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Research Article

PERINATAL DETERMINANTS OF ADIPOSITY IN CHILDREN AGED 3-5 YEARS IN URBAN POOR SETTINGS OF DELHI: A RETROSPECTIVE STUDY

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ABSTRACT

Background: WHO estimates that 22 million under-five children worldwide are overweight. Childhood obesity is rising to epidemic proportions in the developing world, reflecting multitude of underlying reasons; that need to be studied. **Objectives**: The study aims to investigate whether breast-feeding and complementary feeding practices during infancy constitute a risk factor for overweight at preschool age and identify possible determinants that may affect adiposity levels. **Material and Methods**: This data was a part of a case-control study of 266 children (3-5 years) from urban poor settings of Delhi, India. The cases comprised of overweight children, as defined by Body Mass Index (BMI) for age greater than or equal to the 85th percentile of WHO standards and controls with BMI less than 85th percentile. The main exposure analysed was breast-feeding and complementary feeding parameters. **Results**: Birth weight and birth order were significantly associated with the child's BMI at 3-5 years of age (p=0.023 and p=0.034, respectively). The combined odds of birth order and child's BMI were found to be 3.7 OR (2.34- 10.74 CI) for overweight/ obesity in pre-schoolers. Cross-tabulation of breast-feeding and complementary feeding practices revealed that odds for an overweight/obese child were high 3.18 OR (2.02- 5.04 CI) with early introduction of complementary foods. Colostrum consumption had no significant effect on weight status whereas introduction of complementary feeding in the first 6 months increased the odds of being overweight/obese by 1.86 OR (1.11- 9.93 CI). **Conclusion**: To conclude, including growth trajectory, appropriate breastfeeding and complementary feeding may have a protective role against overweight/obesity during early childhood.

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INTRODUCTION

Adiposity defined as the amount of body fat expressed either as total fat mass (in kg) or fraction of total body fat (Bellizzi & Deitz 1999); has emerged as the most crucial correlate of non-communicable and preventable burden of diseases and despite various public health and advocacy programs the problem still persists. With consumption of calories/energy exceeding expenditure, rapidly changing dietary practices with a sedentary lifestyle; adiposity rates have risen, increasing the global chronic disease burden. Worldwide, children are gaining weight, which tracks into adulthood thus increasing the risk of adult diseases such as type 2 diabetes, cardiovascular disease (CVD), the early-onset metabolic syndrome, subclinical inflammation, dyslipidemia, coronary artery diseases, hypertension, polycystic ovarian syndrome (PCOS) and obesity later in life. Furthermore, overweight and obesity affect self-esteem of children and impair social development (Janssen *et al*, 2004;Pierce and Wardle, 1997). Research suggest multiple strategies to screen and manage childhood obesity, which include but are not limited to therapeutic lifestyle changes, maintenance of regular physical activity, nutritional adaptation, parental initiative and social support interventions (Gupta *et al*, 2012; Spear *et al*, 2007; Koplan *et al*, 2005).

Epidemiological analysis of the NCD estimates reveals that developing countries more often have children with diseases at both ends of the spectrum viz. under and over nutrition (Ranjani *et al*, 2014). A meta-analytical review quantifying prevalence of childhood obesity in developing countries, documented obesity estimates to be 41.8% in Mexico, 22.1% in Brazil, 22.0% in India, and 19.3% in Argentina in young children. Moreover, secular trends indicated an increasing prevalence rates in these countries: 4.1 to 13.9% in Brazil during 1974-1997, 12.2 to 15.6% in Thailand during 1991-1993, and 9.8 to 11.7% in India during 2006-2009 (Gupta *et al*, 2012). In many countries, including India, "overweight/obesity is becoming a major problem while underweight continues to

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be a challenge" - a phenomenon known as the double burden of malnutrition (Doak *et al*, 2005; Garrett *et al*, 2005).

Multiple studies have factored the possible determinants of early overweight and obesity in an attempt to understand its pathophysiology (Heerwagen *et al*., 2010; Tounian, 2011). Bammann and his colleagues mentioned that maternal weight, gestational weight gain, glycemic control, smoking and alcohol use during pregnancy, birth weight, breastfeeding practices, pregnancy conditions etc. are some pre-; peri- and post-natal determinants that have produced equivocal results (Bammann *et al*, 2014). With multiple factors at play, some studies tend to document association of adiposity determinants and 'unhealthy' BMI in children as a true causation; others tend to write them off as statistical artifacts (Bartok andVentura, 2009). Also, several studies suggest that schools are a potential setting to target both children and adolescent population for obesity prevention (Wang *et al*, 2003; Gortmaker *et al*, 1999). Obesity rebound studies have resulted in targeting 3-7 years of age to prevent the child from setting itself on an overweight-obese trajectory (Biesmaa andHansonb, 2015). Therefore, identifying risk factors associated with overweight and obesity in children aged 3-5 years would help to develop appropriate interventions to reduce the future burden of overweight and obesity in India. The objective of this study is to delineate the perinatal factors associated with overweight and obesity among3-5-year-old children in urban poor settings in New Delhi, India. This may result in understanding the screening strategies to identify overweight children at appropriate time and design prevention/intervention policies.

MATERIALS AND METHODS

Subjects

The children included in this study were selected from a nutritional epidemiology study of 400 children aged 3-5-year-residing in urban poor settings in New Delhi, India. Appropriate households were selected using (PPS) and cluster sampling. The datum for the presented study was sorted through a case-control analysis conducted in 2017.The sample of 133 cases and 133 controls were resorted with the aid of the SPSS program, for prospective matching. With alpha and beta values, fixed at 5% and 20%, a ratio of 1:1 between the numbers of cases and controls was determined. An expected frequency of the principal exposure i.e. overweight/obesity in the control group was 1.20 OR (odds ratio of chronic disease) (Pereira *et al*, 2014). Assuming the prevalence of overweight to be 20% (Ranjani *et al*, 2014), around 479 children was need to be evaluated in order to identify 133 cases.

This study was approved by the Ethics Committee of the Institute of Home Economics, New Delhi, India in 2014. An informed consent form was sent to all parents or guardians responsible for the children within the desired age group. All children whose parents authorized their participation were included in the study (N=400).

Measurements and Assessment

Multiple measures were collected from children and their mothers. Heights and weights were measured, and their BMIs were calculated. Weight was recorded to the nearest 0.1 kg and height to the nearest 0.1cm using standardized techniques. Body Mass Index (BMI) was calculated as weight (kg) divided by height squared (m).

The case group was constituted by the children who were overweight, which was defined as BMI greater than or equal to the 85th percentile for their age group (Healthy BMI). As there are various definitions of unhealthy BMI, a definite consensus sometimes cannot be reached. According to Gupta *et al* (2012), mostly the 85th and 95th percentiles of BMI data set are taken as cutoffs for assessment of childhood overweight and obesity, respectively. The control group was formed by children whose BMIs were lower than the 85th percentile (Unhealthy BMI). As measurements were repeated thrice, over several days, hence absentee children, or ones presenting diseases or the ones where measurements could not be taken as per standardized guidelines, were not documented in the study.
Maternal anthropometrics were also collected using standardized methods (Armstrong and Reilly, 2002). Each measurement was taken thrice, and BMI calculated with assessment through standard BMI WHO guidelinesas appropriated later in Asians (Barba *et al*, 2004; Misra *et al* 2003)

Questionnaire cum interview schedule were used to collect information about maternal and child characteristics along with socio-economic status and dietary patterns from primary caregivers (mothers). Besides anthropometrics of the child and mother, data on obstetric history of the mothers, child details (age, birth order, morbidity, vaccination etc.), feeding practices, access to health services, hygiene and sanitation practices, lifestyle and physical activity pattern of the child and the mother was collected. A 3 day 24-hour dietary recall and semi-quantitative Food Frequency Questionnaire was used in order to elicit information on dietary habits of the mother-child dyads. Household Food Insecurity Assessment Scale (HFIAS) was also used to assess the prevalence of food insecurity in the households.

For the present analysis, most peri-natal characteristics like breastfeeding practices, complementary feeding, birth order etc. were treated as exposure variables. Children were considered to present this exposure i.e. overweight/obesity or unhealthy BMI, if they had received exclusive breastfeeding or the time frame of how long this was followed. Complementary feeding practices were also included. Birth weight and birth order were other variables included in the study. Socioeconomic variables were also gathered, with the aim of characterizing the sample. Income centiles were used to match socio-economic status to maintain homogeneity. Data relating to breastfeeding and the other variables were gathered and checked through multi-data entry techniques and also for inconsistencies.

Data analysis

Potential nominal exposure factors, such as breastfeeding practices, other postnatal dietary patterns were analyzed and compared by the chi-square method between the paired samples for children groups; with healthy and unhealthy BMI. The odds ratio (OR) and its 95% confidence interval (CI) were also computed through binomial logit models, with both univariate and multivariate analysis after controlling for maternal BMI and maternal age, where significant OR values >1.00 as recorded as a risk factor for unhealthy BMI, while an

OR significantly less than 1.00 was regarded as a protective factor. OR=1, predicts no effect. It is known that with most age groups, risk factors and outcomes may vary and therefore we did not analyze this separately, suggesting that they do share the same risk factors of obesity. Two sided statistics have been reported where p< 0.05 has been considered significant. All statistics were computed using SPSS 23.0 from IBM, India.

RESULTS

A total of 266 children with 133 children of unhealthy BMI and 133 healthy counterparts were assessed. The mean (SD) of age, weight, height, and BMI of the students were 3.5 ±1.3 years, 13.14±2.45 kg, 93.76±7.74 cm, and 17.94±7.33 kg/m^2, respectively.

Table II shows the association between categorical exposure variables and 'unhealthy BMI' in adjusted univariate logistic regression model. The associations have been quantified with chi square and through binomial logit model controlled for maternal BMI and maternal age, parity, occupation and education of the mother. Except for chronicity inheritance from one parent or both, all variables were seen to have a significant association with BMI of the child at p<0.001. There are 44 per cent lesser chances of having an 'unhealthy' BMI if complementary feeding started after 6 months.

Table III shows an association between significant exposure variables and 'unhealthy BMI' in adjusted multivariate logistic regression model. Birth weight and birth order were significantly associated with child's BMI at 3-5 years of age

Table I Association between peri-natal characteristics with child's BMI

Variables	Cases (BMI > 95th percentile) (n = 133) (mean ± SD)	Controls (BMI > 95th percentile) (n = 133) (mean ± SD)	t-test (Significance)	Adjusted for covariates	95% CI
Birth weight (g)	3975. 80 ± 768.80	2978.60 ± 645.60	9.39 (0.001)	1.16	0.63-2.248
Birth order (n)	2.10 ± 1.02	3.09 ± 1.40	6.59 (0.001)	0.82	0.50-0.97
Duration of breast feeding (month)	5.02 ± 2.10	10.76 ± 4.33	13.75 (0.001)	0.78	0.66-0.97
Age of onset of complementary food (month)	5.77 ± 3.56	8.73 ± 1.31	8.99 (0.001)	0.66	0.54-0.98

Model adjusted for Maternal BMI and Maternal age, occupation and education of the mother

Table I presents adjusted OR's (univariate analysis) for birth weight, birth order, duration of breast feeding and age onset of complementary food, as quantitative variables for those with unhealthy BMI when healthy BMI children were held as reference values. The estimated adjusted ORs for birth weight, birth order, duration of breast feeding and age onset of complementary food were statistically significant after being controlled for maternal BMI and age. The means of all variables varied significantly between health and unhealthy BMI children as shown by the paired t-test values, p<0.001 when treated as a case-control study.

The combined odds were found to be 3.7 OR for overweight/ obesity i.e. 'unhealthy' BMI in pre-schoolers. Cross-tabulation of breast-feeding and complementary feeding practices revealed that odds for an overweight/obese child were high. Introduction of complementary feeding in the first 6 months increased the odds of being overweight/obese to 1.86 OR (1.11- 9.93 CI) in completely adjusted models.

Table II Association between categorical exposure variables and 'unhealthy BMI' in adjusted univariate logistic regression model

		'Unhealthy' BMI (n = 133)		Healthy BMI (n = 133)		Chi square-test (Significance)	Adjusted for covariates	95% CI
		N	%	N	%			
Birth Weight	2.5-4.0 kg	65	48.87	93	69.92	12.22 (0.004)	2.03	1.41-4.07
	< 2.5 and > 4.0 kg	68	51.13	40	30.08			
Breastfeedingupto 6months	Yes	114	85.71	130	97.74	12.69 (0.003)	4.22	2.08-15.44
	No	19	14.29	3	2.26			
Time of exclusive breastfeeding	< 6 months	54	47.37	102	77.69	24.1 (0.001)	2.56	2.22-4.34
	≥ 6 months	79	52.63	31	22.31			
Complementary Feeding	< 6 months	75	56.39	56	42.11	5.43 (0.020)	0.56	0.34-0.91
	≥ 6 months	58	43.61	77	57.89			
History of chronic disease	Yes	84	50.68	52	39.10	16.2 (0.001)	0.47	0.23-0.60
	No	49	41.35	81	60.90			
Chronic disease in one parent or in both	Mother or Father	40	42.55	19	36.54	0.5 (0.48)	0.77	0.38-1.56
	Both	54	57.45	33	63.46			

Model adjusted for Maternal BMI and Maternal age, parity, Occupation and Education of the mother

Table III Association between significant exposure variables and 'unhealthy BMI' in adjusted multivariate logistic regression model

Factors	Estimates			95% C.I. for Exp (B)	
	B	Sig.	Exp (B)	Lower	Upper
Birth Weight (Ref: < 2.5 and > 4.0 kg)	4.61	0.023	4.98	2.65	5.36
Birth order	-1.97	0.034	0.74	0.39	0.96
Breastfeeding (Ref: Yes)	3.26	0.052	2.62	0.99	4.36
Time in exclusive breastfeeding (Ref: ≥ 6 months)	3.13	0.01	2.01	1.65	6.32
Complementary Feeding (Ref: ≥ 6 months)	2.26	0.004	1.86	1.11	9.93
Frequency of Weaning (Ref: <3)	2.34	0.023	1.99	10.23	6.39
History of chronic disease (Ref: No)	4.09	0.001	3.9	2.01	7.89
Constant	13.45	0.073	0		

Model adjusted for Maternal BMI and Maternal age, Occupation and Education of the mother
Nagalkerke R square=0.74; Prediction Percentage-87.2; Omnibus Test=p<0.001

DISCUSSION

This present work investigates the impact of peri-natal risk factors on the risk of subsequent childhood obesity. For most of the exposure variables, we documented a significant effect on 'unhealthy' BMI. The study is in accordance with the literature, regarding high and low birth weight as a risk factor of overweight/obesity in preschoolers (Bammann *et al*, 2014; Yu *et al*, 2011;Hirschler *et al*, 2008). Though some researchers are of the opinion that birth weight mainly influences lean body mass and not fat mass (Labayen *et al*, 2006); most others studies have produced unequivocal associations between birth weight and health status for the child (Rossi and Vasconcelos, 2010)and subsequently adult obesity (McNeely *et al*, 2007). One of these studies also combines scientific and epidemiological evidence to establish low birth and macrosomia as factors associated with unhealthy BMI and warrant for preventive measures for both mother and children (Rossi and Vasconcelos, 2010). A systematic analysis even revealed that for low birth infants, if nutritional adequacy can be established in the first year of life, developmental plasticity may lead to phenotype reprogramming and reduce odds of unhealthy BMI and adult obesity (Ribeiro *et al*, 2015).

Low birth rank is seen to be associated with higher risks of having unhealthy BMI and this association is pre-established. A study showed an inverse association with birth rank, children belonging to the category of 1-3 rank were associated with higher odds of being overweight than those of birth rank > 3 (Tchoubi *et al*, 2015).

The study also established that parental chronic history is a significant prognosticator of 'unhealthy' BMI with odds as high as 4 (95% CI 2.01-7.89). Chronicity is inheritable but it has also been discussed that in addition to genetic susceptibility, environmental factors also influence children's body composition (Sekine *et al*, 2002).They were also of the opinion as a child's environment mostly consists of nutritional habits and preferences, routines in sleep and activity, they are usually shaped more by mothers than fathers which the present study could not establish.

The time from conception to second birthday is said to be the most critical period in life for it creates potential for survival with growth and health trajectories. Knowing that this window of opportunity can have lasting impact through maturation, and immunity establishment, all determinants associated with this period are known as perinatal factors. Colostrum and breastfeeding are known to provide protective effects against diseases and childhood obesity (Uwaezuoke *et al*, 2017).The consumption of colostrum did not affect child's BMI but breastfeeding for less than 6 months, increased the odds of unhealthy BMI by two times. Uwaezuoke and his colleagues have also explored five physiologic mechanisms to understand the causality between breastfeeding and lower risk of obesity. Baring a few confounding factors, like socioeconomic status, maternal BMI and maternal smoking (Brion *et al*, 2011) which may mask the effect of presence or absence of exclusive breastfeeding (Kramer *et al*, 2009) as seen in the present study as well; new molecular analysis have established direct and indirect effect of human milk oligosaccharides on the prevention of overweight and obesity (Lessen and Kavanagh, 2015).

WHO recommends exclusive breastfeeding until 6 months of age and continued breastfeeding until 2 years of age or beyond. Appropriate complementary foods, should be introduced in a timely fashion, beginning when the infant is 6 months old (Pearce *et al*, 2013). We found that introduction of complementary feeding in the first 6 months increased the odds of unhealthy BMI in child to nearly 2 but a review documented that there is no clear association between the timing of the introduction of complementary foods and childhood overweight or obesity, though too early may have an effect (Pearce *et al*, 2013). Most studies have focused on the type of complementary feeding rather than the timing. Timing it seems is a direct byproduct of prolonged exclusive breastfeeding and therefore gears up a healthy trajectory for the child. With a controlled timing and type of feeding practices, what we limit is obesogenic environment, and the exact interactions that may predispose some children to gain excess weight leading to obesity in future.

Summary

We evaluated factors in infancy that are the most significant predictors of unhealthy BMI in early childhood (3-5 years of age) through a retrospective approach to a cross sectional study. This is both a limitation and strength of the present use. We did not utilize a standardized scale to quantify SES and some data associated with physical activity levels and diet was not included in the present analysis. Besides birth order or parity, perinatal exposures such as breastfeeding practices, weaning, complementary feeding were found to be significantly associated with unhealthy BMI in early childhood, posing serious health implications in later stages of life. The fact that these are all modifiable may lead to new health promotion programs that focus on determinants in early infancy as practical targets to curb childhood obesity and subsequently adult chronic disease burden.

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