of the infant.

A low birth weight of a neonate can be linked to impaired overall growth and development of the baby and overweight can be related to severe complications of the child during delivery [3]. Fetal and offspring overweight can also be related to obesity in children in later life [3, 4].

Apart from the weight of the neonate, factors such as the maternal height, weight, and metabolic rate are also important anthropometric parameters related to the growth and development of the fetus [5]. Small and selected studies have suggested that pre-pregnancy pre-BMI and weight during the gestation period of the mother are important factors that predict the outcome of the fetal weight and its development [6–11].

Normally it is gestational weight, which is indicative of both nutritional status and tissue development, whereas pre-pregnancy BMI only reflects the nutritional status [12]. However, the relationship between the two is still not clearly established including that of the maternal BMI and other anthropometric parameters related to the fetal growth and development in pregnancy [2].

An early pioneering study in Calcutta led by Prof. K.L.Mukherjee involving anthropometric measures of the aborted human fetus collected ethically from all the trimesters was conducted [13]. They found the weight of the liver decreased with increase in gestational period, whereas organs such as lungs increased in their size with increase in the gestational period [13, 14]. The adrenal glands in the first-trimester remain larger than the kidneys; however, after 12 weeks of gestation the kidney outweighs the adrenal gland.

The group was unable to detect any thymus tissue at 8 weeks of gestation in smaller fetuses. However, they could detect the presence of the thymus gland in larger fetuses weighing more than 5 g between the first and second trimester period. In 28 week old fetuses, the thymus could be easily detected indicating that with an increase in the gestational week, the thymus becomes observable because of its increase in weight and size [15]. In case of sexual organs, the growth and development of the tests were not uniform. However, a trend was observed where there was a decrease in the weight of the testes with an increase in the gestational period in the male fetuses and a similar pattern was also observed in case of the ovaries in female fetuses [13].

2. Relationship between the parental BMI and the anthropometric development of the fetus

Most of the studies conducted are based on the relationship of birth weight as an important anthropometric parameter and its measure of the fetal growth and development [16]. Ay et al., for the first time examined the relationship of maternal anthropometrics with the fetal growth and development at various stages of pregnancy through a large cohort study [2]. They showed that maternal pre-pregnancy BMI (pre-BMI) gestational weight and height has an influence on the fetal growth and development starting from mid-pregnancy onward [2]. These maternal parameters can be associated with the small and large size of the infants and are related to an increasing gestational age. The findings of the study were independent of the social factors such as the socio-economic condition and lifestyle of the mother [2]. Studies pertaining to the timing of the anthropometric development of the fetus have been focused mainly on the birth weight and fetal growth. However, third trimester studies till date remains inconclusive [6, 17–20].

Factors such as diabetes or insulin resistance have a strong effect on the high maternal pre-pregnancy BMI and weight gain and can lead to increased fetal glucose and an increased birth weight along with a risk of cardio-metabolic disorder [20]. Maternal nutritional status is also an important criterion that can be strongly associated with the pre-pregnancy BMI and the outcome of the fetal weight [21]. However, further studies are important to prove this exclusively including the maternal anthropometric mechanisms which affect the fetal growth [2].

Another important study was conducted in Pune to find out the relationship of BMI and height on 557 pregnancies with fetal age between 17 and 29 weeks of gestation and observed through ultrasound method. The group reported that parental height was positively associated with an increase in the fetal head circumference and femur length [22]. In case of higher BMI rates in mothers, ultrasound images showed that the fetus in utero had a smaller head circumference at 17 weeks and it increased during the time of birth. In mothers having lower BMI rates, head to fetal body ratio was observed to be large at 17 weeks. The placental volume was also depended on the maternal BMI and the paternal height [22].

As mentioned before, pre-pregnancy BMI is an important parameter and marker for nutrition, energy, and tissue development [22]. In the above study, further, the group of clinicians found a positive correlation between the paternal height and placental volume at around 17 weeks of fetal development although the direct role of maternal BMI on the 17 weeks fetus was found to negative [22]. Better maternal nutrition is thought to provide the mother with a higher BMI, which helps in the placental development in early pregnancy resulting in greater fetal development in the final gestational phases [23]. Similarly like Goldberg et al., the study further found a positive relationship with head circumference growth in the 29 weeks to birth interval [24].

A study by Tahergorabi et al., showed a weak association of maternal BMI with respect to the sex of the first-trimester fetus [25]. They showed maternal BMI was related to the female fetus rather than the male fetus and maybe sex-dependent in nature [25]. Other factors that can influence the impact of maternal BMI on birth weight of the fetus include maternal age, ethnicity, gestational diabetes mellitus and insulin resistance, education and environmental factors, and hypertension including genetics [26, 27].

Until recently the relationship of BMI and its significant influence on the developing fetus was unknown. Studies and observations have come to acknowledge the fact that maternal weight, BMI including that of the fetus plays an important role in determining the fetal growth and development [2, 28–30].

Recently, the significance of paternal BMI and dietary behavior in animal studies have also shed light into the fact that paternal obesity including BMI can affect the offspring in a gender-dependent manner [31]. Chen et al., in one such pioneer study observed that paternal BMI during the time of conception can be sex dependent and can influence the male but not the female fetus through mechanisms hitherto unknown [31]. However, the above cannot be exclusively confirmed as of yet due to very few studies relating to paternal BMI and its relationship with the fetal development [32].

3. Importance of BMI in fetal growth

BMI is one of the important parameters used along with other measures such as waist circumference, waist to hip and height ratio, subcapsular thickness as a part of the classification of overweight, obesity although it fails to account for the overall fat distribution [33]. It is also an important predictor to assess the healthy outcome of a baby. BMI can be directly correlated to neonate obesity, preterm birth complications, shoulder dystocia, and other complications [33]. Nonetheless, BMI still is an important factor that influences the growth and development of the fetus on a more general basis [34].

In third world countries where maternal nutrition has a profound effect on the fetal growth and development during pregnancy, the anthropometric parameter such as intrauterine growth (IUG) chart alone is not enough to assess the level of fetal malnutrition. BMI, which is based on weight to length ratio, is further an effective and sensitive method to assess the level of malnutrition [35]. As pregnancy is an important period for the fetal growth and development, any metabolic changes like maternal weight gain due to diabetes, dyslipidemia, or weight loss due to the chronic infections and diseases can affect the fetal health and development. Fetal macrosomia, limited or stunted growth of the fetus, pre-term delivery of the offspring are often the result of maternal pre-pregnancy BMI dysregulation [36]. Hence, maternal pre-pregnancy BMI can be an effective tool in poor countries to anticipate and predict neonatal health complications apart from nutritional care [36].

Glucose being one of the major energy substrates has shown to cross the placenta via facilitated diffusion mechanism but no evidence is present to show the feto-maternal placental exchange of insulin [37–39]. In a proposed model of diabetic pregnancy of Pederson, it was presumed that excess maternal glucose could pass through the blood-placental barrier and result in stimulation of endogenous fetal insulin production in the developing fetus rather than direct feto-maternal insulin exchange [40]. There are studies supporting this model where a positive correlation between the cord C peptide along with insulin production and weight of the infant has been shown [38, 39]. This exchange of excess glucose probably can be associated with the insulin resistance of the mother and thereby link the role of maternal BMI in controlling the level of the excess glucose production and its placental exchange leading to up-regulation of fetal insulin secretion and production of bigger babies [41].

4. Conclusion

It can be concluded that the maternal BMI plays a profound role and can be good indicators of birth weight and development of the fetus [42]. Apart from the risk factors associated with the delivery of a preterm and overweight baby, maternal BMI can be also an important indirect predictor of mothers at risk of delivering abnormal weight babies in developing, and poor countries [43, 44]. Also, nutrition plays a major role in fetal and maternal well being [42]. Increased risk of negative pregnancy outcomes like pre-term birth, low birth weight, intrauterine growth retardation (IUGR), small for gestational age (SGA) have shown to be associated with lower maternal pre-pregnancy BMI [45–48]. However, BMI alone cannot be an important anthropometric measurement factor for understanding the growth and development of the fetus. For a more detail understanding of the intrauterine fetal growth, other important factors like maternal height, weight, metabolic rate, total body water, and fetal body density should be also considered [5, 49].

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