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CORRELATION BETWEEN THYROID HORMONES AND SERUM ALBUMIN IN CHILDREN WITH SEVERE ACUTE MALNUTRITION (SAM) AND MODERATE ACUTE MALNUTRITION (MAM): A RETROSPECTIVE OBSERVATIONAL STUDY

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Abstract

Introduction:
Malnutrition in early childhood is a major global health problem, particularly in low- and middle-income countries (LMICs), where it contributes substantially to morbidity and mortality. Protein–energy malnutrition affects multiple organ systems, including the endocrine system, with significant alterations in thyroid hormone metabolism. Albumin, a major carrier protein for thyroid hormones, is often reduced in malnutrition, potentially influencing free hormone availability.

Aim:
To evaluate the correlation between serum albumin and thyroid hormone levels in children with moderate acute malnutrition (MAM) and severe acute malnutrition (SAM).

Materials and Methods:
This retrospective, observational (record-based) study was conducted in the Department of Pediatrics, Saveetha Medical College and Hospital, Tamil Nadu, India. Medical records of children aged 6–60 months diagnosed with MAM or SAM between June 2024 and December 2024 were reviewed. Anthropometric data, serum free triiodothyronine (FT3), free thyroxine (FT4), thyroid-stimulating hormone (TSH), and albumin levels were extracted. Children with chronic systemic illnesses or conditions affecting thyroid function were excluded. Data analysis included descriptive statistics, independent samples t-test for group comparisons, and Pearson's correlation for association between biochemical parameters. A p-value <0.05 was considered statistically significant.

Results:
Of the 100 children included, 43 had MAM and 57 had SAM. The mean age was comparable between groups ($p = 0.369$). Weight tended to be lower in SAM (8.73 ± 2.33 kg) than in MAM (9.59 ± 2.33 kg), but the difference was not statistically significant ($p = 0.073$). FT3 and FT4 levels were significantly higher in MAM (FT3: 3.63 ± 0.09 pg/mL; FT4: 1.82 ± 0.12 ng/dL) compared to SAM (FT3: 3.26 ± 0.13 pg/mL; FT4: 1.30 ± 0.19 ng/dL) (both $p < 0.001$). Serum albumin was also significantly higher in MAM (3.97 ± 0.29 g/dL) than SAM (3.06 ± 0.30 g/dL) ($p < 0.001$). TSH did not differ significantly between groups ($p = 0.656$). Strong positive correlations were observed between FT3 and albumin ($r = 0.992$, $p < 0.001$) and between FT4 and albumin ($r = 0.990$, $p < 0.001$).

Conclusion:
Serum albumin shows a strong positive correlation with FT3 and FT4 levels in children with acute malnutrition, suggesting that hypoalbuminemia may contribute to reduced thyroid hormone availability in SAM. Measuring both parameters may provide valuable insights into nutritional and endocrine status, enabling timely interventions to improve growth and metabolic outcomes.

Key words: Thyroid Hormones, Malnutrition, Free T3, Free T4, Serum Albumin

INTRODUCTION

Failure to thrive (FTT) has classically been the term used to describe children who are not growing as expected. The term malnutrition is used to describe this group of children, classified specifically based on anthropometric measurements. malnutrition refers to undernutrition and is defined as an imbalance between nutrient requirements and intake or delivery that then results in deficits—of energy, protein, or micronutrients—that may negatively affect growth and development[1]. This condition not only affects growth velocity but also compromises immune competence, cognitive development, and overall quality of life. Children with chronic undernutrition are at a higher risk of recurrent infections, delayed developmental milestones, and impaired school performance later in life.

In poor nations, malnutrition—which includes deficiencies in certain micronutrients and protein-energy malnutrition—continues to pose a serious threat to health. In India, 7.7% of children under five have severe wasting, 19.3% have wasting, and 35.5% have stunting[2]. Globally, the prevalence of wasting and stunting is 6.8% and 22.3%, respectively[3]. It is the biggest cause of disease and mortality worldwide, especially affecting a great number of expectant mothers and small children. The burden is disproportionately higher in low- and middle-income countries (LMICs), where poverty, limited access to healthcare, food insecurity, and inadequate sanitation contribute to the vicious cycle of malnutrition and disease.

Malnutrition is not a uniform condition; it manifests in various forms ranging from acute wasting to chronic stunting, with differing etiologies and physiological consequences. Acute malnutrition is often the result of a sudden reduction in food intake or illness, whereas chronic malnutrition reflects long-standing inadequate nutrition. Both forms can co-exist and exacerbate metabolic and hormonal imbalances in the body.

Changes in nutritional status of a child, either in the short-term or the long term, impact the body's internal environment. One significant effect is on thyroid hormone physiology, particularly in peripheral hormone metabolism. The thyroid gland is the only source of thyroxine (T4) in the body. Most triiodothyronine (T3) in the blood is formed from the peripheral conversion of T4 by 5'-deiodinase with small amount being secreted from the thyroid gland. Both T3 and T4 are transported to different organs being bound to various plasma proteins, including thyroxine-binding globulin (TBG), thyroxine-binding pre-albumin (TBPA), and albumin[4]. Studies indicate that protein-energy malnutrition (PEM) leads to significant variations in thyroid hormone secretion, metabolism, as well as the structure of the thyroid gland itself. These changes result in decreased glandular activity and reduced levels of both free as well as bound triiodothyronine (T3) and thyroxine (T4). The alterations in thyroid function are due to changes in iodine metabolism and reduced levels of circulating proteins. These changes are crucial for the adaptive process of energy and protein metabolism in children with PEM, helping to conserve energy when there is a scarcity of energy-producing substrates and protect the child from premature death due to reduced calorie reserves[5].

Thyroid hormones play a pivotal role in growth, neurodevelopment, and metabolic regulation in early life. Any disruption in their synthesis, transport, or action can have far-reaching consequences. In malnutrition, the interplay between protein status, albumin levels, and thyroid hormone physiology is particularly important, as both protein transport mechanisms and hormone metabolism are compromised.

Malnutrition impacts every organ system, leading to organ dysfunction and various metabolic derangements. It results in decreased synthesis of proteins by the liver, thereby lowering the levels of circulating proteins[6]. Hypoalbuminemia is a common and consistent feature seen among all the children with protein energy malnutrition. However, studies done previously in animal models and humans have showed that there is a significant reduction in the catabolism of albumin in children with malnutrition. This change in the rate of catabolism may either be due to reduced intake or the nutritional state of the body[7].

Understanding the correlation between thyroid hormones and nutritional markers such as albumin in malnourished children can provide insights into the severity and systemic impact of undernutrition. Such correlations may also help in early identification of children at risk of endocrine dysfunction, enabling timely interventions.

In this context, the aim of this study was to identify the correlation between thyroid hormone level and nutritional status of the child

MATERIAL AND METHODS

This was a retrospective, observational (record-based) study conducted in the Department of Pediatrics, Saveetha Medical College and Hospital, Thandalam, Tamil Nadu, a tertiary care teaching institution serving

both urban and rural populations. The retrospective design was chosen to allow analysis of pre-existing hospital records without influencing patient management, thereby minimizing ethical and logistical challenges. We reviewed existing clinical and laboratory records from June 2024 to December 2024, covering a continuous six-month period to ensure seasonal variation in disease presentation was accounted for.

Ethics Considerations: As the study utilized anonymized secondary data from routinely collected hospital records, no direct patient contact occurred, and no additional investigations were ordered for research purposes. All data were handled in accordance with institutional policies for confidentiality and privacy.

Inclusion criteria:

Children from age 6 months to 60 months with severe acute malnutrition (SAM) and moderate acute malnutrition (MAM) were eligible for inclusion. SAM and MAM status were defined strictly according to the WHO child growth standards, ensuring uniform classification across all cases.

Exclusion criteria:

Children with metabolic disorders, children with chronic infections, children with malabsorption syndromes, protein-losing enteropathies, or nephrotic syndrome, children with congenital anomalies, children with chronic hepatic or renal diseases, and children on chronic medication were excluded from the study. These criteria were applied to avoid confounding influences on thyroid function and serum protein levels from unrelated chronic conditions.

Data sources and extraction:

Using the Medical Information Archiving Software (MIAS) of our institution, we identified consecutive children aged 6–60 months with a recorded diagnosis of SAM or MAM (WHO definition). This electronic database captures inpatient and outpatient records, laboratory results, and anthropometric data in a standardized format. SAM/MAM were classified per WHO criteria. Anthropometry followed routine departmental procedures — weight was measured using a calibrated digital weighing scale, and height/length was measured using a stadiometer or infantometer as appropriate. Weight and height were recorded to the nearest 10 grams and 0.1 cm, respectively. Measurements were taken by trained nursing staff, with repeated readings obtained in case of discrepancies to ensure accuracy. Values were plotted on WHO growth charts to confirm nutritional status classification.

The thyroid profile (FT3, FT4, TSH) was measured by chemiluminescence immunoassay in the hospital's NABL-accredited laboratory, and serum albumin was measured by the bromocresol green method. Both assays were subject to internal quality control procedures and participated in external quality assurance programs to maintain analytical reliability. We used the first available complete set of values per child within the study window to avoid bias from repeated measures.

A standardized proforma was used to extract demographics (age, sex), anthropometric indices, and laboratory values. Records lacking any key variable (FT3, FT4, TSH, serum albumin, or anthropometry) were excluded from analysis. Data were de-identified prior to entry into the study dataset.

To limit selection bias, we included all consecutive eligible records during the study period. Information bias was minimized by using standardized lab methods from the same accredited laboratory and ensuring anthropometric measurements adhered to departmental SOPs. Records with missing key variables were excluded listwise; no imputation of missing data was performed to preserve the integrity of the results.

Sample size justification:

A total of 100 eligible records were included in the analysis. While no a priori sample size calculation was performed due to the retrospective nature of the study, the achieved sample size exceeded the minimum requirement for detecting medium effect sizes (Cohen's $d \approx 0.5$) at 80% power and $\alpha = 0.05$ in independent samples t-tests. This ensures adequate statistical power for the primary comparisons between SAM and MAM groups. The sample size was also sufficient for correlation analysis, exceeding the commonly cited minimum of 84 observations to detect a moderate correlation ($r = 0.3$) with 80% power at $\alpha = 0.05$.

Statistical analysis:

An independent samples t-test was conducted to explore the relationship between thyroid hormonal status (FT3, FT4, TSH) and serum albumin levels in MAM and SAM children. Pearson's correlation coefficient was calculated to observe the correlation between the various biochemical markers. A two-tailed p-value of <0.05 was considered statistically significant. Descriptive statistics (mean, standard deviation, and frequency distributions) were calculated for demographic and clinical characteristics. The data were analyzed using IBM SPSS Statistics Version 29.0.2.0.

RESULTS

A total of 100 children aged between 6 months and 60 months were included in the study. Based on WHO growth standards, 43 children (43%) were classified as having moderate acute malnutrition (MAM) and 57

children (57%) as having severe acute malnutrition (SAM). The gender distribution showed that in the SAM group, there was a slight female predominance (male-to-female ratio ≈ 0.90:1), whereas in the MAM group, males were more frequent (male-to-female ratio ≈ 1.69:1) (Figure 1).

The mean age of children in the MAM group was 2.67 ± 1.35 years, while that of the SAM group was slightly higher at 2.92 ± 1.41 years; this difference was not statistically significant ($p = 0.369$). The mean weight was greater in the MAM group (9.59 ± 2.33 kg) compared to the SAM group (8.73 ± 2.33 kg), with the difference approaching but not reaching statistical significance ($p = 0.073$). Mean height was almost identical between groups (MAM: 84.86 ± 11.42 cm; SAM: 84.92 ± 13.73 cm; $p = 0.980$).

Marked and statistically significant differences were observed in the thyroid hormone profile and serum albumin levels between the two nutritional status groups.Free Triiodothyronine (FT3) levels were significantly higher in MAM children (3.63 ± 0.09 pg/mL) compared to SAM children (3.26 ± 0.13 pg/mL), with a large effect size ($t = 16.40$, $p < 0.001$). This finding indicates a substantial reduction in circulating FT3 concentrations with increasing severity of malnutrition.Free Thyroxine (FT4) showed a similar but slightly more pronounced pattern, with mean levels of 1.82 ± 0.12 ng/dL in the MAM group versus 1.30 ± 0.19 ng/dL in the SAM group ($t = 16.85$, $p < 0.001$). The magnitude of difference in FT4 suggests that this parameter may be particularly sensitive to changes in nutritional status.Thyroid-Stimulating Hormone (TSH) levels did not differ significantly between groups (MAM: 3.12 ± 1.85 µIU/mL; SAM: 2.97 ± 1.59 µIU/mL; $p = 0.656$), indicating that the changes in FT3 and FT4 levels were likely due to peripheral metabolic adaptations rather than primary hypothyroidism or pituitary overactivity.Serum Albumin was markedly lower in the SAM group (3.06 ± 0.30 g/dL) compared to the MAM group (3.97 ± 0.29 g/dL) ($t = 15.43$, $p < 0.001$), representing the largest effect size observed among all measured variables. This confirms the strong relationship between protein-energy malnutrition severity and hepatic protein synthesis capacity.The comparative values for all demographic, anthropometric, and biochemical variables are summarized in Table 1, and the distributions are visualized in Figure 1 through boxplots illustrating group differences for FT3, FT4, and Albumin.

Pearson's correlation analysis revealed extremely strong positive relationships between FT3 and FT4 ($r = 0.997$, $p < 1.5 \times 10^{-113}$), FT3 and Albumin ($r = 0.992$, $p < .001$), and FT4 and Albumin ($r = 0.990$, $p < .001$). These correlations are near-perfect, suggesting a tightly linked physiological relationship between thyroid hormone concentrations and protein nutritional status. In contrast, TSH did not correlate significantly with any of the other biochemical parameters, indicating that the observed hormone changes likely arise from peripheral rather than central mechanisms.

The correlation matrix with corresponding p-values is presented in Table 2, and these relationships are further illustrated in Figure 3, which shows scatterplots with regression lines for FT3 versus Albumin and FT4 versus Albumin.

DISCUSSION

Severe Acute Malnutrition (SAM) affects nearly all organ systems of the body. Serum protein synthesis declines in SAM, which may have a direct or indirect impact on hormone levels. Thyroid hormones are crucial in regulating lipid and carbohydrate metabolism. In addition to their metabolic role, thyroid hormones are also essential for growth, neurodevelopment, and immune function, all of which can be significantly impaired in the setting of chronic malnutrition. In malnourished states, the body often adapts by altering thyroid hormone metabolism to conserve energy, a phenomenon known as the "low T3 syndrome" or "euthyroid sick syndrome," which has been described in various catabolic conditions[8].

In order to determine the relationship between serum albumin and thyroid hormones, the current study studied the correlation between those in children with moderate acute malnutrition (MAM) and severe acute malnutrition (SAM). The study included 43 children with MAM and 57 children with SAM, aged 6 months to 5 years. In our study, there was slight male predominance among children with MAM (M:F = 27:16) with a slight female predominance among those with SAM (M:F = 27:30), which was not statistically significant ($p = 0.126$). Similar patterns of gender distribution among children with SAM were found by Yadav et al. and Ghimre et al., where females were more prevalent than males[9]. Conflicting results by Sandeep et al. suggested that more male children presented to healthcare facilities, possibly due to cultural biases favouring males for nutrition and healthcare[10].These variations in gender distribution across studies could be related to sociocultural differences, healthcare-seeking behavior, and regional patterns of malnutrition prevalence.

The mean albumin levels were significantly lower in children with SAM compared to those with MAM ($p < 0.001$), with the mean albumin levels of 3.97 ± 0.29 g/dl for MAM and 3.06 ± 0.30 g/dl for SAM. Similar findings were reported by Lazarus et al., who also found a significant correlation between decreased serum albumin and the severity of malnutrition. Dhanjal et al. and Sah et al. reported comparable results, attributing

alterations in serum albumin to decreased protein intake and reduced biosynthesis[11,12].Hypoalbuminemia in SAM can be explained by the dual impact of inadequate dietary protein intake and reduced hepatic protein synthesis due to energy deficiency. Moreover, albumin serves as a major carrier protein for thyroid hormones in the circulation; hence, lower albumin levels can directly influence the free fractions of FT3 and FT4, contributing to the hormonal alterations seen in severe malnutrition.

The mean serum Free T3 levels were also significantly lower in SAM compared to MAM ($p < 0.001$), with values of 3.63 ± 0.09 pg/ml for MAM and 3.26 ± 0.13 pg/ml for SAM, correlating with malnutrition severity. This was consistent with findings by Lazarus et al., who observed a significant association between decreased T3 levels and malnutrition severity[6].This reduction in T3 can be attributed to impaired peripheral conversion of T4 to T3 due to decreased activity of type 1 5′-deiodinase, an enzyme that requires adequate energy and micronutrient cofactors for optimal function. Reduced caloric intake, micronutrient deficiencies (such as selenium and zinc), and increased catabolic stress can all impair this enzymatic activity, leading to a hormonal profile suggestive of metabolic adaptation to starvation.

Our study found that mean serum Free T4 levels were significantly lower in SAM compared to MAM ($p < 0.001$), with mean values of 1.82 ± 0.12 ng/dl for MAM and 2.97 ± 1.59 ng/dl for SAM. Lazarus et al. reported similar results, noting a significant correlation between decreased T4 levels and malnutrition severity. No significant difference in mean TSH levels was observed between MAM and SAM groups ($p=0.325$), aligning with findings by Dhanjal et al[11]. However, studies by Orbak et al. and Kumar et al. found higher TSH levels in malnourished children, possibly due to adaptive mechanisms[13,14]. The absence of significant TSH elevation in our study supports the hypothesis that the primary mechanism is peripheral downregulation of thyroid hormone production and metabolism rather than primary hypothyroidism. This distinction is important, as it implies that routine thyroid hormone replacement may not be indicated unless a true primary thyroid disorder is present.

Taken together, these findings indicate that both FT3 and FT4 are sensitive indicators of nutritional status in children, and their measurement, alongside serum albumin, could provide valuable information for assessing the severity of malnutrition and monitoring recovery during nutritional rehabilitation. The strong correlations observed between albumin and both FT3 and FT4 further reinforce the role of protein-energy balance in maintaining normal thyroid physiology.

CONCLUSION

In conclusion, our study observed a significant positive correlation between serum albumin and thyroid hormones (FT3, and FT4) in children with MAM and SAM, except for TSH. These findings underscore the complex interactions between nutrition and endocrine function in malnourished children, highlighting the importance of addressing nutritional deficiencies to improve thyroid function and overall health.Given the high burden of malnutrition in India and other low- and middle-income countries, these results have important clinical implications for early detection and intervention. Regular assessment of nutritional biomarkers, including serum albumin, along with thyroid hormone profiles, may help identify children at risk of endocrine dysfunction and guide targeted nutritional therapy. Further longitudinal studies are warranted to evaluate the reversibility of these hormonal changes with nutritional rehabilitation and to explore whether such changes have long-term developmental consequences.

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	Nutritional status	Mean	SD	p-value
Age	SAM	2.92	1.41	0.372
	MAM	2.67	1.35	
Weight	SAM	8.73	2.33	0.073
	MAM	9.59	2.33	
Height	SAM	84.92	13.73	0.98
	MAM	84.86	11.42	
FT3	SAM	3.26	0.13	< 0.001
	MAM	3.63	0.09	
FT4	SAM	1.3	0.19	< 0.001
	MAM	1.82	0.12	
TSH	SAM	2.97	1.59	0.65
	MAM	3.12	1.85	
Albumin	SAM	3.06	0.3	< 0.001
	MAM	3.97	0.29	

Table 1: Anthropometric data, Thyroid status and Serum Albumin levels in the study population

Variables	Mean	SD	FT3	FT4	TSH
FT3	3.42	0.22			
FT4	1.52	0.31	0.997**		
TSH	3.03	1.7	-0.014	0.003	-0.004
Albumin	3.45	0.54	0.992**	0.990**	
Note: ** p < 0.01, * p < 0.05					

Table 2: Correlation between thyroid hormone status and serum albumin

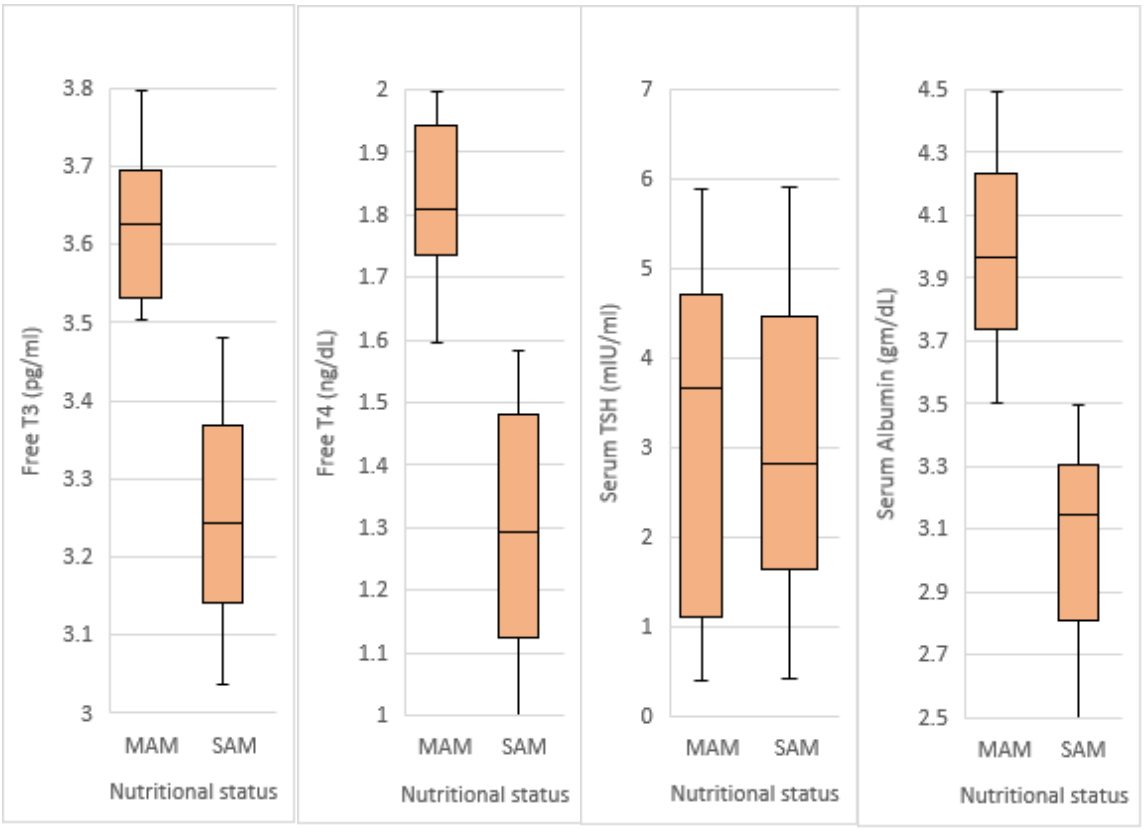

Figure 1: Gender distribution among children with SAM and MAM

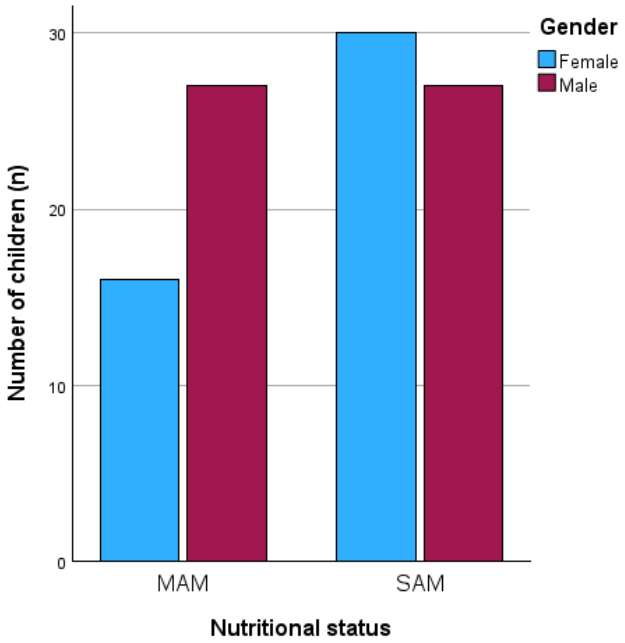

Figure 2: Thyroid hormone and Serum albumin status among children with SAM and MAM

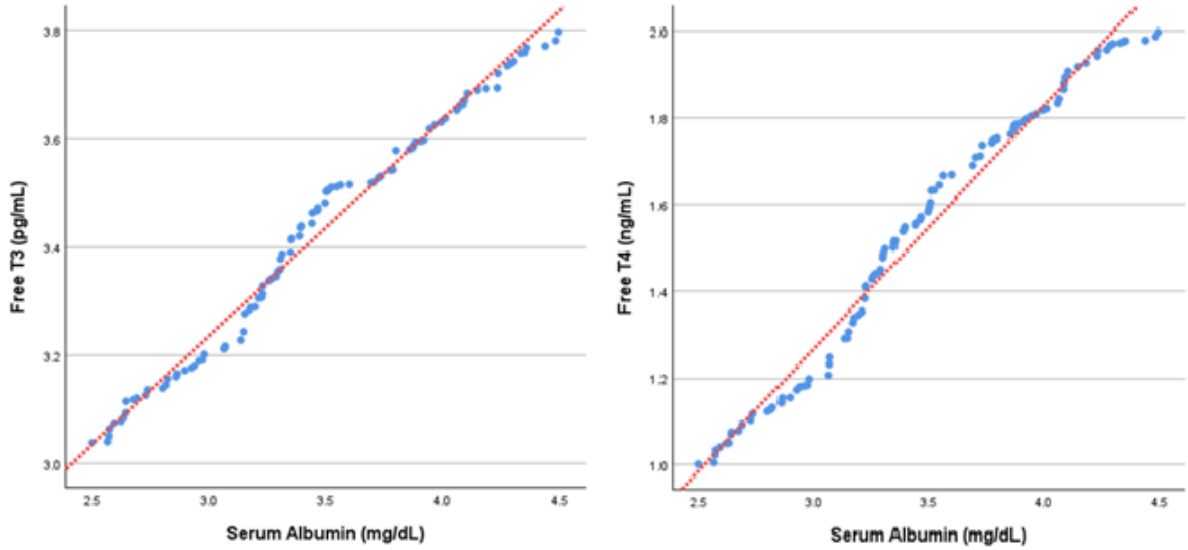

Figure 3: Correlation between Serum Albumin and Free T3 and Free T4