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# Body composition at birth: A hospital based study

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**Abstract:**
The present hospital based study was a situational analysis to study the anthropometric and body composition parameters of the neonates of Vadodara city and to examine the maternal factors associated with it. Maternal obstetric history and anthropometric measurements (weight and height) were recorded. Birth weight of the neonates was recorded immediately after delivery. Length, MUAC and triceps and supra iliac SFT of the neonates was measured within 48 hours of delivery. Pregnant women had poor nutritional status with 71% weighing < 60 kg and 63% anemic. The overall incidence of low birth weight was 30.79% (57% in LIG and 18% in MIG). Normal birth weight neonates had significantly higher mean anthropometric and body composition parameters as compared to the low birth weight neonates ($p \leq 0.000$). Birth weight and anthropometric indices positively correlated with the measures of body composition ($p \leq 0.01$). The poor maternal nutritional status resulted in adverse birth outcome. Highest incidence of chronic severe malnutrition (low head circumference for age Z-score) was seen followed by wasting. The neonates had low muscle mass and fat mass unlike the typical "Asian thin fat phenotype".

**Keywords:** Low birth weight, Body composition, Asian thin fat phenotype

## INTRODUCTION

Alterations in the fetal growth result in developmental adaptations that program and alter expression of the fetal genome, leading to permanent effects on a range of physiological functions and structures which occurs only during a specific window of sensitivity **[1].** A wide range of organs and systems are programmed due to changes in the nutrient and hormonal environment of the fetus during these critical periods **[2].** Induction, deletion or impaired development of a somatic structure and resetting of hormonal feedback cause damage in the early life which have an influence on long term outcomes **[3].** Serious outcomes of fetal growth restriction are lowered weight, down regulation of growth and brain sparing at birth and occurrence of non communicable diseases particularly cardiovascular diseases (CVDs) and Type II diabetes in later life **[4].**

Cohort studies have shown that catch-up growth during childhood and adolescent period is predicted by factors relating to intra uterine restraint of fetal growth and birth weight. It has been observed that the smallest and least mature babies have late and poor catch up growth **[5].** Mechanisms that signal and regulate early catch-up growth in the postnatal period may influence associations between small size at birth and risks for disease in adulthood. As compared to UK babies, the Mysore babies were found to be lighter and smaller but at four years of age, sub scapular skin fold thickness was larger than UK and Dutch standards despite all other body measurements remaining smaller showing higher propensity for truncal body fat preservation and thus in turn a greater risk for obesity in later life **[6].**

Of the 19 million infants born low birth weight (less than 2500 grams) in the developing world, 8.3 million are in India **[7].** The morphology of the Indian babies is such that these babies are longer and are born with lower birth weights but have higher measures of body fat especially central fat judged by sub scapular skin fold as compared to western babies **[8].** This is described as the "thin-fat" baby syndrome which shows that the excess visceral adiposity, a marker of chronic diseases, in most Asian adults can be traced back to the neonatal period.

The relationship between birth weight, early growth and the later occurrence of insulin resistance, type 2 diabetes, hypertension, hyperlipidemia and cardio vascular diseases (CVD) have been documented in studies of both men and women in distinct populations in the UK, Europe, Asia, Africa and the USA. In a study in Kerala it was found that high triglyceride values and overweight/obesity was significantly higher in low birth weight adolescents as compared to normal birth weight adolescents **[9].**

Maternal pre-conceptional body weight and composition, as well as gestational weight gain, are also found to be

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important in determining the birth outcome. The findings of a Jamaican study revealed that shorter and thinner women had babies with lower birth weight, who were shorter, had smaller heads, and lighter placentas **[10].** Studies in Scotland suggested that the increase in birth weight of the neonates was contributed by increased maternal height and age, by a decrease in the proportion of induced births and also by a reduction in maternal smoking **[11].**

In India, for specific regions around the country there is a dearth of maternal and neonatal anthropometric data. Therefore, the present hospital based study was carried out to develop a baseline data on body parameters and body composition of neonates and its association with maternal nutrition status.

## MATERIALS AND METHODS

The present hospital based prospective study was approved by the 'Medical Ethical Committee' of the Department. Women in the 3rd trimester of pregnancy were enrolled for the study from two gynecological hospitals of Vadodara city, one which catered to the middle income group (MIG) (N=202) and the other that catered to the low income group (LIG) (N=100). The study was carried out during the month of October 2008 to February 2009. Cases of gestational diabetes, twin pregnancy and pre-maturity were excluded from the study. The study was approved by the Departmental Medical Ethical Committee.

**Obstetric History and Anthropometric measurements of the mothers:** Detailed information regarding biochemical parameters like hemoglobin, blood pressure, random blood sugar and weight was obtained from the individual's medical reports. The height was measured using standard tools and technique.

**Anthropometric measurements of neonates:** Nutritional status of the neonates was assessed by measuring weight at birth. Length, head circumference and MUAC within 48 hours of birth using standard tools and techniques. Skin fold thickness at the triceps and supra iliac regions were measured using Harpenden calipers **[12].** The ponderal index was calculated and 'WHO Anthro' software was used to calculate Z-scores according to growth standards.

**Body Composition of the neonates:** MUAC indices namely total mid upper arm area, arm muscle area, arm fat area and arm fat index and skin fold thickness indices namely percent body fat, total body fat, fat free mass and central fat/total fat ratio were also calculated **[13,14].**

**Statistical analysis:** Results are expressed as mean ± standard error (SE). Student's t-Test, Pearson's test for univariate correlations and partial correlation were performed. Data analysis was done using Microsoft Excel (ver. 2003) and the Statistical Package for Social Sciences (SPSS, Inc. 16.0) software for Windows.

## RESULTS

**Profile of the pregnant women:** Table 1 gives the profile of the women by income groups. Almost 71% of women weighed less than 60 kg by the end of 9th month of pregnancy. Similar trends were observed in MIG (67%) and LIG mothers (80%). About 55% of the total women were taller than 155 cm however only 39% of LIG women had height more than 155 cm. Nearly 64% women had hemoglobin levels between 7 to 10.9 g/dl and only 36% women had hemoglobin levels greater than 11 g/dl. Incidence of anemia was higher in LIG (83%) than in the MIG (54%) women.

Table 1: Maternal Profile by Socio Economic Group

| Variables | | Total (N=302) | | MIG (n=202) | | LIG (n=100) | |
|---|---|---|---|---|---|---|---|
| | | n | % | n | % | n | % |
| Age (years) | >30 | 13 | 4.30 | 4 | 1.98 | 9 | 9 |
| | 21-30 | 252 | 83.44 | 185 | 91.58 | 67 | 67 |
| | ≤20 | 37 | 12.25 | 13 | 6.43 | 24 | 24 |
| Weight (kg) | ≥60 | 87 | 28.80 | 67 | 33.16 | 20 | 20 |
| | <60 | 215 | 71.19 | 135 | 66.83 | 80 | 80 |
| Height (cm) | ≥155 | 154 | 54.60 | 115 | 63.18 | 39 | 39 |
| | <155 | 128 | 45.39 | 67 | 36.81 | 61 | 61 |
| Hb (g/dl) | ≥ 11 | 110 | 36.42 | 93 | 46.03 | 17 | 17 |
| | <11 | 192 | 63.57 | 109 | 53.96 | 83 | 83 |

Table 2: Incidence of LBW and Associated Maternal Factors

| Maternal Parameters | | % LBW | | | | | |
|---|---|---|---|---|---|---|---|
| | | Total | | MIG | | LIG | |
| | | N | % | n | % | n | % |
| Age (years) | >30 | 4 | 4.30 | 1 | 2.77 | 3 | 5.26 |
| | 21-30 | 65 | 69.89 | 27 | 75 | 38 | 66.66 |
| | ≤20 | 24 | 25.80 | 8 | 22.22 | 16 | 28.07 |
| Weight (kg) | ≥60 | 5 | 5.37 | 3 | 8.33 | 2 | 3.50 |
| | <60 | 88 | 94.62 | 33 | 91.66 | 55 | 96.49 |
| Height (cm) | ≥155 | 41 | 47.12 | 18 | 60 | 23 | 40.35 |
| | <155 | 46 | 52.87 | 12 | 40 | 34 | 59.64 |
| Hemoglobin (g/dl) | ≥11 | 14 | 15.05 | 12 | 33.33 | 2 | 3.50 |
| | <11 | 79 | 84.94 | 24 | 66.67 | 55 | 96.49 |

**Incidence of Low Birth Weight and associated maternal factors:** The overall incidence of low birth was 30.79% which is similar to the national average of 31%. The incidence of LBW was higher in LIG (57%) as compared to the MIG (18%). The incidence of low birth weight was higher in mothers in the age group of 21-30 years (70%), weighing <60 kg (95%), shorter than 155 cm (53%) and with hemoglobin level <11 g/dl (85%) (Table 2).

**Body Parameters of the Neonates:** Table 3 presents data on anthropometric measurements of neonates categorized by birth weight. The mean birth weight (a proxy measure for intrauterine growth retardation) and length (a measure of linear growth) of the neonates were 2.61 kg and 48.48 cm respectively with the mean gestational age of 36.8 weeks. The mean head circumference, MUAC, triceps and supra iliac SFT was 31.3 cm, 9.09 cm, 3.10 mm and 2.09 mm respectively. The mean neonatal anthropometric parameters were higher in males than in females, the difference being non significant between the two groups. Normal birth weight neonates had significantly higher mean anthropometric parameters as compared to the low birth weight neonates (p≤0.000).

Table 3: Details of Anthropometric Measurements of Neonates by Birth Weight

| VARIABLES | N | MEAN±SE (RANGE) | n | MEAN±SE (RANGE) | n | MEAN±SE (RANGE) | 't' value |
|---|---|---|---|---|---|---|---|
| | Total | | NBW | | LBW | | |
| Weight (kg) | 302 | 2.61±0.01 (1.69-3.75) | 209 | 2.74±0.01 (2.50-3.75) | 93 | 2.33±0.15 (1.69-2.49) | 15.76*** |
| Length (cm) | 302 | 48.48±0.10 (43.9-53.1) | 209 | 49.09±0.11 (43.9-53.1) | 93 | 47.11±0.15 (43.9-50.2) | 9.67*** |
| HC (cm) | 302 | 31.30±0.06 (28.3-33.9) | 209 | 31.6±0.07 (29.3-33.9) | 93 | 30.48±0.08 (28.3-32.9) | 12.46*** |
| CC (cm) | 302 | 29.90±0.06 (26.7-33.3) | 209 | 30.2±0.06 (27.1-33.1) | 93 | 29.03±0.11 (26.7-32.1) | 10.22*** |
| AC (cm) | 302 | 27.29±0.06 (25.0-31.2) | 209 | 27.67±0.06 (25.1-31.1) | 93 | 26.43±0.08 (25.0-30.1) | 10.43*** |
| MUAC (cm) | 302 | 9.02±0.07 (7.6-10.2) | 209 | 9.29±0.09 (8.1-10.2) | 93 | 8.39±0.04 (7.6-9.3) | 15.97*** |
| Triceps SFT (mm) | 194 | 3.10±0.02 (2.0-3.8) | 128 | 3.23±0.02 (2.6-3.8) | 66 | 2.86±0.03 (2.0-3.2) | 9.41*** |
| Supra iliac SFT (mm) | 194 | 2.09±0.02 (0.9-2.7) | 128 | 2.17±0.02 (0.9-2.7) | 66 | 1.93±0.03 (0.9-2.3) | 5.75*** |

***significantly different at p≤0.000 **significantly different at p≤0.01 *significantly different at p≤0.05

Table 4 : Details of Anthropometric indices by birth weight

| VARIABLES | N | MEAN±SE (RANGE) | n | MEAN±SE (RANGE) | n | MEAN±SE (RANGE) | 't' value |
|---|---|---|---|---|---|---|---|
| | Total | | NBW | | LBW | | |
| WHZ | 302 | -1.86±0.05 [(-4.46)-2.01] | 209 | -1.79±0.06 [(-3.83)-0.87] | 93 | -2.03±0.10 [(-4.46)-2.01] | 2.05* |
| WAZ | 302 | -1.53±0.03 [(-4.03)-1.68] | 209 | -1.34±0.04 [(-4.03)-1.68] | 93 | -1.98±0.06 [(-3.48)-0.8] | 8.27*** |
| HAZ | 302 | -0.53±0.05 [(-3.16)-1.7] | 209 | -0.32±0.05 [(-2.82)-1.7] | 93 | -1.02±0.93 [(-3.16)-1.37] | 6.87*** |
| HCZ | 302 | -2.26±0.05 [(-5.01)-3.31] | 209 | -2.03±0.57 [(-4.85)-3.31] | 93 | -2.79±0.09 [(-5.01)-2.65] | 7.11 |
| BMI for Age | 302 | -2.05±0.04 [(-5.05)-0.71] | 209 | -1.90±0.053 [(-5.05)-0.71] | 93 | -2.37±0.08 [(-4.27)-0.67] | 4.75*** |
| Ponderal Index ($g/cm^3$) | 302 | 2.30±0.02 (1.81-2.92) | 209 | 2.33±0.30 (1.94-2.92) | 93 | 2.23±0.01 (1.81-2.66) | 3.23** |
| HC/Length | 302 | 0.64±0.001 (0.43-0.95) | 209 | 0.64±0.002 (0.43-0.95) | 93 | 0.64±0.001 (0.60-0.70) | 0.17 |
| MUAC/HC | 302 | 0.28±0.002 (0.25-0.93) | 209 | 0.29±0.003 (0.25-0.93) | 93 | 0.27±0.001 (0.25-0.31) | 9.55*** |

***significantly different at p≤0.000 **significantly different at p≤0.01 *significantly different at p≤0.05

**Anthropometric indices of neonates by birth weight:** Table 4 details the anthropometric indices of neonates by birth weight. Head Circumference for age (HCZ) scores were the lowest (-2.26), followed by the Weight for Height Z scores (WHZ) (-1.86), Weight for Age Z scores (WAZ) (-1.53) and Height for Age Z scores (-0.53). Poor scores were recorded for BMI for age (-2.05) and Ponderal Index (2.30) a measure of thinness. The mean anthropometric indices were significantly higher in Normal Birth Weight neonates except for the HCZ scores.

Table 5: Distribution of neonates into various grades of malnutrition by birth weight

| Grades of malnutrition | WHZ | | WAZ | | HAZ | | HCZ | |
|---|---|---|---|---|---|---|---|---|
| | Total (=302) | | | | | | | |
| | n | % | n | % | n | % | n | % |
| Normal | 152 | 50.3 | 238 | 78.85 | 278 | 92.05 | 122 | 40.39 |
| Moderate | 119 | 39.40 | 59 | 19.53 | 23 | 7.61 | 162 | 53.64 |
| Severe | 31 | 10.26 | 5 | 1.65 | 1 | 0.33 | 18 | 5.96 |
| | NBW (n=209) | | | | | | | |
| Normal | 114 | 54.54 | 195 | 93.30 | 199 | 95.21 | 109 | 52.15 |
| Moderate | 81 | 38.75 | 11 | 5.26 | 10 | 4.78 | 77 | 36.84 |
| Severe | 14 | 6.69 | 3 | 1.43 | - | - | 23 | 11.00 |
| | LBW (n=93) | | | | | | | |
| Normal | 45 | 43.01 | 43 | 46.23 | 78 | 83.87 | 11 | 11.82 |
| Moderate | 38 | 40.86 | 48 | 51.61 | 13 | 13.97 | 39 | 41.93 |
| Severe | 10 | 10.75 | 2 | 2.15 | 2 | 3.22 | 43 | 46.23 |

**Incidence of various forms of malnutrition by birth weight:** Table 5 gives the distribution of neonates into various grades of malnutrition by birth weight. Incidence of poor brain sparing as indicated by HCZ scores was highest (59%) followed by thinness (49%) as measured using WHZ, under weight (21%) measured using WAZ and stunting (8%) measured using HAZ. On segregating the data on the basis of birth weight the trends remained the same though the incidence of all the forms of malnutrition was higher in the low birth weight neonates.

A sizable population of LBW neonates had normal height for age Z-score (83.87%), weight for age Z-score (46.23%) and weight for height Z-score (43.01%). A high incidence of moderate (41.93%) and severe (46.23%) forms of malnutrition was observed by HCZ in the LBW neonates. Brain sparing had occurred only in 11.82% of the LBW neonates.

**Body composition of the neonates:** The muscle mass as measured by total mid upper arm area and arm muscle area was higher in the female neonates while the fat area as measured by arm fat area and arm fat index was higher in male neonates the difference being significant only for arm fat index ($p \leq 0.000$). Mean percent body fat, total body fat and fat free mass were higher in male neonates, the difference being significant for percent body fat and total body fat ($p \leq 0.05$).

The NBW neonates had significantly higher mean MUAC indices as compared to LBW neonates indicating greater muscle and fat mass ($p \leq 0.000$). Mean total body fat and fat free mass were significantly higher in NBW neonates as compared to LBW neonates ($p \leq 0.000$). The mean values for various body parameters, incidence of malnutrition by anthropometric indices and differences in body composition were very similar in neonates from two income groups to those observed in NBW and LBW neonates. The observed trends are due to the fact that 64% of the NBWs were from MIG.

**Body composition by birth weight:** Table 6 depicts the body composition of neonates in terms of MUAC indices (total mid upper arm area, arm muscle area, mid upper arm fat area and arm fat index) and skin fold thickness measures (% body fat, total body fat, fat free mass and ratio of central fat to total fat) in the NBW and LBW neonates. In the NBW neonates, the mean total mid upper arm area was 6.73 $cm^2$, arm muscle area was 5.32 $cm^2$, mid upper arm fat area was 1.40 $cm^2$ and arm fat index was 20.81%. In case of LBW neonates the mean total mid upper arm area was 5.64 $cm^2$ arm, muscle area was 4.49 $cm^2$, mid upper arm fat area was 1.14 $cm^2$ and arm fat index was 20.34% . The mean percent body fat was 4.47 in the NBW neonates while in the LBW neonates the mean was 3.75. The mean total body fat was 0.12 kg and 0.08 kg in the NBW and LBW babies respectively. The mean fat free mass was 2.61 kg in the NBW neonates while it was 2.23 kg in the LBW neonates. The mean values for the ratio of central fat to total body fat were slightly higher in NBWs than LBWs. The mean values for all the body composition parameters were significantly higher in the NBW neonates than the LBW neonates with the exception of % body fat and ratio of central fat to total fat.

Table 6: Details of Body Composition by birth weight

| VARIABLES | N | MEAN±SE (RANGE) | n | MEAN±SE (RANGE) | n | MEAN±SE (RANGE) | 't' value |
|---|---|---|---|---|---|---|---|
| | Total | | NBW | | LBW | | |
| Total mid Upper Arm Area (TUA) ($cm^2$) | 194 | 6.36±0.05 (4.59-8.28) | 128 | 6.73±0.09 (5.22-8.28) | 66 | 5.64±0.04 (4.59-6.73) | 12.32*** |
| Arm Muscle Area (UMA) ($cm^2$) | 194 | 5.04±0.04 (3.46-6.68) | 128 | 5.32±0.06 (4.04-6.69) | 66 | 4.49±0.03 (3.46-5.49) | 11.58*** |
| Mid Upper Arm Fat Area (UFA) ($cm^2$) | 194 | 1.31±0.03 (0.75-1.74) | 128 | 1.40±0.05 (0.90-1.74) | 66 | 1.14±0.01 (0.75-1.33) | 11.64*** |
| Arm Fat Index (% Arm Fat Area) | 194 | 20.65±0.10 (14.76-24.69) | 128 | 20.81±0.11 (16.84-23.9) | 66 | 20.34±0.22 (14.76-24.69) | 2.08* |
| % Body fat | 194 | 4.23±0.05 (1.50-5.72) | 128 | 4.47±0.05 (2.00-5.72) | 66 | 3.75±0.08 (1.50-4.71) | 1.82 |
| Total body fat (kg) | 194 | 0.11±0.002 (0.03-0.21) | 128 | 0.12±0.002 (0.05-0.21) | 66 | 0.08±0.002 (0.03-0.12) | 3.41** |
| Fat free mass (kg) | 194 | 2.48±0.01 (1.64-3.54) | 128 | 2.61±0.01 (2.38-3.54) | 66 | 2.23±0.01 (1.64-2.42) | 14.49*** |
| Central Fat/Total Fat | 194 | 40.11±0.18 (25.71-47.37) | 128 | 40.17±0.21 (25.71-47.37) | 66 | 40.00±0.39 (28.13-45.95) | 0.42 |

***significantly different at p≤0.000 **significantly different at p≤0.01

**Association between maternal nutritional status and neonatal body parameters:** Neonates born to mothers weighing ≥60 kg and/or with normal hemoglobin levels had significantly higher mean birth weight, length, MUAC, triceps and supra iliac SFT (p≤0.000). The incidence of under nutrition and stunting was lower in neonates born to mothers with hemoglobin levels of ≥11g/dl (Table 7).

Table 7: Association between maternal nutritional status and Neonatal body parameters

| Neonatal Parameters | Maternal Weight (kg) | n | Mean±SE | 't' value | Maternal Hb Levels (g/dl) | n | Mean±SE | 't' value |
|---|---|---|---|---|---|---|---|---|
| | | Total | | | Total | | | |
| Weight (kg) | ≥60 | 92 | 2.84±0.03 | 11.04*** | ≥11 | 110 | 2.74±0.02 | 6.66*** |
| | <60 | 210 | 2.51±0.01 | | <11 | 192 | 2.54±0.01 | |
| Length (cm) | ≥60 | 92 | 49.65±0.13 | 7.81*** | ≥11 | 110 | 49.31±0.14 | 6.72*** |
| | <60 | 210 | 47.97±0.12 | | <11 | 192 | 48.08±0.11 | |
| HC (cm) | ≥60 | 92 | 31.73±0.09 | 4.74*** | ≥11 | 110 | 31.64±0.08 | 4.26*** |
| | <60 | 210 | 31.10±0.08 | | <11 | 192 | 31.16±0.07 | |
| MUAC (cm) | ≥60 | 92 | 9.56±0.22 | 4.97*** | ≥11 | 110 | 9.19±0.04 | 6.06*** |
| | <60 | 210 | 8.7±0.03 | | <11 | 192 | 8.81±0.04 | |
| Triceps SFT (mm) | ≥60 | 51 | 3.32±0.03 | 6.31*** | ≥11 | 67 | 3.19±0.04 | 3.08** |
| | <60 | 143 | 3.03±0.02 | | <11 | 127 | 3.05±0.02 | |
| Supra iliac SFT (mm) | ≥60 | 51 | 2.27±0.03 | 5.02*** | ≥11 | 67 | 2.15±0.04 | 1.89* |
| | <60 | 143 | 2.03±0.02 | | <11 | 127 | 2.06±0.02 | |
| WAZ | ≥60 | 92 | -1.2±0.08 | 5.93*** | ≥11 | 110 | -1.33±0.06 | 4.00*** |
| | <60 | 210 | -1.68±0.03 | | <11 | 192 | -1.65±0.04 | |
| HAZ | ≥60 | 92 | -0.20±0.09 | 4.49*** | ≥11 | 110 | -0.24±0.07 | 4.45*** |
| | <60 | 210 | -0.68±0.05 | | <11 | 192 | -0.70±0.06 | |

***significantly different at p≤0.000 **significantly different at p≤0.01

## DISCUSSION

Low maternal weight at term (<53 kg) and a height of < 145 cm is known to be associated with higher incidence of LBW [**15**]. Also maternal anemia is an independent risk factor for LBW [**16**]. By the above criteria a majority of the mothers from MIG as well as LIG were light, short and /or anemic. The study further demonstrated that mothers weighing>60 kg and /or with normal hemoglobin gave birth to neonates with higher mean body weight, length, MUAC, triceps and suprailiac SFT. Similar results were obtained in a study carried out in Pune and Cairo [**8,17**].

Mean birth weight (a proxy for intra uterine growth retardation) and length (a measure of linear growth) observed in this study were similar to those reported by other Indian investigators [**8,6**]. As compared to Indian babies, the western babies have been found to have higher weight at birth. Studies from Australia and West Indies have reported a higher mean birth weight of 3.35 kg and 3.19 ± 0.53 kg respectively [**18,15**]. Under most adverse intra uterine conditions the head circumference is maintained at the cost of neonatal weight and length. In the present study the mean head circumference was found to be 31.30 cm which is slightly lower as compared to the value of 33.10 cm reported for neonates born in rural Pune and 33.26 cm for the neonates from urban Vadodara [**8,19].** There is paucity of data on body composition of neonates by anthropometry. Mean MUAC of 9.7cm, 10.4 cm and 9.6 cm has been reported from rural Pune, urban Mysore and Bangalore respectively [**8,6,20**]. This shows that the neonates in the present study had lower subcutaneous fat and muscle mass as compared to neonates from other studies. Sub scapular skin fold thickness, has been used as a measure of truncal subcutaneous fat by other investigators and a mean value of 4.2 mm has been reported for neonates from rural Pune and 4.4 mm for neonates from urban Mysore. Death from coronary heart disease was found to be associated with low birth weight and, more strongly, with a low ponderal index (<2.2g/m$^3$) at birth. In the present study the neonates were found to have normal ponderal index of 2.30 g/cm$^3$. A slightly higher mean ponderal index of 2.45 g/cm$^3$ and 2.48 g/cm$^3$ has been reported for neonates born in rural Pune and urban Mysore respectively [**8, 6**]. Incidence and severity of all forms of under nutrition was lower in NBW neonates. Unlike other studies poor brain sparing was observed as measured by head circumference and head circumference for age Z scores followed by wasting, under nutrition and stunting. Further, incidence of all forms of malnutrition was higher in male neonates.

Mid upper arm circumference is a measure of subcutaneous fat and muscle mass and indices derived from it namely total mid upper arm area and mid upper arm muscle area are good indicators of protein nutritional status while mid upper arm fat area and arm fat index reflect the fat content. Studies carried out in Southern India have reported a slightly higher value of 6.6 cm$^2$ for arm muscle area for neonates from urban Bangalore and slightly lower value of 5.64 cm$^2$ for neonates from urban Mysore as compared to the present investigation. The mean arm fat area was 1.69 cm$^2$ and the mean arm fat index was 23.3% in Mysore babies **[6].** On comparing these values with the values obtained in the present study, it can be concluded that neonates from the hospital setting of urban Vadodara had both muscle and fat deficit at birth. All the anthropometric parameters, indices and body composition measures were lower in LBW neonates and male neonates. The ratio of central fat to total fat was low indicating absence of abdominal obesity. The 'thin fat phenotype' as described by other investigators was not found in the present study and with increase in birth weight, there was proportional increase in total body fat and fat free mass [**8**].

## CONCLUSION

Concerted efforts are required to improve maternal nutritional status in order to reduce the incidence of LBW and consequently the incidence and severity of malnutrition. The same will also help in improving body composition and reduce the future susceptibility to insulin resistance.

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