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Glycemic Control and Its Relationship Between Lipid Profiles and Thyroid Profiles: Insights from a Case? Control Study from Coastal Karnataka, South India

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Abstract **Introduction:** In India, the burden of diabetes mellitus is rising swiftly, mirroring a global trend that is being observed in both developed and developing countries. Examining the correlation between indices of glycemic status & thyroid and lipid parameters at different glycemic control levels was the goal of the present study. **Methods:** This case control study included 50 cases (HbA1c > 6.5 %) and 150 controls (HbA1C < 6.5) who were attending an executive health check up at a tertiary level health care hospital attached to a medical college in a coastal city in Southern India. Glycemic indices, thyroid profile and lipid profile were evaluated. Correlation analyses, t-tests, and chi-square tests were carried out. **Results:** Cases had a mean age of 57.80±10.71 years whereas controls had a mean age of 48.47±13.89 years. The cases and controls did not have discernable differences in the lipid profile characteristics. However, T4 and HbA1C (Glycated Hemoglobin), depicted a weak positive correlation with the value of correlation coefficient r= 0.211 (p= 0.014). With respect to T4, there was a higher mean rank contrast observed among the cases than that of controls (p=0.014). **Conclusion:** A positive association between thyroid hormone T4 levels and glycemic status was found in this study, even if no correlation was found between glycemic control and lipid profile. This research lays emphasis on closely observing thyroid function in addition to glycemic parameters for the all-encompassing control of diabetes mellitus.

Keywords Glycemic Control, Lipid Profile, Thyroid Profile, HbA1c

1. Introduction

A swiftly escalating global health crisis of profound community health significance, manifesting as type 2 diabetes mellitus (T2DM), is becoming evident, with

far-reaching implications that profoundly affect patients' quality of life, economic stability, and health systems worldwide [1,2]. According to International diabetes federation (IDF), a staggering 425 million individuals globally are afflicted with diabetes mellitus and projections for the year 2045 indicate a sharp rise, with an estimated 629 million individuals expected to suffer from this comorbidity, alongside an additional 352 million people at heightened risk for contracting diabetes mellitus [3]. Societal changes and lifestyle modifications have greatly contributed to this peaking of the prevalence of T2DM in India. According to estimates from World Health Organization (WHO), 72 million Indians were suffering from T2DM in the year 2017, and by 2025, that number is projected to nearly double to 134 million, making India country with the highest number of DM patients worldwide [4]. The endocrine system is overworked due to flaws in the machinery that processes glucose and the physiological system's recurring attempts to adjust the irregularity in glucose digestion. Maintaining the breakdown of endocrine regulation exacerbates the unpleasant effects of metabolism and primarily results in hyperglycemia [5].

In patients with T2DM, level of Glycated Hemoglobin (HbA1c) indicates the likelihood of development of complications due to diabetes mellitus [6]. Increased oxidative damage in the blood has been found in the blood of diabetic patients, and a decrease in the complications relates to the quality of these lipids [7]. Individuals who are suffering from diabetes mellitus have atherosclerotic changes in their arteries because of the typical characteristic of their lipid profile comprised of low ranges of high-density lipoprotein cholesterol (HDL-C). Other lipid parameters that are conducive to the development of atherosclerosis are also observed, namely escalated amount of total cholesterol (TC), and high levels of low-density lipoproteins. Deranged levels of triglycerides also add to the magnitude of the problem of atherosclerosis. Additionally, there is an increase in free fatty acids and small dense LDL (sdLDL), which significantly increases the risk of cardiovascular disease (CVD) through atherosclerosis [8]. Some studies have reported that while hyperglycemia is linked to the onset of atherosclerotic lesions, adding additional cholesterol results in dyslipidemia, which is the main cause of the progression of atherosclerosis [9].

Numerous reports highlight the influence of both endocrine and non-endocrine organs, beyond the pancreas on type 2 diabetes mellitus. Additionally, patients with diabetes may sometimes exhibit other endocrine aberrations like deranged thyroid profile [10]. Hypothalamic-pituitary-thyroid pivots are altered in artificially induced diabetic animals in several ways, including pituitary and plasma Thyroid Stimulating Hormone (TSH). Also, it is observed that plasma and hypothalamic Thyrotropin Releasing Hormone (TRH), TSH emission rate, and the TSH response to TRH are altered, in addition to usual fringe TSH digestion. The production of thyroid hormones namely T3 & T4 is decreased. Also, the uptake of iodide is decreased. Significant auxiliary changes have also been noted in the pituitary and thyroid glands, which are corresponded to prominent changes in their function of secretion. Parallelly, fringe tissues exhibit reduced deiodination of T4 to T3. [11]. Although iodothyronines are insulin competitors and high levels of the hormone are diabetogenic, their absence slows the progression of diabetes [12].

The literature that is currently being published indicates that opinions on the relationships between the thyroid profile, lipid profile and HbA1C are widely divided. Therefore, in order to strengthen the evidence of this association, the current case-control research was implemented to understand correlation between glycemic status and lipid parameters, thyroid profile, as well as to investigate the relationship between varying levels of lipid profile and thyroid profile at different levels of glycemic status. Insights from the research will help clinicians in holistic management of patients with respect to lipid profile, thyroid profile and glycemic status and aid in risk stratification, early diagnosis and intervention.

2. Materials and Methodology

The study settings consisted of the Health-Check Longue at Kasturba Medical College Hospital, Manipal, which is a tertiary care facility catering to patients from all over the state of Karnataka. A record-based case–control study was conducted among patients who visited an executive health check at the health check longue, Kasturba Hospital, Manipal, from April 2022 to April 2023. Executive health checks consisted of all routine blood tests, fasting lipid profiles, thyroid profiles, cardiac evaluations, abdominal ultrasound and chest X-rays. Adult patients more than 18 years of age who fulfilled the criteria for cases & controls were considered eligible. The sample size for the investigation was determined using the equation as follows.

$$n1 = \frac{(\sigma_1^2 + \sigma_2^2/\kappa)\,(Z_{1-\alpha/2} + Z_{1-\beta})^2}{\Delta^2}$$

$$n2 = \frac{(\kappa * \sigma_1^2 + \sigma_2^2)\,(Z_{1-\alpha/2} + Z_{1-\beta})^2}{\Delta^2}$$

wherein

n1 and n2 are the sample sizes of the two study groups.

σ_1 = Standard deviation of the case group

σ_2 = Standard deviation of the control group

Δ = Difference in group mean

$Z_{1-\alpha/2}$ – 1.96 (from the Z table) at a type 1 error of 5% (confidence level of 95%)

$Z_{1-\beta}$ – 1.64 (from Z table) at 95% power

$p_1 - p_2$ = Difference in the proportion of quality of life between the two groups

κ = ratio of n1/n2

The lipid profile values in the case and control groups were taken into consideration for calculation of the sample size. In earlier research conducted by Yadav et al [4], it was observed that the average triglyceride level in the cases was 161.85 (± 44.42) mg/dl, and that in the control group was 134.15 (± 16.88) mg/dl. Equal numbers of cases and controls were included in the sample size calculation for the study (κ = 1). At the 95% confidence level and 95% power of the study, 39 was determined to be the minimum sample size in each category. We included 50 cases and 150 controls, with a ratio of 1:3, in the present study. Adult patients with HbA1c levels > 6.5 mg/dl were included as cases. The controls were adult patients with HbA1c < 6.5 mg/dl. Cases and controls were selected randomly using a computer-generated random number table from the list of cases and controls available in the electronic medical records repository in the hospital, and group matching (± 5 years) of the cases and controls was performed. Lipid profile values were categorized according to ATP guidelines [13]. Thyroid hormone levels were classified in accordance with the United States Preventive Services Task Force Guidelines [14]. Following classifications were used as per the guidelines: TC (normal <200, borderline 200-240, high > 240), TG (low <60, normal 60-150, high > 150), LDL (optimal < 100, borderline 100-159, high ≥ 160), TC/HC (normal <5, high ≥ 5), T3 (low < 0.8, normal 0.8-2, high > 2), T4 (low < 5.5, normal 4.5-11.7, high > 11.7), and TSH (low < 0.3, normal 0.3-4.2, high > 4.2).

The gathered data were documented and fed into master excel data worksheet. To analyze and tabulate the data the Statistical Package for Social Sciences (SPSS) Version 24 was used. The presentation of categorical data consisted of numbers and percentages. Chi-square test was used for cross-tabulating data and measuring strength of association. The normality of distribution of variables was assessed using the Kolmogorov Smirnov test & the Shapiro wilk test. Quantitative variables were represented using mean and standard deviation (SD). They were analyzed using independent sample student t test if they followed parametric distribution and Mann-Whitney test if they followed non-parametric distribution. To ascertain relationships between different quantitative characteristics, Pearson and Spearman tests of correlation were employed. P value less than 0.05 was considered indicative of statistical significance.

3. Results

Fifty cases and 150 controls were recruited in our study. The cases had a mean ± SD age of 57.80 ± 10.71 years, whereas in the controls it was 48.47 ± 13.8 years. Among the cases everyone was married and among the controls, 137 (73.3%) were married, and the rest were unmarried. The mean ± SD and total cholesterol (mg/dl) among the cases and controls were 184.82 ± 48.28 and 195.67 ± 43.37, respectively.

Table 1 shows the mean differences in parameters such as blood sugars, lipid profiles and thyroid profiles among the cases and controls. The fasting blood sugar (FBS) depicted a difference of mean= -61.240 between cases & controls. The average rank for cases was 165.27, and for controls, it was 78.91, concerning postprandial blood sugar (PPBS), which was also statistically significant (p= 0.000). Regarding T4, the mean rank for controls was 94.20, and for cases, it was 117.28. The two groups depicted a statistically remarkable difference, indicated by a p value of 0.014.

Table 1. Mean differences in parameters between the patients and controls

Parameters	Case and Control	Mean difference/Mean Rank	P value
FBS#	Case	-61.240	0.000
	Control	-	-
PPBS$	Case	165.27	0.000
	Control	78.91	-
TC$	Case	91.01	0.181
	Control	103.66	-
TG#	Case	-23.393	0.057
	Control	-	-
HDL$	Case	93.63	0.332
	Control	102.79	-
LDL$	Case	91.10	0.185
	Control	103.63	-
TC/HDL$	Case	97.32	0.654
	Control	101.56	-
T3$	Case	106.71	0.341
	Control	97.75	-
T4$	Case	117.28	0.014
	Control	94.20	-
TSH#	Case	0.442	0.394
	Control	-	-

#Student t-test was conducted, $Mann Whitney test was conducted

The association between lipid profile, thyroid profile, blood sugar and glycated Hb is shown in Table 2. For cases, glycated hemoglobin (HbA1c), FBS and PPBS exhibited a robust positive correlation, indicating statistical significance. Additionally, in some cases, a moderately favorable association between T4 (thyroxine) and HbA1c (r = 0.211, p = 0.014) indicated a statistically meaningful association. With p value=0.000 and r values of 0.435 and 0.315, respectively, for the controls, FBS and PPBS showed a moderately favorable association with HbA1c.

Table 2. Correlations between lipid profiles, thyroid profiles, fasting blood sugar levels and glycated hemoglobin levels in patients and controls

Parameters	Cases		Controls	
	HbA1c		HbA1c	
	r value	p value	r value	p value
T3	0.004	0.980	-0.041	0.622
T4	0.211	0.014	0.017	0.833
TSH	-0.167	0.246	-0.065	0.437
TC	-0.006	0.969	0.003	0.971
TG	-0.082	0.571	0.158	0.054
HDL	0.066	0.648	0.049	0.551
LDL	0.008	0.959	-0.032	0.700
TC/HDL	-0.025	0.861	0.086	0.294
FBS	0.814	0.000	0.435	0.000
PPBS	0.821	0.000	0.315	0.000

Table 3 shows the associations between varying lipid profiles and thyroid profiles among the patients and controls. The distributions of controls and cases with low, normal, and high T4 levels were significantly different (p value of 0.015).

Table 3. Association of varying lipid profiles and thyroid profiles among patients and controls

Parameters		Cases frequency (%)	Controls frequency (%)	p value
TC	Normal	32	85	0.464
	Borderline	9	40	
	High	9	25	
TG	Low	0	12	0.119
	Normal	34	94	
	High	16	44	
LDL	Optimal	15	30	0.302
	Borderline	22	81	
	High	13	39	
TC/HDL	Normal	36	104	0.722
	High	14	46	
T3	Low	1	6	0.562
	Normal	49	141	
	High	0	2	
T4	Low	1	2	0.015
	Normal	45	146	
	High	4	1	
TSH	Low	0	0	0.452
	Normal	44	122	
	High	6	24	

4. Discussion

Our study could not elucidate a statistically remarkable difference in association between varying lipid profiles and thyroid profiles among the cases and controls except for the T4 level (p=0.015). Diabetes is a complicated disease with many facets. Metabolic dysregulation associated with diabetes mellitus causes secondary pathophysiologic changes in multiple organ systems and significantly increases mortality and morbidity as a result of microvascular and macrovascular issues. [15]. The relationship between glycated hemoglobin and one or several lipid parameters in individuals with T2DM has been shown in numerous research. HbA1c may also be used as a biomarker to identify T2DM patients who have abnormal lipid profiles and who are at risk of cardiovascular disease, according to certain research. [1,16–18].

With respect to the aforementioned findings in our research, a study carried out by Kumar S et al[19] depicted a statistically remarkable contrast in the proportion of study participants in the group of diabetic cases (HbA1c > 6.5) and prediabetic cases (HbA1c < 6.5), with deranged values of lipid profiles, wherein the proportions of people with higher levels of TC (> 200 mg/dl) among diabetic patients and prediabetic patients were 183 (31.8%) and 58 (24.4%), respectively (p=0.03); those with higher TG values (> 150 mg/dl) were 255 (44.3%) and 82 (34.5%), respectively (p=0.01); those with higher VLDL values (> 30 mg/dl) were 255 (44.3%) and 82 (34.5%), respectively (p=0.01); and those with higher LDL values (> 130 mg/dl) were 146 (25.3%) and 45 (18.9%), respectively.9%). These findings are important because high serum TG levels, low HDL levels, and high HDL levels are indicative of atherogenic dyslipidemia, as indicated by various studies [20]. Although glycated hemoglobin is used as an indicator of control of glycemic status and related problems of T2DM, some researchers have doubted whether there is any association between HbA1c and dyslipidemia [21–24]. In Vidarbha, India a study by Sarkar et al [25] found no association between the lipid profile and glycated hemoglobin. A smaller number of studies have demonstrated that, in comparison with type 2 diabetes mellitus and a HbA1C < 7.0 %, those with type 2 diabetes mellitus with a HbA1C level of at least 7.0% have a significant increase in TC and LDL levels but no appreciable changes in TG or HDL values [26].

The mean rank of T4 readings differed significantly between the cases and controls in the present investigation (p=0.014). Furthermore, a modest +ve correlation between T4 and glycosylated hemoglobin was found among cases in our study with a p value of 0.014. The findings of a research carried out in Riyadh by Karar T et al [27] showed a non-significant association alongside thyroxin T4 (r=-0.018, p=0.855) and a slight positive correlation between HbA1C and TSH (r=0.212, p=0.034). Previous research indicated that patients with diabetes mellitus

didn't change free T4 levels, leading researchers to hypothesize that medication might have had an effect on TSH, T3 and T4 [28]. HbA1c & TSH were found to be significantly correlated in the research carried out by Udiong et al [29]. Above findings suggest that thyroid hormone levels, particularly T4, are correlated with glycemic status and can serve as an important prognostic marker.

The case–control design, thorough evaluation of metabolic markers, focuses on an understudied population, sufficient sample size, and age-matched controls are few of our study's strengths. These findings support the validity and applicability of our findings. However, this study has several limitations. The lack of information on lifestyle factors, the duration of diabetes, or treatment regimens may have an impact on how our results are interpreted. Furthermore, our research did not take into consideration any potential confounding factors other than age. Finally, the dynamic nature of these metabolic metrics may not be fully captured by our dependence on single time-point observations. Despite these limitations, our research offers important new insights into the connections among lipid profiles, thyroid function, and glycemic control in our target population. These intricate relationships may be further clarified by longer-term research that overcomes these constraints.

5. Conclusions

In summary, the results point to a possible relationship between thyroid hormone T4 levels and glycemic status in diabetes patients, even though no remarkable relationship was observed between glycemic control and profile of various lipid parameters in this study population. To validate and elucidate this link of association, more research with bigger sample numbers may be desirable. The overall findings of this study support the necessity of tracking thyroid function in addition to glycemic indicators in the holistic and evidence-based management of T2DM patients.

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Data Availability Statement

Data pertaining to the study can be obtained by sending appropriate requests to the corresponding author.

Ethical Clearance Statement

The Ethics regulatory committee of KMC, Manipal and KH Hospital, Manipal provided ethical approval for the current study (letter no: IEC2: 457/2023 dated July 14, 2023)

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Conflict of Interest

Nil

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