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Seasonality in maternal intake and activity influence offspring's birth size among rural Indian mothers—Pune Maternal Nutrition Study

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Background Farming populations from developing countries are exposed to seasonal energy stress due to variations in food availability and energy output related to agricultural activities. This study aims to examine the impact of seasonality in maternal intake and activity on neonatal size.

Methods Maternal anthropometry, dietary intakes (24-h recall and food-frequency questionnaire) and activity pattern (questionnaire) at 18 ± 2 and 28 ± 2 weeks gestation, and neonatal anthropometry, were measured in a prospective study of 797 rural Indian women.

Results Maternal energy and protein intakes were inadequate (70% of recommended dietary allowance). Both intake and activity showed seasonal variation ($P = 0.001$), with peak values in winter i.e. during harvest, at 18 weeks (median energy 1863 kcal/day, protein 47.5 g/day) and 28 weeks (median energy 1687 kcal/day, protein 43.7 g/day), coinciding with the maximum maternal activity (median score 86.1 at 18 weeks and 79.5 at 28 weeks). Mean birth weight and length (adjusted for pre-pregnant weight, parity, gestation and sex) of babies was highest in summer (peak at February 2733 g, 48.6 cm, respectively) and lowest in winter (nadir at January 2591 g, 47.1 cm, respectively). Regression analysis showed that maternal intake at 18th week had a positive association ($P = 0.05$), maternal activity at 28th week had a negative association ($P = 0.002$) and exposure (in weeks) to winter during gestation had a positive association ($P = 0.04$) with birth size. Furthermore, higher maternal intakes, coupled with lower maternal activity in late gestation were associated with higher birth weight, especially during winter.

Conclusions If causal, these observations indicate that complete exposure (16 weeks) to the winter season (harvest-time) in late gestation could increase birth weight by 90 g in poor farming communities in rural India, and the benefit would increase further by lowering maternal activity. Our results underscore the importance of

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considering seasonality in planning targeted intervention strategies in such settings.

Keywords Seasonality, maternal intake, activity, birth size, rural India

Introduction

It is widely believed that most rural populations in the Third World suffer from seasonal energy stress because of fluctuations in their access to food, or increased energy expenditure needed for peak agricultural work. Ferro-Luzzi and Branca[1] have calculated the dimensions of seasonality risk in the world on the basis of an Index of Agro-Climatic Seasonality (IACS). It has been shown that Asia has the highest adult population exposed to severe agro-climatic seasonality and the largest number of people at risk (371 million) of seasonal energy stress, due to the unique combination of low body mass index (BMI) and a very large rural population.[2] Exposure to energy stress is considered to have detrimental nutritional and functional effects.

Low birth weight (LBW) is a well-known phenomenon in developing countries[3–6] and is largely attributed to widespread maternal undernutrition. Nutritional insults during different periods of gestation have differing effects on birth size. Farming communities are often exposed to seasonal energy stress due to slack and harvest periods, which affect maternal intakes. In fact, it has been shown that the prevalence of LBW differed significantly in these seasons.[7,8] Furthermore, the seasonal decline in birth weight was eliminated through supplementation, contributing to reduction in the incidence of LBW.[8] This has been attributed to the seasonal deterioration of nutritional status due to food shortages and an increase in agricultural labour that often coincides with seasonal epidemics of infectious and parasitic illnesses.[9,10]

The proportion of the population residing in rural India is considerably large and has agriculture as their main occupation. Agricultural activity is dependent on climatic conditions, and seasonality affects dietary intake as well as activity pattern in this rural population. Effects of wet and dry seasons on BMI[2] and dietary intake or activity pattern[11,12] are well documented in populations from developing countries. However, there is limited information in India on the effects of season on maternal intakes, activity and on neonatal size. Such information will be valuable for improving the quality of maternal intervention programmes and forms the objective of this study.

Methods

The Pune Maternal Nutrition Study was established in six villages located 40–50 km from Pune city and covered a population of approximately 35 000. The area is drought prone, and most families live by subsistence farming on small landholdings. The majority of women (75%) worked on their farms or as labourers in addition to performing domestic chores.

During the study period, June 1994 to April 1996, 1102 women reported missing periods. Of these, 770 women delivered (after excluding 112 early abortions/terminations, 8 fetal anomalies, 3 multiple pregnancies, 14 with incomplete pre-pregnant anthropometry, 168 late entries, i.e. beyond 21 weeks of gestation, 12 late spontaneous abortions, 14 late terminations and 1 death due to pregnancy-induced hypertension). Out of 770 babies born, 8 were stillborn, 9 had major anomalies detected at birth and 51 did not have birth measurements within 72 h, giving data on 702 live births. Of 702 normal live births, our analysis relates to 633 full-term babies. Details of obtaining gestational age have been described earlier.[13] Ethical permission for the study was granted by the King Edward Memorial Hospital Ethical Committee, and by the local village leaders.

Maternal dietary intake

The conventional 24-h recall method was modified and made more objective.[13] Trained fieldworkers recorded the average weight of servings of all food items at each mealtime, on the day before the visit for 24-h recall. One of four nutritionists interviewed women for 24-h recall on the following day and recorded consumption of food items in terms of servings, in chronological order from morning until dinner time. Average weights of servings recorded by the fieldworker were therefore used to convert the consumption of food items into weight equivalents. Energy and protein intake for each woman was calculated using a database generated for the nutritive values of 288 distinct cooked food preparations commonly consumed in the community.

Maternal activity

A detailed activity questionnaire was developed after incorporating the community specifics obtained from Focus Group Discussion (FGD). It consisted of 36 subquestions related to 14 different major daily activities including farming and domestic activities.[14] Using published data for the energy expenditure of various activities,[15] a weighted score was derived for each activity such that a higher weighted score reflected heavier activity. This questionnaire was field tested and validated with a detailed observer-maintained diary.[14]

The women's dietary intake and typical daily physical activity were recorded at two time points (18 ± 2 and 28 ± 2 weeks) during gestation.

Maternal anthropometry

Before women became pregnant, their weight was measured to the nearest 100 g using a digital balance (SOEHNLE, CMS Weighing Equipment Ltd, UK) and height was recorded to the nearest 0.1 cm using a portable stadiometer (CMS Weighing Equipment Ltd, UK) every 3 months. The last set of measurements made before confirmation of pregnancy was used as pre-pregnant anthropometry. Measurements were repeated during pregnancy at 18 ± 2 weeks and 28 ± 2 weeks of gestation. BMI was derived as the ratio of weight (kg) to the square of height (m).

Neonatal anthropometry

Babies were measured by trained fieldworkers within 72 h of birth. Birthweight was measured to the nearest 50 g using a Salter spring balance (Salter Abbey, Suffolk, UK); crown-heel length was measured to the nearest 0.1 cm using a portable Pedobaby Babymeter (ETS J.M.B., Brussels, Belgium). Ponderal Index was derived as the ratio of birth weight (g) to the cube of birth length (cm).

Seasonality

In rural India, three seasons define its subtropical climate: summer (from February to May), the monsoon or rainy season (from June to September) and winter (from October to January). As the study area belongs to a drought-prone region, summer is very hot and dry and rains are moderate. Since most of the land is non-irrigated, the yield of crops depends on rainfall.

Traditionally, the major agricultural crops (staple) are bajra (millet) and sorghum, whereas legumes (rajma, cowpea, etc.) are grown as intercrops. Onion, groundnut and vegetables are cash crops grown only by rich farmers on irrigated land. Major agricultural activities consist of land preparation prior to the rainy season (ploughing, clearing and digging the soil, applying fertilizers), planting and weeding during the rainy season, harvesting (cutting of crops, shelling pods/grains) in winter and post-harvest activities (winnowing and baling or bagging) in early summer.

Men participate in agricultural work, but only in land preparation, whereas the other activities involving squatting or bending postures are done exclusively by women. Therefore, at the time of land preparation, which is generally done at the end of summer before the rain starts (May/June), women perform fewer agricultural activities. They spend most of the time in light activities at home such as stitching quilts and making *papadam*. Throughout the rainy season, women are involved in planting and weeding. Winter, which coincides with the harvesting of staple foods, is the period of most intensive agricultural work. All harvesting tasks are carried out by hand, using cutlasses, hoes, and a variety of other hand-held implements. After harvesting, food availability improves considerably but only during the winter season. However, it diminishes during summer and stocks become exhausted before the next harvest arrives. In contrast, agricultural work is not restricted to the rainy season only, but extends several months before and after. Therefore, in such a setting, examining seasonal variability in maternal intake, activity pattern and its impact on birth size is promising and is attempted using longitudinal data.

Statistical methods

Maternal intakes and activity scores were highly variable and, as such, differences between the months of visits or seasons were tested using non-parametric median tests. Analysis of variance (ANOVA) was used to examine the variability in mean values of maternal weight or BMI between the months of visits or seasons and the variability in the mean values of birth weight and length (adjusted for sex, maternal parity, gestational age at delivery, pre-pregnant weight) by the months of delivery or seasons. The effect of exposure to various seasons on birth size was assessed using multiple linear regression analysis (MLRA), wherein birth weight was considered as dependent variable (continuous). Among the confounding variables, parity was a discrete variable whereas gestation was used as a continuous variable. Maternal activity and intake were used as categorical variables, which were grouped into three using their tertile values for respective visits. We have reported earlier[14] that maternal activity at 28th week was significantly inversely associated with birth size whereas maternal intake at 18th week was associated positively; hence these were considered as independent variables in regression models. Exposure (in weeks) to a season during the entire gestation was also considered as an independent variable (continuous) and regressions were carried out separately for each season. Model 1 initially considered maternal confounding variables (sex, parity, gestation and pre-pregnancy weight); Model 2 additionally considered explanatory variables such as maternal activity and intake; whereas Models 3–5 additionally considered exposure to summer or rainy or winter, respectively, during the whole gestation, as independent variables. Findings at $P < 0.05$ were considered significant. Analysis was carried out using SPSS/PC+, version 11.0. Values unless otherwise stated are mean $\pm$ standard deviation (SD).

Results

Mothers and infants

The mean age of the mothers was 21.4 years, and 31.6% were primiparous. They were short, light and thin (Table 1). Twenty-three per cent of the women had a pre-pregnant body weight <38 kg and 9% were shorter than 145 cm, considered high risk for LBW.[16] About 31.3% of women had a BMI <17 kg/m^2, indicating severe chronic energy deficiency.[17]

The mean birth weight was 2665 g (Table 1), and 28% of babies were LBW (<2500 g). Even among full-term babies, mean birth weight and length increased with gestational age ($r = 0.363$, $P < 0.001$ and $r = 0.377$, $P < 0.001$, respectively). Birth weight and length were higher ($P < 0.01$) in boys (2717 ± 362 g, 48.1 ± 2.0 cm, respectively) than girls (2604 ± 345 g, 47.3 ± 1.9 cm, respectively). Birth weight was lower in babies born to primiparous (2579 ± 331 g) than multiparous (2703 ± 364 g) mothers ($P < 0.01$). Therefore, birth weight and length were adjusted for confounding variables such as sex of the newborn, parity and gestation. Birth weight and length were further adjusted for pre-pregnant weight in view of their significant relationship with pre-pregnant weight ($r = 0.225$, $P < 0.001$ and $r = 0.193$, $P < 0.001$, respectively).

Seasonality in maternal intakes

Seasonality in maternal intakes was examined by month of visit at 18th week (Figure 1) as well as 28th week of gestation. Median energy (1863; range 617–3762 kcal/day) and protein intakes (47.5; range 14.8–93.4 g/day) in winter were higher ($P = 0.001$) than in the summer season (1665; range 444–3755 kcal/day and 43.1; range 10.6–96.5 g/day, respectively) or rainy season (1660; range 627–2979 kcal/day; 42.2; range 17.9–82.8 g/day, respectively). Average intake was highest during January (1920 kcal/day, 50.4 g/day) and lowest during June (1609 kcal/day, 39.0 g/day). Seasonal variability in energy and protein intakes were also observed at 28 weeks of gestation, but was less prominent.

Seasonality in maternal activity

Seasonality in maternal activity scores was also examined by month of visit at 18th week (Figure 1) and 28th week of gestation. Median total activity scores in early gestation were higher ($P < 0.001$) in winter (86.1; range 23.5–156.5) compared with summer (77.60; range 24.8–141.1) or rainy season (57.1; range 16.5–128.3). The total activity score was highest in October (88.3) and lowest in June (44.6). Similar seasonal variation was also evident in scores for farming activity when considered separately, perhaps owing to the fact that majority of women belonged to farming families. Prominent seasonal variability in total activity and farming activity were also observed at late gestation.

Table1 Characteristics (mean ± SD) of rural women

Parameter	Maternal anthropometry			**Neonatal Anthropometry ($n = 633$)**
	Pre-pregnant ($n = 633$)	18 weeks ($n = 633$)	28 weeks ($n = 594$)	
Anthropometric measurements				
Weight (kg)	41.7 ± 5.1	43.8 ± 5.0	47.3 ± 5.2	2664.8 ± 358.4[a]
Height (cm)	151.9 ± 5.1	–	–	47.8 ± 2.0
BMI (kg/m^2)	18.1 ± 1.9	18.9 ± 1.8	20.5 ± 1.7	2.5 ± 0.5[b]
Nutrient intake[c]				
Energy (kcal/day)	–	1752	1644	–
		(1405–2100)	(1337–1978)	
Protein (g/day)	–	45.17	42.24	–
		(35.5–55.1)	(34.1–51.4)	
Daily activity scores[c]				
Farming women	–	38.5	38.5	–
		(23.0–41.0)	(11.7–38.5)	
Non-farming women	–	39.7	40.3	–
		(32.6–52.5)	(33.7–52.67)	
All women	–	80.0	63.16	–
		(50.6–92.6)	(42.1–86.3)	

[a]Weight (in g).
[b]Ponderal Index (kg/m^3).
[c]Median and Inter Quartile Range is given.

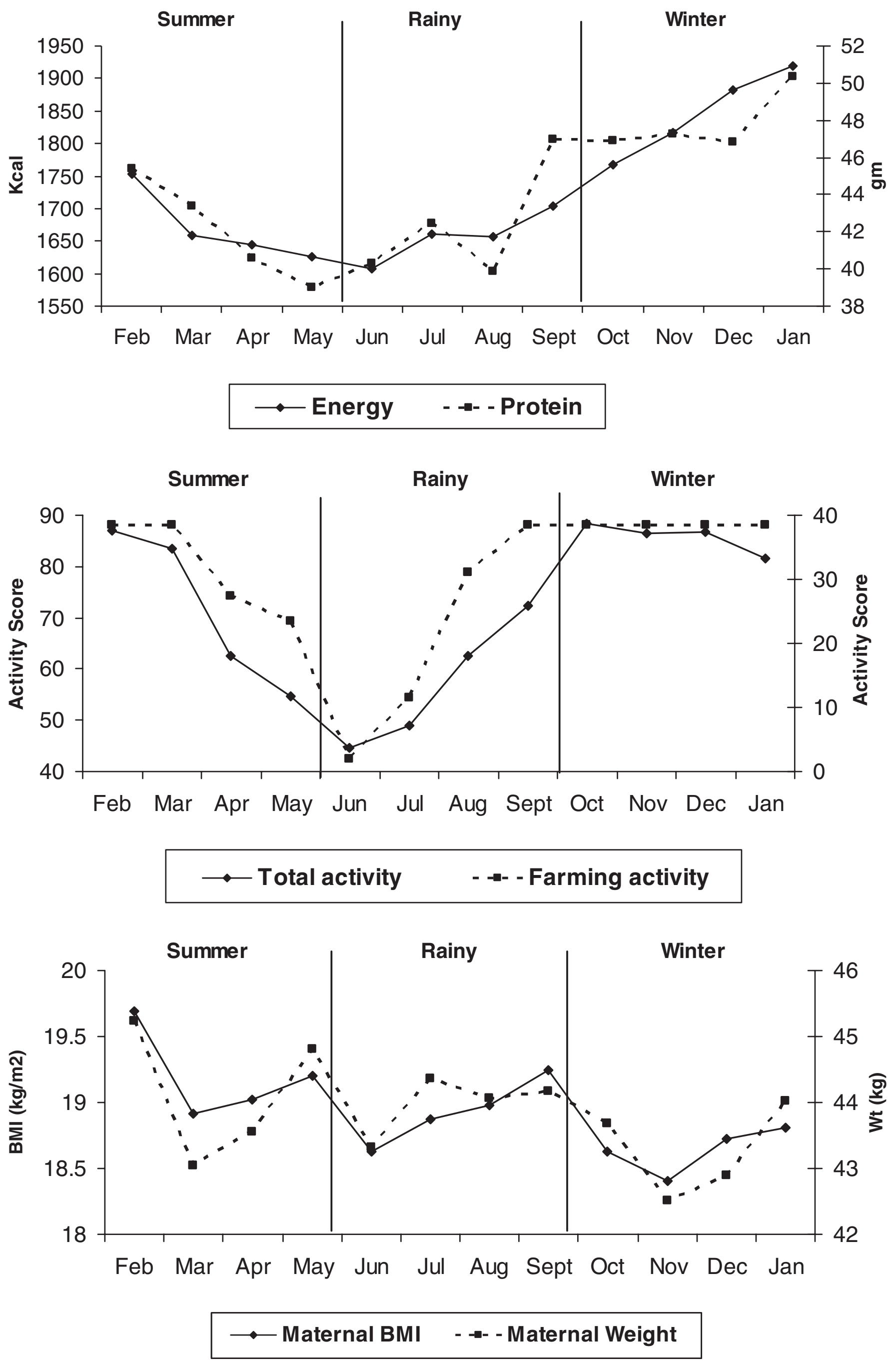

Figure 1 Median maternal intakes, activity and mean maternal weight and BMI by month of visit at 18th week

Seasonality in maternal weight and BMI

Seasonality in maternal weight and BMI was also examined by months of visit at 18th week (Figure 1) as well as 28th week of gestation. Mean weight at 18 and 28 weeks of gestation did not vary by season. However, variations in maternal BMI were prominent: at both time points, it was highest in February ($19.7 \pm 1.9\,kg/m^2$, $21.0 \pm 2.4\,kg/m^2$, respectively), i.e. end of the harvest period, and lowest in November ($18.4 \pm 1.6\,kg/m^2$, $19.6 \pm 1.3\,kg/m^2$, respectively), i.e. during the period of higher activity.

Seasonality in birth weight and length

Seasonal variability was seen (Figure 2), both in mean adjusted birth weight ($P = 0.02$) and length ($P = 0.07$). Birth size was highest in summer, especially for babies born in February ($2733 \pm 236\,g$ and

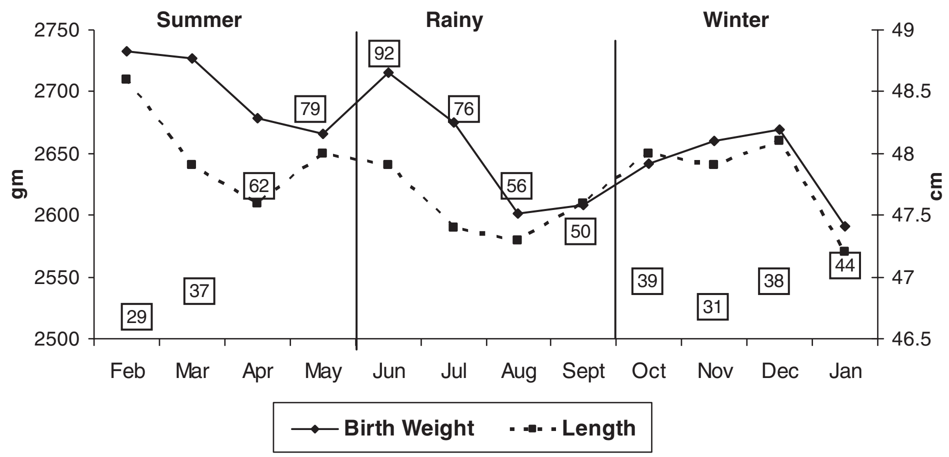

Figure 2 Mean birth weight and length by months of delivery. Weight and length adjusted for gestation at delivery, sex (of the baby), parity, maternal pre-pregnant weight. Figures in boxes represent birth frequency in the respective months of delivery

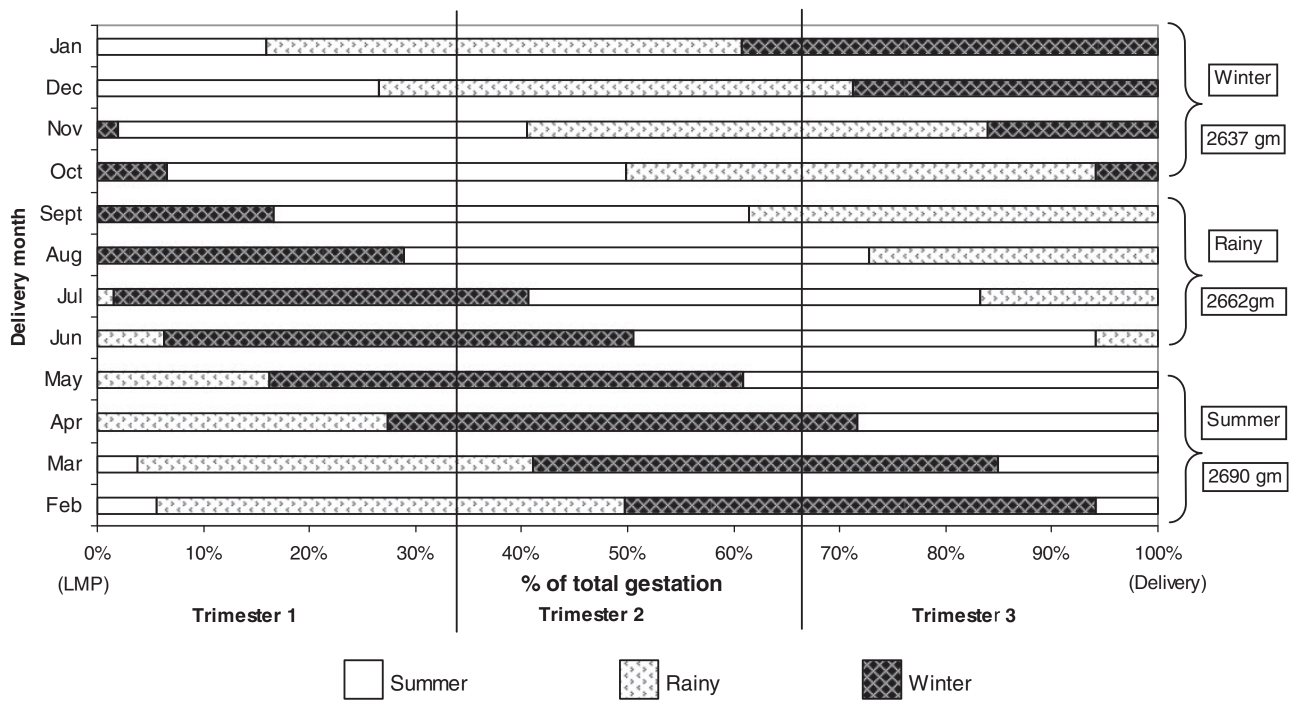

Figure 3 Exposure (%) to various seasons during gestation according to month of delivery

48.6 ± 1.0 cm, respectively) and lowest in winter particularly, in January (2590 ± 311 g and 47.1 ± 1.4 cm, respectively).

Seasonality in birth size in relation to maternal intake and activity

Since mothers will have had varying exposure to different seasons, exposure (% duration) to the three seasons across gestation (trimesters) was plotted by month of delivery (Figure 3). For example, women who delivered in January had the initial 6.5 weeks (15.9% of total gestation) exposure to summer, the next 18.3 weeks (44.9%) to the rainy season, and the last 16 weeks (39.2%) to winter. Effect of exposure to each season on birth weight was therefore examined using MLRA (Table 2). It can be observed that, apart from major maternal covariates, maternal intake at 18th week had a positive association ($P = 0.05$), whereas activity at 28th week had a negative association ($P = 0.002$) with birth size in all the seasons. Finally, among the three seasons, exposure to the winter season had an independent positive effect ($P = 0.04$) of 5.6 g of increase in birth weight

Table 2 Results of MLRA for birth weight (g) as a dependent variable and maternal factors (pre-pregnant weight, parity and gestation), sex of the child and exposure (weeks) to seasons during gestation as independent variables

Independent variables	Model 1 ($n = 633$)		Model 2 ($n = 604$)		Model 3 ($n = 604$)		Model 4 ($n = 604$)		Model 5 ($n = 604$)	
R^2 (%)	22.8		23.9		24.1		24.0		24.5	
	β ± SE	*P*	β ± SE	*P*	β ± SE	*P*	β ± SE	*P*	β ± SE	*P*
Sex	−114.1 ± 25.2	0.00	−110.7 ± 25.7	0.00	−112.2 ± 25.7	0.00	−110.6 ± 25.7	0.00	−112.9 ± 25.7	0.00
Parity	62.1 ± 10.7	0.00	68.7 ± 10.9	0.00	68.7 ± 11.0	0.00	68.9 ± 11.0	0.00	69.6 ± 11.0	0.00
Gestation (weeks)	109.1 ± 10.9	0.00	105.9 ± 11.0	0.00	106.4 ± 11.0	0.00	106.0 ± 11.0	0.00	102.5 ± 11.1	0.00
Pre-pregnant weight (kg)	13.1 ± 2.5	0.00	12.9 ± 2.5	0.00	12.7 ± 2.5	0.00	12.9 ± 2.5	0.00	12.6 ± 2.5	0.00
Calorie intake (kcal) (18th week)	–		34.4 ± 16.0	0.03	35.0 ± 16.0	0.03	33.8 ± 16.1	0.04	31.2 ± 16.0	0.05
Activity score (28th week)			−45.5 ± 16.3	0.00	−49.5 ± 16.7	0.00	−45.1 ± 16.3	0.00	−50.4 ± 16.4	0.00
Exposure to summer (weeks)	–		–		−3.3 ± 3.0	ns	–		–	
Exposure to monsoon (weeks)	–		–		–		−0.83 ± 2.6	ns	–	
Exposure to winter (weeks)	–		–		–		–		5.6 ± 2.7	0.04

ns = not significant.
SE = standard error.

per week. In other words, babies born to women who are exposed to the entire winter season (16 weeks) during gestation were likely to have birth weights higher by 90 g. In the case of birth length, significance was observed for maternal covariates, maternal intake and activity but not for exposure to season.

Mean birth weights did not differ for mothers with high or low (above or below median) intakes, or high or low activity (above or below median activity score) in any season. Therefore, interactive effects of maternal intake and activity on birth weight were examined. In winter, mean adjusted birth weight for women engaged in low activity was higher compared with those engaged in high activity only when maternal intake was high at 18 weeks (2799 ± 345 g vs 2654 ± 280 g, respectively, the difference of 145 g; $P = 0.01$). This was also true for late gestation, but the difference was not significant. In summer, a similar comparison showed a difference in mean birth weight of 99 g ($P = 0.09$) at higher maternal intakes but it was negligible at low levels of maternal intake.

Discussion

The differences in the prevalence of fetal growth retardation among developed and developing countries relate not only to the differences in quantity or quality of maternal diets but also to differences in timing and duration of nutritional insults. Agricultural communities, especially in the Third World, are exposed to seasonal energy inadequacy, either due to shortage of food in the dry seasons or due to increased energy expenditure during the harvest period. This may impact adversely on birth size in countries like India, where large rural populations are subsistence farmers. In addition to the immediate perinatal effects, this may have long-term implications for health of the populations.[18] In a prospective study of rural Indian mothers, we observed that there were prominent seasonal variations in maternal intake and activity, with prominent interactive effects on newborn size. Maternal intake in early gestation were positively associated whereas activity in late gestation was negatively associated with birth weight with prominent interactive effect seen in the winter season.

Habitual dietary intakes of rural women were inadequate in energy and protein (~70%) as compared with the recommended daily amount (RDA) for Indian pregnant women[19] and were comparable with another reported study from rural India.[20] The adequacy of maternal intakes varied considerably (from 50 to 120% of the RDA) in different seasons. The proportion of women with intakes >75% of the RDA was considerably higher in winter (46%) than in summer or rainy season (32%), indicating higher food availability in winter. Studies from Africa[21] have also shown seasonality in maternal intakes, with energy adequacy varying from 55% of the RDA in the hungry season to 100% in the harvest season, but its effect on birth size was not examined.

Seasonal fluctuations in energy expenditure assessed using activity diaries have been reported among rural women in Tanzania.[4,22] Although we did not attempt to estimate energy expenditure in these rural mothers, their scores based on an activity questionnaire showed significant seasonal variation. They were higher during harvest particularly in October, reduced only marginally during post-harvest months (February to April) and were minimum in June when the rains begin. Thus, during the post-harvest period, with considerable reduction in maternal intakes, these rural women were exposed to energy stress. Studies using either observer-maintained diaries[12] or the doubly-labelled water technique[11] have also confirmed seasonal energy stress in farming women from the Gambia.

A seasonal pattern was not seen prominently in maternal weights at 18th week of gestation. However, at 28th week of gestation they were highest in August and lowest in June showing a difference of 4 kg in mean maternal weights. Similar differences in mean maternal weight have been reported among rural Gambian women.[15] Variations in maternal BMI were more reflective of seasonal effects than maternal weight at both time points. It was highest at the end of the harvest period (peaking in February), reflecting greater food availability, and lowest in November, a period of greater maternal activity without substantial increase in food availability. This is in confirmation with the observation made by Ferro-Luzzi *et al.*,[2] that for estimating seasonality risk for the Third World, on the basis of agro-climatic seasonality index, maternal BMI should be considered along with absolute weight loss.

Mean birth weight and length (after controlling for confounding variables) were lowest for those born in the late rainy or winter season. Consequently, the prevalence of LBW was observed to be highest (41.1%) in the rainy season and lowest in summer (13.8%). Among rural Gambian women, mean birth weight was low for those born in the wet season compared with those born in the dry season.[11,12] Most studies examining this phenomenon[6,23,24] have shown that seasonality in intake and activity are associated with variations in birth size. Some researchers have examined seasonal effects of non-nutritional factors like temperature[25,26] or sunlight[27,28] but without taking maternal intake or activity into consideration. The observation reported by Rayco-Solon *et al.*,[29] that the lowest birth frequency occurs 9 months after the annual hungry season, highlights the importance of maternal nutrition in early gestation. Our data too shows similar seasonality in birth frequency, which was lowest from November to February, 9 months after the post-harvest period of maximal energy stress.

Regression analysis showed that among the maternal confounders, gestation explained the largest portion of variability in birth weight (12.7%), whereas pre-pregnant weight contributed only 3.5%. Using pre-pregnant BMI in place of pre-pregnant weight did not improve much its contribution. Among the explanatory variables, maternal intake at 18th week had a positive impact, maternal activity at 28th week a negative impact, and exposure to winter a positive impact on birth size. Exposure to the entire winter season during gestation showed an estimated increase of ~90 g in birth weight. The observation that birth weights of babies born in summer were highest further signifies the importance of exposure to winter in late gestation. Moreover, higher maternal intakes combined with low activity showed beneficial effects on birth weight, which was prominent in winter and moderate in summer. The findings suggest that the benefits of higher intake in the winter season could be maximized by a reduction in maternal activity. Alternatively, in summer when agricultural activity is at its lowest level, supplementing maternal intakes could be beneficial. However, in view of the fact that the majority of the rural Indian population is economically poor, reducing maternal activity, especially during harvest, would be a more feasible approach compared with increasing maternal intakes.

Agarwal *et al.*[30] have shown that hard physical activity combined with low maternal intakes among rural undernourished women from Uttar Pradesh, India, was associated with LBW. Although the importance of maternal supplementation has been well recognized[31,32] and its effectiveness has been proved[33] among women from Gambia, our observations suggest that simultaneous reduction in activity levels is essential. This may partly explain the fact that, in the Gambian trial, seasonal variation in birth size was not eradicated by maternal supplementation i.e. intake alone.[31] It is reported that maternal supplementation among different population results in varying effect on birth size,[34] which could be due to the fact that activity patterns differ (either in type or in intensity) in different populations.

In conclusion, our observations show that seasonal energy inadequacy in farming communities influences birth size. There are several implications of our findings. First, among poor farming communities of rural India, reduction in maternal activity especially during the harvest period, when maternal intakes are at a higher level, could be beneficial, for improving birth size. This can be achieved by avoiding maternal activities in squatting and bending positions, male family members or male labourers taking over maternal activity, or using appropriate agricultural machinery. Secondly, benefits of maternal interventions could be maximized by giving maternal supplementation during slack or dry periods, when farming activity is naturally at its lowest level but intakes are inadequate. Thirdly, it may be worthwhile to offer counselling to rural women for planning their pregnancy in such a way that they will have a higher exposure to the winter season especially in the last trimester, for better birth size. Our findings thus underscore the fact that it is important to consider seasonality in planning targeted strategies for implementing maternal interventions in such settings.

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Conflict of interest: None declared.

KEY MESSAGES

- Prominent seasonality in maternal intakes, activity and birth size were observed in rural Indian mothers. Higher maternal intakes, reduced activity and exposure to winter season predicted larger birth size.
- Reduction in maternal activity especially in the harvest season could be a potential intervention for improving birth size in poor farming communities of rural India.
- It is important to consider seasonality in planning targeted strategies for implementing maternal interventions in such settings.

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