



MATERNAL ANTHROPOMETRY DURING PREGNANCY AND ITS ASSOCIATION WITH MATERNAL AND NEONATAL HEALTH OUTCOMES: AN EXPANDED FOCUSED LITERATURE REVIEW

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ABSTRACT

Maternal anthropometry is an important component of nutritional and risk assessment during pregnancy. Maternal height, pre-pregnancy body mass index (BMI), gestational weight gain (GWG), mid-upper arm circumference (MUAC), and other measures of adiposity provide relatively inexpensive indicators that can be incorporated into antenatal and community health services. Evidence indicates that both inadequate and excessive maternal nutritional status are associated with adverse maternal, fetal, and neonatal outcomes. Low pre-pregnancy BMI is particularly associated with small-for-gestational-age birth, low birth weight, and preterm birth, whereas overweight and obesity are associated with gestational diabetes mellitus, hypertensive disorders, caesarean delivery, large-for-gestational-age birth, and macrosomia. GWG provides longitudinal information beyond baseline BMI; inadequate gain is associated with adverse fetal growth and preterm birth, whereas excessive gain is associated with excessive fetal growth and several maternal complications. MUAC is a practical additional measure where reliable pre-pregnancy weight is unavailable, although population-specific thresholds require validation. Evidence from South Asian populations also indicates that BMI and body-fat distribution may not have identical risk relationships to those observed in European populations. This focused review synthesizes evidence on maternal height, BMI, GWG, MUAC, adiposity, fetal growth, and neonatal outcomes, with particular attention to India and South Asia. Maternal anthropometric indicators should be interpreted as complementary measures and integrated with dietary, metabolic, clinical, fetal-growth, and neonatal assessment. Further prospective studies in India, including under-represented populations of northeastern India, are required to establish locally appropriate anthropometric reference values and clinically useful thresholds.

KEYWORDS: Maternal anthropometry; pregnancy; body mass index; gestational weight gain; mid-upper arm circumference; maternal adiposity; fetal growth; birth weight; South Asia.

1. INTRODUCTION

Maternal nutritional status before and during pregnancy is closely related to fetal growth, birth outcomes, maternal metabolic health, and subsequent child health. Anthropometric assessment offers a practical approach because several measurements can be obtained with inexpensive equipment and incorporated into routine antenatal services. Important indicators include maternal height, pre-pregnancy weight and BMI, GWG, MUAC, skinfold thickness, and measures of central adiposity.

Large-scale evidence demonstrates that maternal pre-pregnancy BMI is associated with multiple maternal,

fetal, and neonatal outcomes. Underweight is particularly associated with small-for-gestational-age (SGA) birth and preterm birth, whereas overweight and obesity are associated with gestational diabetes, hypertensive disorders, caesarean delivery, large-for-gestational-age (LGA) birth, and macrosomia.^[1]

Maternal height provides information about long-term growth and nutritional history. A systematic review and meta-analysis involving more than 333,000 women found that short maternal stature was associated with increased unadjusted risks of preterm birth and low birth

weight, although associations were attenuated in some adjusted analyses.^[2]

Anthropometric measurements, however, should not be regarded as diagnostic tests for individual fetal growth restriction. A meta-analysis evaluating maternal height, weight, BMI, and GWG found limited diagnostic accuracy for predicting SGA when these measures were used alone.^[3]

The interpretation of BMI is especially relevant in Asian populations. A WHO expert consultation concluded that associations between BMI, body fat, and metabolic risk differ between Asian and European populations, supporting careful population-sensitive interpretation.^[4]

South Asian evidence further indicates associations between maternal anthropometrics and gestational anthropometric change, birth weight, mode of delivery, and gestational diabetes, although the evidence is heterogeneous and incomplete.^[5]

2. MATERNAL HEIGHT AND LONG-TERM NUTRITIONAL STATUS

Maternal height is largely determined before adulthood and therefore reflects cumulative growth, childhood nutrition, health, and genetic influences. Unlike weight or BMI, height does not directly describe current nutritional status. Nevertheless, short maternal stature has been associated with adverse perinatal outcomes.^[2]

An individual-participant-data meta-analysis of approximately 177,000 women from low- and middle-income countries reported that short maternal stature was associated with increased risks of SGA and preterm birth.^[6]

A dose-response meta-analysis also reported a nonlinear inverse association between maternal height and SGA risk.^[7]

These findings suggest that maternal height can provide useful background information during antenatal assessment, but it should be interpreted as a marker of long-term growth rather than a direct measure of current nutritional adequacy. Maternal height should therefore complement, rather than replace, assessment of weight, BMI, GWG, diet, and fetal growth.

3. PRE-PREGNANCY BMI AND PREGNANCY OUTCOMES

Pre-pregnancy BMI remains the most widely used baseline anthropometric indicator in pregnancy. The worldwide systematic review and meta-analysis by Vats et al. demonstrated associations between low BMI and SGA/preterm birth and between high BMI and gestational diabetes, hypertensive disorders, caesarean delivery, LGA, and macrosomia.^[1]

Large individual-participant-data analyses have confirmed that pre-pregnancy BMI and GWG are independently and jointly associated with pregnancy complications. In 265,270 births from 39 cohorts, higher BMI was associated with increased risks of gestational hypertensive disorders, gestational diabetes, and LGA birth.^[8]

A large Korean cohort similarly found that pre-pregnancy obesity increased the risk of adverse maternal and infant outcomes and that excessive GWG added further risk, particularly among women who were overweight or obese before pregnancy.^[9]

More recent dose-response evidence involving more than 50 million pregnancies found a clear relationship between increasing pre-pregnancy BMI and hypertensive disorders of pregnancy, including gestational hypertension, pre-eclampsia, and eclampsia.^[10]

These findings support the use of pre-pregnancy or early-pregnancy BMI for risk stratification and preconception counselling. However, BMI does not distinguish fat mass from lean mass and does not describe fat distribution.

4. MATERNAL UNDERWEIGHT, FETAL GROWTH AND BIRTH OUTCOMES

Low maternal BMI may indicate inadequate nutritional reserves and may coexist with micronutrient deficiencies, low energy availability, chronic illness, or previous undernutrition. Across large populations, maternal underweight is consistently associated with SGA and preterm birth.^[1]

Maternal anthropometric measurements may also correlate with birth weight, but their ability to predict SGA accurately at the individual level is limited.^[3]

In practical terms, women who enter pregnancy underweight require attention to dietary adequacy, appropriate GWG, anaemia and micronutrient status, and fetal-growth surveillance. Anthropometry should be integrated with clinical and fetal assessment rather than used as an isolated predictor.

5. OVERWEIGHT, OBESITY AND MATERNAL ADIPOSITY

Maternal overweight and obesity have become major components of the global maternal-health burden. Higher maternal adiposity is associated with gestational diabetes, hypertensive disorders, caesarean delivery, LGA birth, and macrosomia.^[1,8,10]

BMI is convenient but imperfect because it does not distinguish lean tissue from adipose tissue or characterize central adiposity. A systematic review and meta-analysis of maternal adiposity measures found that measures other than BMI, including waist circumference, may also be associated with adverse maternal outcomes, particularly metabolic complications.^[11]

The South Asian literature is particularly relevant because higher body-fat percentage and central adiposity may occur at BMI levels associated with substantial metabolic risk. The WHO consultation emphasized that Asian populations may experience increased metabolic risk at lower BMI than many European populations.^[4]

Thus, BMI should be considered a practical screening measure rather than a complete measure of maternal adiposity.

6. GESTATIONAL WEIGHT GAIN

GWG is a dynamic indicator reflecting fetal, placental, uterine, fluid, and maternal tissue changes during pregnancy. The National Academies report on pregnancy weight gain established BMI-specific recommended ranges and emphasized that appropriate GWG depends on pre-pregnancy nutritional status.^[12]

A systematic review and meta-analysis involving more than one million women found that GWG below or above the recommended ranges was associated with adverse maternal and infant outcomes. Excessive gain was associated with higher risks of LGA, macrosomia, and caesarean delivery, whereas inadequate gain was associated with higher risk of SGA and preterm birth.^[13]

An individual-participant-data meta-analysis involving 196,670 pregnancies further demonstrated that pre-pregnancy weight and GWG jointly influence adverse maternal and infant outcomes, although the predictive value of GWG alone was modest.^[14]

Gestational weight gain is also influenced by multiple individual, family, behavioural, and social factors. A systematic review and meta-analysis identified pre-pregnancy overweight/obesity, younger age, primiparity, smoking, unemployment, and other factors as determinants of excessive GWG.^[15]

Evidence from Korean women supports the interaction between baseline BMI and GWG, with the combination of overweight/obesity and excessive GWG associated with substantially increased adverse-outcome risk.^[9]

7. MID-UPPER ARM CIRCUMFERENCE AS A COMPLEMENTARY MEASURE

MUAC is inexpensive, rapid, and relatively easy to obtain, making it attractive in community and resource-limited antenatal settings. It is particularly useful where pre-pregnancy weight is unavailable or recalled weight is unreliable.

In the MAASTHI prospective cohort in India, MUAC showed the highest agreement among the maternal anthropometric measures studied with total skinfold thickness, supporting its potential use as a practical marker of maternal adiposity in public facilities.^[16]

A prospective study from the National Institute of Nutrition in India followed 928 pregnant women and found positive relationships between maternal MUAC and neonatal anthropometry. A MUAC of 23 cm showed useful sensitivity and specificity for predicting low birth weight in that study.^[17]

These findings support MUAC as a complementary screening indicator. However, the cut-off obtained in one population should not automatically be generalized to all Indian or South Asian populations because gestational age, ethnicity, nutritional environment, measurement protocol, and outcome definitions may influence performance.

8. MATERNAL ANTHROPOMETRY AND FETAL GROWTH

Maternal anthropometry is associated with fetal growth through multiple pathways involving maternal nutritional reserves, glucose metabolism, insulin resistance, placental function, and nutrient availability. Low maternal nutritional status may be associated with restricted fetal growth, whereas higher BMI and excessive GWG may increase the probability of excessive fetal growth.^[1,13]

A recent retrospective cohort study found associations between higher maternal pre-pregnancy BMI and longitudinal fetal growth and reported that maternal fasting plasma glucose partly mediated these associations.^[18]

These observations support an integrated model in which maternal anthropometry provides risk information but does not directly measure fetal well-being. Appropriate clinical and ultrasonographic assessment remains necessary when fetal growth abnormality is suspected.

9. GESTATIONAL WEIGHT GAIN, POSTPARTUM WEIGHT RETENTION AND INTERPREGNANCY HEALTH

The implications of maternal anthropometry extend beyond delivery. A recent systematic review and meta-analysis of 34 observational studies found that excessive GWG was associated with greater postpartum weight retention, including additional retained weight several years after delivery.^[19]

Interpregnancy BMI change may also influence the next pregnancy. A systematic review and meta-analysis involving 925,065 women found that substantial interpregnancy BMI gain was associated with increased risks of GDM, caesarean delivery, LGA, and macrosomia, whereas weight loss was associated with lower risks of some outcomes but a higher risk of SGA.^[20]

These findings indicate that maternal weight management should be viewed across the reproductive life course rather than only during a single pregnancy.

10. MATERNAL ANTHROPOMETRY IN SOUTH ASIAN AND INDIAN SETTINGS

South Asian populations require particular attention because undernutrition and excess adiposity may coexist. The systematic review by Slack et al. found evidence linking maternal pre-pregnancy or early-pregnancy anthropometrics with gestational anthropometric change, birth weight, mode of delivery, and GDM in South Asian women, while also emphasizing substantial heterogeneity and gaps in evidence.^[5]

Indian studies demonstrate the potential value of MUAC and other simple anthropometric measures in predicting birth weight and identifying nutritional risk.^[16,17]

At the same time, the limitations of anthropometry must be recognized. Maternal BMI and MUAC do not directly measure dietary quality, micronutrient status, insulin sensitivity, placental function, or fetal growth. Their value is therefore greatest when they are integrated into a broader antenatal assessment framework.

11. PRACTICAL APPLICATION IN ANTENATAL CARE

Table 1: Practical framework for maternal anthropometric assessment during and after pregnancy.

Pregnancy stage	Anthropometric assessment	Clinical interpretation
Early pregnancy	Measured height, weight and BMI	Baseline nutritional and metabolic risk
Antenatal follow-up	Serial maternal weight/GWG	Assess trajectory in relation to baseline BMI and gestational age
When pre-pregnancy weight is unavailable	MUAC	Additional nutritional/adiposity screening
Throughout pregnancy	Anthropometry plus BP, glucose, diet and clinical assessment	Integrated maternal risk assessment
Late pregnancy/delivery	Maternal trajectory plus birth weight and gestational age	Interpret fetal/neonatal growth outcome
Postpartum	Maternal weight	Assess postpartum weight retention and future pregnancy risk

12. RESEARCH GAPS AND FUTURE DIRECTIONS

Important gaps remain in the evidence base. First, population-specific MUAC thresholds and GWG references require further validation. Second, prospective longitudinal studies from India and South Asia are still less numerous than studies from Europe and North America. Third, future research should combine anthropometry with dietary intake, physical activity, blood glucose, blood pressure, fetal biometry, placental measures, and neonatal anthropometry.^[5,16,17]

There is also a need to distinguish between different South Asian populations rather than treating the region as homogeneous. Studies from northeastern India, including Tripura, could contribute valuable information because local nutritional patterns, ethnic composition, socioeconomic circumstances, and health-service access may differ from those represented in existing national datasets.

Future prospective cohorts should use standardized protocols for height, weight, MUAC, GWG, gestational age, fetal growth, and neonatal anthropometry. Measured rather than recalled pre-pregnancy weight should be prioritized wherever possible. Locally derived reference values should then be compared with international recommendations.

13. CONCLUSION

Maternal anthropometry provides a practical and relatively inexpensive approach to antenatal nutritional

and risk assessment. Maternal height, pre-pregnancy BMI, GWG, and MUAC provide different and complementary information.^[1,2,16]

Low maternal BMI is associated particularly with SGA, low birth weight, and preterm birth, whereas high BMI is associated with gestational diabetes, hypertensive disorders, caesarean delivery, LGA birth, and macrosomia. GWG adds longitudinal information and should be interpreted in relation to baseline BMI and gestational age.^[1,13,14]

MUAC is particularly useful where pre-pregnancy weight is unavailable, but population-specific thresholds require validation. Anthropometric measures should not be used in isolation; their greatest value is obtained when they are integrated with dietary, metabolic, clinical, fetal-growth, and neonatal assessment.^[16,17]

Further prospective research in India and South Asia, particularly in under-represented populations, is needed to establish locally appropriate reference values and strengthen the use of maternal anthropometry in routine antenatal and public-health practice.

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