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Auxological Dynamics of Body Mass Index in Full-term Symmetric and Asymmetric Small for Gestational Age Infants

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ABSTRACT:

Background & Aims: *Tracking of body mass index (BMI) helps to plan need based interventions to improve and predict health outcome of individuals from neonatal period to adulthood. Owing to non-availability of auxological information on Indian babies this presentation, aims to study pattern of BMI of full-term symmetric and asymmetric small for gestational age (SGA) infants.*

Material & Methods:
BMI amongst 100 symmetric and 100 asymmetric full-term SGA infants born to parents inhabiting North-western India was studied mixed-longitudinally. One hundred full-term appropriate for gestational age (AGA) infants served as controls. Weight and length of each infant was measured at birth, 1, 3, 6, 9 & 12 months in the Growth Laboratory/Clinic of Institute. Mean(SD) BMI (weight(kg)/length(m^2) was calculated. Inter-group, intra-group, gender differences were evaluated using unpaired t-test.

Results:
BMI amongst all infants demonstrated a regular increase upto 6 months whereafter, it depicted a stabilized trend. In general, BMI in symmetric male SGA babies measured significantly ($p \leq 0.01$) more than asymmetric infants. BMI measured higher in female symmetric SGA infants, between 3 to 6 months. Male symmetric SGA and AGA infants had higher BMI than the females. While, it measured lesser in asymmetric SGA male infants than females, gender differences became significant during second half of infancy.

Conclusion:
Substantially, lower placement of BMI curves of SGA infants of the two types and sexes as compared to AGA, normal Indian and Western infants reveal a compromised auxological/nutritional state of symmetric and asymmetric SGA infants, which did not improve during first year of their life.

Key Words: *AGA, Asymmetric SGA, BMI, Symmetric SGA, Indian origin*

INTRODUCTION:

Body Mass Index (BMI) is an important measure of body build of an individual and is frequently used as an index of obesity or under nutrition (Goldbourt & Medalie. 1974, Keys et al. 1972). Childhood obesity and more recently infantile obesity (Dayal et al. 2017) has become a prominent health disparity. Children who are born small for gestational age (SGA) often possess greater adiposity and have a higher prevalence of developing obesity in later childhood and adulthood (Crume et al. 2014, Dolan et al. 2007, Kramer et al. 2014). According to the Centers for Disease Control and Prevention (Kuczmarski et al. 2000), being obese as a child is defined as having a body mass index at or above the 95th percentile; however, there are no normal data sets available for BMI in infancy. Though inter-relationship between small for gestational age infants and high adulthood BMI is well documented yet, longitudinal efforts made to study pattern of BMI amongst SGA infants are scarce and altogether missing amongst symmetric and asymmetric small for gestational age (SGA) infants of Indian origin. Hence, we attempted to study growth attainments of BMI amongst two types of SGA as well as appropriate for gestational age (AGA) babies during first year of life.

MATERIAL AND METHODS:

The sample for this mixed-longitudinal study consisted of 200 SGA (symmetric SGA: boys 50 & girls 50; asymmetric SGA: boys 50 & girls 50) and 100 AGA (boys 50 & girls 50) singleton newborns who were delivered between January 2006 through October 2007 at the Labor Room of Postgraduate Institute of Medical Education & Research (PGIMER), Chandigarh, India. These babies were born to upper middle to upper high socioeconomic strata (Aggarwal et al. 2005) parents residing in north-western parts of India.

Infants weighing below 10^{th} percentile of intrauterine growth curves (Lubchenco et al. 1963) at birth were categorized as SGA, those weighing within 10^{th} to 90^{th} percentile as AGA. The full-term SGA babies with Ponderal Index (PI) below 2.2 g/cm^3 were treated as asymmetric SGA, and those having $\geq$ 2.2 g/cm^3 as symmetric SGA. The written informed consent of one of the parents of each child was obtained prior to his/her enrolment in the study. The study protocol was approved by the Ethics Committee of the Institute.

Body weight and crown-heel length of each child was measured at 1 month (±3 days), 3, 6, 9 and 12 months of age with a time tolerance limit of ±15 days in the Growth Clinic/ Growth Laboratory, Child Growth & Anthropology Unit, Department of Pediatrics using standardized techniques and instruments (Weiner & Lourie. 1969, Eveleth & Tanner. 1990) . The body weight of infants upto four months was measured with an Electronic Weighing Scale (Make: Avery, India Limited, Capacity: 12kg, Least count: 2g). Subsequently, another Electronic Weighing Scale (Make: Avery, India Limited, Capacity: 150 kg, Least count: 50g,) was used to weigh children upto 12 months of age. The crown-heel length (CHL) till 1 month of age was measured with 'Neonatometer' (Make: Holtain Limited) upto an accuracy of 1mm and afterwards, 'Supine Length Measuring Table' (Make: Holtain Limited) was used.

BMI was calculated by dividing weight (kg) by square of CHL (m^2) (presented elsewhere, Kaur et al. 2017) for all the study subjects. Age and sex specific (mean and standard deviation) distance growth statistics for BMI was computed amongst two types of SGA and AGA infants. The magnitude of intra-group (symmetric vs. asymmetric), inter-group (SGA vs. AGA) as well as gender differences for distance growth was calculated by applying Student's unpaired t-test.

RESULTS

Mean BMI amongst symmetric SGA, asymmetric SGA and AGA male and female infants in general, increased continuously till 6 months of age whereafter, it depicted a decline in its value (Table 1 & Figs. 1 & 2). Symmetric SGA male infants possessed significantly ($p \leq 0.001$) higher mean values than their asymmetric counterparts from birth till 9 months. While, at 12 months the magnitude of intra-group difference diminished to a non-significant level as male symmetric (15.1± 1.02 kg/m^2) and asymmetric SGA infants (15.2± 0.97 kg/m^2) possessed almost similar mean BMI. Symmetric SGA female infants possessed higher mean BMI values than their asymmetric female counterparts from birth to 1 month of age. However, from 3 months till the completion of infancy, asymmetric SGA female babies possessed higher BMI than the symmetric SGA infants. The intra-group differences between symmetric and asymmetric SGA females were found to be statistically significant at birth ($p \leq 0.001$) and at 9 months ($p \leq 0.01$). The symmetric and asymmetric SGA babies of the two sexes possessed lower BMI than their AGA controls from birth till the completion of first year of life and the inter-group differences remained statistically highly significant ($p \leq 0.001$) at most of the age points (Table 1).

Symmetric SGA male infants were found to possess higher mean BMI than their female counterparts throughout the period of infancy and the magnitude of gender differences became statistically significant at 3, 6 ($p \leq 0.01$) and 9 ($p \leq 0.05$) months. While, asymmetric male infants possessed lower mean BMI than the asymmetric females throughout study period and gender differences depicted statistical significance during second half of infancy i.e. at 6 ($p \leq 0.01$), 9 ($p \leq 0.001$), and 12 ($p \leq 0.05$) months. Female AGA babies possessed higher mean BMI at birth and from 1 to 12 months of age BMI amongst male AGA infants measured higher (Table 1).

DISCUSSION

Tracking of BMI from neonatal period to adulthood is recommended to plan intervention and predict outcome (Nair et al. 2006). BMI amongst symmetric SGA, asymmetric SGA and AGA infants of the two sexes, demonstrated a regular increase from birth to 6 months, whereafter an almost stable trend was observed till 12 months of age (Figs 1 & 2). This corroborates with similar trend for BMI observed amongst normal Punjabi infants (Bhalla & Walia. 1996). The symmetric SGA male infants though being etiologically more affected possessed higher BMI than asymmetric ones. Female symmetric SGA infants after an initial sharp increase experienced a decline in BMI compared to asymmetric SGA infants who are known to suffer from nutritional/placental insufficiency during last trimester of pregnancy (Figs 1 & 2).

The net percent increase recorded for BMI from birth and 6 months in male (47.27%) and female (40.37%) symmetric SGA babies measured lesser than that recorded for both male (57.3%) and female (63.5%) asymmetric SGA infants. Relatively, lesser percent increase in BMI of symmetric babies than asymmetric ones appear to be continuation of the severer initial auxological/nutritional insult experienced by the former than latter, as weight and length are known to affect early during first trimester of pregnancy in symmetric infants. While, asymmetric SGA infants get affected during last trimester of their antenatal life. AGA babies measured significantly more than their SGA counterparts of the two types and sexes yet, net percent increase for BMI in AGA (male: 36.5%, female: 32.5%) babies remained lesser than SGA during first half of infancy. Male infants representing symmetric SGA and

AGA categories possessed greater BMI values as compared to their female counterparts. In contrast asymmetric SGA male infants possessed lesser BMI than their female peers (Table 1).

The significantly lower placement of distance curves of our SGA infants of the two types and gender when contrasted with their AGA, MGRS (WHO. 2006), European (van't Hof & Haschke. 2000) and normal Punjabi (Bhalla & Walia. 1996) counterparts reveals that symmetric and asymmetric SGA infants demonstrate a compromised nutritional state, and never come at par with their other normal counterparts during first year of life. The magnitude of this differential remained more in male asymmetric SGA infants upto 9 months of age and for symmetric SGA female babies beyond 1 month of age. Similar to our results, Taal et al. (2013) in their longitudinal study on Dutch SGA and AGA children from 2 months to 4 years of age, did not find higher BMI values in children born SGA, indicating that the increase risk of obesity develops later in life and is not yet seen at this young age. While, results from a Brazilian study (Cardoso & Falção. 2007) show no differences in BMI of preterm SGA and AGA infants from birth to first 28 days of life. Similarly Beltrand et al. (2009) reported complete catch-up in weight and length of their infants with fetal growth restriction as their BMI values were similar to those without fetal growth restriction by the age of 12 months. However, our findings remain at variance with those published by Valuneine et al. (2009) who reported higher BMI amongst SGA infants of Lithuanian origin as compared to their AGA peers from birth to 6 years of life. These authors commented that a greater catch-up in body mass index during the first years of life might be a predisposing factor for the development of long-term metabolic complications in these individuals. Torre et al. (2008) opined that catch-up growth in BMI amongst Italian children born as SGA is neither associated with reduced insulin sensitivity nor with altered lipid profile, hence, it remains an issue to be researched upon.

Contrary to the common practice of treating and evaluating SGA infants without differentiating in symmetric and asymmetric types as a single entity, the existence of statistically significant difference in BMI amongst two types and gender of SGA infants, suggests that they be treated as two distinct entities for evaluating their varied auxological, nutritional as well as other overall health related aspects.

Conflict of Interest: None

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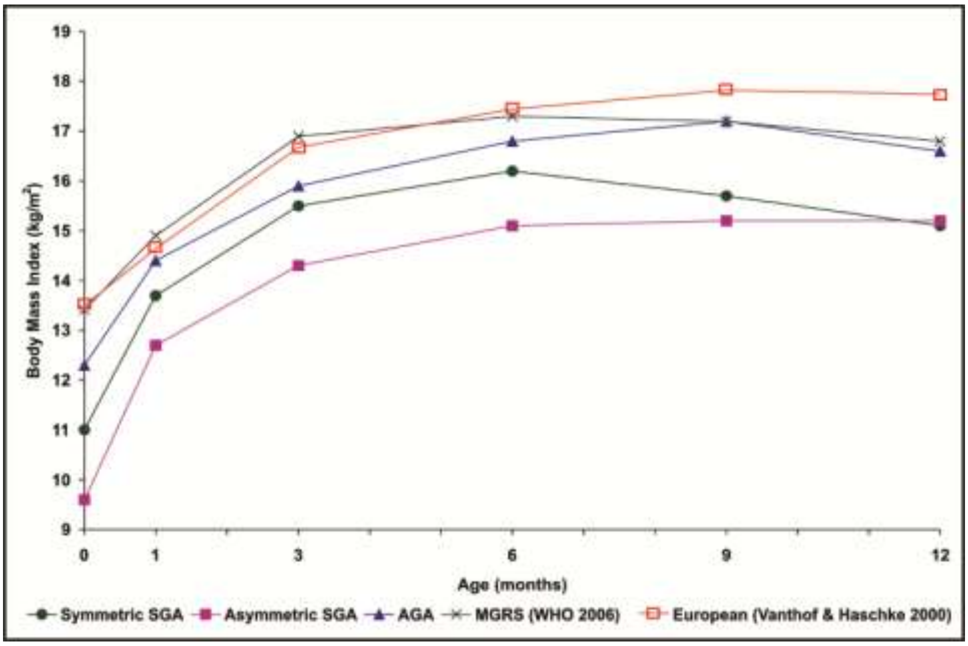

Fig 1: Comparison of Body Mass Index (kg/m^2) of Male Symmetric SGA, Asymmetric SGA, AGA and Normal Infants

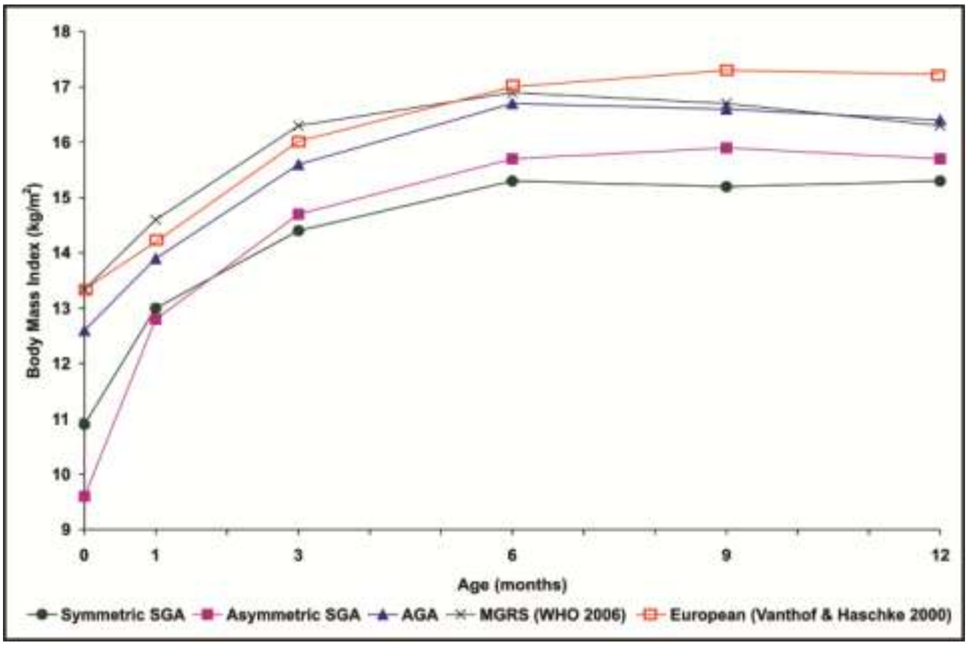

Fig 2: Comparison of Body Mass Index (kg/m^2) of Female Symmetric SGA, Asymmetric SGA, AGA and Normal Infants

Table 1: Mean, (SD) and t-values of Body Mass Index (kg/m^2) of Male and Female Symmetric SGA, Asymmetric SGA and AGA Infants

Age (months)	Symmetric SGA		Asymmetric SGA		AGA	
	Male	Female	Male	Female	Male	Female
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
0	11.0 (0.81)	10.9 (0.73)	9.6 (0.63)	9.6 (0.55)	12.3 (1.05)	12.6 (1.25)
1	13.7 (2.15)	13.0 (1.52)	12.7 (0.96)	12.8 (1.66)	14.4 (1.36)	13.9 (1.89)
3	15.5 (1.72)	14.4 (1.16)	14.3 (1.25)	14.7 (1.49)	15.9 (1.61)	15.6 (1.49)
6	16.2 (1.48)	15.3 (1.00)	15.1 (0.98)	15.7 (1.35)	16.8 (1.59)	16.7 (1.76)
9	15.7 (1.43)	15.2 (0.87)	15.2 (0.84)	15.9 (1.10)	17.2 (1.31)	16.6 (1.15)
12	15.1 (1.02)	15.3 (0.92)	15.2 (0.97)	15.7 (1.00)	16.6 (1.16)	16.4 (0.85)

t-values									
Age (months)	Gender Differences			Symmetric SGA Vs Asymmetric SGA		Symmetric SGA Vs AGA		Asymmetric SGA Vs AGA	
	Symmetric SGA	Asymmetric SGA	AGA	Male	Female	Male	Female	Male	Female
0	0.514	0.111	1.085	9.915***	10.485***	6.957***	7.979***	15.817***	15.403***
1	1.874	0.165	1.384	2.906**	0.711	1.891	2.683**	6.998***	3.220**
3	3.607**	1.462	1.016	3.831**	1.127	.997	4.044***	5.189***	2.601**
6	3.143**	2.620**	0.223	3.909**	1.712	1.961*	4.713***	5.914***	2.842**
9	2.091*	3.486***	2.225*	2.154*	3.382**	5.125***	6.557***	8.785***	2.954**
12	1.223	2.251*	1.358	0.326	1.566	6.769***	5.584***	6.381***	3.485**

***p≤0.05, **p≤0.01, ***p≤0.001, df= n-2**