Research Article

Maternal Anthropometry as a Tool to Screen Mothers at High Risk of Delivering Low Birth Weight Neonates: A Multi-Centered Study in Lahore, Pakistan

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Abstract

Background: Maternal anthropometric measurements have influence on birth weight of neonates with varying extent and can be used to screen high risk pregnancies.

Objective: To identify appropriate maternal anthropometric cut-off values associated with high risk of delivering Low Birth Weight (LBW) neonates in Lahore, Pakistan.

Methods: An analytical cross sectional study was carried out in 2 government and 5 private hospitals in Lahore. Postnatal women were approached consecutively and those fulfilling the inclusion and exclusion criteria, and gave written consent were enrolled in the study. Anthropometric measurements i.e. weight, height and mid upper arm circumference (MUAC) of 800 postnatal women and birth weight of their neonates were recorded. Ethical approval was obtained from Institutional Review Board (IRB) of one of the hospital. Data was analyzed with the help of SPSS version 22.

Results: Mean maternal age was 27.72(+4.392) years and mean maternal education was 12.1(+4.425) years. Optimum cut-offs to detect risk of LBW were identified as MUAC <28.75 cm (OR=1.334,CI=0.919-1.935), height <157.5 cm (OR=2.134,CI=1.460-3.120), booking weight <62.5 kg (OR=1.971,CI=1.349-2.881), pre-delivery weight <72.5 kg (OR=2.348,CI=1.593-3.461), booking BMI <26.6 kg/m2 (OR=1.003,CI=0.680-1.479), pre-delivery <BMI 28.8 kg/m2 (OR=1.461,CI=1.004-2.127), and weight gain <17.8 lbs. (OR=3.088,CI=2.089-4.565).

Conclusion: Country specific cut-off values for maternal anthropometric measurements have been identified. Cut-off for maternal height, booking weight and weight gain were effective in screening mothers at high risk of delivering LBW neonates.

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Introduction

The prevalence of Low Birth Weight (LBW) i.e. weight less than 2500 grams was 14.6% World-wide in 2015. In South Asia the prevalence of LBW has been reported to be 28%, whereas in Pakistan it was 32%. Pre-conception and gestational under-nutrition increased the risk of fetal growth retardation (FGR), small for gestational age (SGA), preterm births (PTB), and low birth weight (LBW), which augmented neonatal morbidity and mortality. Later in life, LBW neonates have low immunity and cognitive

abilities; and have a higher risk of chronic diseases.[1]

Numerous factors like genetics, maternal as well as other environmental factors effect fetal growth and consequently neonatal health; but maternal factors have been explored in greater detail. A recent meta-analysis of secondary data from 10 countries demonstrated that LBW was more prevalent among mothers who are 35–49 years, not receiving antenatal care, illiterate, conceived late, underweight and have low wealth status.[2]

An early antenatal care visit provided the opportunity to screen[3] mothers at risk of delivering LBW neonates through anthropometric measurements.[4] Studies done in different parts of the world had repeatedly revealed association amid low maternal anthropometric measurements and an increased risk of LBW neonate. Maternal anthropometric parameters which were good predictors of birth weight and survival were maternal height, pre-pregnancy weight, Body Mass Index (BMI) weight gain in pregnancy and MUAC.[5,6]

Only a few studies have explored the link between maternal anthropometry and LBW in Pakistan.[7,8] Country specific cutoffs have not been identified to screen pregnant women who were at risk of delivering LBW neonates. Standardized cut-off points for maternal anthropometric measurements could help screen mothers for provision of timely intervention through maternal health and nutrition programs. A good predictor is one which has a high sensitivity and high specificity. In this context, sensitivity means how successful maternal anthropometric variables were in this study, to identify an LBW baby. Specificity means, how specific maternal variables were to predict or identify a normal birth weight baby. Sensitivity and specificity are dependent on one another. In this research, more sensitive indicators were needed than specific to avoid false negatives.

Keeping in mind the aforementioned facts, the current study was carried out to identify optimum maternal anthropometric cut-off values associated with high risk of delivering Low Birth Weight (LBW) neonates in Lahore, Pakistan.

Methods

The research design was an analytical cross-sectional survey. Sample of postnatal women and newborns was taken from 2 government and 5 private hospitals of Lahore. Two staged sampling design was used. In the first stage, convenient sampling technique was employed. 5 government and 5 private centrally located hospitals with large patient turnover were identified and consented for participation in the study. Among the government hospitals only 2 granted permission and all 5 private hospitals consented to participate.

In the second stage purposive sampling technique was employed. All postnatal women who delivered their neonates from July 2016 till August 2017 in the selected hospitals, and fulfilled inclusion and exclusion criteria, were consecutively enrolled. Only those women were selected whose records were complete, were booked at least at the start of second trimester and had more than 3 antenatal checkups. Congenital abnormalities, multiple births and still births were excluded from the study. All participants gave written informed consent after they were informed about the study. Anonymity and confidentiality was ensured at all levels.

According to Central Intelligence Agency (U.S.) world fact book population of Lahore was 8.741 million (2015 estimated) and birth rate was 21.9 birth/1000 (2017 estimate)[9] therefore, each year 191,428 neonates are born. A sample size of 400 was calculated on online sample size calculator using population of 191,428 newborn, 95% confidence level and 5% standard error. A larger sample was selected i.e. 800 for better generalization of results.

An interview schedule was developed to collect data on demographic factors like urban/rural setting, city of residence, religion, maternal age, maternal education, and family income.

Socioeconomic status was determined by inquiring about husband's income, total and dependent family members. Per person income was calculated by dividing husband's income with number of dependent family members and per person/day income was calculated by further dividing with 30. Those earning less than $1.9/person/day were classified as living below poverty line.[10]

Anthropometric measurements of the mother were assessed using Nutrition Assessment Guidelines [11].

Mother's weight was measured by a portable digital weighing scale and rounded off to the nearest 100 grams. Mothers' height was assessed with a regular stadiometre and rounded to the nearest millimeter and the maternal MUAC was recorded by a non-stretchable tape and rounded to the nearest millimeter. Booking weight and height was retrieved from patient files (at gestational age mean 19.012 + 6.190 weeks). Pre-delivery weight was taken immediately before delivery (at gestational age mean 37.854 + 1.786 weeks). MUAC and height (to reconfirm booking height) were measured within 24 hours of birth in the postnatal wards. It is a standard procedure to record maternal height, booking and pre-delivery weight of the mother in most of the hospitals in Pakistan.

Body Mass Index was calculated by dividing weight in kilograms with height in meter squares. BMI was categorized according to World Health Organization's recommendation. A BMI less than 18.5 as underweight, BMI 18.5-24.9 as normal, BMI 25-29.9 as overweight and BMI greater than 30 was classified as obese.[12]

Weight gain was calculated by subtracting booking weight from pre-delivery weight. Weight gain was classified according to Institute of Medicine (IOM) criteria for pregnant women.[13] If mothers who were underweight at booking gained 28-40 lbs. (12.5-18 kg.) at pre-delivery they were categorized as having desirable weight gain. Similarly a weight gain of 25-35 lbs. (11.5-16 kg.) for mothers with normal BMI, 15-25 lbs. (7-11.5 kg.) for overweight mothers and 11-20 lbs. (5-9 kg.) for obese mothers was classified as desirable weight gain. A lesser or more than desirable was categorized as less than desirable or more than desirable weight gain.

Birth weight of the neonate was taken by infant pan scale immediately after birth.[11] Measurements were taken by neonatal nurses who were trained by the researcher in neonatal anthropometry. To ascertain accuracy and quality of data, all maternal and neonatal measurements were taken thrice and an average was calculated.

Written permission was obtained from Secretary Health, Secretariat Lahore and Medical Superintendent to collect data from government hospitals; and from Managing Directors and Head of Departments of private hospitals. Institutional Review Board Fatima Memorial Hospital Medical and Dental College, Lahore (IRB# FMS-2-2016-IRB-O-116) granted ethical approval for the study.

Descriptive statistics were calculated to describe the data. Pearson correlation was applied to observe significance in relationship between maternal variables with neonatal birth weight. Receiver operating characteristic (ROC) curves were drawn to identify cut-offs in research data and sensitivity and specificity were calculated. Optimum cut-off values were used to dichotomize the maternal anthropometric measurements and Odds Ratio with confidence interval was calculated to measure risk. Chi square Test was applied to observe significance in association. Data was stored and analyzed in IBM Statistical Package for Social Sciences (SPSS v 22). A p-value < 0.05 was set for statistical significance.

Results

The sample was quite diverse selected from 5 private (n=393) and 2 (n=407) public hospitals of Lahore. 763 (95.4%) were Muslims and 37 (4.6%) were Non-Muslims. Majority (n=706, 88.3%) were resident of Lahore, the rest (n=94, 11.7%) came from different villages, cities and provinces of Pakistan. 741 (92.6 %) belonged to urban settings whereas 59 (7.4%) came from rural background. Among 800 neonates 96 (12.0%) were pre-term (gestational age <37 weeks) and 704 (88%) were term (gestational age >37 weeks).

Table 1 shows the socio-demographic and anthropometric profile of the participants. Pearson correlation was applied and significance was assessed. All maternal variables had a weak correlation (Pearson correlation value less than 3) with neonatal birth weight. Mean maternal age was 27.720 years. Majority of the mothers (n=598, 74.8%) were aged 20-30 years; only 12 (1.5%) were <19 years of age. More than half (n=528, 66%) of the mothers were educated more than 10 years. Almost one third of the sample women 243 (30.4%) were living below poverty line (<$1.9/ person/day). Mean MUAC was 29.405 and only 48 (6.0%) had a height <150 cm (mean=158.495 cm). Mean weight at booking and pre-delivery was 63.949 and 72.956 kg respectively. Mean BMI at

Table 1: *Descriptive statistics of maternal characteristics and anthropometry and its relationship with birth weight of neonate*

Characteristics		N (%)	Mean (S. D.)	R*	P-value
Maternal age (years)	≤19	12 (1.5)	27.720 (4.392)	0.175	0.000
	20-30	599 (74.9)			
	≥31	189 (23.6)			
Maternal education (years)	≤10	272 (34.0)	12.100 (4.425)	0.155	0.000
	>10	528 (66.0)			
Household income	≤$1.25/person/day**	135 (16.9)	RS. 53976.25 (45467.624)	0.079	0.026
	>$1.25/person/day	665 (83.1)			
	≤$1.9/person/day***	243 (30.4)			
	>$1.9/person/day	557 (69.6)			
MUAC (cm)	≤23	39 (4.9)	29.409 (3.951)	0.135	0.000
	>23	761 (95.1)			
Height (cm)	≤150	48 (6.0)	158.495 (5.253)	0.131	0.000
	>150	752 (94.0)			
Booking weight (kg)	≤50	89 (11.1)	63.949 (11.354)	0.246	0.000
	>50	711 (88.9)			
Pre-delivery weight (kg)	≤55	39 (4.9)	72.956 (11.403)	0.269	0.000
	>55	761 (95.1)			
Booking BMI (kg/m^2)	≤18.5	29 (3.6)	25.455 (4.342)	0.206	0.000
	>18.5	771 (96.4)			
Pre-delivery BMI(kg/m^2)	≤18.5	3 (0.4)	29.023 (4.224)	0.232	0.000
	>18.5	797 (99.6)			
Weight Gain	< Desirable	336 (42.0)	9.035 (4.344)	0.093	0.008
	Desirable	357 (44.6)			
	> Desirable	107 (13.4)			
Birth weight (kg)	LBW (<2.5 kg)	134 (16.75)	2.972 (0.524)	--	--
	NBW (≥2.5 kg)	666 (83.25)			

*Pearson correlation.
**Line of Poverty, 2008 (15)
*** Line of Poverty, 2015 (15)
Rate of dollar taken as equivalent to Rs. 105 (6 December 2017)

booking and pre-delivery was 25.455 and 29.02 kg/m2 respectively. Mean weight gain was 9.035 kg and 42% women gained weight less than desirable.[19]

Receiver operating characteristic (ROC) curves were drawn. Figure 1 shows sensitivity and specificity curves for maternal MUAC, height, weight, BMI and weight gain. The legends explain the Area Under Curve (AUC) with it's significance (p-value) and Confidence Interval of ROC analysis. AUC ranged from 0.547-0.661. Besides MUAC all maternal anthropometric variables were statistically significant.

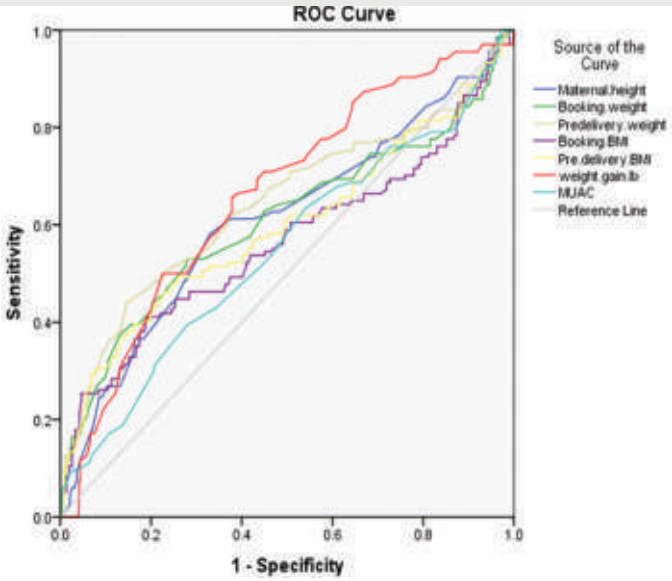

Figure 1: *Sensitivity and Specificity Curve for Maternal Anthropometric Characteristics*

MUAC (AUC 0.547, p=0.082, CI=0.490-0.605), Height (AUC 0.610, p=0.000, CI=0.553-0.667),

Booking weight (AUC 0.607, p=0.000, CI=0.546-0.669),
Pre-delivery weight (AUC 0.642, p=0.000, CI=0.583-0.701),
Booking BMI (AUC 0.564, p=0.019, CI=0.502-0.626),
Pre-delivery BMI (AUC 0.597, p=0.000, CI=0.536-0.568),
Weight gain (AUC 0.661, p=0.000, CI=0.610-0.711).

Table 2 gives the detailed description of high specific, optimum and high sensitive cut-off values for maternal anthropometric variables. Optimum cut-offs to detect risk of LBW were identified as MUAC < 28.75 cm, height < 157.5 cm, booking weight < 62.5 kg, pre-delivery weight < 72.5 kg, booking BMI< 26.6 kg/m2, pre-delivery < BMI 28.8 kg/m2, and weight gain < 17.8 lbs.

The odds of increased risk at above mentioned cut-offs has been given in table 3. In order of increased risk weight gain < 17.8 lbs. (OR=3.088, CI=2.089-4.565), pre-delivery weight < 72.5 kg (OR=2.348, CI=1.593-3.461) and height < 157.5 cm (OR=2.134, CI=1.460-3.120) had the highest odds of delivering an LBW neonate, followed by booking weight < 62.5 kg (OR=1.971, CI=1.349-2.881). Pre-delivery < BMI 28.8 kg/m^2 (OR=1.461, CI=1.004-2.127), MUAC < 28.75 cm (OR=1.334, CI=0.919-1.935) and booking BMI< 26.6 kg/m^2 (0R=1.003, CI=0.680-1.479) were nonsignificant. Chi square Test was applied to observe significance in association.

Table 2: *Sensitivity and Specificity Values for H-SPEC, Optimum and H-SENS Cut-offs for Maternal Anthropometry*

			Sensitivity %	Specificity %
MUAC (cm)	H-SPEC	≤26.25	29.9	79.4
	Optimum	≤28.75	53.7	53.5
	H-SENS	≤34.5	85.1	10.5
Height (cm)	H-SPEC	≤155	36.6	81.7
	Optimum	≤157.5	61.2	62.6
	H-SENS	≤162.5	84.3	19.4
Booking weight (kg)	H-SPEC	≤55.25	42.5	79.7
	Optimum	≤62.5	61.2	55.6
	H-SENS	≤74.5	80.6	13.5
Pre-delivery weight (kg)	H-SPEC	≤65.5	47.0	80.5
	Optimum	≤72.5	65.7	55.4
	H-SENS	≤81.5	80.0	18.9
Booking BMI kg/m^2	H-SPEC	≤22.4	41.0	80.0
	Optimum	≤26.6	56.0	52.0
	H-SENS	≤30.0	80.0	12.6
Pre-delivery BMI kg/m^2	H-SPEC	≤26.5	14.8	80.0
	Optimum	≤28.8	59.0	50.9
	H-SENS	≤32.0	81.3	21.0
Weight gain (lb.)	H-SPEC	≤12.6	41.8	80.3
	Optimum	≤17.8	66.4	61.0
	H-SENS	≤24.0	80.0	37.1

Discussion

Table 3: *Association between Maternal Anthropometry and Neonatal Birth Weight*

		LBW N (%)	NBW N (%)	OR*	CI**	P***
MUAC (cm)	≤28.75	72 (18.8)	310 (81.2)	1.334	0.919-1.935	0.131
	>28.75	62 (14.8)	356 (85.2)			
Height (cm)	≤157.5	82 (17.0)	283 (83.0)	2.134	1.460-3.120	0.000
	>157.5	52 (12.0)	383 (88.0)			
Booking weight (kg)	≤62.5	82 (21.7)	296 (78.3)	1.971	1.349-2.881	0.000
	> 62.5	52 (12.3)	370 (87.7)			
Pre-delivery weight (kg)	≤72.5	88 (22.7)	299 (77.3)	2.348	1.593-3.461	0.000
	>72.5	46 (11.1)	367 (88.9)			
Booking BMI (kg/m^2)	≤26.5	87 (16.8)	432 (83.2)	1.003	0.680-1.479	1.000
	>26.5	47 (16.7)	234 (83.3)			
Pre-delivery BMI (kg/m2)	≤28.8	78 (19.4)	325 (80.6)	1.461	1.004-2.127	0.058
	>28.8	56 (14.1)	341 (85.9)			
Weight gain (lb.)	≤17.8	89 (25.5)	260 (74.5)	3.088	2.089-4.565	0.000
	>17.8	45 (10.0)	406 (90.0)			

*Odds Ratio
**Confidence Interval
***P-value of Chi-Square Test

Low birth weight is a major public health dilemma as LBW neonates have lower chances of survival and growth and development is compromised.[1] The etiology of LBW is multifactorial and to a large extent is effected by maternal socio-demographic factors, health and nutritional status.[2] A study in Pakistan found that neonates born to teenage, anemic, illiterate mothers, belonging to poor socio-economic stratum with close birth spacing were more likely to be LBW.[7] In our study, a weak yet significant associa-tion was found between maternal age, education, household income and LBW.

A risk factor which has a high sensitivity and high specificity is considered a good predictor. The purpose of the test determines the optimum balance of sensitivity and specificity. Generally, a screening test should be highly sensitive, whereas a follow-up confirmatory test should be highly specific.[14] In the current research, optimum cut-off values (high sensitive and high specific) for maternal anthropometric measurements that can be effectively used as predictors of LBW, have been identified according to characteristics of Pakistani population.

Maternal anthropometry is a very valuable instrument to screen mothers at risk of having

neonates, who experience suboptimal fetal growth.[6] MUAC is a good indicator of the protein reserves of a body, and is rather insensitive to changes over the total period of pregnancy. Food and Nutrition Technical Assistance III Project (FANTA) concluded that MUAC cutoffs (19.0 cm to 23.0 cm) had higher specificity. Analysis of MUAC of Pakistani pregnant women showed that <24 cm had higher specificity (88.5%) but lower sensitivity (17.4%).[15] The results of the current study suggest that a cut-off value of ≤28.75 cm to be more suitable as it had good specificity and sensitivity. The best cut-off value identified in current research was higher than other part of Pakistan[15] reflects influence of demographic and ethnic differences on maternal height and thus neonatal birth weight. MUAC <28.75 increases the odds of having an LBW neonate by 1.334 times which was statistically non-significant.

Maternal undernutrition is manifested as short stature, low weight prior to conception and low weight gain during pregnancy are among the reliable predictors of LBW neonate. Women with short stature have increased chances of neonates with IUGR and thus LBW. A community based longitudinal study in Bangladesh reported <150 cm the most suitable cut-off to predict LBW, but <154 cm gave 80% sensitivity[4] whereas in India 152 cm was identified as critical limit.[16] The results of this research indicated that a height of < 157.5 cm had a good specificity and sensitivity. The cut-off value identified from the data was higher than cut-off values of other South Asian countries due to demographic and ethnic characteristics of our population. Previously, one study in Pakistan found a non-significant odds of 1.4 times using a cut-off of <155 cm[17] yet another found a significant association between <150 cm and LBW.[7] In our study height <157.5 cm MUAC increased the odds of having an LBW neonate by 2.134 times which was statistically significant.

Importance of pre-conception nutritional status has been a focus of debate recently as studies show that women who were nourished at the start of pregnancy had better outcomes than women who were under nourished at the start. In order to break the intergenerational cycle of malnutrition the pre-conceptional nutritional status of women needs to be given priority. Weight at registration/booking during the first trimester is taken as proxy for preconception nutritional status.[18] Previously, a cut-off for weight of <43 kg for 3-5 month and BMI <19 kg/m^2 for 3-5 month was suggested as it gave 80% sensitivity in Bangladeshi population[4] whereas in India weight of <45 kg and BMI 20 kg/m^2 were reported as critical limits to identify risk of LBW.[16] In the current study, booking weight of < 62.5 kg and a BMI of < 26.6 kg/m^2 was identified as optimum cut-off value. At this cut-off the associated odds of delivering an LBW neonate were 1.971 (significant) and 1.003 (non-significant) respectively. Cut-off values determined in this research are quite higher than the cut-offs identified in other South Asian countries. In Pakistan, booking weight was not recorded previously as the studies were cross sectional and data was collected at the time of delivery.[7,8]

Pre delivery measurements have a limited value for a pragmatic point of view as less or no time is left for intervention. In India at 6 months a cut-off of <22 kg/m^2 gave 80% sensitivity[4]. Earlier studies in Pakistan found that maternal weight < 60 kg and BMI

<25 kg/m² at term had significant association with LBW,[7] and weight <57 kg increased the odds of LBW 1.8 times significantly.[17] In this research, pre-delivery weight of < 72.5 kg and a BMI of < 28.8 kg/m² and were identified as ideal cut-off values. At this cut-off the associated odds of delivering an LBW neonate were 2.348 (significant) and 1.461(non-significant) respectively. Cut-offs and OR were higher than previous studies in Pakistan[7,17] as well as neighboring countries.[4]

Institute of Medicine (1OM) has recommended a range of adequate weight gain according to pre-conception or early pregnancy BMI.[13] Recent international studies show that weight gain less than IOM recommendations results in IUGR, SGA and LBW whereas a higher weight gain caused LGA and macrosomia.[19,20] In Bangladesh, second/third trimester weight gain of < 2.5 kg had 80% sensitivity in detection of LBW.[4] In Pakistan, women a lower weight gain than the IOM recommendations were at a greater risk of having LBW as compared to those who gained appropriately (8.7% vs. 7.3%, p = 0.08). The optimal weight gain was estimated to be 8.5 kg to prevent low birth weight in Pakistani population [21]. Our results are in line with this previous research. The best cut-off was identified as a weight gain of < 17.8 lbs. (8.1 kg). At this cut-off the odds of delivering an LBW neonate were 3.088 times than those who gain more weight. As booking/registration weight was not recorded in other research conducted in Pakistan, effect of weight gain was not assessed previously.[7,17]

Although, low AUC ROC were identified, yet maternal anthropometry is plausible for routine use in IUGR/ LBW screening in settings with limited resources where ideal methods like an ultrasound cannot be employed. Almost all anthropometric cut-offs were very different, mainly higher, from those reported in literature. First of all the reason for high cut-off value was the changed demographic, nutritional and health profile of the participants. Secondly a high cut off would mean more false positives and increase cost of screening and intervention. But if a high specific cut-off (lower value) is chosen the number of false negatives will increase. A lot of false negative would mean that a lot of newborns are wrongly labelled as normal. False negatives can be critical as LBW is a major health concern responsible for life long health implications and can be treated more effectively if timely identified.

Optimum cut-off maternal anthropometric values may be used to screen mothers at high risk of delivering LBW neonates as pregnancy is the part of first 1000 days critical period for optimal growth of the brain and body of the neonate.[22] Major strengths of this research was a large sample size belonging to varied socio-economic groups. The sample was quite diverse and multi-ethnic, although majority were resident of Lahore (88.3%). Both urban and rural residents, Muslims and minorities were included. Almost all previous studies were conducted at government hospitals, the current data was collected from both public and private hospitals in Lahore. A major confounder antenatal care was controlled (all women were receiving high quality antenatal care). Booking weight was recorded and weight gain was calculated in this study, which lacking in previous studies in Pakistan. The sample was drawn from women visiting hospitals of Lahore, thus women who give birth at private maternity homes or MCH centers, or at homes with help of midwives or TBA, were not included in the study.

Conclusion

Maternal anthropometry is a simple non-invasive tool to screen mothers at high risk of delivering LBW neonates. Country specific cut-off values for maternal anthropometric measurements have been identified. In order of increased risk weight gain, pre-delivery weight and height had the highest odds of delivering an LBW neonate, followed by booking weight. Practically height, booking weight and weight gain should be effective in screening mothers at high risk of delivering LBW neonates. Its routine application in healthcare settings to detect such mothers so they can referred to nutritionists to provide targeted interventions to ensure ideal fetal growth and improved pregnancy outcomes.

List of Abbreviations

LBW-Low Birth Weight
SGA-Small for Gestational Age
IUGR-Intra Uterine Growth Retardation
MUAC-Mid Upper Arm Circumference
IRB-Institutional Review Board
SPSS-Statistical Package for Social Sciences

FGR-Fetal Growth Retardation
PTB-Pre Term Birth
BMI-Body Mass Index
CIA-Central Intelligence Agency
WHO-World Health Organization
IOM-Institute of Medicine

Figure Legend

Figure 1 Sensitivity and specificity curve for maternal anthropometric characteristics

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