Dietary intake and serum concentrations of zinc, copper and iron in pregnant Jordanian women and their relationship with pregnancy outcome.

Salma Tukan, PhD, Muiz Shalbak, MSc, Hamed Takruri, PhD, Mazen Zibdeh, MRCOG, FRCOG

ABSTRACT

Objectives: To assess the nutritional status of zinc, copper and iron in pregnant Jordanian women during the third trimester and to study the relationships between these elements and pregnancy outcome.

Design: Dietary intake data was collected using the 24-hour recall method for three days. Serum iron, zinc and copper concentrations were determined at 30±2 weeks and ≥37 weeks of gestation. Cord blood hemoglobin was determined at delivery. Information on outcome of pregnancy (infant birth-weight, recumbent length, head circumference, gestational age and congenital abnormalities) were obtained.

Subjects: Eighty pregnant Jordanian healthy volunteer women at 30±2 weeks of gestation.

Setting: Obstetrics and Gynecology Clinics of the Islamic Hospital in Amman and the University of Jordan.

Results: Total dietary intakes of iron, zinc and copper were 33.7, 12.1 and 1.6 mg/d respectively. Serum zinc and iron concentrations declined significantly during the third trimester. Serum copper concentration at 30±2 weeks of gestation was significantly (p<0.05) lower among women who were taking iron supplements in comparison with those without supplements. A significant relationship (r=0.25, n=67, p<0.05) was obtained between intake and serum iron level at 30±2 weeks of gestation. About one third of subjects had either a low or marginal level of hemoglobin. Outcome of pregnancy was related to dietary and serum levels of trace elements.

Conclusions: Attention should be paid to maternal mineral status and to supplement intake to reduce maternal and outcome hazards.


Keywords: Pregnancy outcome, dietary intake, serum zinc, serum iron, serum copper.

The trace elements zinc, copper and iron are known to be essential for life, health and reproduction and have a vital role in fetal growth and development. They have well established functions as co-factors in enzyme reactions, components of body fluids, sites for binding of oxygen and structural components of non-enzymatic macromolecules.

It is well known that zinc is an essential element for normal embryogenesis and fetal growth, uterine contractility and the initiation of labor. Adequate maternal intake of zinc is necessary to meet increased zinc requirements during pregnancy. The adverse effects of zinc deficiency on reproduction have been demonstrated in both experimental animals and humans. Low maternal serum zinc was associated with congenital malformations, fetal prematurity and maternal complications such as hypertension and pre-eclampsia. Zinc supplementation has been documented to increase birth-weight and head circumference.

Adequate copper nutrition is also important during pregnancy and for fetal growth and development. A relationship was observed between maternal and umbilical serum copper concentration which reflects the dependence of the fetus on maternal copper concentration. Interactions between copper and other dietary components may alter the copper status. Dietary factors that may affect the bioavailability of copper include excess zinc, iron, fiber and phytate intake.

Iron deficiency anemia is a common health problem among pregnant women throughout the world. Hemodilution of blood plasma may decrease serum iron and hemoglobin concentrations. Dietary iron supplements are usually given to pregnant women to maintain a hemoglobin concentration not less than 10.5 g/dl.

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Table 1 - Maternal mean daily intake of iron, zinc and copper and their % of RDA*

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Total daily intake</th>
<th>From diet</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>X ± SEM</td>
<td>% RDA</td>
</tr>
<tr>
<td>iron (mg)</td>
<td>16.2 ± 0.6</td>
<td>54</td>
</tr>
<tr>
<td>zinc (mg)</td>
<td>9.7 ± 0.3</td>
<td>65</td>
</tr>
<tr>
<td>copper (mg)</td>
<td>1.4 ± 0.0</td>
<td>...1</td>
</tr>
</tbody>
</table>

* RDA for copper for pregnant women is not available.

Although dietary iron supplements are proportionally related to serum iron concentration during pregnancy, they may inversely affect both serum zinc and copper concentrations.13 The objectives of this work, therefore, are to assess the nutritional status of zinc, copper and iron in pregnant Jordanian women during the third trimester and to study the relationship between those elements and pregnancy outcome.

Subjects and methods A total of 80 pregnant Jordanian women attending the Obstetrics and Gynecology Clinics of the Islamic Hospital in Amman between June 1992 and May 1993, volunteered to participate in the study. Subjects were at 30±2 weeks of gestation. They were ethnically similar, healthy, had no chronic diseases and did not seem to belong to any specific socio-economic class. Dietary intake data, including nutrient supplements, was collected under the supervision of the investigators using the 24-hour recall method for three days. Only 4 subjects reported that they were smoking and were considered light smokers as they reported to smoke between 3-5 cigarettes per day. Blood samples were obtained at 30±2 weeks and ≥37 weeks of gestation. The samples were immediately centrifuged and blood sera were separated and kept frozen until assayed. Serum iron, zinc and copper concentrations were determined using atomic absorption spectrophotometer (PYE UNICAM SP9) at wavelengths 248.3, 213.9 and 324.9 nm for iron, zinc and copper respectively, according to the method described by Aggett14 and Hereberg et al.15 Cord blood hemoglobin was determined at delivery colorimetrically using the cyanomethemoglobin method as described by Dacie and Lewis.16 Information on outcome of pregnancy included infant birth weight, recumbent length, head circumference, gestational age and congenital abnormalities.

Statistical analyses included correlation and Student's t-test using Statistical Analysis System (SAS) Program.

Results The mean total and dietary daily intake of iron, zinc and copper found in this study and their contribution to the recommended dietary allowances (RDAs) of the National Research Council of the USA,17 are shown in Table 1. The distribution of mothers according to the adequacy (i.e. ≥65% of the RDA or more) of nutrient intake as suggested by Brown and Story,18 is shown in Table 2.

Table 3 shows the mean serum concentrations of zinc, copper and iron for pregnant women at 30±2 weeks and ≥37 weeks of gestation as well as cord blood hemoglobin concentration at birth. It is worth mentioning that all the pregnancies in this study were singletons.

Table 4 shows the distribution of the sample according to maternal hemoglobin concentration. Data show that about one third of the subjects had either low (<10 g/dl) or marginal (10.0-10.9 g/dl) level of hemoglobin.

Table 5 shows maternal biochemical data according to infant gestational age (<37 weeks and

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>No and % of women with daily intake: ≤65 % RDA</th>
<th>≥65 % RDA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No</td>
<td>%</td>
</tr>
<tr>
<td>zinc (mg):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>total</td>
<td>41</td>
<td>51</td>
</tr>
<tr>
<td>dietary</td>
<td>47</td>
<td>59</td>
</tr>
<tr>
<td>iron (mg):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>total</td>
<td>14</td>
<td>17</td>
</tr>
<tr>
<td>dietary</td>
<td>61</td>
<td>76</td>
</tr>
</tbody>
</table>

*RDA for copper for pregnant women is not available.
Table 3 - Maternal mean serum concentrations of zinc, copper, iron and blood hemoglobin at 30 and ≥37 weeks of gestation.

<table>
<thead>
<tr>
<th>Biochemical variable</th>
<th>30 weeks (n=67)</th>
<th>≥37 weeks (n=54)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>zinc (μg/dl)</td>
<td>74.4 ± 1.6</td>
<td>60.7 ± 1.6</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>copper (μg/dl)</td>
<td>255.3 ± 6.7</td>
<td>251.3 ± 5.9</td>
<td>NS</td>
</tr>
<tr>
<td>iron (μg/dl)</td>
<td>87.0 ± 2.1</td>
<td>75.5 ± 1.4</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>hemoglobin (g/dl) * t</td>
<td>...</td>
<td>11.7 ± 0.3</td>
<td></td>
</tr>
</tbody>
</table>

* values were measured at the date of delivery. t N = 80

≥37 weeks). Maternal mean serum zinc and copper concentrations measured at 30 weeks of gestation were slightly but not significantly higher for the group who delivered premature infants than the group who delivered full term infants, whereas maternal mean serum iron concentration was significantly lower (p<0.05) among pregnant women who delivered premature infants compared to those who delivered full-term infants, but the level in both groups was above the acceptable level (>40 μg/dl).

Table 6 shows maternal mean serum iron, zinc and copper concentrations according to infant birth weight. Mean serum zinc concentration at ≥37 weeks of gestation was significantly lower for the pregnant group who delivered low birth weight infants than the group who delivered full-term infants. Table 6 also shows that serum copper, iron and blood hemoglobin were slightly but not significantly lower for the group who delivered low birth weight infants.

Discussion

Maternal dietary intake

Mean daily dietary intakes of Fe, Zn and Cu were 16.2, 9.7 and 1.4 mg respectively. It is clear from Table 1 that food intake contributed only 54% of the RDAs for iron and 65 for zinc. However, when nutrient supplements were included, the daily intake increased to 112% and 81% of the RDA for Fe and Zn respectively. The intake of zinc in this study was higher than that found by Takruri (7.3 mg/day) in 1982. Dietary copper supplements were prescribed to only 7 pregnant women as part of a multi-vitamin and mineral supplement which led to an increase in the mean of copper intake to 1.6 mg/day (Table 1). The mean dietary intake of copper was 1.40±0.36 mg/d, whereas the RDA for adults is 1.5-3.0 mg/day. Thus the intake of this micronutrient by the pregnant women in this study can be considered marginal or low.

Table 2 shows that the use of iron supplements has increased the proportion of pregnant women with adequate intake of iron from 24 to 83% whereas the use of zinc supplements has increased the proportion from 41 to 49%.

Maternal biochemical data

Serum zinc: circulating zinc is the most common index to characterize zinc status in humans because it responds quickly to changes in dietary zinc content.

Mean serum zinc concentration (Table 3) significantly declined from 76.4 μg/dl to 60.7 μg/dl which is in agreement with the findings of other investigators. This decline has been attributed to increased fetal needs and to the expansion of plasma volume. Takruri in 1982 found that the mean serum zinc concentration in Jordanian women during the third trimester of pregnancy was 66.9 μg/dl and was considered marginal, whereas Turnlund et al reported a mean serum zinc concentration of 57.0 μg/dl in 51 pregnant Lebanese women in the last six weeks of pregnancy and the level was considered normal. On the other hand, in a cross-study comparison of circulating zinc concentration of normal pregnant women, it was found that the normal range of serum zinc concentration during pregnancy was from 49 to 72 μg/dl.

In this study no significant relationship was found between serum concentration and intake of zinc, whereas Cavdar et al found that poor zinc nutrition during the third trimester of pregnancy

Table 4 - Distribution of subjects according to hemoglobin level.

<table>
<thead>
<tr>
<th>Hemoglobin level (g/dl)</th>
<th>No</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;10</td>
<td>11</td>
<td>14</td>
</tr>
<tr>
<td>10.0 - 10.9</td>
<td>14</td>
<td>17</td>
</tr>
<tr>
<td>11.0 - 11.9</td>
<td>16</td>
<td>20</td>
</tr>
<tr>
<td>12.0 - 12.9</td>
<td>20</td>
<td>25</td>
</tr>
<tr>
<td>≥13</td>
<td>19</td>
<td>24</td>
</tr>
</tbody>
</table>
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Table 5: Maternal mean (±SEM) serum zinc, copper and iron concentrations at 30±2 weeks according to infant gestational age.*

<table>
<thead>
<tr>
<th>Variable</th>
<th>&lt;37 wk</th>
<th>≥37 week</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>serum zinc (µg/dl)</td>
<td>81.0 ± 4.7 (6)</td>
<td>78.1 ± 1.7 (61)</td>
<td>NS†</td>
</tr>
<tr>
<td>serum copper (µg/dl)</td>
<td>237.0 ± 25.1 (6)</td>
<td>255.1 ± 7.0 (61)</td>
<td>NS</td>
</tr>
<tr>
<td>serum iron (µg/dl)</td>
<td>81.0 ± 1.7 (6)</td>
<td>87.5 ± 2.3 (61)</td>
<td>&lt;0.05</td>
</tr>
</tbody>
</table>

* Number in brackets refers to number of subjects.
† NS: not significant.

was associated with low serum zinc values.

Serum copper: mean serum copper concentration at the beginning of the third trimester was 225 µg/dl (Table 3). As shown by others, it slightly but not significantly increased towards the end of pregnancy. O'Leary et al reported a value of 261µg/dl during the third trimester, whereas Dreo et al reported a value of 219 µg/dl at 32 weeks of gestation in healthy pregnant women. Hence, the mean values obtained in this study are acceptable. No significant relationship was found between intake of copper and maternal serum concentrations neither at 30 nor at ≥37 weeks.

Serum iron: mean serum iron concentration (Table 3) decreased significantly throughout the third trimester. This could be due to the increase in both plasma volume and fetal needs. It has been found by Bodgen et al that normal serum iron level was 85 µg/dl when determined at delivery, whereas the normal pregnancy values are >40 µg/dl. A significant relationship (r=0.25, n=67, p<0.05) was obtained between intake of iron and mean serum iron level at 30 weeks of gestation but not at ≥37 weeks.

Blood hemoglobin: mean hemoglobin concentration determined for the eighty subjects was 11.7±1.9 g/dl (Table 3) whereas the minimum acceptable concentration near term is 11 g/dl.

Effect of iron intake on serum iron and hemoglobin concentrations

Sixty subjects were taking iron supplements (the range from 10-75 mg elemental iron/d). The mean (±SD) total daily intake of iron for the group receiving the supplement was 39.7±14.7 mg/d and for the other without supplement (20 subjects) was 15.9±4.9 mg/d. The intake of iron during the third trimester was significantly correlated (n=67, r=0.25, p<0.05) with serum iron concentrations at 30 weeks of gestation as well as with hemoglobin concentration at the time of delivery (n=80, r=0.25, p<0.05), but was not significantly associated with serum iron measured at the end of gestation. On the other hand, the mean serum copper concentration at 30 weeks of gestation was significantly lower (p<0.05) among women who were taking iron supplements in comparison with the group without supplement (246.9±7.1 vs 282.3±15.3 µg/dl respectively). In addition iron supplements tended to affect inversely serum copper concentrations at ≥37 weeks of gestation.

This study also showed that serum zinc concentrations during the third trimester of pregnancy were not affected by iron supplement. Furthermore, the mean serum iron concentrations were not significantly different between the supplemented and non-supplemented groups.

Trace minerals and pregnancy outcome In this study maternal zinc concentrations at the beginning of the third trimester were not significantly related to birth weight (Table 6), recumbent length or head circumference of the new-born infants. Lazebnik et al on the other hand, reported that low serum zinc levels (<57 µg/
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dl) were associated with the incidence of post-dates (gestational age >42 weeks). Also Goldenberger et al found that zinc supplementation to mother led to increased birth weight and head circumference. Associations between serum zinc concentrations and the incidence of low birth weight or small-for-gestational age infants were reported by many investigators. It is worth mentioning that one woman in this study delivered an abnormal new-born. The infant was anencephalic and the mother had lower serum zinc concentration than the mean of the sample (57 vs 78 μg/dl respectively). Cavdar et al also reported lower serum zinc concentrations among women who delivered anencephalic infants compared to those who delivered unaffected infants (62.1 vs 73.2 μg/dl respectively). Serum iron concentration at the beginning of the third trimester was positively related to the new-born head circumference (n=67, r=0.28, p<0.05) and also tended to influence infant birth weight and recumbent length. Serum copper concentrations determined earlier or later during the third trimester were not significantly correlated to any birth measurements (birth weight, recumbent length, head circumference and congenital defects) nor to length of gestation.

Conclusion It is concluded from the findings of this study that daily maternal intake of copper was either marginal or inadequate compared to RDA; dietary intakes of iron and zinc were inadequate but mineral supplements markedly increased the intake of iron and zinc to a lesser extent. Attention should be paid to copper when high iron supplements are given.

Mean serum zinc concentration at the beginning of the third trimester was normal, but declined to a marginal level towards the end of gestation. On the other hand, both serum iron and copper concentrations were normal. Dietary iron supplementation during the third trimester was positively associated with serum iron at 30 weeks of gestation as well as with hemoglobin concentration at delivery. Also maternal serum iron concentration was associated positively with infant head circumference and to a lesser extent with birth weight and recumbent length. There was an association between serum zinc and infant birth weight. Adequate mineral nutrition during pregnancy is therefore necessary for a better outcome.

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References


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