Comparative Analysis of Total Cholesterol and Selected Electrolytes in Pregnant and Non-Pregnant Women: An Implications for Feminine Health

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Abstract—**Background: Pregnancy is associated with significant physiological and biochemical changes, particularly in lipid metabolism and electrolyte balance, which may influence maternal and fetal outcomes.**

Methods: This comparative cross-sectional study included 250 participants (125 pregnant women in the second trimester and 125 age-matched non-pregnant controls). Total cholesterol was estimated using the CHOD/POD method, while sodium, potassium, and calcium were measured using ion-selective electrodes. Statistical analysis was performed using SPSS v20.0, with $p < 0.05$ considered significant.

Results: Total cholesterol was significantly higher in pregnant women (218.9 ± 30.2 mg/dL) compared to non-pregnant women (188.3 ± 25.5 mg/dL). Normal cholesterol (<200 mg/dL) was observed in 32.0% of pregnant women versus 71.2% of controls, while borderline high (200–239 mg/dL) and high (≥240 mg/dL) levels were found in 49.6% and 18.4% of pregnant women, compared to 24.0% and 4.8% in non-pregnant women. Serum sodium was lower in pregnant women (135.2 ± 3.5 mmol/L vs. 137.7 ± 3.1 mmol/L), with hyponatremia (<135 mmol/L) in 32.8% vs. 8.0%. Potassium levels were 4.00 ± 0.40 mmol/L vs. 4.25 ± 0.37 mmol/L, with hypokalemia (<3.5 mmol/L) in 9.6% vs. 2.4%. Calcium levels were reduced (8.42 ± 0.51 mg/dL vs. 9.12 ± 0.48 mg/dL), with hypocalcemia (<8.5 mg/dL) in 35.2% vs. 8.0%. Anemia (Hb <11 g/dL) was present in 46.4% of pregnant women compared to 17.6% of controls. Supplement use (72.0% vs. 28.8%), fatigue (56.8% vs. 23.2%), back/body ache (48.0% vs. 16.8%), and edema (30.4% vs. 7.2%) were more prevalent among pregnant women.

Conclusion: Pregnancy, particularly in the second trimester, is associated with significant hyperlipidemia, electrolyte imbalance, and increased prevalence of anemia and related symptoms. These findings highlight the importance of routine biochemical monitoring and targeted nutritional interventions to improve maternal and fetal health outcomes

Index Terms—**Biochemical Alterations, Calcium, Cardiovascular Risk, Electrolytes, Maternal Health, Nutritional Interventions, Potassium, Pregnancy, Second Trimester, Sodium, Total Cholesterol**

I. INTRODUCTION

Pregnancy, also referred to as gravidity or gestation, is a physiological condition lasting approximately 40 weeks from the last menstrual period and is divided into three trimesters [1–3]. It is characterized by profound hormonal, metabolic, and systemic adaptations that support fetal development and maternal well-being. These changes affect multiple body systems, and many physiological alterations observed during pregnancy would be considered abnormal in non-pregnant individuals [4,5]. Among these, biochemical changes in lipid metabolism and electrolyte balance are of particular clinical importance [6,7].

During pregnancy, there is a significant increase in renal plasma flow and glomerular filtration rate, which alters electrolyte homeostasis [8,9]. Such changes may predispose pregnant women to electrolyte imbalances associated with complications such as hypertension, edema, muscle dysfunction, cardiac disturbances, and renal impairment [10–13]. Electrolytes, including sodium, potassium, and calcium, are essential for maintaining fluid balance, nerve transmission, muscle contraction, and vascular tone [14]. Even slight deviations from normal ranges can adversely affect maternal and fetal health, emphasizing the importance of regular monitoring during pregnancy.

In addition to electrolyte changes, pregnancy induces marked alterations in lipid metabolism. Total cholesterol plays a crucial role in fetal development as a precursor for steroid hormone synthesis and cellular membrane formation [15,16]. Hormonal changes, particularly increased levels of estrogen and progesterone, contribute to elevated cholesterol levels during pregnancy [17]. This physiological hyperlipidemia supports fetal growth; however, excessive increases in cholesterol have been associated with adverse outcomes such as preeclampsia, gestational diabetes mellitus, and preterm delivery [18-20]. Pregnancy-related lipid changes occur in stages, with fat accumulation in early gestation and increased lipolysis and circulating lipids in later stages [21,22].

In contrast, non-pregnant women generally exhibit relatively stable lipid and electrolyte profiles, regulated by dietary intake, hormonal balance, and metabolic control mechanisms [23,24,25]. However, variations may still occur due to factors such as obesity, lifestyle habits, or underlying medical conditions.

Despite considerable research on pregnancy-related biochemical changes, limited comparative studies have specifically evaluated differences in total cholesterol and electrolyte levels between pregnant and non-pregnant women [26]. Understanding these variations is essential for early identification of potential complications and for guiding nutritional and clinical interventions.

Therefore, this study aims to comparatively assess total cholesterol and selected electrolytes—sodium, potassium, and calcium in pregnant women and non-pregnant controls, to provide insights into biochemical alterations and their implications for maternal health.

II. MATERIAL AND METHODS

A comparative cross-sectional observational study was conducted to evaluate and compare total cholesterol and selected electrolyte levels among pregnant and non-pregnant women. The study was carried out at the School of Health Sciences, C.S.J.M. University, Kanpur, in collaboration with G.S.V.M. Medical College, Kanpur, over a period of 6 months. A total of 250 participants were enrolled, comprising 125 pregnant women in their second trimester and 125 age-matched non-pregnant women, selected based on predefined inclusion and exclusion criteria. Participants were within the age group of 18–45 years and were apparently healthy, with no history of chronic diseases such as diabetes, hypertension, cardiovascular, renal, or hepatic disorders. Pregnant women were confirmed to be in the second trimester by a gynecologist and were regularly attending antenatal check-ups. Ethical approval for the study was obtained from the Human Ethical Committee, C.S.J.M. University, Kanpur, (Approval No.: 2025-Apr-07), Written informed consent was obtained from all participants prior to inclusion in the study. Venous blood samples were collected under aseptic conditions using standard venipuncture techniques. Approximately 5 mL of blood was drawn from each participant into plain red-top/SST vacutainers. Samples were centrifuged at 3000 rpm for 10 minutes to separate serum, which was then used for biochemical analysis. Total cholesterol, sodium, potassium, and calcium levels were estimated from the separated serum. Total cholesterol was measured using the CHOD/POD enzymatic method, while sodium and potassium were estimated using the ion-selective electrode (ISE) method. Calcium estimation was performed using either the ion-selective electrode method or the o-cresol phthalein complex one (OCPC) method. All analyses were carried out using automated analyzers, including Selectra Pro and Erba Chem-7 for cholesterol estimation and Innolyte electrolyte analyzer for electrolyte measurement, following standard operating procedures and quality control measures. Data were compiled using Microsoft Excel and statistically analyzed using SPSS version 20.0. Continuous variables were expressed as mean ± standard deviation, and comparisons between pregnant and non-pregnant groups were performed using the independent t-test or appropriate parametric tests. Categorical variables were analyzed using the chi-square test. A p-value of less than 0.05 was considered statistically significant.

III. RESULT

Demographic Profile: Age-wise Distribution of Participants

The age-wise distribution showed that the majority of both pregnant and non-pregnant women were in the prime reproductive age group. Among pregnant women, 44.8% were aged 25–31 years, followed by 30.4% in the 18–24 years group, while 18.4% and 6.4% belonged to 32–38 years and 39–45 years, respectively. A similar pattern was observed in non-pregnant women, with 41.6% in the 25–31 years group, 27.2% in 18–24 years, and slightly higher proportions in older age groups (21.6% in 32–38 years and 9.6% in 39–45 years). Overall, the study population predominantly comprised women in early adulthood, consistent with peak reproductive age, ensuring appropriate comparability for biochemical and physiological assessment.

Table 1: Age-wise distribution of study participants		
Age group (Years)	Pregnant women (n = 125)	Non-Pregnant women (n = 125)
18–24	38 (30.4%)	34 (27.2%)
25–31	56 (44.8%)	52 (41.6%)
32–38	23 (18.4%)	27 (21.6%)
39–45	8 (6.4%)	12 (9.6%)

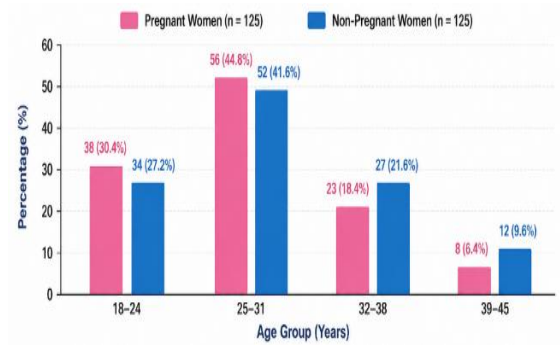


Figure 1: Age-wise Distribution of Pregnant and Non-Pregnant Women

Demographic characteristics of study participants

The demographic characteristics between pregnant and non-pregnant women were comparable, with no statistically significant differences in age (27.6 ± 4.9 vs. 28.1 ± 5.2 years), marital status (97.6% vs. 94.4%), or tertiary education (37.6% vs. 40.0%) (p > 0.05).

Table 2: Demographic characteristics of study participants (n = 250)			
Variable	Pregnant Women (n = 125)	Non-Pregnant Women (n = 125)	p-value
Age (years), mean ± SD	27.6 ± 4.9	28.1 ± 5.2	0.38
Married (%)	122 (97.6%)	118 (94.4%)	0.28
Tertiary Education (%)	47 (37.6%)	50 (40.0%)	0.7

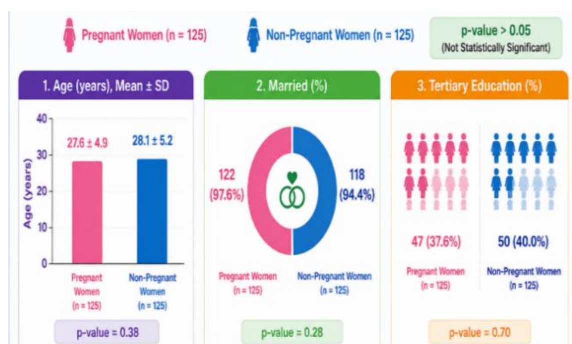


Figure 2: Sociodemographic Characteristics of Pregnant and Non-Pregnant Women

Categorical clinical parameters between pregnant and non-pregnant women Pregnant women showed a significantly higher prevalence of anemia (46.4% vs. 17.6%), supplement use (72.0% vs. 28.8%), edema (30.4% vs. 7.2%), fatigue (56.8% vs. 23.2%), and backache/bodyache (48.0% vs. 16.8%) compared to non-pregnant women, with all differences being statistically highly significant (p < 0.001).

Table 3: Categorical clinical parameters between pregnant and non-pregnant women				
Parameter	Pregnant Women (n = 125)	Non- Pregnant Women (n = 125)	χ^2	p- value
Anemia (Hb < 11 g/dL)	58 (46.4%)	22 (17.6%)	23.82	<0.001
Supplement Use (Yes)	90 (72.0%)	36 (28.8%)	46.66	<0.001
Edema (Clinical Observation)	38 (30.4%)	9 (7.2%)	21.45	<0.001
Fatigue Complaints (Self-Reported)	71 (56.8%)	29 (23.2%)	30.55	<0.001
Backache/Bodyache (Self-Reported)	60 (48.0%)	21 (16.8%)	27.69	<0.001

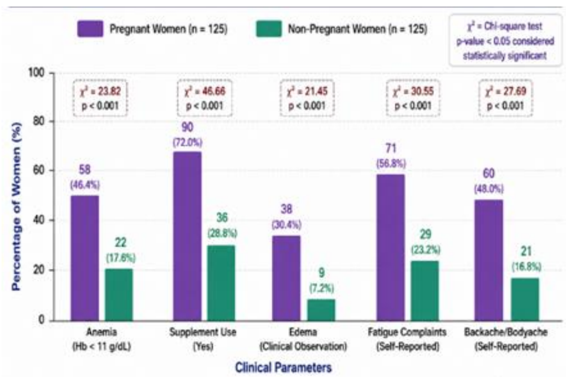


Figure 3: Categorical clinical parameters between pregnant and non-pregnant women

Comparison of biochemical parameters between pregnant and non-pregnant women

Pregnant women showed significantly higher total cholesterol levels (218.9 ± 30.2 mg/dL vs. 188.3 ± 25.5 mg/dL) and significantly lower levels of sodium (135.2 ± 3.5 vs. 137.7 ± 3.1 mmol/L), potassium (4.00 ± 0.40 vs. 4.25 ± 0.37 mmol/L), and calcium (8.42 ± 0.51 vs. 9.12 ± 0.48 mg/dL) compared to non-pregnant women, with all differences being statistically highly significant ($p < 0.001$).

Table 4: Comparison of biochemical parameters between pregnant and non-pregnant women					
Parameter	Pregnant women (Mean ± SD)	Non-pregnant women (Mean ± SD)	p-value	t-value	Significance
Total Cholesterol (mg/dL)	218.9 ± 30.2	188.3 ± 25.5	<0.001	8.22	Significant
Sodium (Na+ , mmol/L)	135.2 ± 3.5	137.7 ± 3.1	<0.001	-6.18	Significant
Potassium (K+ , mmol/L)	4.00 ± 0.40	4.25 ± 0.37	<0.001	-5.19	Significant
Calcium (Ca²+ , mg/dL)	8.42 ± 0.51	9.12 ± 0.48	<0.001	-10	Significant

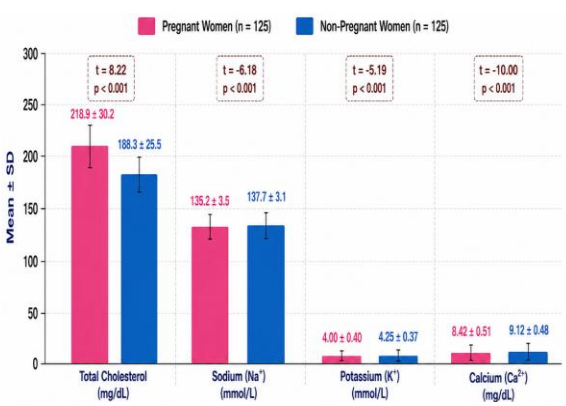
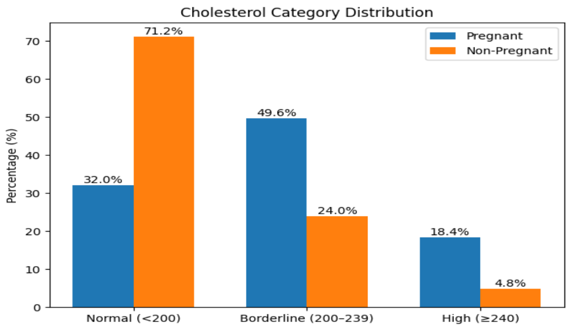


Figure 4: Comparison of clinical parameters between pregnant and non-pregnant women

Cholesterol classification of study participants with Chi-Square analysis

Pregnant women had a significantly higher proportion of borderline (49.6%) and high (18.4%) cholesterol levels compared to non-pregnant women (24.0% and 4.8%), while normal cholesterol was more common in non-pregnant women (71.2% vs. 32.0%), with a highly significant difference ($\chi^2 = 39.72$, $p < 0.001$).

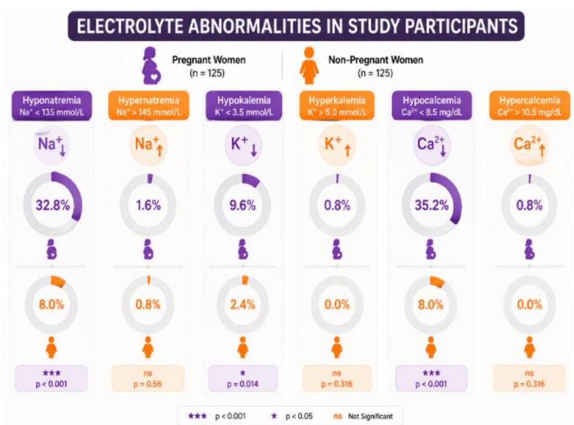
Table 4: Cholesterol classification of study participants with Chi-Square analysis				
Cholesterol Category	Pregnant Women (n = 125)	Non-Pregnant Women (n = 125)	Chi square (χ^2)	p-value
Normal (<200 mg/dL)	40 (32.0%)	89 (71.2%)		
Borderline (200–239 mg/dL)	62 (49.6%)	30 (24.0%)		
High (≥240 mg/dL)	23 (18.4%)	6 (4.8%)		
Total	125 (100%)	125 (100%)	$\chi^2 = 39.72$	< 0.001



Electrolyte abnormalities in study participants

Pregnant women showed a significantly higher prevalence of hyponatremia (32.8% vs. 8.0%), hypokalemia (9.6% vs. 2.4%), and hypocalcemia (35.2% vs. 8.0%) compared to non-pregnant women ($p < 0.05$), while hypernatremia, hyperkalemia, and hypercalcemia were rare and showed no significant difference between the groups ($p > 0.05$).

Table 5: Electrolyte abnormalities in study participants			
Electrolyte Abnormality	Pregnant Women (n = 125)	Non-Pregnant Women (n = 125)	p-value
Hyponatremia (Na^+ < 135 mmol/L)	41 (32.8%)	10 (8.0%)	<0.001
Hypernatremia (Na^+ > 145 mmol/L)	2 (1.6%)	1 (0.8%)	0.56
Hypokalemia (K^+ < 3.5 mmol/L)	12 (9.6%)	3 (2.4%)	0.014
Hyperkalemia (K^+ > 5.0 mmol/L)	1 (0.8%)	0 (0.0%)	0.316
Hypocalcemia (Ca^{2+} < 8.5 mg/dL)	44 (35.2%)	10 (8.0%)	<0.001
Hypercalcemia (Ca^{2+} > 10.5 mg/dL)	1 (0.8%)	0 (0.0%)	0.316



IV. DISCUSSION

Discussion The present study demonstrated significant physiological and biochemical alterations in pregnant women compared to non-pregnant controls, reflecting adaptive mechanisms during gestation. The comparable age distribution between groups reduces confounding bias and is consistent with reproductive patterns reported by Singh et al. (2020)

A markedly higher proportion of pregnant women reported supplement use (72.0% vs. 28.8%), which aligns with antenatal care recommendations and findings by Kumari et al. (2022), indicating improved compliance during pregnancy. Clinical symptoms such as fatigue (56.8% vs. 23.2%), back/bodyache (48.0% vs. 16.8%), and edema (30.4% vs. 7.2%) were also significantly more prevalent among pregnant women, supporting observations by Sharma et al. (2019) that these symptoms arise due to hormonal changes, increased metabolic demand, and fluid retention during pregnancy.

In the present study, total cholesterol levels were significantly higher in pregnant women (218.9 ± 30.2 mg/dL) compared to non-pregnant women (188.3 ± 25.5 mg/dL). Furthermore, only 32.0% of pregnant women had normal cholesterol levels, while 49.6% and 18.4% exhibited borderline high and high levels, respectively, compared to 24.0% and 4.8% in non-pregnant women. These findings strongly support the concept of gestational hyperlipidemia and are in agreement with Enquobahrie et al. (2004), who reported progressive increases in lipid levels during pregnancy. Similarly, Herrera et al. (2016) emphasized that although such elevations are physiological, excessive increases may predispose to adverse outcomes such as preeclampsia and future cardiovascular risk. The higher proportion of dyslipidemia observed in the present study suggests the need for monitoring lipid profiles even during normal pregnancies.

Electrolyte analysis revealed significantly lower sodium levels in pregnant women (135.2 ± 3.5 mmol/L vs. 137.7 ± 3.1 mmol/L), with a higher prevalence of hyponatremia (32.8% vs. 8.0%). Potassium levels were also reduced (4.00 ± 0.40 mmol/L vs. 4.25 ± 0.37 mmol/L), with hypokalemia observed in 9.6% of pregnant women compared to 2.4% of controls.

Similarly, calcium levels were significantly lower (8.42 ± 0.51 mg/dL vs. 9.12 ± 0.48 mg/dL), with hypocalcemia present in 35.2% of pregnant women compared to 8.0% in non-pregnant women. These findings indicate a clear trend of electrolyte depletion during pregnancy. Comparable results have been reported by Awwad et al. (2021) and Mahale et al. (2018), who attributed such changes to hemodilution, increased renal clearance, and hormonal influences such as aldosterone.

The higher prevalence of electrolyte imbalance observed in the present study is also supported by Rathi et al. (2015) and Rasheed et al. (2019), who linked these disturbances to clinical symptoms such as fatigue, muscle weakness, and edema. The observed clinical symptoms in this study further reinforce this association, suggesting that electrolyte imbalance may contribute to the symptomatic burden experienced by pregnant women.

Additionally, anemia was significantly more prevalent among pregnant women (46.4% vs. 17.6%), indicating increased hematological demand during pregnancy despite supplementation. This finding highlights the persistence of nutritional deficiencies and is consistent with global maternal health trends reported in developing regions. The coexistence of anemia, electrolyte imbalance, and hyperlipidemia reflects complex metabolic adaptations and emphasizes the need for integrated clinical monitoring.

Overall, the findings of this study are consistent with existing literature and demonstrate that pregnancy is associated with significant biochemical and clinical changes. While these alterations are largely physiological, their magnitude—as evidenced by higher rates of dyslipidemia, electrolyte imbalance, anemia, and clinical symptoms—suggests potential risks if left unmonitored. Therefore, routine biochemical assessment, early detection, and targeted nutritional and clinical interventions are essential to ensure optimal maternal and fetal health outcomes.

V. CONCLUSION

This study shows that pregnancy is associated with significant biochemical and clinical changes, including increased total cholesterol and higher prevalence of electrolyte imbalances such as hyponatremia, hypokalemia, and hypocalcemia. Pregnant women also exhibited higher rates of anemia and symptoms like fatigue, backache, and edema.

These changes reflect normal physiological adaptations but may contribute to complications if not properly monitored. The findings highlight the importance of routine biochemical screening, nutritional supplementation, and regular antenatal care for early detection and management of abnormalities.

Overall, continuous monitoring and targeted interventions are essential to ensure optimal maternal and fetal health outcomes

VI. LIMITATIONS AND FUTURE SCOPE

This study has certain limitations. The cross-sectional design restricts causal interpretation and does not capture changes across different trimesters. Potential confounding factors such as dietary habits, socioeconomic status, and physical activity were not fully controlled, which may influence biochemical parameters. The sample size, though adequate, may limit generalizability to broader populations. Additionally, the study assessed limited biochemical markers, and self-reported symptoms may be subject to bias.

Future studies should adopt longitudinal designs to evaluate trimester-wise and postpartum changes. Inclusion of a larger and more diverse population, along with detailed assessment of dietary and lifestyle factors, would improve generalizability. Further research incorporating additional biomarkers such as lipid fractions (HDL, LDL, triglycerides) and other electrolytes can provide a more comprehensive understanding. These approaches will help in developing targeted clinical and nutritional interventions for improved maternal health outcomes.

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