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Perturbation in Serum Calcium, Inorganic Phosphate and Alkaline Phosphatase in Trimesters of Gestation: A Cross-Sectional Study of an Antenatal Cohort

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Abstract

The biochemical markers involving serum calcium, inorganic phosphate, and alkaline phosphatase (ALP), play crucial roles in maternal and fetal health. This study evaluated the changes in serum calcium, inorganic phosphate, and alkaline phosphatase in different trimesters of gestation compared to non-pregnant controls. We employed a case control design in which serum calcium, inorganic phosphate and alkaline phosphate levels in pregnant and non-pregnant women were investigated using o-cresophthalein complexone method, ammonium molybdate method and King and King's method respectively. Data analysis was carried out using SPSS version 25 program using ANOVA and t- tests. The findings indicated significant decrease in serum phosphate (p= 0.038), calcium (p= 0.019) and alkaline phosphatase (p = 0.008) across trimesters. It is therefore, recommended to monitor these parameters closely, especially in regions with low nutrient intake, to prevent deficiency-related complications.

Keywords: Calcium, Inorganic Phosphate, Alkaline Phosphatase, Trimester.

Introduction

Pregnancy is a complex physiological process characterized by significant biochemical changes that enable maternal adaptation and ensure optimal fetal development.1 It induces specific physiological, biochemical and hormonal changes for the pregnant mother.2 Regulation of serum calcium, inorganic phosphate and alkaline phosphatase (ALP) levels is therefore critical during pregnancy.3 These biochemical markers play a pivotal role in maternal and fetal health, particularly in supporting the skeletal development of the fetus and maintaining maternal bone homeostasis. Alteration in their concentration reflects the complex interplay between maternal and fetal requirements, dietary intake, hormonal modulation and placental function but if not regulated may have some pathological implications [1]. While alterations in these parameters have been well documented, there remain a scarcity of studies that have examine the interplay and variations of calcium, inorganic phosphate and ALP across trimesters in pregnant women for the Nigerian population. This study aimed at addressing this gap by providing a holistic analysis of these biomarkers throughout pregnancy, offering valuable insights into their trends and potential implications for maternal and fetal health [2].

Materials and Method

Study Design

The study employed a case -control research design.

Study Population

The study population consisted of pregnant women from Enugu State University Teaching Hospital (ESUTH) and non-pregnant controls.

Inclusion Criteria

Pregnant women confirmed to be in their first, second, or third trimester at the time of sample collection, healthy pregnant women without any underlying health condition and non-pregnant controls were recruited after informed consent [3].

Exclusion Criteria

Pregnant women with underlying health conditions were excluded from the study.

Sample size: A total of 95 participants were recruited for this study; 25 for each trimester and 20 non pregnant women as the control group. This sample size was determined by the relation9

Sample size = $\frac{Z^2 \times P(1 - P)}{\sum^2}$

Where Z is the Z score
P is the population
∑ is the margin of error

Ethical Consideration

Ethical approval for this study was obtained from the Ethical Review Board of Enugu State University Teaching Hospital (Ref No: ESUT/HREC/2024/11/233). Informed consent was obtained from all participants, and their data were kept confidential.

Estimation of the Parameters

Serum Calcium was analyzed using O-cresolphthalein complexone method, Inorganic phosphate by the Ammonium Molybdate method while alkaline phosphatase was analyzed using King and King's method [4-6].

Data and Statistical Analysis

Data was analysed using a statistical package for social sciences (SPSS) . The differences between the groups were compared using one-way analysis of variance (ANOVA) and student t-tests for differences between groups with P<=0.05 considered significant. Results were expressed as the mean±SD (Standard Deviation) [7,8].

Result

Table 1 shows the level of serum phosphate, serum calcium and alkaline phosphatase for the pregnant women across the three trimesters. The mean serum phosphate level in the first trimester was 1.23±0.22mmol/L with slightly decrease in second trimester 0.24±0.13mmol/L and 0.05±0.17mmol/L at the third trimester [9-12].

For calcium, the level was 2.32±0.25mmol/L with a decrease to 1.31±0.30mmol/L and 0.44±0.16mmol/L in the third trimester. The mean level of alkaline phosphatase in the first trimester was 126.9±78IU/L, 108.93±38.09IU/L in the second trimester and decreased to 98±42.83IU/L in the trimester.

Table 1: Level of Serum Phosphate, Serum Calcium and Alkaline Phosphatase in Pregnant Women

Parameters	Trimesters	Mean ± SD	Confidence Interval (95%) (mmol/L)	F-ratio	P-value (ANOVA)
Inorganic phosphate (mmol/L)	Ist trimester 2nd trimester 3rd trimester	1.23±0.22 0.24±0.13 0.05±0.17	(1.56, 1.30) (1.71, 1.31) (1.18, 1.32)	0.18	0.038
Calcium (mmol/L)	Ist trimester 2nd trimester 3rd trimester	2.32±0.25 1.31±0.30 0.44±0.16	(2.22, 2.42) (2.21, 2.41) (2.34, 2.54)	2.19	0.019
Alkaline phosphatase (IU/L)	Ist trimester 2nd trimester 3rd trimester	126.9±78 108.93±38.09 98±42.83	(104.6, 149.2) (88.66,131.21) (99.40,143.95)	0.68	0.008

Table 2 compares the levels of inorganic phosphate, serum calcium and alkaline phosphatase between pregnant and non-pregnant women during the three trimesters of pregnancy. The mean value of inorganic phosphate in the first trimester (1.23±0.22mmol/L) is lower than that of non-pregnant women (1.34±0.11mmol/L). In the second trimester, pregnant women had a mean value of 1.24±0.13mmol/L, still lower than 1.34±0.11mmol/L in non-pregnant women reinforcing that the parameter remains lower in pregnant women. By the third trimester, the value reduced to 1.26±0.17mmol/L [13].

The calcium level in the first trimester (2.32±0.25mmol/L) is slightly lower than in non-pregnant women (2.42±1.15) while in the second trimester, pregnant women had a calcium level of 2.31±0.30, which remains lower than the 2.42±1.15 in non-pregnant women. At the third trimester, the calcium level for pregnant women rose to 2.44±0.16, nearly equal to the 2.42±1.15 in non-pregnant women suggesting similar calcium levels between the two groups as pregnancy progresses [14].

The alkaline phosphatase in the first trimester was 126.9±78IU/L, slightly higher than the 123.5±40.9IU/L observed in non-pregnant women while in the second trimester, pregnant women had lower alkaline phosphatase level of 108.9±40.9 compared to 123.5±40.9 in non-pregnant women. In the third women trimester, pregnant women showed a value of 121.7±42.8, which is again close to the non-pregnant value of 123.5±40.9 suggesting that alkaline phosphatase levels were fairly consistent between pregnant and non-pregnant women across the different trimesters.

Table 2: Comparison of Inorganic Phosphate, Serum Calcium, and Alkaline Phosphatase Levels between Pregnant and Non-Pregnant Women

Parameters	Trimesters	Mean ± SD (pregnant women)	Mean ± SD (non-pregnant women)	T-statistics	P-value (t-test)
Inorganic phosphate (mmol/L)	1st trimester 2nd trimester 3rd trimester	1.23±0.22 1.24±0.13 1.25±0.17	1.34±0.11 1.34±0.11 1.34±0.11	-2.17 -2.73 -1.97	0.036 0.009 0.055
Serum calcium (mmol/L)	1st trimester 2nd trimester 3rd trimester	2.32±0.25 2.31±0.30 2.44±0.16	2.42±1.15 2.42±1.15 2.42±1.15	-1.55 -1.48 0.44	0.129 0.146 0.66

Alkaline phosphatase (IU/L)	1st trimester 2nd trimester 3rd trimester	126.9±78 108.93±38.09 121.68±42.83	123.5±40.9 123.5±40.9 123.5±40.9	0.17 -1.24 -0.15	0.862 0.223 0.883

Discussion

This study seeks to evaluate the levels of serum calcium, inorganic phosphate, and alkaline phosphatase in different trimesters of gestations. The findings revealed significant decrease in the levels of serum calcium, inorganic phosphate, and alkaline phosphatase across the three trimesters of pregnancy. This aligns with literature suggesting that pregnancy imposes increased demands on maternal mineral metabolism and homeostatic mechanisms. This stability also aligns with the findings in some studies, where progressive calcium depletion is more pronounced due to fetal skeletal development [15,16].

Studies have shown that enhanced intestinal calcium absorption and increased renal calcium conservation during pregnancy maintain calcium homeostasis despite elevated fetal demand. However, disparities arise in low-resource settings, where inadequate dietary intake or supplementation exacerbates calcium deficiency. Phosphate is critical for fetal bone development and cellular energy metabolism. Studies often report stable phosphate levels during pregnancy, attributed to effective renal reabsorption and dietary intake. However, deficiencies are more prevalent in developing regions, linked to limited access to phosphate rich foods and prenatal supplements. Alkaline phosphatase is crucial for fetal bone mineralization. While slight fluctuations are expected due to placental activity, significant deviations may signal placental or hepatic dysfunction.

Low serum calcium levels across the trimesters aligns with findings indicating that pregnancy alters calcium metabolism to meet fetal developmental needs. Studies suggest that lower calcium levels in pregnancy are attributed to increased maternal demand for fetal skeletal development and the up regulation of calcitriol production to enhance calcium absorption. In Nigeria, a study observed similar patterns, emphasizing the compounded effects of poor dietary calcium intake in some population [17]. This shows the importance of nutritional interventions to mitigate maternal calcium deficiency, particularly in low resource settings.

For inorganic phosphate, pregnant women exhibited lower levels compared to non-pregnant women, with significant differences in the first and second trimesters. This reduction aligns with findings from studies, which highlighted the role of increased phosphate utilization during pregnancy for fetal bone mineralization [18].

Alkaline phosphatase (ALP) levels, on the other hand, showed minimal variation between pregnant and non-pregnant women, with no statistically significant differences across trimesters. While studies report rising ALP levels during pregnancy due to placental isoenzyme activity, lack of significant changes in alkaline phosphatase in this study may reflect localized variations.19 Similarly, there has been noted discrepancies in ALP among pregnant women in Nigeria likely influenced by genetic, dietary, and healthcare factors [19,20].

Conclusion

This study revealed significant decrease in the levels of serum calcium, inorganic phosphate, and alkaline phosphatase across the three trimesters of pregnancy. These findings emphasize the need for tailored nutritional and diagnostic guidelines to address the unique physiological and healthcare challenges of pregnancy in diverse population. Thus, establishing regional reference ranges is essential for distinguishing physiological changes from pathological conditions such as preeclampsia, particularly in resource-limited settings.

References

1. Longo, L. D. (2018). Maternal physiology of pregnancy. In L. D. Longo (Ed.), The rise of fetal and neonatal physiology: Basic science to clinical care (pp. 217–280). Springer.
2. Deoghare, B., & Saroq, H. (2017). Hematological profile of pregnant women in first, second and third trimesters: A cross-sectional study. Journal of Clinical and Diagnostic Research, 11(9), EC21–EC24.
3. Hamdoon, A. S., Aldabbagh, E. H., & Ahmad, A. J. (2021). Biochemical changes in bone profile during pregnancy. Annals of the College of Medicine, Mosul, 43(2), 191–197.
4. Living, M., Shipman, A. R., & Shipman, K. E. (2024). Investigative algorithms for disorders affecting human plasma alkaline phosphatase: A narrative review. Journal of Laboratory and Precision Medicine, 9, 1–12.
5. Taylor, S. N. (2021). Calcium, magnesium, phosphorus, and vitamin D. In Nutritional care of preterm infants (World Review of Nutrition and Dietetics, Vol. 122, pp. 122–139). Karger.
6. Prentice, A. (1994). Maternal requirements of calcium during pregnancy and lactation. The American Journal of Clinical Nutrition, 59(2 Suppl), 477S–482S.
7. Nagah, A. A., Mohammed, M., Amanullah, F. B., Ahmed, M. A., & Elsafi, A. (2016). Serum calcium and phosphorus levels during different stages of pregnancy. Journal of Middle East and North Africa Sciences, 2(4), 47–49.
8. Ikaraoha, C. I., Usoro, C. A. O., Igwe, C. U., Nwobu, G. O., Mokogwu, A. T. H., & Okwara, J. E. (2005). Does pregnancy actually affect serum calcium and inorganic phosphate levels? Shiraz E-Medical Journal, 6(1–2), 17–22.
9. Naing, L., Winn, T., & Rusli, B. N. (2006). Practical issues in calculating the sample size for prevalence studies. Archives of Orofacial Sciences, 1, 9–14.
10. Archer, D. G., Bonham, C. A., Harlan, W. R., & Schoenberg, D. G. (1973). O-cresolphthalein complexone method and calcium supplementation in preeclampsia. Medical Journal of Australia, 190(11), 634–638.
11. Fiske, C. H., & Subbarow, Y. (1925). The colorimetric determination of phosphorus. Journal of Biological Chemistry, 66(2), 375–400.
12. King, P. R. H., & King, E. J. (1954). Determination of serum alkaline phosphatase by the King and King method. Journal of Clinical Pathology, 7(4), 322–326.
13. Indrayan, A., & Malhotra, R. K. (2017). Medical biostatistics (4th ed.). Chapman & Hall/CRC. https://doi.org/10.4324/9781315100265

14. Goswami, R., Singh, N., & Rani, R. (2013). Maternal vitamin D status and its effect on maternal and newborn outcomes: A review. The Journal of Clinical Endocrinology & Metabolism, 98(11), 4592–4598.
15. Sparling, T. M., Henschke, N., Nesbitt, R. C., & Gabrysch, S. (2017). The role of diet and nutritional supplementation in perinatal depression: A systematic review. Maternal & Child Nutrition, 13(1), e12234.
16. Kovacs, C. S. (2014). The role of PTHrP in regulating mineral metabolism during pregnancy, lactation, and fetal/neonatal development. Clinical Reviews in Bone and Mineral Metabolism, 12, 142–164.
17. Okonofua, F. E., Menon, R. K., Houlder, S., Thomas, M., & Taylor, A. (1991). Calcium and phosphorus homeostasis in Nigerian women during pregnancy and lactation. The Journal of Nutrition, 121(5), 653–659.
18. Njoku, C. O., Emegoakor, C. D., & Obeagu, E. I. (2015). Evaluation of serum calcium levels among pregnant women attending antenatal clinic in a tertiary health institution in Nigeria. International Journal of Current Microbiology and Applied Sciences, 4(8), 522–527.
19. Bowyer, L., Catling-Paull, C., Diamond, T., Homer, C., & Davis, G. (2009). Calcium deficiency in pregnant women with preeclampsia and the effect of calcium supplementation. Medical Journal of Australia, 190(11), 634–638.
20. Ezegwui, H. U., Dim, C. C., Dim, N. R., & Ikeme, A. C. (2010). Changes in serum alkaline phosphatase during pregnancy in Enugu, Nigeria. Nigerian Journal of Clinical Practice, 13(4), 432–435.