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Heavy Metals in Tea and Their Adverse Effects on Mother and Fetal Outcome

Tazeen Shah[1], Farheen Shaikh[2]*, Shafaq Ansari[3], Saima Shaikh[4], Benazir Mehar[5], Rubina Zareen[6]

[1] Associate Professor of Physiology, Department of Physiology, Liaquat University of Medical and Health Sciences, Jamshoro, Sindh, Pakistan

[2] Associate Professor of Biochemistry, Department of Biochemistry, Peoples University of Medical and Health Sciences for Women, Nawabshah, Shaheed Benazir Abad, Sindh, Pakistan

[3] Assistant Professor of Physiology, Department of Physiology, Muhammad Medical College, Mirpurkhas, Sindh, Pakistan

[4] Assistant Professor of Physiology, Department of Physiology, Liaquat University of Medical and Health Sciences, Jamshoro, Sindh, Pakistan

[5] Ph.D. Scholar, Department of Community Health, Faculty of Medicine and Health Sciences, University of Putra Malaysia, Serdang, Malaysia

[6] Physiology Lecturer, Department of Physiology, Liaquat University of Medical and Health Sciences, Jamshoro, Sindh, Pakistan

Abstract: This study aimed to analyze the adverse effects of heavy metals in tea on pregnant mothers and fetal outcomes, using Camellia sinensis tea as a more common beverage after water. The tea constituents are flavonoids containing catechins, which are primary polyphenols recognized as having a strong anti-oxidant activity preventing cellular damage by free radicals. During pregnancy, excessive tea intake negatively impacts the newborn. Tea constituents and their contamination have gained attention as heavy metal contamination exceeds its critical concentrations in tea infusions which may cause adverse effects on both mother and fetus. A total of 400 pregnant women participated in the present study. A cross-sectional study was conducted at the department of Physiology of University of Sindh in collaboration with the Department of gynecology and obstetrics of Liaquat University of Medical and Health Sciences (LUMHS), Jamshoro, from September 2018 to August 2020. Selected pregnant women were informed and gave written consent. Chemical analysis of maternal blood was conducted at the National Centre of Excellence in Analytical Chemistry, University of Sindh. The statistical data were analyzed using SPSS v 21.0 (IBM incorporation, USA). The student`s and Person tests for correlation were applied, presenting the results as mean ± standard deviation (SD). Statistical significance difference was calculated at 95% ($p \leq 0.05$). The results of maternal parameters such as age, marital age, maternal height, body temperature, respiratory rate, and diastolic pressure had no significant difference. Simultaneously, gestational age, neck circumference, gestational weight gain, and systolic blood pressure had significant differences between pregnant tea and non-tea drinkers. Iron, Total iron-binding capacity (TIBC), and Ferritin also showed statistically significant differences at $p < 0.0001$. In the present study, the fetal weight positively correlated with aluminum, lead, mercury, and zinc and negatively correlated with copper and cadmium. Foot length showed a positive correlation with aluminum, copper, lead, cadmium, mercury, and zinc; the chest circumference showed a negative correlation with aluminum and copper.

Keywords: heavy metals, tea, pregnancy, the newborn.

茶葉中的重金屬及其對母胎結局的不利影響

摘要：本研究旨在分析茶中重金屬對孕婦和胎兒結局的不利影響，將茶葉茶作為一種僅

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About the authors: Tazeen Shah, Associate Professor of Physiology, Department of Physiology, Liaquat University of Medical and Health Sciences, Jamshoro, Pakistan; Farheen Shaikh, Associate Professor of Biochemistry, Department of Biochemistry, Peoples University of Medical and Health Sciences for Women, Nawabshah, Pakistan; Shafaq Ansari, Assistant Professor of Physiology, Department of Physiology, Muhammad Medical College, Mirpurkhas, Pakistan; Saima Shaikh, Assistant Professor of Physiology, Department of Physiology, Liaquat University of Medical and Health Sciences, Jamshoro, Pakistan; Benazir Mehar, Ph.D. Scholar, Department of Community Health, Faculty of Medicine and Health Sciences, University of Putra Malaysia, Serdang, Malaysia; Rubina Zareen, Physiology Lecturer, Department of Physiology, Liaquat University of Medical and Health Sciences, Jamshoro, Pakistan

Corresponding author Farheen Shaikh, Shaikhfarheen14@gmail.com

次於水的更常見的飲料。茶成分是含有兒茶素的類黃酮，兒茶素是一種主要的多酚，被認為具有很強的抗氧化活性，可防止自由基對細胞造成損害。在懷孕期間，過量飲茶會對新生兒產生負面影響。茶葉成分及其污染已引起人們的關注，因為重金屬污染超過了茶葉浸泡液中的臨界濃度，這可能對母親和胎兒造成不利影響。共有400名孕婦參與了本研究。2018年9月至2020年8月，信德大學生理學係與利亞卡特醫學與健康科學大學婦產科合作進行了一項橫斷面研究。選定的孕婦是知情並給予書面同意。母血的化學分析在信德大學國家分析化學卓越中心進行。使用SPSS21.0（IBM公司，美國）分析統計數據。應用學生和個人相關性測試，將結果表示為平均值±標準偏差。統計顯著性差異計算為95百分(p≤0.05)。年齡、婚齡、身高、體溫、呼吸頻率、舒張壓等產婦參數結果無顯著差異。同時，孕齡、頸圍、孕期體重增加和收縮壓在懷孕喝茶和不喝茶的人之間存在顯著差異。鐵、總鐵結合力和鐵蛋白在p<0.0001時也顯示出統計學上的顯著差異。在本研究中，胎兒體重與鋁、鉛、汞和鋅呈正相關，與銅和鎘呈負相關。腳長與鋁、銅、鉛、鎘、汞和鋅呈正相關；胸圍與鋁和銅呈負相關。

关键词：重金屬、茶、懷孕、新生儿。

1. Introduction

A physiological state of child bearing is termed as gestation [1] the outcome of pregnancy depends on the quality of life of the mothers, it can lead to a live birth, miscarriage or still birth. It is a gentle balanced relationship of mother and fetus [2]. Maternal influences may enhance the chances of problems throughout pregnancy, fetal maturation, and epigenetic effects in post-delivery life [3].

The beverage that is most common to water is tea (Camellia sinensis) consumed by the population for 2000 years. It is estimated that the overall consumption of tea around the world per day is approximately 18 to 20 billion cups [2]. Tea has lots of varieties depending upon the process of fermentation[3] the constituents of tea are usually recognized as having antioxidant effect that scavenge free radicals and prevent cellular damage, among them tea flavonoids containing catechins are primary polyphenols which has strong antioxidant activity [4].Tannins are other constituents containing >20 hydroxyl radicals, responsible for the bitter taste of tea, Ellagitannin is the name of tannin found in tea, their origin is from tannic acid, Which is plant polyphenol protecting against pests [5] tannins interfere with the bioavailability of iron by acting as chelating agent, making insoluble complexes that leads to decreased availability of iron [6].

Tea chemical constituents and their contaminations have gained attention as heavy metal contaminations critical concentrations in tea infusions [7], which if consumed during pregnancy will have adverse effects both on the mother and fetus. Trace heavy metals: aluminum (Al), cadmium (Cd), copper (Cu), lead (Pb), manganese (Mn), zinc (Zn), and contamination are a constant threat to the health of the population, which occurs because of heavy industry wastes, soil contamination by fertilizers and pesticides [8]. Trace elements are poisonous to individuals in minute quantities and can be a source of different ailments of kidney, bones, heart and nerves, etc. [9] Exposure to the heavy metals for the developing embryo in the prenatal life would lead to growth retardation in both physical and mental and will lead to further damaging effects in postnatal life [10] that is a great health issue in developing countries like Pakistan, where tea is consumed as a drink. This study presents the effect of heavy metals in tea and their effect on the mother and the babies.

2. Methodology

A total of 400 pregnant women were included in the present study using random sampling. A cross-sectional study was conducted at the department of Physiology, University of Sindh in collaboration with the department of gynecology and obstetrics Liaquat University of medical and health sciences (LUMHS), Jamshoro, from September 2018 to August 2020. The pregnant tea drinker females aged 18–40 with singleton pregnancy. Gestational diabetes, multiple pregnancies, liver disease and cardiovascular disorders were excluded from the study. Selected pregnant women were informed of the study protocol and wrote consent. A structured questionnaire was used to collect data from pregnant women in personal interviews at hospital. The tea consumption regularity in terms of the number of cups (one cup equals 150 ml, or 6 ounce) was in cups per day (week, month). The average single cup serving (125ml) of black tea is considered 30 mg [11]. The Chemical analysis of maternal blood was carried out at the Center of excellence laboratory,

University of Sindh. The serum iron and total iron binding capacity**,** serum iron concentrations and TIBC (total iron binding capacity) levels were analyzed by the kit method (Bioassay kits) on electrochemiluminescence immunoassay analyzer ECLIA. Reagents and Kits were purchased form World Scientific's. PK**.** Heavy metals were analyzed on Atomic Absorption Spectrometer (ContrAA 700 - Analytik Jena AG, Jena, Germany).

2.1. Statistical Analysis

The statistical data were analyzed by SPSS v 21.0 (IBM, incorporation, USA). The student`s test was applied and results were presented as mean ± standard deviation (SD). Categorical variables were presented as frequency and percentage by applying Chi-square test. The correlation between heavy metals with numerical variables (foot length, head circumference, etc.) used Pearson`s correlations and association of categorical variables (premature birth, etc.) and Spearman`s correlation. Statistical significance difference was calculated at 95% ($p \leq 0.05$).

3. Results

A total 400 pregnant women were included in the present study, the frequency of tea consumption during pregnancy per day such one (01), two (02), three (03), four (04), and five (05) cups were found in 20 (10%), 41 (20.5%), 69 (34.5%), 18 (9%) and 52 (26%) respectively (P = 0.0001) shown in Table 1, and the eating habits of the study group represented a significant difference with ($p < 0.0001$) shown in Table 2.

Table 1 Frequency of tea drinking in pregnant mothers

	Pregnant		**X^2 value**	**P-value**
	Tea-drinkers	**Non-tea-drinkers**		
No tea cups	0	200		
One cup	20	0		
Two cups	41	0		
Three cups	69	0	400.0	0.0001
Four cups	18	0		
Five cups	52	0		
Total	200	200		

Table 2 Eating habits of the study groups

	Pregnant		**X^2 value**	**P-value**
	Tea-drinker	**Non-tea-drinkers**		
Vegetarian	136	96	22.75	0.0001
Beget + Carnivorous	47	69		
Carnivorous	17	35		
Total	200	200		

The results of maternal parameters such as age, marital age, maternal height, body temperature, respiratory rate and diastolic pressure found no any significant difference between the groups, whereas gestational age, neck circumference, gestational weight gain and systolic blood pressure showed significant results between pregnant tea and non-tea drinkers as shown in Table 3.

Table 3 Maternal parameters of pregnant tea and non-tea drinkers

Maternal parameters (units)	**Pregnant tea-drinkers (n = 200)**	**Pregnant non-tea-drinkers (n = 200)**	**P-value**
Age (years)	37.42 ± 6.23	36.59 ± 7.23	0.22
Marital age (years)	19.30 ± 1.39	19.19 ± 1.27	0.38
Gestational-Age(weeks)	33.36 ± 0.85	36.98 ± 0.66	< 0.001
Maternal height (cm)	158.9 ± 4.6	158.3 ± 3.9	0.203
Neck circumference (cm)	33.76 ± 2.42	34.39 ± 2.80	< 0.017
Gestational weight gain (GWG) Kg	9.6 ± 0.56	8.2 ± 0.92	< 0.0001
Pulse pressure	42.3 ± 6.18	46.56 ± 5.98	< 0.0001
Body temperature (^{0}F)	98.6 ± 0.09	98.7 ± 0.24	0.07
Respiration rate (bpm)	15.75 ± 1.47	16.57 ± 1.19	0.056
Systolic-blood-Pressure (mmHg)	127.56 ± 12.27	133.96 ± 13.31	< 0.05
Diastolic-blood pressure (mm Hg)	82.47 ± 8.24	85.33 ± 8.56	0.058

In the present study, fetal parameters showed significant differences between pregnant tea drinkers and non-drinkers (P < 0.001) as shown in Table 4. Iron, TIBC and Ferritin also shown statistically significant differences with p < 0.0001 compared with pregnant tea drinkers and pregnant non-tea drinkers, as shown in Table 5.

Table 4 Fetal parameters of pregnant tea and non-tea drinkers

Fetal parameters	**Babies of pregnant tea-drinkers (n = 200)**	**Babies of pregnant non-tea-drinkers (n = 200)**	**P-value**
Fetal weight (lbs.)	3.84 ± 0.19	3.91 ± 0.05	< 0.0001
Foot length (mm)	42.53 ± 1.55	44.37 ± 0.46	< 0.0001
Chest circumference (cm)	26.77 ± 1.14	27.49 ± 1.42	< 0.0001
MUAC (cm)	32.76 ± 5.62	36.21 ± 5.74	< 0.0001
Head circumference (cm)	26.77 ± 1.14	27.66 ± 1.46	< 0.0001

Table 5 Iron concentration in the study groups

Iron profile (concentration unit)	Pregnant		t-value	P-value
	Tea-drinkers	Non-tea-drinkers		
Iron (Fe) (µg/dl)	84.87 ± 23.63	118.32 ± 10.80	278.6	0.0001
TIBC (µg/dl)	347.13 ± 56.49	258.95 ± 12.28	217.7	0.0001
Ferritin (ng/dl)	98.57 ± 32.94	149.97 ± 12.83	258.1	0.0001

In the present study, we found high concentrations of heavy metals in the blood of pregnant tea drinker's women as compare to pregnant non-tea drinkers. Aluminum, copper, lead, cadmium, mercury concentrations were significantly higher in pregnant tea drinkers compared to pregnant non-tea drinkers P < 0.000 and, shown in Table 6.

Table 6 Heavy metal concentration in the study groups

Heavy metal (concentration unit)	Pregnant		t-value	P-value
	Tea drinker	Non-tea-drinkers		
Aluminum (µg/dl)	38.26 ± 13.91	13.2 ± 4.82	23.63	< 0.0001
Copper (µg/dl)	93.11 ± 10.81	67.33 ± 12.23	22.33	< 0.0001
Lead (µg/dl)	0.44 ± 0.14	0.32 ± 0.17	7.14	< 0.0001
Cadmium (nmol/l)	1.56 ± 0.40	1.07 ± 0.12	16.70	< 0.0001
Mercury (µg/dl)	11.93 ± 4.15	6.50 ± 3.51	14.11	< 0.0001
Zinc (µg/dl)	0.36 ± 0.24	1.13 ± 0.09	41.30	< 0.0001

3.1. Correlation between the Heavy Metals and Their Impact on Maternal and Fetal Physical Parameters

In the present study, the fetal weight positively correlated with aluminum, lead, mercury and zinc whereas negative with copper and cadmium. Foot length showed a positive correlation with aluminum, copper, lead, cadmium, mercury and zinc. The chest circumference shows a negative correlation with aluminum, and copper.

4. Discussion

This study demonstrates a basic link between tea drinking and a mother's and fetus's health. We noticed fetal development retardation, gestational hypertension, maternal iron deficiency, and maternal gestational weight gain (GWG). Pregnancy-related changes in fetal weight (FW), fetal foot length (FL), chest circumference (CC), mid upper arm circumference (MUAC), and head circumference (HC) were associated with premature births, LBW babies, and fetal growth retardation (FGR). Pregnant tea users have higher than average quantities of the heavy metals, aluminum, copper, lead, cadmium, and mercury, but lower than average concentrations of zinc. Pregnant tea drinkers with enhanced TIBC capacity demonstrate low levels of serum iron and Ferritin levels. The results of the current study confirm that pregnant women who drink tea run a higher risk of maternal problems and fetal growth retardation.

The dangerous heavy elements lead (Pb), mercury (Hg), manganese (Mn), arsenic (As), cadmium (Cd), and others are found in tea leaves [12]. Toxic heavy metal exposure during pregnancy, such as lead, mercury, manganese, arsenic, and cadmium, can result in the offspring's physical and mental growth being stunted and impaired neurological development [13]. According to reports, the xanthine alkaloids in tea, which are caffeine, easily cross the placenta to reach the fetus [14].They disrupt placental perfusion [15] and negatively affect embryonic growth by reducing blood supply. Furthermore, the catechins in tea block the metabolism of folate, which increases plasma total homocysteine levels during pregnancy and increases the risk of premature birth [16]. Low folate and high homocysteine levels increase premature birth and FGR risk [17]. Reactive oxygen species (ROS) are produced because of exposure to heavy metals and pesticides, and these ROS play a significant role in premature delivery [18]. In the current investigation, higher plasma concentrations of aluminum, copper, lead, cadmium, and mercury in pregnant tea drinkers served as proof that the subjects had been exposed to heavy metals. Low levels of plasma zinc and iron were discovered. The results concur with earlier research [19]. Similarly high levels were reported in plasma, Earlier studies had mentioned pesticides and organic contaminants such perfluorooctanoic acid, dichloro-diphenyl-trichloroethane (DDT), and atrazine [20]. According to a previous study [21], a 1 g/dl rise in maternal lead levels during the first trimester increased the chance of preterm birth by 40%. In this study, pregnant tea users' Pbs (mean ± SD) levels are 0.44 ± 0.14 g/dl, compared to 0.32 ± 0.17 g/dl in pregnant non-tea drinkers (P = 0.0001). The study mentioned above backs up this result. A previous study [22] from Beijing, China, which discovered Pb values of 0.20 to 6.35 mg/kg in tea samples from a local market, supports the findings of the current analysis. One, two, three, four, and five cups were consumed on average by 20 (10%), 41 (20.5%), 69 (34.5%), 18 (9%), and 52 (26%) participants in the current study, respectively (P = 0.0001). The findings agree with a previous

American study [23] that discovered high coffee consumption (roughly 350 mg per day before and during early pregnancy). Our findings regarding tea consumption are consistent with another research [24]. Young pregnant individuals with a mean age in the fourth decade made up the study population for the current investigation, which found no statistically significant differences between the groups. The study respondents' ages are matched, according to a non-significant P-value. These results follow earlier research [25]. More GWG was discovered in pregnant tea users. GWG was 9.60 ± 0.56 and 8.20 ± 0.92 kilograms (Kgs) tea drinkers and non-drinkers during pregnancy, respectively (P = 0.0001). The results demonstrate considerable GWG in the study group of expectant tea drinkers. Earlier research [26] corroborated the results. Gestational hypertension is reported in 59 (29.5%) of pregnant tea drinkers compared with 13 (6.5%) non-drinkers (P = 0.0001). This result is consistent with earlier research [27]. However, [28] discovered that drinking tea while pregnant considerably increases the risk of pregnancy-induced hypertension (PIH). The presence of pre-eclampsia and PIH are both said to be very susceptible to raised Hcy [29]. According to [30], drinking tea increases the risk of developing pre-eclampsia. The results of the earlier investigations concur with the current study.

The variety in study design, measuring caffeine intake, and identifying confounders may help explain some of these disparate results. Numerous national guidelines encourage limiting caffeine intake during pregnancy considering these findings, however the wide range of cutoff values (0-300 mg caffeine) highlights the inconsistency of the available research [31]. According to the current study, pregnant tea consumers have reduced fetal weights compared with pregnant non-tea drinkers. Previous research [24] found LBW infants who consumed 100–199-mg caffeine per day during the first trimester, which supports the findings. Previous research found no link between preterm delivery and a higher risk of delivering low birth weight babies [32]. n contrast to current and earlier studies, [28] revealed that contrary to the findings of the present and other investigations, caffeine intake during pregnancy has no effect on birth weight or length.

Pregnant women's consumption of tea has raised health concerns because it could actually have a negative impact on the fetus. Zn, Pb, Cu, and Cd have all been reported to be present in tea [11]. In the analysis of 15 green and black teas, [33] found that the average amounts of Zn, Cd, and Pb per 100g of tea were 0.02, 0.036, and 0.016 mg, respectively. The mean concentrations of Zn, Cd, Pb, and Cu were 2.88, 0.0134, 0.021, and 1.59 mg/100g tea, respectively, the mean concentrations of Zn, Cd, Pb, and Cu were 2.88, 0.0134, 0.021, and 1.59 mg/100g tea, respectively, according to [34].

In this study, we found a negative association between heavy metals, which supports the idea that heavy metal contamination can stunt fetal growth, and a positive link between heavy metals and iron. The risk of iron, mineral, and vitamin deficiencies is already high in developing nations [35], an increased risk of iron, mineral, and vitamin deficiencies may result from increasing tea consumption during pregnancy.

While interpreting the results, this study's limitations may be considered. This study was unable to measure the amount of caffeine that tea drinkers consume, which limits the connection between caffeine and preterm deliveries. Because data on tea consumption were collected from personal records, there is a possibility that recall bias may have skewed the results of the study.

5. Conclusion

In this study, we found that the intake of tea during pregnancy increased the risk of maternal complications. The serum concentration of heavy metals was higher in tea drinker mothers as compared the non-tea drinker pregnant mothers. We also found a strong positive correlation between aluminum, lead mercury and zinc with fetal growth and weight. We recommended that avoid the usage of an aluminum utensil and avoid the use of low-quality tea, (which might be contaminated). Further studies are required to analyze the local tea content on HPLC and its effects.

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