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The Role of Selenium and Copper on Placental Weight and Efficiency

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Abstract

Background A healthy maternal diet, including essential trace elements like selenium and copper, is crucial for optimal pregnancy outcomes. Selenium acts as an antioxidant, protecting placental tissues, while copper supports mitochondrial function. Both elements influence placental weight and function, which are key determinants of fetal growth and neonatal health. Excessive or insufficient levels of these trace elements have been associated with the adverse outcomes such as gestational hypertension or impaired placental efficiency.

Objective To investigate the impact of maternal selenium and copper levels on placental weight and efficiency.

Methods A cross-sectional study was conducted on 50 mother-neonate pairs at Al-Diwaniya Obstetric Hospital (December 2024–February 2025). Maternal serum selenium and copper were measured using atomic absorption spectrophotometry. Placental weight, birth weight of the neonate, and placental efficiency (birth weight/placental weight) were assessed. Statistical analyses included Pearson correlation and multiple linear regression.

Results Maternal selenium showed a highly significant positive correlation with placental weight ($r = 0.523$, $p < 0.001$), while copper had no significant association with placental weight. Maternal serum copper showed significant negative correlation ($r = -0.316$, $p = 0.025$) with neonatal birth weight. Both trace elements negatively correlated with placental efficiency (selenium: $r = -0.418$, $p = 0.003$; copper: $r = -0.312$, $p = 0.027$). Regression analysis confirmed selenium's strong association with placental weight ($p < 0.001$).

Conclusion Maternal selenium levels significantly associated with placental weight. Serum copper levels negatively correlated with neonatal birth weight, whereas both selenium and copper are associated with reduced placental efficiency. These findings highlight the importance of balanced trace element levels for optimal placental efficiency, though further research is needed to clarify their clinical implications.

Keywords Maternal, selenium, copper placental weight, placental efficiency, birth weight

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List of abbreviations: BMI = Body mass index

Introduction

Pregnancy requires a healthy diet rich in energy, vitamins, protein, and minerals to support both maternal and fetal needs [1]. Pre-pregnancy weight influences weight gains recommendations, with studies highlighting excessive or insufficient weight gain as risk factors for complications like preterm birth and large for gestational age infants [2,3]. Regular weight monitoring is recommended to support healthy pregnancy outcome [4].

Trace elements such as selenium and copper play critical roles in pregnancy. Selenium, a component of antioxidant enzymes, protects placental tissues from oxidative stress, reducing risks like pre-eclampsia and fetal growth restriction [5]. Maternal selenium status is linked to reduced infection risk and improved infant survival, though supplementation alone is not universally recommended [6,7]. Copper, essential for mitochondrial respiration and ant oxidative defense, supports placental growth, but excessive exposure has been associated with gestational hypertension and oxidative stress [8].

The placenta serves as the interface between maternal and fetal circulation, facilitating nutrient exchange, endocrine signaling, and immune regulation [9]. Placental weight and shape are influenced by nutrient conditions, affecting birth weight and neonatal health outcomes [10]. Placental weight correlates with birth weight and fetal metabolic rate, offering insight into pregnancy outcomes [11,12].

This study aimed to study the impact of maternal selenium and copper levels on placental weight and efficiency.

Methods

A cross-sectional study was conducted involving 50 pairs of pregnant mothers and their neonates in the delivery room of Obstetric Hospital of Al-Diwaniya City, with data collected between December 1, 2024, and February 10, 2025. Maternal history was recorded, including age, gestational age, gravidity, parity, abortion history, body mass index (BMI) before pregnancy, and medical conditions such as hypertension, diabetes, and thyroid disease. Inclusion criteria encompassed women aged 18–35 years with singleton term pregnancies (37–41 weeks+6 days) delivered vaginally, while exclusions included pregnancies with congenital anomalies or maternal chronic conditions.

Blood samples (2 ml of venous blood) were collected from mothers at admission using low-adsorption tubes to prevent contamination. Samples were processed via centrifugation and stored at −20°C for 2 months until analysis. Heavy metal concentrations in serum were determined using an atomic absorption spectrophotometer (Model AA-7000, Shimadzu, Japan), employing techniques such as Flame Atomic Absorption Spectroscopy (FAAS) for copper and Hydride Generation AAS (HG-AAS) for selenium. Digestion procedures involved nitric acid and hydrogen peroxide to break down proteins and release metals into measurable solutions [6]. Standard solutions were prepared for calibration, ensuring accuracy through optimization of gas flow rates and flame types.

Heavy metal concentrations were compared to permissible limits set by World Health Organization (WHO) and the European Food Safety Authority (EFSA), with copper ranging from 700-1,500 μg/l and selenium from 46-143 μg/l. Quality control samples ensured result accuracy, with matrix interference corrected where needed [13]. If concentrations exceeded thresholds, samples were diluted and reanalyzed.

Immediately after delivery, both the placenta and the neonate were weighed using calibrated scales. The fresh placenta was weighed with a mechanical kitchen scale, while the neonate was weighed using an electronic digital scale. Then the placental efficiency was calculated depending of the following equation

Placental efficiency = birth weight / placental weight.

Statistical analysis

was performed using statistical package for social sciences (SPSS) version 26 and Microsoft Excel 2019, with data expressed as mean, standard deviation, median, and range. According to Shapiro-Wilk test, most of variables were not normally distributed except for maternal age, placental weight and maternal serum selenium level. Bivariate correlations assessed relationships between trace elements and maternal outcomes as Spearman correlation for not normally distributed and Pearson correlation for normally distributed. Multivariate analysis determined the most impactful trace elements. A significance level of P <0.05 was considered [14].

Results

The sample group consists of mostly young adult women; the median age of the mothers was 26 years (range 17-39), with a mean of 26.38±5.42 years. Their gravida median was 2 (range 1-7) while their parity median was 1 (0–5). The abortion rate was low for most of them, as median of abortion was zero (range 0-3). All were at term regarding gestational age as median was 39 weeks (range 37–40). The mothers BMI before pregnancy Median was 23.44 (range 16.44-36.72), as shown in table (1).

Table 1. Maternal demographic characteristics

Parameter	Mean ± SD	Median (Range)
Age (yr)	26.38±5.42	26 (17-39)
Gravida	2.74±1.68	2 (1-7)
Parity	1.52±1.54	1 (0-5)
Abortion	0.22±0.55	0 (0-3)
Gestational age (wk)	38.68±1.08	39 (37-40)
BMI (kg/m^2) *	24.53±4.26	23.44 (16.44-36.72)

* Body mass index before pregnancy

The mean concentrations of copper in the mothers' serum during labor was 1.68±0.69 (μg/l), while selenium mean was 75.92±24.64 (μg/l) as shown in table (2).

Table (2): Maternal serum copper and selenium levels at time of labor

Parameter	Mean ± SD	Median (Range)
S. Copper (μg/L)	1.68±0.69	1.76 (0.2-4.17)
S. Selenium (μg/L)	75.92±24.64	74.46 (37.2-135.91)

Table (3) shows that the mean weight of placenta was 577.2±109.71 g, and the neonatal birth weight mean was 3000 g, thus the calculated placental function index mean was 5.22±0.95. All placental samples were normal in shape after manual examination.

Table 3. Characteristics of placenta

Parameter	Mean ± SD	Median (Range)
Placental weight (g)	577.2±109.71	600 (350-880)
Newborn weight (g)	2938±379.52	3000 (2100-4300)
Placental efficiency	5.22±0.95	5 (3.41-8.5)

Bivariate correlation between both maternal serum copper and selenium and other cofactors showed insignificant correlation except a highly significant positive correlation between selenium and placental weight (r = 0.523, p <0.001), as shown in table (4) and figure (1).

Table 4. Bivariate Pearson correlation of placental weight with maternal copper and selenium levels and other parameters

Parameter		Placental weight (g)
Age (yr)	r	0.215*
	p	0.134
Gravida	r	0.145**
	p	0.314
Parity	r	0.136**
	p	0.346
Abortion	r	0.096**
	p	0.508
Gestational age (wk)	r	0.071**
	p	0.625
BMI (kg/m^2) [a]	r	0.107**
	p	0.461
S. Copper (µg/L)	r	0.098**
	p	0.497
S. Selenium (µg/L)	r	0.523
	p	**<0.001***

[a] Body mass index before pregnancy * Pearson correlation, ** Spearman correlation

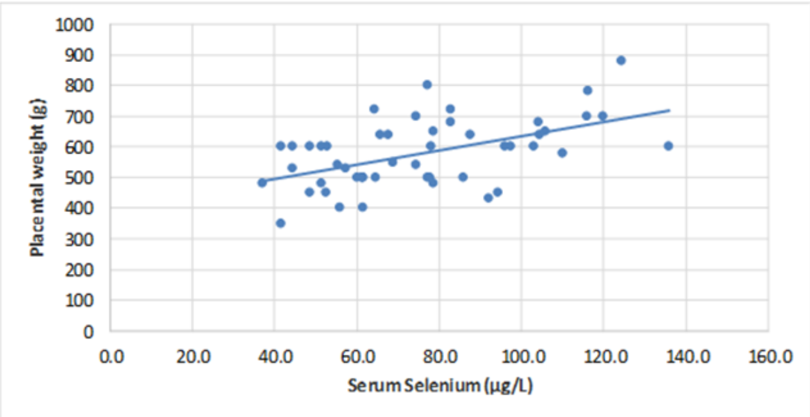

Figure 1. Bivariate correlation of maternal serum selenium with placental weight

The correlation between neonatal birth weight with studied trace elements and other cofactors were not significant except for gestational age, which showed significant positive correlation (r = 0.315, p = 0.026), also with serum copper which showed significant negative correlation (r = -0.316, p = 0.025) as shown in table (5) and figure (2)

Table 5. Bivariate correlation of newborn weight with maternal copper and selenium levels and other parameters

Parameter		Birth weight (g)*
Age (yr)	r	0.183
	p	0.203
Gravida	r	0.102
	p	0.480
Parity	r	0.080
	p	0.582
Abortion	r	-0.078
	p	0.592
Gestational age (wk)	r	0.315
	p	**0.026**
BMI (kg/m^2) [a]	r	-0.094
	p	0.517
S. Copper (µg/L)	r	-0.316
	p	**0.025**
S. Selenium (µg/L)	r	0.204
	p	0.155

[a] Body mass index before pregnancy * Spearman correlation

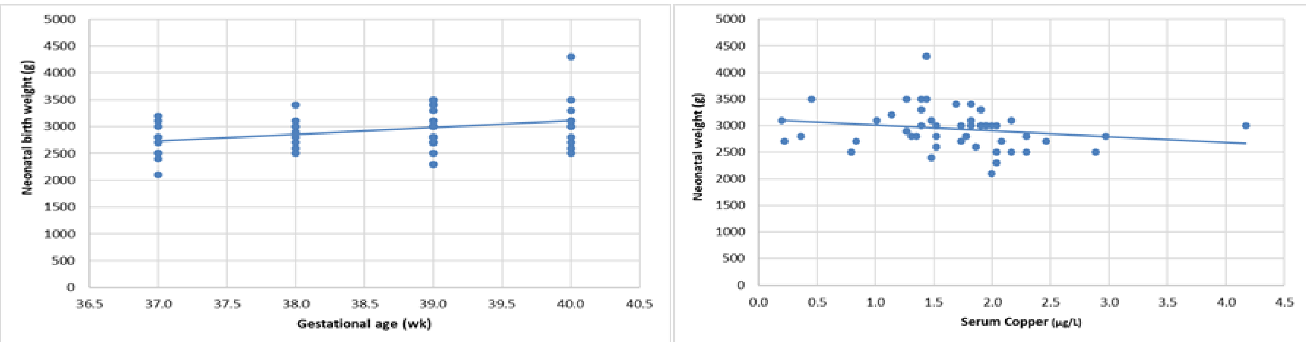

Figure 2. Bivariate correlation between gestational age and maternal serum copper with newborn weight

Table (6) and figure (3) shows that maternal serum selenium is more significantly negatively correlation with placental efficiency (r = -0.439, p = 0.001) that that of maternal serum copper (r = -0.321, p = 0.023) while other parameters had no significant correlation with placental function index.

Table 6. Bivariate correlation of placental efficiency with maternal copper and selenium levels and other parameters

Parameter		Placental efficiency*
Age (yr)	r	-0.047
	p	0.746
Gravida	r	-0.017
	p	0.905
Parity	r	-0.020
	p	0.889
Abortion	r	-0.138
	p	0.339
Gestational age (wk)	r	0.171
	p	0.234
BMI (kg/m^2) [a]	r	-0.010
	p	0.948
S. Copper (µg/L)	r	-0.321
	p	**0.023**
S. Selenium (µg/L)	r	-0.439
	p	**0.001**

[a] Body mass index before pregnancy * Spearman correlation

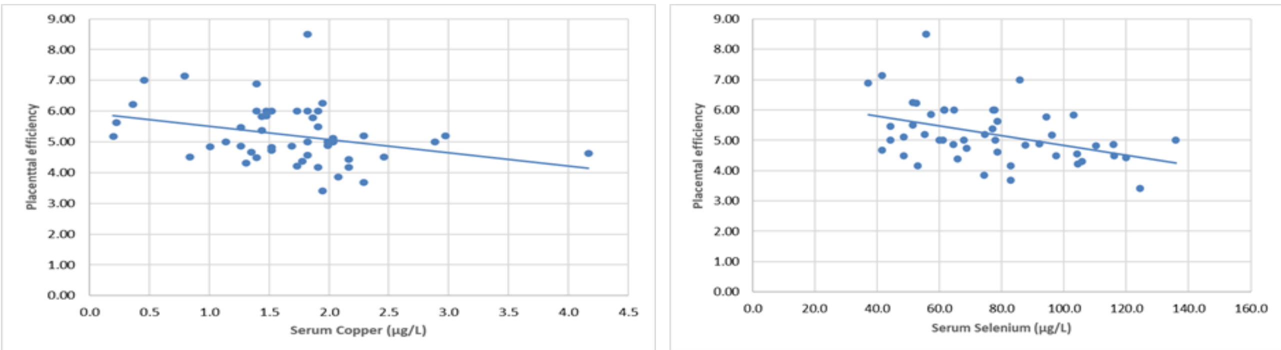

Figure 3. Correlation of maternal serum copper and selenium with placental efficiency

By using multiple linear regression to show which of the studied maternal serum level of trace elements and other cofactors that affect placental weight, only selenium showed highly significant positive correlation between serum selenium levels and placental weight (p value <0.001), indicating that this relationship is highly significant. For each unit increase in selenium, placental weight increases by 2.641 g and the standardized increase in placental weight is 0.546 for each unit increase in serum selenium level, however, the copper and other cofactors did not show any significant correlation with placental weight as shown in table (7).

Table 7. Multiple linear regression analysis for effect of maternal copper and selenium levels and other parameters on placental weight

Predictor	B	SE	β	P value	95% CI Lower	95% CI Upper
Age (yr)	0.467	3.499	0.023	0.894	-6.598	7.533
Gravida	38.833	73.468	0.593	0.600	-109.538	187.203
Parity	-36.368	73.757	-0.511	0.625	-185.323	112.588
Abortion	-45.955	80.956	-0.228	0.573	-209.450	117.539
Gestational age (wk)	8.381	14.359	0.082	0.563	-20.618	37.380
BMI (kg/m2) *	3.933	3.529	0.153	0.272	-3.195	11.061
S. Copper (µg/L)	18.326	21.182	0.115	0.392	-24.453	61.104
S. Selenium (µg/L)	2.430	0.621	0.546	**<0.001**	1.176	3.684

* Body mass index before pregnancy

Table (8) shows multiple linear regression of maternal serum copper and selenium with other cofactors effect on birth weight, yet none of them could be considered as a predictor for change in neonatal birth weight as none of them showed significant correlation with it

Table 8. Multiple linear regression analysis for effect of maternal trace elements levels and other parameters on newborn weight

Predictor	B	SE	β	p-value	95% CI Lower	95% CI Upper
Age (yr)	12.003	12.956	0.172	0.360	-14.162	38.168
Gravida	198.242	272.068	0.875	0.470	-351.210	747.695
Parity	-185.504	273.140	-0.754	0.501	-737.122	366.114
Abortion	-226.670	299.801	-0.326	0.454	-832.130	378.790
Gestational age (wk)	101.082	53.176	0.287	0.064	-6.309	208.474
BMI (kg/m^2) *	-2.801	13.070	-0.031	0.831	-29.196	23.594
S. Copper (µg/L)	-112.771	78.443	-0.205	0.158	-271.189	45.648
S. Selenium (µg/L)	2.229	2.299	0.145	0.338	-2.415	6.873

* Body mass index before pregnancy

In table (9), both maternal serum copper and selenium apart from other factors had a statistically significant negative impact on placental efficiency, however, selenium showed a higher significance than copper (p = 0.036, p = 0.002) respectively.

Table 9. Multiple linear regression analysis for effect of maternal trace elements levels and other parameters on placental efficiency

Predictor	B	SE	β	p-value	95% CI Lower	95% CI Upper
Age (yr)	0.010	0.031	0.057	0.745	-0.052	0.072
Gravida	-0.156	0.643	-0.275	0.809	-1.454	1.142
Parity	0.191	0.645	0.310	0.769	-1.112	1.494
Abortion	0.185	0.708	0.106	0.795	-1.245	1.615
Gestational age (wk)	0.157	0.126	0.178	0.219	-0.097	0.411
BMI (kg/m^2) *	-0.043	0.031	-0.191	0.173	-0.105	0.020
S. Copper (µg/L)	-0.401	0.185	-0.290	**0.036**	-0.775	-0.027
S. Selenium (µg/L)	-0.018	0.005	-0.456	**0.002**	-0.029	-0.007

* Body mass index before pregnancy

Discussion

Placental weight and placental efficiency are critical indicators of fetal health and development, as the placenta plays a vital role in nutrient transfer, oxygen exchange, and hormone production, directly influencing birth outcomes. The balance of essential trace elements, such as copper and selenium, is particularly important in maintaining placental efficiency and fetal growth [(15)].

In this study, maternal serum copper showed a no statistically significant association with placental weight, which contrasts with previous findings suggesting a negative correlation between maternal copper levels and placental weight. Ozdemir et al. (2007) reported that higher maternal copper levels were associated with lower placental weight, emphasizing the complexity of these relationships and the need for further research [(16)]. Additionally, Kennedy et al. (2020) found that maternal copper levels were linked to differential methylation in placental DNA, indicating that copper status may influence gene expression related to placental development. Copper plays a crucial role in antioxidant defense mechanisms, particularly as a component of superoxide dismutase, which protects placental tissues from oxidative damage [(17)]. Rafeeinia et al. (2014) highlighted that imbalances in copper levels can disrupt oxidative balance, potentially leading to placental dysfunction and complications such as preeclampsia [(18)].

Furthermore, Garlapati et al. (2024) suggested that insufficient copper may impair placental nutrient transport, contributing to low birth weight [(19)].

Current findings show that serum copper levels were negatively correlated with neonatal birth weight, suggesting that higher copper status may impair fetal growth. This aligns with evidence from a recent systematic review indicating that elevated maternal copper concentrations are inversely associated with birth weight [(20)]. Similarly, Ozdemir et al. reported a negative association between birth weight and both maternal and cord copper levels [(16)], while Bermúdez et al. confirmed that higher umbilical cord copper concentrations were significantly linked to reduced birth weight in adjusted models [(21)]. Together, these studies consistently indicate that elevated copper levels may contribute to fetal growth restriction.

A prominent finding of this study was the significant positive relationship between maternal serum selenium levels and placental weight. This suggests that higher selenium levels may support placental growth, possibly through enhanced antioxidant defense mechanisms that mitigate oxidative stress within the placental environment [(15)]. Regression analysis confirmed that serum selenium was the only variable significantly influencing placental weight, reinforcing its potential as a key determinant in placental development. However, there are other studies that contrast the current findings; a study in Poland observed an association between maternal selenium exposure during pregnancy and placental weight loss [22], which aligns with a study in China that found elevated maternal selenium exposure during pregnancy was negatively associated with birth weight. The reduction in placental weight may partially mediate the association between prenatal selenium exposure and birth weight. However, Wang et al. (2022) did not find a significant association between maternal selenium exposure in the third trimester and placental weight [23]. The inverse association of selenium with placental weight may reflect increased transport of selenium to the fetus in late gestation [22].

Regression analyses further supported these findings, indicating that maternal serum copper and selenium were significant negative predictors of placental efficiency variation. These outcomes align with existing literature cautioning against both deficiencies and excesses of trace elements during pregnancy, highlighting the need for optimal not merely elevated—micronutrient levels.

Current findings regarding selenium align with some previous studies. Hofstee et al. (2019) demonstrated that selenium deficiency reduced fetal glucose concentrations, leading to lower birth weight. Placental glycogen content was increased within the placenta, as was Slc2a3 mRNA expression, suggesting that selenium deficiency may impair thyroid metabolism and placental nutrient transporter expression. This study was the first to propose that selenium deficiency commonly reported in pregnant women may be sufficient to impair thyroid metabolism but not placental antioxidant concentrations [24]. Additionally, Wang et al. (2022) found that lower selenium concentrations were linked to increased placental oxidative stress and elevated mRNA expression of inflammatory genes, including HO-1, HIF1α, GRP78, CRP, and CD68. These findings suggest that inadequate selenium during pregnancy can lead to oxidative stress and inflammation, adversely affecting fetal development [23].

The limitation of this study was the small sample size, single-centered, cross-sectional design.

In conclusion, serum copper levels were negatively correlated with neonatal birth weight, indicating a potential role in fetal growth restriction. Maternal serum selenium showed a stronger positive effect on placental weight than copper, maternal age, gestational age, gravidity, parity, abortion history, and maternal BMI. Both maternal serum copper and selenium were negatively associated with placental efficiency, suggesting that higher levels of these trace elements may reduce placental functional efficiency.

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Author contribution

Dr. Toman: Data collection, obtaining maternal history, conducting neonatal and placental examinations, and preparing the initial draft of the manuscript. Dr. Ahmed: Designed the study, performed the statistical analysis, and conducted the final revision of the manuscript. Dr. Nasir: Managed the deliveries of the participating mothers and supervised the placental examinations.

Conflict of interest

The authors declare there is no conflict of interest.

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