The Journal of Obstetrics and Gynecology of India (November–December 2020) 70(6):471–478
https://doi.org/10.1007/s13224-020-01340-6

ORIGINAL ARTICLE

Anthropometric and Skin Fold Thickness Measurements of Newborns of Gestational Glucose Intolerant Mothers: Does it Indicate Disproportionate Fetal Growth?

Ramya Shankar[1,2,3,4] · Arulmozhi Ramarajan[1] · Susheela Rani[1,5] · V. Seshiah[6]

Received: 24 December 2019 / Accepted: 15 June 2020 / Published online: 25 August 2020

Abstract

Aim of the Study Studies have shown that gestational diabetes mellitus (GDM) causes disproportionate growth and increased adiposity in their newborns; however, the effect of gestational glucose intolerance (GGI), i.e., 2 h plasma glucose (PG) between 120 and 139 mg/dl in pregnancy on their newborns growth and adiposity is not well established. The objective of the present study is to evaluate the effect of GGI in pregnancy on anthropometry and adiposity of their newborns at birth in urban South Indian population.

Materials and Methods An observational study was conducted on 119 urban South Indian pregnant women and their newborns. PG levels 2 h after ingestion of 75 g glucose load were determined between 24 and 28 weeks of gestation, and depending on their PG levels, these women were categorized into three different groups, (a) normal glucose tolerance

Dr. Ramya Shankar: MBBS, DGO, DNB in obstetrics and Gynaecology, Department of Obstetrics and Gynaecology, Church of South India Hospital, Post Graduate, No. 2, Hazarat Kambal Posh Road, Bengaluru, Karnataka, Pincode: 560051, Department of Obstetrics and Gynaecology, Assistant Professor, MVJ Medical College and Research Hospital, Dandupalya, National Highway 4, 30th Km, Milestone, Kolathur P.O, Hoskote, Karnataka Pincode: 562114, Department of Obstetrics and Gynaecology, Consultant, St Mary's Hospital. Guddanahalli Road, Lingapura, Malur, Karnataka, Pincode: 563130, Department of Obstetrics and Gynaecology, Consultant, St Mary's Hospital, Rayan Circle, Sultan Rd, New taragypet, Anandapuram, Chamrajpet, Bengaluru, Karnataka, Pincode: 560018; Dr. Arulmozhi Ramarajan: Department of Obstetrics and Gynaecology, Church of South India Hospital, Head of the Department, No. 2, Hazarat Kambal Posh Road, Bengaluru, Karnataka, Pincode: 560051; Dr. Susheela Rani: Department of Obstetrics and Gynaecology, Church of South India Hospital, Consultant, No. 2, Hazarat Kambal Posh Road, Bengaluru, Karnataka, Pincode: 560051, Department of Obstetrics and Gynaecology, Manjushree Speciality Hospital, #22/70, St John's Road, opposite to R.B.A.N.M.S Ground, Bengaluru, Karnataka; Dr. V Seshiah: Distinguished Professor, The Tamil Nadu Dr MGR Medical University. Established First Dept and University PG course in Diabetology in the country. Founder and Consultant Diabetologist at Dr. V. Seshiah and Dr. Balaji Diabetes care centre & Research Institute, Chennai, India. Patron-Research Society for the Study of Diabetes in India. Founder Patron-Diabetes In Pregnancy Study Group, India (DIPSI). Vice chairman ,Executive Board International Association of Diabetes and Pregnancy Study Group. Member "Expert group of the technical and operational guideline on Gestational Diabetes" of Ministry of Health, Govt of India.

Extended author information available on the last page of the article

(NGT)-2 h PG < 120 mg/dl, (b) GGI-2 h PG between 120 and 139 mg/dl and (c) GDM-2 h PG > or = 140 mg/dl. GDM mothers were treated with insulin and MNT advised. GGI mothers were advised MNT. These women were followed up till delivery. After delivery, their newborn's anthropometry like weight, length, head circumference (HC), chest circumference (CC), mid-arm circumference, abdominal circumference, bisacromial diameter and subscapular and triceps skin fold thicknesses (SFT) was measured within 72 h of birth. Effect of GGI in pregnancy on newborn's anthropometry and SFT was analyzed and studied in comparison with newborns of other two categories. Further, the newborns were stratified into four groups according to their birth weight and newborns of GGI category were compared with newborns of other two categories of same weight.

Results The triceps and subscapular skin fold thicknesses which are direct measurements of adiposity were significantly higher in newborns of GGI mothers compared to newborns of GDM and NGT mothers. GGI category newborns showed increased adiposity even when they were compared with newborns of GDM and NGT category of same weight. Also measurements which are likely to increase due to increased adiposity like bisacromial diameter, abdominal circumference, mid-arm circumference were significantly higher in GGI category newborns. On the other hand, measurements which indicate skeletal growth like length, HC, CC were similar in all three category newborns. This confirmed disproportionate growth and increased adiposity in newborns of GGI mothers. It should be noted here that the GDM mothers were on MNT and treated with insulin, the dose of insulin was adjusted so as to mimick Fasting PG and Post Prandial PG levels of NGT mothers.

Conclusion Gestational glucose intolerance during pregnancy does cause disproportionate growth (increased fat body mass but not skeletal mass) and increased adiposity in their newborns. This emphasizes the need for strict glycemic control (2 h of PG level after 75 grams glucose load to < 120 mg/dl and PPPG levels to < 120 mg/dl) during pregnancy. Larger multicentered studies are recommended to confirm this association.

Keywords Gestational diabetes mellitus (GDM) · Gestational glucose intolerance (GGI) · Skin fold thickness (SFT) · Fasting plasma glucose (FPG) · Postprandial plasma glucose (PPPG) · Newborn anthropometric measurements · Disproportionate growth · Adiposity · Plasma glucose (PG)

Introduction

The offspring of diabetic mothers are at risk of metabolic complications in the short run and in the long run are predisposed to childhood obesity, adulthood obesity and metabolic syndrome. These complications have been attributed to large for gestational age, disproportionate growth and increased adiposity at birth. Few studies have indicated that adverse neonatal outcome occurs even at maternal plasma glucose levels below those diagnostic of diabetes in pregnancy and have suggested the need to reconsider the current criteria for diagnosing and treating hyperglycemia in pregnancy [1–3]. The Toronto tri-hospital gestational diabetes project assessed the maternal–fetal outcomes in patients with increasing carbohydrate intolerance not meeting the current criteria for the diagnosis of gestational diabetes and concluded that increasing maternal carbohydrate intolerance in pregnant women without gestational diabetes is associated with a graded increase in adverse maternal–fetal outcome [4]. The objective of our study is to determine the effect of gestational glucose intolerance in pregnancy (2 h venous plasma glucose between 120 and 139 mg/dl at 24–28 weeks of gestation with 75 g oral glucose) on anthropometry and skin fold thickness (SFT) of their newborns at birth.

Materials and Methods

A hospital-based observational study was conducted in the department of Obstetrics and Gynaecology at CSI Hospital, Bengaluru, India. Clearance was obtained from the scientific and ethical committee of the institution recognized by National Board of Examination, and an informed consent was obtained from all pregnant women who were studied. In this study, 119 urban South Indian pregnant women underwent "A single step" screening and diagnostic test for diagnosing hyperglycemia in pregnancy as recommended by the Diabetes in Pregnancy Study Group India (DIPSI). As per this DIPSI guidelines, all pregnant women between 24 and 28 weeks of gestation were given 75 g oral glucose load, without regard to the time of the last meal, after 2 h a venous blood sample was collected for estimating plasma glucose (PG). Depending on their PG levels, pregnant women were categorized into three different categories as normal glucose tolerance (NGT) when PG levels were < 120 mg/dl, gestational glucose intolerance (GGI) when PG levels were between 120 and 139 mg/dl and gestational diabetes mellitus (GDM) when PG levels were > or = 140 mg/dl. GGI mothers were advised medical nutrition therapy (MNT) and were monitored fortnightly with fasting plasma glucose (FPG) and PPPG (postprandial plasma

glucose) tests. GDM mothers were admitted for sugar control, were advised MNT and started on Insulin. Six-point sugar testing was done in them and dose of insulin titrated such that the FPG and PPPG levels mimicked the FPG and PPPG levels of a normal glucose tolerant women (i.e., FPG < 92 mg/dl and PPPG < 120 mg/dl). These GDM mothers who were started on Insulin were further monitored with home glucose monitoring and fortnightly FPG and PPPG tests and dose of insulin readjusted to achieve the desired FPG and PPPG levels. These women were followed up until delivery and anthropometric measurements like weight, length, head circumference (HC), chest circumference (CC), abdominal circumference (AC) mid-arm circumference (MAC), bisacromial diameter (BAD) and skin fold measurements like triceps and subscapular skin fold thicknesses (SFT) were measured in their newborns using Harpenden Skinfold Calipers (Fig. 1) within 72 h of birth. Total SFT was obtained by adding triceps and subscapular skin fold thicknesses. Three measurements for each of the above parameters were taken and average of the three considered. Confounding factors which can alter the birth weight of newborns like type 2 diabetes mellitus (pre-gestational DM), preterm deliveries, gestational hypertension, preeclampsia, eclampsia and multiple pregnancies were excluded from the study. Pregnant women who belonged to GGI category to begin with but their 2 h PG levels increased beyond 140 mg/dl during later gestation were shifted from GGI category to GDM category. The relation between gestational glucose intolerance (GGI) in pregnancy and anthropometric measurements and triceps and subscapular skin fold thicknesses of their newborns at birth were studied in comparison with newborns of the other two categories.

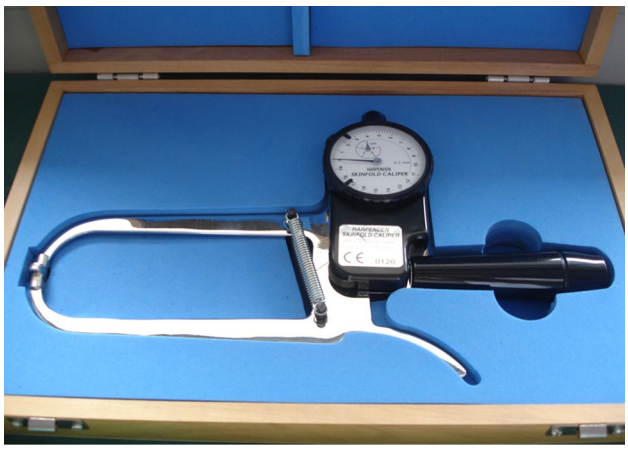

Fig. 1 Harpenden Skinfold Calipers

Statistical Methods

Descriptive statistical analysis was carried out. Chi-square/Fisher's exact test was used to find significance of study parameters on categorical scale between two or more groups and ANOVA—one-way analysis used to test the difference between the two groups. When comparing more than two means, an "*F*" test was used to determine whether means are significantly different from each other, but as this does not indicate which mean differs from which other mean, further student "*t*" test has been used to determine the significance between two group means of various parameters. In this study, when significant difference in anthropometric and SFT measurements between the three categories was noted, further analysis was carried out to see the intragroup mean differences.

Results

The weight of newborns of GGI mothers was higher than newborns of GDM mothers who were treated with insulin and newborns of NGT mothers (Tables 1 and 4). When weight of newborns of GDM and NGT category was compared, they did not show statistically significant difference between them (Table 4). When the anthropometric measurements like abdominal circumference, mid-arm circumference, bisacromial diameter (whose measurements tend to increase due to increased adiposity) were studied, statistically significant difference was noted between the newborns of NGT, GGI and GDM categories; hence, further intragroup analysis was carried out. On the other hand, measurements like length, head circumference and chest circumference (which indicates skeletal growth) did not show statistically significant difference among the three categories (Table 1),

Table 1 Anthropometric measurements

Categories	Mean weight in kg SD	Mean AC in cm SD	Mean MAC in cm SD	Mean bisacromial diameter in cm SD	Mean length in cm SD	Mean HC in cm SD	Mean CC in cm SD
NGT	3.0419 ± 0.39	32.52 ± 1.83	10.75 ± 0.99	14.87 ± 1.20	47.94 ± 6.19	33.30 ± 1.34	32.23 ± 1.89
GGI	3.2814 ± 0.40	33.48 ± 1.54	11.63 ± 0.99	16.11 ± 1.39	49.16 ± 1.40	34.26 ± 1.29	32.96 ± 1.36
GDM	3.0886 ± 0.40	33.41 ± 2.37	11.21 ± 1.07	15.60 ± 1.52	48.90 ± 1.88	33.91 ± 1.09	31.71 ± 5.89
P value	0.015* (sig)	0.033* (sig)	0.000* (sig)	0.000* (sig)	0.568	0.246	0.137

Table 2 Anthropometric ratios

Categories	HC/CC ratio	HC/AC ratio	HC/bisacromial diameter ratio
NGT	1.051 ± 0.49	1.047 ± 0.61	2.285 ± 0.65
GGI	1.034 ± 0.49	1.028 ± 0.04	2.133 ± 0.17
GDM	1.031 ± 0.65	1.015 ± 0.07	2.184 ± 0.19
P value	0.204	0.048* (sig)	< 0.001* (sig)

Table 3 Comparison of skin fold thicknesses

Categories	Mean triceps SFT SD	Mean subscapular SFT SD	Mean total SFT SD
NGT	3.860 ± 0.85	3.56 ± 0.69	7.34 ± 1.51
GGI	5.955 ± 1.56	6.53 ± 2.09	12.268 ± 3.82
GDM	5.121 ± 1.28	5.021 ± 1.37	10.143 ± 2.54
P value	0.000* (sig)	0.000* (sig)	0.000* (sig)

and hence, intragroup analysis was not carried out for these measurements.

Increase in anthropometric measurements which are known to get altered due to adiposity (AC, MAC, BAD) but no change in measurements indicating skeletal growth (length, HC, CC) (Table 1) implied disproportionate growth in GGI category newborns followed by GDM category newborns whose mothers were treated with insulin. GDM category newborns showed more disproportionate growth than NGT category newborns probably because the plasma glucose levels of GDM mothers did not exactly match with plasma glucose levels of NGT mothers at all times though their FPG and PPPG were controlled with insulin as desired. Also fluctuations in PG levels were noted as gestational age advanced necessitating further titration of insulin dose, in due course fetus would have got exposed to hyperglycemia for a short duration.

Ratios like HC/CC, HC/AC and HC/BAD were compared between the three groups. HC/CC ratio did not show statistically significant difference between the three categories, and hence, intragroup analysis was not carried out, whereas HC/AC and HC/BAD ratios showed statistically significant difference between the three categories (Table 2), and hence, intragroup analysis was carried out.

Though HC/AC ratio was lowest in newborns of GDM followed by newborns of GGI and highest in newborns of NGT category, there was no statistically significant difference between GGI and GDM categories. On the other hand, HC/AC ratio of newborns GDM mothers was significantly lower than newborns of NGT category.

HC/BAD ratio was lowest in GGI category newborns followed by newborns of GDM and highest in newborns of NGT category. Intragroup analysis of HC/BAD ratio showed that GGI category newborns had statistically significant lower ratio than NGT category newborns and no significant difference when compared with GDM category newborns (Table 4).

Triceps and subscapular skin fold thicknesses (which are direct measurements of adiposity) showed significant difference between the three categories (Table 3); further, intragroup analysis showed that it was highest in newborns of GGI category followed by newborns of GDM and NGT category with high statistical significance (Table 4). This confirmed the increased predisposition of adiposity in GGI category newborns compared to other two category newborns.

Percentage of newborns with skin fold thicknesses > 90 percentile for each of the three categories were determined, Newborns of GGI category had the highest percentage of newborns with > 90% SFT followed by GDM category and least in NGT category newborns. These differences were

Table 5 Percentage of newborns with > 90th percentile for triceps, subscapular and total SFT

Categories	% > 90th percentile triceps SFT	% > 90th percentile subscapular SFT	% > 90th percentile total SFT
NGT	6.4% (3)	8.5% (4)	8.5% (4)
GGI	52.3% (23)	93.2% (41)	81.8% (36)
GDM	35.7%(10)	57.1% (16)	53.6% (15)
P value	0.000* (sig)	0.000* (sig)	0.000* (sig)

Table 4 Intragroup analysis of anthropometric measurements, SFT and anthropometric ratios

Categories compared	BW *P* value	AC *P* value	MAC *P* value	BAD *P* value	Triceps SFT *P* value	Subscapular SFT *P* value	Total SFT *P* value	HC/AC ratio *P* value	HC/BAD ratio *P* value
NGT versus GGI	0.006* (sig)	0.009* (sig)	0.000* (sig)	0.000 (sig)	0.000* (sig)	0.000* (sig)	0.000* (sig)	0.088	0.000* (sig)
NGT versus GDM	0.638	0.073	0.053* (sig)	0.024* (sig)	0.000* (sig)	0.000* (sig)	0.000* (sig)	0.053* (sig)	0.017* (sig)
GGI versus GDM	0.053* (sig)	0.088	0.086	0.152	0.021* (sig)	0.000* (sig)	0.011* (sig)	0.294	0.231

Table 6 Comparison of total SFT in newborns of NGT, GGI, GDM categories with birth weight between 2.5 and 3.0 kg $N=51$

Birth weight (2.5 to 3.0 kg) $N=51$ Group 1	Mean total SFT in mm SD
NGT ($n=25$)	6.712 ± 0.890
GGI ($n=13$)	9.985 ± 1.584
GDM ($n=13$)	9.431 ± 2.724
P value	0.000* (sig)

Table 7 Comparison of total SFT in newborns of NGT, GGI, GDM categories with birth weight between 3.01 and 3.5 kg $N=48$

Birth weight (3.01 to 3.5 kg) $N=48$ Group 2	Mean total SFT in mm SD
NGT ($n=15$)	7.753 ± 1.262
GGI ($n=20$)	12.090 ± 2.260
GDM ($n=13$)	10.369 ± 1.675
P value	0.000* (sig)

Table 8 Comparison of Total SFT in newborns of NGT, GGI, GDM categories with birth weight between 3.51 and 4.0 kg $N=16$

Birth weight (3.51 to 4.0 kg) $N=16$ Group 3	Mean total SFT in mm SD
NGT ($n=6$)	8.400 ± 2.620
GGI ($n=9$)	14.778 ± 5.424
GDM ($n=1$)	9.800
P value	0.05* (sig)

Table 9 Comparison of total SFT in newborns of NGT, GGI, GDM categories with birth weight > 4 kg $N=4$

Birth weight (> 4 kg) $N=4$ Group 4	Mean total SFT in mm SD
NGT ($n=1$)	10.60
GGI ($n=2$)	17.60 ± 9.05
GDM ($n=1$)	16.80

highly statistically significant with respect to all the skin fold thicknesses (triceps, subscapular and total SFT) (Table 5).

Further, newborns of the three categories (NGT, GGI & GDM) were grouped as per their birth weight. Group 1: 2.5 to 3.0 kg, Group 2: 3.01 to 3.50, Group 3: 3.51 to 4.0 kg and Group 4: > 4 kg and their total SFT compared. Among weight Groups 1, 2 and 3, total SFT was highest in GGI category newborns followed by GDM and least in NGT category newborns and these differences showed statistical significance (Tables 6, 7, 8). Group 4 could not be studied for statistical significance due to small sample size (Table 9).

Discussion

Hyperglycemia and adverse pregnancy outcome (HAPO) study studied the association of maternal glycemia with neonatal anthropometry and skin fold measurements (adiposity) and confirmed that increase in glucose concentration less severe than diabetes is associated with fetal overgrowth, specifically adiposity and that this overgrowth and increased adiposity is mediated by fetal insulin response. This not only confirmed the Pedersen hypothesis which was limited only to overt diabetics in pregnancy postulated > 50 years ago but also extended it across the full range of maternal glycemia [5]. Also, Krishnaveni et al. [6] indicated that even in non-diabetic pregnancies, variations within the normal range of maternal fasting glucose concentrations are associated with altered neonatal adiposity. In our study, an attempt has been made to find out the effect of maternal glycemia which is less than the diagnostic range for diagnosis of diabetes in pregnancy termed as gestational glucose intolerance (75 g 2 h value between 120 and 139 mg/dl) on the anthropometry and skin fold thickness measurements of their newborns at birth. These newborns of gestational glucose-intolerant (GGI) mothers were compared with the anthropometry and skin fold thickness measurement of newborns of gestational diabetics mellitus (GDM) and normal glucose tolerant (NGT) mothers.

In our study, newborns of GGI were heavier than newborns of GDM and NGT mothers indicating that plasma glucose in the range of 120–139 mg/dl predisposes to increased birth weight. Similarly, Franks et al. [3] in his study on young Pima Indian offspring's noticed that the maternal glycemia of 2 h plasma glucose > 120 mg during pregnancy was associated with increased birth weight. Jacqueline et al. [7] in their study found that birth weight was positively related to maternal glucose levels even in non-diabetic pregnancies. It was noted that there was no statistically significant difference in weight between newborns of GDM and NGT category; this could be due to GDM mothers receiving insulin injection for glycemic control.

The AC, MAC and BAD measurements of newborns of GGI were significantly greater than newborns of NGT category. On the other hand, when GDM and NGT newborns were compared, GDM category newborns showed significantly increased measurements of these parameters (AC, MAC and BAD) even though the FPG and PPPG of GDM mothers were brought down with insulin to mimic FPG and PPPG values of NGT women. This was because of the following reasons: (a) It took some time to bring down the FPG and PPPG of GDM mothers to mimic that of NGT women and in due course the fetus was exposed to hyperglycemia. (b) There were undue fluctuations in the plasma glucose levels throughout the day in spite of achieving the

FPG and PPPG values as desired, (c) as gestational age progressed, the FPG and PPPG went above the desired values and insulin dose had to be increased and here again the fetus was exposed to hyperglycemia for a short duration. Some women who were initially in GGI group got shifted to GDM group later as their PPPG levels exceeded 140 mg/dl and had to be started on Insulin Inj. This probably explains why these anthropometric measurements were comparable between GGI and GDM category newborns. In one such study by Shailaja et al. [8], they found that the newborns of GDM mothers had greater AC, MAC than newborns of NGT mothers.

HC/CC ratio of the newborns of the three category did not show significant statistical difference, whereas HC/AC ratio and HC/Bisacromial ratios showed significant statistical difference between the three categories, wherein it was lower in newborns of GGI and GDM compared to newborns of NGT category. This indicates the presence of disproportionate growth in both the newborns of GGI and GDM. Also, fetuses of GDM and GGI are at increased risk of shoulder dystocia during delivery due to increase in the bisacromial diameter and decrease in HC/BAD ratio. Again here, the HC/AC and HC/BAD ratios did not show statistically significant difference between GDM and GGI category newborns. This could be due the fact that the GDM mothers though were treated with MNT and insulin to obtain glycemic control, their plasma glucose levels did not exactly mimic the plasma glucose levels of NGT mothers at all times of the days and all periods of gestation but probably mimicked the plasma glucose levels of GGI mothers. Mc Farland et al. [9] reported the presence of increased bisacromial diameter in newborns of GDM compared to newborns of NGT mothers and stated that this increase in bisacromial diameter leads to decrease in head circumference to shoulder circumference ratio further contributing to the development of asymmetrical growth.

Triceps, subscapular and total skin fold thickness (obtained by adding triceps and subscapular SFT) were compared between the three groups, it was highest in newborns of GGI followed by newborns of GDM and least in newborns of NGT category, and these differences showed very high statistical significance. This confirmed increased adiposity in newborns of GGI category to a greater extent and GDM category newborns to a lesser extent. Here, newborns of GGI mothers had more adiposity than newborns of GDM mothers as GDM mothers received treatment with MNT and insulin. On the other hand, adiposity of newborns of GDM mothers treated with insulin was significantly greater than newborns of NGT mothers as newborns of GDM were exposed to intermittent short periods of hyperglycemia, i.e., during initiation and adjustment of the required dose of insulin to GDM women at the time of diagnosis and also later as pregnancy advanced, during other times of the day where in fluctuations in plasma glucose were noted other than the time of FPG and PPPG point testing which were normal. Shailaja et al. [8] in their study noted similarly that the triceps and subscapular SFT of newborns of GDM were significantly greater than the newborns of NGT mothers. Keller and co-workers inferred from their study that preferential growth occurs in the insulin-sensitive tissues (adipose tissue, liver) and not in insulin insensitive tissues (bones) and probably this accounts to some of these differences in growth patterns [10].

The percentage of newborns with SFT > 90th percentile for each of the skin fold thickness (triceps, subscapular and total SFT) were highest in GGI category newborns followed by GDM and NGT category newborns.

Finally, all the newborns studied in this study were divided into four groups depending on their birth weight (Group 1: 2.5 to 3.0 kg, Group 2: 3.01 to 3.5 kg, Group 3: 3.51 to 4.0 kg and Group 4: > 4 kg). In each weight group, number of newborns belonging to NGT, GGI and GDM categories were determined. Further, the differences in the skin fold thickness in the newborns who belonged to same weight group but different category (NGT, GGI and GDM) were studied. In all the 4 weight groups studied, it was evident that newborns of GGI category had the highest SFT followed by newborns of GDM and least in newborns of NGT category. Therefore, newborns of GGI showed increased adiposity even while their weight was matched with newborns of other two category. This confirms that adiposity increases as the plasma glucose level increases beyond 120 mg/dl and this is independent of the birth weight. Nasrat et al. [11] stratified the studied population into six categories according to their birth weight percentiles. Within each category, the skin fold measurements in the newborns of diabetic mothers were greater than the newborns of non-diabetic mothers.

In summary, it could be noted that measurements which are likely to increase due to increased deposition of subcutaneous fat like abdominal circumference, mid-arm circumference and bisacromial diameter were highest in newborns of GGI mothers followed by newborns of GDM mothers treated with insulin and least in newborns of NGT mothers, while measurements which are unlikely to get affected by increased adiposity like length, head circumference and chest circumferences did not show difference among the three categories, indicating disproportionate growth in newborns of GGI mothers. Also the newborns of GGI mothers showed greater body fat mass (adiposity; measured in terms of SFT's) but similar lean body mass (skeletal growth; measured in terms of length, head and chest circumferences) confirming increased adiposity and disproportionate growth in them. Therefore, the PG levels between 120 and 139 mg/dl in mothers had high association with increased adiposity and disproportionate growth in their newborns independent of their birth weight and this needs cognizance.

This study emphasizes on the need to bring down the PPPG levels of Gestational Glucose Intolerant women to < 120 mg/dl on par with normal glucose tolerant women so as to prevent increased adiposity and disproportionate growth in their newborns. It also warrants more stringent control of plasma glucose levels in GDM mothers, and continuous glucose monitoring may be instrumental in achieving this. Further RCT's and meta-analysis are suggested to confirm this association.

Funding No funding obtained from any organization and/or personnel.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical Approval All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008. Permission was obtained from the science and ethical committee of the institution for the study.

Informed Consent Informed consent was obtained from all patients for being included in the study; also consent was taken from mothers to obtain anthropometric measurements and skin fold thicknesses of newborns.

References

1. Metzger Boyd E, Lowe Lynn P, Dyer Alan R, et al. Hyperglycaemia and adverse pregnancy outcome (HAPO) study. N Engl J Med. 2008;358:1991–2002.
2. Balaji V, Balaji MS, Seshiah V, Mukundan S, Datta M. Maternal glycemia and neonates birth weight in Asian Indian women. Diabetes Res Clin Pract. 2006;73(2):223–4.
3. Franks PW, Looker HC, Kobes S, Leslie Touger P, Tataranni A, Hanson RL, Knowler WC. Gestational glucose tolerance and risk of type 2 diabetes in young pima Indian offspring. Diabetes. 2006;55:460–5.
4. Sermer M, Naylor CD, Phil D, et al. Impact of increasing carbohydrate intolerance on maternal-fetal outcomes in 3637 women without gestational diabetes. Am J Obstet Gynecol. 1995;173(1):146–56.
5. The HAPO Study Cooperative Research Group. Hyperglycemia and adverse pregnancy outcomes (HAPO) study. vol 58. Association with Neonatal Anthropometrics; 2009.
6. Ghattu V. Krishnaveni, glucose tolerance, and insulin concentrations in Indian children, relationships to maternal glucose and insulin concentrations during pregnancy. Diabetes Care. 2005;28(12):2919–25.
7. Hill JC, Krishnaveni GV, Annamma I, Leary SD, Fall Caroline H D. Glucose tolerance in pregnancy in South India: relationships to neonatal anthropometry. Acta Obstet Gynecol Scand. 2005;84(2):159–65.
8. Kale SD, Kulkarni SR, Lubree HG, Meenakumari K, Deshpande VU, Rege SS, Deshpande J, Coyaji KJ, Yajnik CS. Characteristics of gestational diabetic mothers and their babies in an Indian diabetes clinic. JAPI. 2005;53:857–62.
9. McFarland MB, Trylovich CG, Langer O. Anthropometric differences in macrosomic infants of diabetic and non-diabetic mothers. J Matern Fetal Med. 1998;7(6):292–5.
10. Keller JD, Metzger BE, Dooley SL, Tamura RK, Sabbagha RE, Freinkel N. Infants of diabetic mothers with accelerated fetal growth by ultrasonography: are they all alike? Am J Obstet Gynecol. 1990;163(3):893–7.
11. Nasrat H, Abalkhail B, Fageeh W, Shabat A, el Zahrany F. Anthropometric measurement of newborns of gestational diabetic mothers: does it indicate disproportionate fetal growth? Matern Fetal Med. 1997;6(5):291–5.

About the Author

Dr. Ramya Shankar is a senior consultant in Obstetrics and Gynaecology at St Mary's Hospital, Chamarajpet, Bengaluru, Karnataka. In the past, she has worked as consultant in Department of OBG at St Mary's Hospital, Malur, Kolar district, Karnataka. Also she has worked as an Assistant Professor in the Department Obstetrics and Gynaecology at MVJ Medical College and Research Hospital, Dandupalya, Hoskote, Karnataka. She has done her DGO from JJM Medical College, Davangere, Karnataka and DNB in Obstetrics and Gynaecology from Church of South India Hospital, Bengaluru, Karnataka. She has undergone training in fetal and gynec imaging from Bangalore Fetal Medicine Centre, Bengaluru and has been practicing Fetal and Gynec imaging since last 3 years. Her areas of interests are high risk pregnancy, infertility, fetal medicine and preventive oncology.

Affiliations

Ramya Shankar[1,2,3,4] · Arulmozhi Ramarajan[1] · Susheela Rani[1,5] · V. Seshiah[6]

✉ Ramya Shankar
drramyashankar@yahoo.co.in

[1] Department of Obstetrics and Gynaecology, Church of South India Hospital, No. 2, Hazarat Kambal Posh Road, Bengaluru, Karnataka 560051, India

[2] Department of Obstetrics and Gynaecology, MVJ Medical College and Research Hospital, Dandupalya, National Highway 4, 30th km Milestone, Kolathur P.O., Hoskote, Karnataka 562114, India

[3] Department of Obstetrics and Gynaecology, St Mary's Hospital, Guddanahalli Road, Lingapura, Malur, Karnataka 563130, India

[4] Department of Obstetrics and Gynaecology, St Mary's Hospital, Rayan Circle, Sultan Rd, New Taragypet, Anandapuram, Chamrajpet, Bengaluru, Karnataka 560018, India

[5] Department of Obstetrics and Gynaecology, Manjushree Speciality Hospital, #22/70, St John's Road, Opposite to R.B.A.N.M.S Ground, Bengaluru, Karnataka, India

[6] Department of Diabetology, Dr V Seshiah and Dr Balaji Diabetes Care Centre and Research Institution, Chennai, India