Original Article

The relationship of neonatal serum vitamin B\textsubscript{12} status with birth weight

S Muthayya PhD\textsuperscript{1}, P Dwarkanath MSc\textsuperscript{1}, M Mhaskar MD\textsuperscript{2}, R Mhaskar MD\textsuperscript{3},
A Thomas MD\textsuperscript{2}, CP Duggan MD MPH\textsuperscript{3}, WW Fawzi MPH MS Dr PH\textsuperscript{3}, S Bhat MD\textsuperscript{4},
M Vaz MD\textsuperscript{1} and AV Kurpad MD PhD\textsuperscript{1}

\textsuperscript{1} Division of Nutrition, Institute of Population Health and Clinical Research, St. John’s National Academy of Health Sciences, Bangalore, India
\textsuperscript{2} Department of Obstetrics & Gynecology, St. John’s Medical College Hospital, Bangalore, India
\textsuperscript{3} Department of Nutrition, Harvard School of Public Health, Huntington Avenue, Boston, USA
\textsuperscript{4} Department of Pediatrics, St. John’s Medical College Hospital, Bangalore, India

Earlier studies have shown a relationship between maternal vitamin B\textsubscript{12} status and birth weight. This study extends those findings directly in terms of neonatal vitamin B\textsubscript{12} status and birth weight. One hundred and twelve women were followed from the first trimester of pregnancy and maternal blood was obtained in all three trimesters along with cord blood at birth of their neonates. The maternal and cord serum vitamin B\textsubscript{12} concentrations were examined in relation to birth weight. There was a significant correlation between vitamin B\textsubscript{12} concentration in maternal antenatal serum during each of the trimesters of pregnancy and cord serum (all \(P<0.01\)). Neonates that were born with lower birth weights (categories of \(< 2500 \text{ g} \) and \(2500-2999 \text{ g} \)) had significantly lower mean cord serum vitamin B\textsubscript{12} concentrations when compared to those who were \(\geq 3000 \text{ g} \) (\(P = 0.02\) and \(P = 0.05\) respectively). A similar, however, non significant trend was observed for antenatal vitamin B\textsubscript{12} concentrations at first and third trimesters. Cord serum vitamin B\textsubscript{12} concentrations were significantly correlated with birth weight, up to 40 weeks of pregnancy (\(r=0.28, P=0.01\)) but not beyond that (\(\geq 40 \text{ weeks gestation}\)). Vitamin B\textsubscript{12} status in the mother was related to neonatal vitamin B\textsubscript{12} status as measured by cord serum vitamin B\textsubscript{12} concentration. In addition, low neonatal vitamin B\textsubscript{12} concentrations were adversely associated with low birth weights.

Key Words: neonatal vitamin B\textsubscript{12}, birth weight, India

Introduction

The prevention of low birth weight (LBW; <2500g), which affects nearly 30\% of infants born in India, is a public health priority. Adverse outcomes for mothers and infants during pregnancy have been largely attributed to widespread maternal malnutrition. Previous studies have suggested that maternal status of micronutrients may influence the risk of LBW\textsuperscript{1}, and multiple micronutrient supplementation to antenatal women, at the level of once or twice the recommended daily allowance, has been shown to increase birth weight by approximately 100g.\textsuperscript{2-4} In a prospective observational study, recently carried out in Bangalore, India, we demonstrated a significant relationship between low maternal vitamin B\textsubscript{12} status and an increased risk of intra-uterine growth retardation (IUGR) after adjusting for potential confounding factors such as maternal weight, weight gain, age, education and parity.\textsuperscript{5} In that study, we also demonstrated that vitamin B\textsubscript{12} intake was significantly correlated to the antenatal serum vitamin B\textsubscript{12} concentrations, implicating poor vitamin B\textsubscript{12} intake as a possible cause of low vitamin B\textsubscript{12} status. Vitamin B\textsubscript{12} intake in this study population was mainly from consumption of fish, egg, milk and minimally from red meat.

Other reports from Brazil\textsuperscript{6} and India\textsuperscript{7} have also demonstrated low maternal vitamin B\textsubscript{12} status in pregnancy. In the general Indian population, low vitamin B\textsubscript{12} intakes have been recorded in men and women living in urban slums\textsuperscript{8} and low vitamin B\textsubscript{12} status has been shown in middle class men and women, some of whom were non-vegetarians reporting intakes of egg, poultry and lamb >2 times a week.\textsuperscript{9} Low cobalamin status has also been demonstrated in Asian Indians living in the USA, due primarily to low dietary intake; interestingly, homocysteine concentration did not always reflect a low cobalamin status.\textsuperscript{10} Given the relationship between maternal vitamin B\textsubscript{12} intake and B\textsubscript{12} status, and between status and birth outcome\textsuperscript{5}, it is of interest to confirm that these relationships also extend to more direct measures of vitamin B\textsubscript{12} status in the neonate.

Correspondence address: Dr S Muthayya, Division of Nutrition, Institute of Population Health and Clinical Research, St. John’s National Academy of Health Sciences, Bangalore 560 034, India
Tel: (91 80) 2205 5059, Ext 134; Fax: (91 80) 2553 2037
E-mail: sumithra@iphcr.res.in
Accepted: 30th April, 2006
such as in the cord serum at birth, in addition to documenting the relationship and magnitude of difference between the maternal and cord serum concentrations of vitamin B$_{12}$. In particular, the relationship between neonatal serum vitamin B$_{12}$ status at birth and birth weight has not been documented. Therefore, we investigated neonatal vitamin B$_{12}$ status at birth using measures of cord serum, its association with maternal status and its direct effect on birth size in an urban hospital-based study, where the mothers came from differing socioeconomic strata and had heterogeneous dietary intakes.

**Subjects and Methods**

**Study design**

The study was a prospective cohort study conducted at St. John’s Medical College Hospital, Bangalore, India, from November 2001 to August 2003. This 1200 bed tertiary hospital draws patients of diverse socioeconomic status, from urban slums to high income residential areas. Pregnant volunteers were enrolled in early pregnancy (baseline) and followed up until delivery. Information on socio-demographic factors at baseline (approximately 12 weeks of gestation, 12.9 ± 3.3 weeks) and on maternal anthropometry, dietary intake, and blood at baseline, 2nd trimester of pregnancy (approximately 24 weeks of gestation, 24.1 ± 2.0 weeks) and 3rd trimester of pregnancy (approximately 34 weeks of gestation, 33.9 ± 1.2 weeks) and cord blood collected from the placental side of the cut umbilical cord, at delivery, were collected. The Institutional Ethical Review Board at St. John’s Medical College approved all study procedures, and written informed consent was obtained from each study subject at enrolment.

**Study population**

All pregnant women aged 17-40 years who were below 20 weeks of gestation, and registered for antenatal screening at the Department of Obstetrics and Gynecology at St. John’s Medical College Hospital were invited to participate in the study. Every effort was made to recruit women as early in their pregnancy to carry out baseline measurements at 12 weeks of gestation. Women with multiple pregnancies, those with a clinical diagnosis of chronic illness such as diabetes mellitus, hypertension, heart disease and thyroid disease, those who tested positive for hepatitis B (HbSAg), HIV or syphilis (VDRL) infections or who anticipated moving out of the city before delivery were excluded. Four hundred and seventy eight women consented to be part of the study and were recruited. Of them, 410 (85.8%) completed the study with a known pregnancy outcome. In a sub-sample of 185 women, in whom blood collections were available for at least two trimesters of pregnancy, micronutrient concentrations of vitamin B$_{12}$ were measured from serum samples obtained at all three trimesters of pregnancy and from cord serum at delivery. Cord blood was obtained in 112 cases.

**Sociodemographic and anthropometric information**

At the baseline visit, trained research assistants interviewed the study subjects to obtain information on age, obstetric history, family composition and socioeconomic status. Gestational age (in weeks) was calculated from the reported first day of the last menstrual period (LMP). Subsequent ultrasonographic measurements done within 2 weeks of the initial visit and again closer to the time of delivery were used to confirm gestational age calculated by LMP. A digital balance (Soehnle, Germany) was used to record the weights of all mothers to the nearest 100 g. Measurements of height were made using a stadiometer to the nearest 1 cm. Maternal body mass index (BMI) was calculated using weight and height at baseline (kg/m$^2$). None of the women were smokers.

**Serum vitamin measurement**

Blood samples drawn from all subjects after an overnight fast by venipuncture using trained personnel or collected at birth from the placental side of the cord, were collected in plain vacutainers (Beckton Dickinson, New Jersey, USA). Serum vitamin B$_{12}$ was determined using a kit employed on an Automated Chemiluminescence System ACS:180 (Bayer Diagnostics, Tarrytown, USA). The intra batch CV assessed by using multiple determinations of pooled human serum with a vitamin B$_{12}$ concentration of 348 pmol/L (n = 20) was 2.6% and inter batch CV (n=20) done over a period of 3 weeks (n=15) was 3.4%.

**Birth data**

Infants were weighed to the nearest 10 g on a standard beam scale balance immediately after birth. LBW was defined as birth weight <2500g (WHO, 1995). Preterm delivery was defined as delivery before 37 weeks of gestation. Of the 410 women who had a known pregnancy outcome, there were 26 spontaneous abortions, 7 still births, 30 premature deliveries and 347 births at full term.

**Statistical analysis**

All analyses were done with the SPSS program (version 11.5, SPSS, Chicago, IL). Only cases who delivered a full-term infant and in whom cord vitamin B$_{12}$ concentration was also available (n=112) are included in this analysis. Results are presented as mean ± SD. Mean values were compared by the one way analysis of variance with post-hoc tests (LSD). Correlations between cord serum vitamin B$_{12}$ and birth weight was assessed using Pearson’s correlation coefficient. Two sided P values <0.05 were considered statistically significant. Women who delivered full term live babies and in whom cord blood was not collected had similar serum vitamin B$_{12}$ concentrations (pg/ml) when compared with those used in this analysis at the 1st, 2nd and 3rd trimesters of pregnancy; 255 ± 125 (n=22), 202 ± 55 (n=27) and 206 ± 74 (n=28) vs 229 ± 81 (n=89), 208 ± 57 (n=100) and 197 ± 54 (n=106) respectively. Mean serum vitamin B$_{12}$ concentrations in mothers who had fetal losses and pre-term babies were not significantly different from the group of mothers used in the main analysis of this report.

**Results**

Demographic characteristics of the study population are listed in Table 1. Approximately 40% of the mothers were educated up to high school and the remaining 60% had either a post-high school diploma or at least a university degree. Primiparous women made up 64% of the study cohort. Approximately 20% of the women had a
Neonatal serum vitamin B12 and birth weight

Mean birth weight was 2.90 ± 0.39 kg; 18% of the newborns had low birth weights (<2.5 kg). Concentrations of vitamin B12 in the newborns and their mothers during the 3 trimesters of pregnancy are presented in Figure 1. Neonatal concentrations were about 27% higher than in maternal samples measured at all times during pregnancy. There was a significant correlation between vitamin B12 concentration in maternal antenatal serum during each of the trimesters of pregnancy and cord serum (Fig. 1); a strong relationship was observed for the 2nd and 3rd trimesters \( [r=0.54 (P=0.000) \text{ and } r=0.56 (P=0.000)] \).

The relationship between neonatal serum B12 levels and birth weight was assessed initially by a group-wise analysis which showed that significant differences existed in cord serum vitamin B12 concentrations between groups of infants, based on birth weight (Table 2).

Maternal serum vitamin B12 concentrations at each trimester increased with increasing birth weight. However, these increases in maternal serum B12 were significant only during the 2nd trimester; here maternal serum vitamin B12 values were significantly higher in the ≥3000 g birth weight group as compared to the LBW (<2500g) group (Table 2). We extended the analysis of the

Table 1. Maternal baseline characteristics (n=112)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>24.2 ± 4.0</td>
</tr>
<tr>
<td>Parity</td>
<td>0: 72 (64.3); 1-2: 38 (33.9); &gt;3: 2 (1.8)</td>
</tr>
<tr>
<td>Educational level</td>
<td>Up to high school: 44 (39.3); Diploma: 33 (29.5); University degree &amp; above: 35 (31.3)</td>
</tr>
<tr>
<td>Anthropometry</td>
<td>Weight (kg): 53.1 ± 11.0; Height (m): 1.54 ± 0.06; BMI (kg/m^2): 22.2 ± 4.13</td>
</tr>
</tbody>
</table>

Mean ± SD; N (%).

Table 2. Neonatal (cord) and maternal (first, second and trimester) serum vitamin B12 status (pg/ml) in relation to birth size

<table>
<thead>
<tr>
<th>Period</th>
<th>Birth weight</th>
<th>ANOVA (P value)</th>
<th>Post –hoc group comparisons (P value)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group 1 &lt;2500 g</td>
<td>Group 2 2500-2999 g</td>
<td>Group 3 &gt;3000 g</td>
</tr>
<tr>
<td>Neonate</td>
<td>264 ± 85† (n=20)</td>
<td>268 ± 93† (n=45)</td>
<td>320 ± 127 (n=47)</td>
</tr>
<tr>
<td>Mother 1st trimester</td>
<td>211 ± 88 (n=16)</td>
<td>231 ± 78 (n=39)</td>
<td>234 ± 78 (n=39)</td>
</tr>
<tr>
<td>Mother 2nd trimester</td>
<td>188 ± 45† (n=19)</td>
<td>208 ± 56 (n=43)</td>
<td>221 ± 62 (n=44)</td>
</tr>
<tr>
<td>Mother 3rd trimester</td>
<td>186 ± 52 (n=19)</td>
<td>191 ± 45 (n=44)</td>
<td>211 ± 61 (n=42)</td>
</tr>
</tbody>
</table>

Group 1: < 2500 g; Group 2: 2500-2999 g; Group 3: > 3000 g; †Significant difference by one-way ANOVA between birth weight category <2500 g vs >3000 g. Significant difference by one-way ANOVA between birth weight category 2500-2999 g vs > 3000 g.

Figure 1. X-axis in the different panels represents maternal serum vitamin B12 status. Upper Left Panel : First trimester, Lower Left Panel: Second trimester, Upper Right Panel: Third trimester. Correlation values (r and P value) given in each panel for respective trimester.

BMI less than 18.5 kg/m^2 at enrolment. Mean birth weight was 2.90 ± 0.39 kg; 18% of the newborns had low birth weights (<2.5 kg). Concentrations of vitamin B12 in the newborns and their mothers during the 3 trimesters of pregnancy are presented in Figure 1. Neonatal concentrations were about 27% higher than in maternal samples measured at all times during pregnancy. There was a significant correlation between vitamin B12 concentration in maternal antenatal serum during each of the trimesters of pregnancy and cord serum (Fig. 1); a strong relationship was observed for the 2nd and 3rd trimesters \( [r=0.54 (P=0.000) \text{ and } r=0.56 (P=0.000)] \).

The relationship between neonatal serum B12 levels and birth weight was assessed initially by a group-wise analysis which showed that significant differences existed in cord serum vitamin B12 concentrations between groups of infants, based on birth weight (Table 2).

Maternal serum vitamin B12 concentrations at each trimester increased with increasing birth weight. However, these increases in maternal serum B12 were significant only during the 2nd trimester; here maternal serum vitamin B12 values were significantly higher in the ≥3000 g birth weight group as compared to the LBW (<2500g) group (Table 2). We extended the analysis of the

Table 1. Maternal baseline characteristics (n=112)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>24.2 ± 4.0</td>
</tr>
<tr>
<td>Parity</td>
<td>0: 72 (64.3); 1-2: 38 (33.9); &gt;3: 2 (1.8)</td>
</tr>
<tr>
<td>Educational level</td>
<td>Up to high school: 44 (39.3); Diploma: 33 (29.5); University degree &amp; above: 35 (31.3)</td>
</tr>
<tr>
<td>Anthropometry</td>
<td>Weight (kg): 53.1 ± 11.0; Height (m): 1.54 ± 0.06; BMI (kg/m^2): 22.2 ± 4.13</td>
</tr>
</tbody>
</table>

Mean ± SD; N (%).

Table 2. Neonatal (cord) and maternal (first, second and trimester) serum vitamin B12 status (pg/ml) in relation to birth size

<table>
<thead>
<tr>
<th>Period</th>
<th>Birth weight</th>
<th>ANOVA (P value)</th>
<th>Post –hoc group comparisons (P value)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group 1 &lt;2500 g</td>
<td>Group 2 2500-2999 g</td>
<td>Group 3 &gt;3000 g</td>
</tr>
<tr>
<td>Neonate</td>
<td>264 ± 85† (n=20)</td>
<td>268 ± 93† (n=45)</td>
<td>320 ± 127 (n=47)</td>
</tr>
<tr>
<td>Mother 1st trimester</td>
<td>211 ± 88 (n=16)</td>
<td>231 ± 78 (n=39)</td>
<td>234 ± 78 (n=39)</td>
</tr>
<tr>
<td>Mother 2nd trimester</td>
<td>188 ± 45† (n=19)</td>
<td>208 ± 56 (n=43)</td>
<td>221 ± 62 (n=44)</td>
</tr>
<tr>
<td>Mother 3rd trimester</td>
<td>186 ± 52 (n=19)</td>
<td>191 ± 45 (n=44)</td>
<td>211 ± 61 (n=42)</td>
</tr>
</tbody>
</table>

Group 1: < 2500 g; Group 2: 2500-2999 g; Group 3: > 3000 g; †Significant difference by one-way ANOVA between birth weight category <2500 g vs >3000 g. Significant difference by one-way ANOVA between birth weight category 2500-2999 g vs > 3000 g.

Figure 1. X-axis in the different panels represents maternal serum vitamin B12 status. Upper Left Panel : First trimester, Lower Left Panel: Second trimester, Upper Right Panel: Third trimester. Correlation values (r and P value) given in each panel for respective trimester.

BMI less than 18.5 kg/m^2 at enrolment. Mean birth weight was 2.90 ± 0.39 kg; 18% of the newborns had low birth weights (<2.5 kg). Concentrations of vitamin B12 in the newborns and their mothers during the 3 trimesters of pregnancy are presented in Figure 1. Neonatal concentrations were about 27% higher than in maternal samples measured at all times during pregnancy. There was a significant correlation between vitamin B12 concentration in maternal antenatal serum during each of the trimesters of pregnancy and cord serum (Fig. 1); a strong relationship was observed for the 2nd and 3rd trimesters \( [r=0.54 (P=0.000) \text{ and } r=0.56 (P=0.000)] \).

The relationship between neonatal serum B12 levels and birth weight was assessed initially by a group-wise analysis which showed that significant differences existed in cord serum vitamin B12 concentrations between groups of infants, based on birth weight (Table 2).

Maternal serum vitamin B12 concentrations at each trimester increased with increasing birth weight. However, these increases in maternal serum B12 were significant only during the 2nd trimester; here maternal serum vitamin B12 values were significantly higher in the ≥3000 g birth weight group as compared to the LBW (<2500g) group (Table 2). We extended the analysis of the
relationship between neonatal serum B$_{12}$ concentration and birth weight by evaluating whether there was a linear association between these variables (Fig. 2). When cord serum B$_{12}$ concentrations were plotted against birth weight for all infants, there was no significant relationship. However, when cord serum B$_{12}$ values were correlated with birth weights of infants born between 37-39 weeks of gestation, there was a significant correlation ($r=0.28, P=0.01, n=76$). In contrast, there was no relationship ($r=-0.13, P=0.45, n=36$) between cord serum B$_{12}$ concentrations and birth weight when this was assessed in infants who were born at or after 40 weeks of gestation.

**Discussion**

The present study showed that vitamin B$_{12}$ status in the mothers was correlated to neonatal vitamin B$_{12}$ status, as measured by cord serum vitamin B$_{12}$, at all trimesters of pregnancy, similar to what has been shown before.$^{11,12}$ In general, both maternal and fetal vitamin B$_{12}$ concentrations were lower than reported in western subjects$^{11}$; this may be linked to their lower dietary vitamin B$_{12}$ intake as has been suggested in ovo-lacto vegetarians and low-meat eaters$^{13}$ and our earlier report in vegetarian and non-vegetarian Indian pregnant women.$^5$ Cord serum vitamin B$_{12}$ concentrations were linearly associated with birth weight, such that increasing concentrations were associated with increasing birth weight. In an earlier analysis using the same, but extended, dataset$^5$, we had demonstrated that a low maternal vitamin B$_{12}$ concentration throughout pregnancy was independently associated with an increased risk of intrauterine growth retardation (IUGR), after controlling for confounding factors, in urban Indian women.

Furthermore, vitamin B$_{12}$ status was significantly related to vitamin B$_{12}$ intake at each of the 3 trimesters in these women. The association between vitamin B$_{12}$ in the mother and neonate as early as in the first trimester suggests that it is important to enhance maternal B$_{12}$ stores. This may need to be considered as early as the peri-conceptual period, although this would need to be tested prospectively. Previous studies on vitamin B$_{12}$ status and its effect on birth weight have produced conflicting results. An earlier study reported negative correlations between birth weight and maternal vitamin B$_{12}$ concentration at delivery in smokers in a group of western women.$^{14}$ More recently, Yajnik et al.,$^7$ reported no relationship between maternal plasma vitamin B$_{12}$ concentration and offspring size in rural Indian women. The authors concluded that the lack of an association might have been due to an overall low vitamin B$_{12}$ status. Another study conducted in the United Kingdom showed no relationship between maternal vitamin B$_{12}$ concentrations in early pregnancy and birth weight$^5$; the mean vitamin B$_{12}$ status in this study was $324 \pm 132$ pg/ml, which was about one and a half times the value observed in the present study, suggesting that it would be difficult to demonstrate a nutrient effect in these women who were vitamin B$_{12}$ replete. The reason the present study may have shown an association between vitamin B$_{12}$ and birth size might be related to the relatively wide inter-quartile ranges of vitamin B$_{12}$ status observed; 132-363 pg/ml across all trimesters of pregnancy compared to 118-203 pg/ml in the rural Indian study.$^7$

Vitamin B$_{12}$ deficiency has a role in elevating plasma homocysteine (Hcy) and lowering methyl donor levels in pregnancy and has been implicated in adverse pregnancy outcomes including low birth weight.$^{16}$ Methionine synthase is an enzyme which catalyzes the methylation of homocysteine to methionine using vitamin B$_{12}$ as a co-factor and methylytetrahydrofolate as a substrate.$^{17}$ The formation of methionine through this pathway represents an important component of the one-carbon metabolism for synthesis of phospholipids, proteins, myelin, catecholamines, DNA and RNA. A deficiency of either vitamin B$_{12}$ and/or folic acid is likely to affect this pathway resulting in an elevation of plasma Hcy with a relatively low methionine level. Low vitamin B$_{12}$ concentrations in pregnant women and their babies are associated with low S-adenosyl methionine to S-adenosyl homocysteine ratios.$^8$ An earlier report on Indian subjects showed an association between higher plasma homocysteine (Hcy) concentrations and low birth weight, but could not demonstrate a relationship between vitamin B$_{12}$ status and birth weight although there was a significant inverse relationship between vitamin B$_{12}$ status and plasma homocysteine (Hcy) status.$^7$ From a speculative viewpoint, it might also be considered that the antenatal supplementation of folate, as is the norm, without vitamin B$_{12}$ could aggravate the methyl folate trap,$^{18}$ and decrease the rate of neural growth and myelination in utero, leading to a diminished trophic effect on muscle growth and baby size. This is not unreasonable, as myelination has been shown to be retarded in a vitamin B$_{12}$ deficient child$^{19}$ and clinical cobalamin deficiency with growth failure has been reported in 2 breast fed children of vegan mothers$^{20}$; after treatment for cobalamin deficiency, both children showed marked improvement in cobalamin status and development. An association between low serum and amniotic fluid concentrations of B$_{12}$ and neural-tube defects has also been reported.$^{21}$

It is not clear why there was a significant association between birth weight and cord serum B$_{12}$ of term infants with a gestational age of 37-39 weeks and not in infants.
who were delivered ≥ 40 weeks gestation in the present study. It is known that as pregnancy extends post term, the incidence of placental insufficiency and fetal post-maturity (dysmaturity) increases rapidly as a consequence of reduced respiratory and nutritive placental function. Postmaturity is correlated with an increased incidence of placental lesions, fetal hypoxia-asphyxia, intrauterine growth retardation, increased perinatal death, and neonatal morbidity. At a biochemical level, placental physiopathology in post term, post mature pregnancies is not well understood. However, it can be speculated that the relationship between blood nutrient concentrations and birth weight might be confounded by poor placental function in late term pregnancies.

In summary, the present study extends and confirms our earlier observations that there is a relationship between increasing antenatal vitamin B₁₂ concentrations and birth weight in Indian babies. The low maternal vitamin B₁₂ status translates into a low neonatal vitamin B₁₂ status as evinced by cord serum vitamin B₁₂ concentrations. The neonatal vitamin B₁₂ status – birth weight relationship seems to operate up to a term gestation of 40 weeks. Beyond this age, there appears to be no relationship between neonatal vitamin B₁₂ status and birth weight.

Acknowledgement

We greatly appreciate the assistance of Nancy Nanditha, V Manjula, MN Selvi and Mercy in the collection and entry of data and of JY Gnanou for sample handling and all laboratory measurements. We thank the women and their infants who participated in this study and the doctors, nurses and laboratory technicians who made this study possible.

References

Original Article

The relationship of neonatal serum vitamin B\textsubscript{12} status with birth weight

S Muthayya PhD\textsuperscript{1}, P Dwarkanath MSc\textsuperscript{1}, M Mhaskar MD\textsuperscript{2}, R Mhaskar MD\textsuperscript{2}, A Thomas MD\textsuperscript{2}, CP Duggan MD MPH\textsuperscript{3}, WW Fawzi MPH MS Dr PH\textsuperscript{3}, S Bhat MD\textsuperscript{4}, M Vaz MD\textsuperscript{1} and AV Kurpad MD PhD\textsuperscript{1}

\textsuperscript{1}Division of Nutrition, Institute of Population Health and Clinical Research, St. John’s National Academy of Health Sciences, Bangalore, India
\textsuperscript{2}Department of Obstetrics & Gynecology, St. John’s Medical College Hospital, Bangalore, India
\textsuperscript{3}Department of Nutrition, Harvard School of Public Health, Huntington Avenue, Boston, USA
\textsuperscript{4}Department of Pediatrics, St. John’s Medical College Hospital, Bangalore, India

新生兒血清維生素B\textsubscript{12}狀況與出生體重的相關性

早期研究指出母親的維生素B\textsubscript{12}營養狀況與嬰兒出生體重具相關性。本研究延伸先前的發現，針對新生兒維生素B\textsubscript{12}營養狀況與出生體重。112名女性從懷孕第一期即開始追蹤，並且取得其三個孕期的血液及其新生兒出生時的臍帶血。評估母親及新生兒臍帶血中的血清維生素B\textsubscript{12}濃度與出生體重的相關性。懷孕三個時期與臍帶的血清血均與母親產前的血清維生素B\textsubscript{12}濃度具有顯著相關(所有P<0.01)。新生兒出生時體重較輕者(分＜2500公克及2500-2999公克兩類)比出生時體重≥3000公克者，其臍帶血清的維生素B\textsubscript{12}平均濃度顯著較低(P值分別為0.02及0.05)。然而，產前第一孕期跟第三孕期之維生素B\textsubscript{12}濃度雖有類似的趨勢，但是不顯著。懷孕週數40週以前，臍帶血清中維生素B\textsubscript{12}濃度與出生體重達統計顯著相關(r=0.28, P=0.01)，但是之後就沒有此現象(懷孕週數≥40週)。母親維生素B\textsubscript{12}的營養狀況與新生兒的維生素B\textsubscript{12}的營養狀況(以臍帶血清中的維生素B\textsubscript{12}濃度代表)相關。此外，低新生兒維生素B\textsubscript{12}濃度與低出生體重呈相關負相關。

關鍵字：新生兒維生素B\textsubscript{12}、出生體重、印度。