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Investigating lipid and glucose profiles in type 2 diabetes mellitus: Evidence from a cross-sectional study in North Sulawesi, Indonesia

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Abstract

Type 2 Diabetes Mellitus (T2DM) is a chronic metabolic disorder often accompanied by dyslipidemia, a condition that exacerbates cardiovascular risks. Despite extensive research, the relationship between total cholesterol levels and fasting blood sugar levels remains unclear, particularly in underrepresented populations. This study investigates the correlation between total cholesterol and fasting blood sugar levels in T2DM patients treated at ODSK Hospital, North Sulawesi, Indonesia. A cross-sectional observational study was conducted using secondary data from the medical records of 65 T2DM patients between April 2022 and July 2024. Total cholesterol and fasting blood sugar levels were classified according to established clinical guidelines. The Spearman-Rank correlation test assessed the relationship between the variables. Among the patients, 52.3% were female, and 33.8% were aged 65–74 years. Approximately 47.7% had normal cholesterol levels, while 81.5% exhibited fasting blood sugar levels ≥126 mg/dL. Statistical analysis revealed no significant correlation between total cholesterol and fasting blood sugar levels ($r = -0.129$, $\rho = 0.307$). The findings suggest independent regulation of lipid and glucose metabolism in T2DM patients. These results emphasize the need for individualized management strategies targeting both dyslipidemia and hyperglycemia as separate clinical priorities. Future research should explore larger populations and additional metabolic markers to further elucidate these complex interactions.

Keywords: Type 2 diabetes mellitus (T2DM); Total cholesterol; Dasting blood sugar; Diabetes Management

1. Introduction

Type 2 Diabetes Mellitus (T2DM) is a chronic metabolic disorder characterized by persistent hyperglycaemia due to impaired insulin action, secretion, or both [1–3]. Beyond its defining dysregulation of glucose metabolism, T2DM frequently coexists with dyslipidaemia, a condition marked by abnormal lipid levels, including elevated total cholesterol [4, 5]. Dyslipidaemia and hyperglycaemia are significant risk factors for cardiovascular disease (CVD), the leading cause of morbidity and mortality among T2DM patients [6, 7]. Thus, understanding the interplay between total cholesterol and fasting blood sugar levels holds critical implications for improving patient outcomes.

Extensive research has examined the interconnection between lipid and glucose metabolism, often identifying insulin resistance as a common foundational mechanism [8–10]. Insulin resistance can impair lipid metabolism, leading to elevated levels of low-density lipoprotein cholesterol (LDL-C) and total cholesterol[11]. Conversely, poorly managed lipid profiles may exacerbate insulin resistance, compounding glycemic dysregulation [1, 12]. While some studies have reported a positive correlation between total cholesterol and fasting blood sugar levels in T2DM [13–15], others have found no significant association [16–19], highlighting a gap in the literature and the need for further investigation in diverse populations and clinical settings.

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This study explores the relationship between total cholesterol and fasting blood sugar levels in T2DM patients treated at ODSK Hospital, North Sulawesi Province, Indonesia. By focusing on a specific population, this research seeks to contribute nuanced insights to the broader discourse on lipid-glucose interplay in diabetes management. The study leverages retrospective data and employs statistical analyses to clarify whether these parameters are interrelated or operate independently in this context. The findings aim to address existing gaps in the literature and inform targeted interventions to mitigate the dual burden of dyslipidaemia and hyperglycemia.

1.1. Research Objectives and Significance

The primary objective of this study is to assess the correlation between total cholesterol levels and fasting blood sugar levels in T2DM patients. This research is significant because it examines a clinically relevant issue that could enhance the understanding of metabolic regulation in diabetes. Identifying potential associations, or lack thereof, provides a foundation for improving personalized treatment approaches and public health strategies aimed at reducing cardiovascular risk in T2DM populations.

2. Material And Method

This study employed a quantitative observational analytic research design with a cross-sectional approach to investigate the relationship between total cholesterol levels and fasting blood sugar levels in patients with Type 2 Diabetes Mellitus (T2DM). Data were collected retrospectively using secondary sources, specifically medical records of outpatients and inpatients diagnosed with T2DM at ODSK Hospital, North Sulawesi Province. The study period spanned from April 2022 to July 2024.

2.1. Population and Sampling

The study population consisted of T2DM patients aged 19 years or older who had undertaken laboratory tests for total cholesterol and fasting blood sugar levels. The total sampling technique was used, resulting in 65 patients who met the inclusion criteria. Inclusion criteria required participants to have a confirmed diagnosis of T2DM, aged ≥19 years, and have recorded laboratory results for the two primary variables of interest. Exclusion criteria were not specified, which may limit the ability to control for confounding factors such as comorbidities or medication use.

2.2. Data Collection

The medical records reviewed included demographic data (e.g., age and gender), total cholesterol levels, and fasting blood sugar levels. Total cholesterol levels were categorized based on guidelines from the National Cholesterol Education Program (NCEP ATP III) and the Indonesian Endocrinology Association (PERKENI) [20, 21]. Fasting blood sugar levels were classified according to the 2021 PERKENI criteria [22].

2.3. Data Analysis

The Kolmogorov-Smirnov test was initially employed to assess the normality of the data, as it is a well-established method for determining whether a dataset follows a normal distribution [23]. This test was particularly relevant given that clinical variables in this study, such as fasting blood sugar and total cholesterol levels, frequently exhibit skewed distributions, often clustering in abnormal ranges—a pattern commonly observed in T2DM populations [24]. Moreover, factors such as the small sample size (n = 65) and population heterogeneity (e.g., differences in disease severity, medication use, and lifestyle factors) further increased the likelihood of deviations from normality, underscoring the necessity of this evaluation [25].

Upon confirming a non-normal distribution through the Kolmogorov-Smirnov test, the Spearman rank correlation test was applied. This non-parametric test was selected due to its robustness in analyzing non-normally distributed data and its appropriateness for ordinal variables [26]. Schober & Schwarte [2018] emphasized that this test measures associations without assuming linearity or homogeneity of variances. Therefore, it was well-suited for analyzing the relationship between total cholesterol and fasting blood sugar levels in this study. All statistical analyses were performed using SPSS software version 29.

2.4. Ethical Approval

This study was conducted following ethical principles of WHO 2011 standards and was approved by the Ethics Committee of Manado Health Polytechnic Ministry of Health, with approval reference number KEPK.01/12/502/2024. Due to the retrospective nature of the research, which involved the use of secondary data from medical records of patients already diagnosed with type 2 diabetes mellitus at ODSK Hospital, the need for informed consent was waived

by the ethics committee. All patient data were anonymized and handled confidentially to ensure privacy and compliance with ethical standards.

3. Results And Discussions

3.1. Sample Characteristics

The study analyzed 65 patients diagnosed with Type 2 Diabetes Mellitus (T2DM) at ODSK Hospital, North Sulawesi Province. The gender distribution revealed a slightly higher proportion of female patients (52.3%, n = 34) compared to male patients (47.7%, n = 31) (Table 1). Regarding age, the majority of patients were in the 65–74 years age group (33.8%, n = 22), with the smallest representation in the 19–24 years age group (1.5%, n = 1) (Table 2). This distribution aligns with the increasing prevalence of T2DM in older populations, as indicated by previous studies [4, 28].

Table 1 Sample Distribution by Gender

Gender	Frequency (n)	Percentage (%)
Male	31	47.7
Female	34	52.3

Table 2 Sample Distribution by Age

Age Group (years)	Frequency (n)	Percentage (%)
19–24	1	1.5
25–34	0	0
35–44	6	9.2
45–54	13	20.0
55–64	17	26.2
65–74	22	33.8
≥ 75	6	9.2

3.2. Total Cholesterol Levels

The classification of total cholesterol levels, based on the National Cholesterol Education Program (NCEP ATP III) guidelines, showed that 47.7% of patients (n = 31) had normal cholesterol levels, 29.2% (n = 19) had borderline levels, and 23.1% (n = 15) had high cholesterol levels (Table 3). These results indicate that nearly half of the sampled T2DM patients did not exhibit elevated total cholesterol levels, a finding consistent with previous studies linking lipid imbalances to variable risk factors.

Table 3 Distribution of Samples Based on Total Cholesterol Levels

Cholesterol Category	Frequency (n)	Percentage (%)
Normal	31	47.7
Borderline	19	29.2
High	15	23.1

3.3. Fasting Blood Sugar Levels

Fasting blood sugar levels were categorized using the PERKENI 2021 criteria. The majority of patients (81.5%, n = 53) exhibited fasting blood sugar levels ≥126 mg/dL, indicating uncontrolled blood glucose levels. Only 18.5% (n = 12) of the patients had fasting blood sugar levels within the normal range (<126 mg/dL) (Table 4). This result highlights the prevalence of poorly managed glycemic control among T2DM patients in this population.

Table 4 Distribution of Samples Based on Fasting Blood Sugar Levels

Fasting Blood Sugar (mg/dL)	Frequency (n)	Percentage (%)
<126	12	18.5
≥126	53	81.5

3.4. Correlation Analysis

The Kolmogorov-Smirnov normality test revealed that the data were not normally distributed (Table 5). Consequently, the Spearman-Rank correlation test was applied to assess the relationship between total cholesterol levels and fasting blood sugar levels. The analysis yielded a correlation coefficient (r) of -0.129 with a significance value (ρ) of 0.307 (ρ > 0.05) (Table 5). This indicates that there is no statistically significant relationship between total cholesterol levels and fasting blood sugar levels in the study population.

Table 5 Kolmogorov-Smirnov Normality Test Results

Parameter	Value
Sample Size (N)	65
Mean	0.0000000
Standard Deviation	91.72625587
Most Extreme Differences	
- Absolute	0.156
- Positive	0.156
- Negative	-0.103
Test Statistic (D)	0.156
Asymptotic Significance (2-tailed)	<0.001
Monte Carlo Significance (2-tailed)	<0.001
99% Confidence Interval (Monte Carlo)	0.000 - 0.001

*With Lilliefors Significance Correction †Based on 10,000 Monte Carlo samples with starting seed 2000000

Note: Results indicate significant deviation from normality (p < .001)

Table 6 Correlation Analysis Between Total Cholesterol and Fasting Blood Sugar

Variable	n	Correlation Coefficient (r)	Significance (ρ)
Total Cholesterol and Fasting Blood Sugar	65	-0.129	0.307

The weak negative correlation coefficient (-0.129) suggests that total cholesterol levels and fasting blood sugar levels are minimally related in this sample. This may indicate that these variables operate through independent physiological mechanisms or are influenced by unmeasured confounding factors, such as dietary habits, medication use, or genetic predispositions. The absence of a significant relationship aligns with some prior studies but contrasts with others that have reported positive correlations, warranting further investigation.

3.5. Overview of Key Findings

This study investigated the relationship between total cholesterol levels and fasting blood sugar levels in T2DM patients at ODSK Hospital, North Sulawesi Province. Female patients were slightly more represented in the sample, and the majority of patients were aged 65–74 years, reflecting the higher prevalence of T2DM among older adults and women in similar populations. Nearly half of the patients maintained normal cholesterol levels, yet a significant proportion exhibited uncontrolled fasting blood sugar levels, highlighting the challenge of managing hyperglycemia in this population. Importantly, no significant correlation was found between total cholesterol levels and fasting blood sugar

levels, suggesting that lipid and glucose metabolism may operate independently in this sample. These findings provide valuable insights into the demographic and metabolic profiles of T2DM patients and underscore the need for individualized clinical management strategies. Additionally, they highlight opportunities for public health interventions targeting the dual burden of hyperglycemia and dyslipidemia through routine screening and tailored lifestyle programs.

3.6. Comparison with Existing Literature

The absence of a significant relationship between total cholesterol and fasting blood sugar levels aligns with some studies that have also found no association between these parameters in T2DM populations [17–19]. For instance, Saptaningtyas et al. [2022] reported similar findings, indicating that lipid and glucose metabolism may not be directly linked. In contrast, other studies have observed positive correlations, particularly in populations with a higher prevalence of diabetic dyslipidemia [13–15]. This variation indicates that differences in population characteristics, research methodologies, or sample sizes may influence outcomes. By focusing on an underrepresented population in North Sulawesi, this study contributes valuable regional data, highlighting the role of population-specific factors such as genetic predispositions, dietary patterns, and healthcare access in shaping metabolic relationships.

3.7. Mechanistic Interpretation

The observed lack of correlation between total cholesterol and fasting blood sugar levels may reflect the independent regulation of these parameters. Insulin resistance, a common feature of T2DM, affects both glucose and lipid metabolism; however, additional factors such as diet, physical activity, medication use, or genetic variability may mediate their interactions. Differences in individual responses to lifestyle interventions or pharmacological treatments may also contribute to this independence, underscoring the complexity of metabolic regulation in T2DM.

4. Practical Implications and Recommendations for Clinical Practice

The findings highlight the importance of individualized management for T2DM patients. Clinicians should monitor lipid and glucose parameters independently and adopt dual-targeted interventions to address specific metabolic imbalances. Lipid management may involve statins or dietary changes targeting cholesterol subfractions, while glycemic control could focus on insulin therapy or glucose-lowering medications tailored to patient needs. Routine and detailed monitoring of both lipid and glucose profiles should become standard practice to mitigate long-term cardiovascular risks.

Furthermore, the results dispel assumptions that improvements in one parameter will naturally influence the other, emphasizing the need to treat dyslipidemia and hyperglycemia as separate clinical priorities. Such individualized care ensures comprehensive management of the dual burden of T2DM, ultimately improving patient outcomes.

4.1. Public Health Implications

Public health initiatives can play a crucial role in complementing clinical efforts to address dyslipidemia and hyperglycemia. Early detection programs, including routine screening for fasting blood sugar and lipid profiles, enable timely interventions. Lifestyle modification programs promoting balanced diets, regular physical activity, and smoking cessation can help address modifiable risk factors. Culturally tailored interventions and digital health tools, such as mobile applications and wearable devices, can enhance patient engagement and adherence. Educating patients about the independent management of dyslipidemia and hyperglycemia empowers them to take an active role in preventing complications and improving their quality of life. These strategies collectively support the broader goal of reducing the burden of T2DM and associated complications.

4.2. Study Limitations and Future Directions

This study has several limitations. The reliance on secondary medical records may introduce inaccuracies or biases due to incomplete or inconsistent data. The relatively small sample size (n = 65) limits the generalizability of the findings to other populations. Additionally, the absence of data on confounding variables, such as dietary habits, medication use, or comorbidities, restricts the ability to explore factors influencing the relationship between total cholesterol and fasting blood sugar levels.

Future studies should address these limitations by incorporating larger, more diverse populations and collecting primary data with detailed information on lifestyle and treatment variables. Longitudinal studies could also provide a more comprehensive understanding of the dynamic interactions between lipid and glucose metabolism over time. Further research into advanced diagnostic markers, such as LDL-C or glycemic variability, could offer deeper insights into the complex regulation of these parameters in T2DM patients.

5. Conclusion

This study highlights the independent regulation of total cholesterol and fasting blood sugar levels in T2DM patients, as evidenced by the absence of a significant correlation between these parameters. This finding underscores the importance of individualized management in diabetes care, where dyslipidemia and hyperglycemia should be addressed as separate clinical priorities. Routine and detailed monitoring of both parameters is essential to mitigate the risk of long-term complications, particularly cardiovascular disease.

Additionally, the study emphasizes the role of public health initiatives in reducing the dual burden of hyperglycemia and dyslipidemia through early detection and lifestyle modification. Programs that promote routine screening, balanced diets, physical activity, and culturally tailored interventions can enhance patient engagement and improve outcomes.

By focusing on an underrepresented population in North Sulawesi, this study adds valuable insights to the global body of diabetes research, highlighting the need to consider regional and population-specific factors in T2DM management. However, limitations such as the small sample size and the reliance on secondary data warrant further investigation. Future research should explore larger and more diverse populations, incorporate advanced diagnostic markers like LDL-C and glycemic variability, and adopt longitudinal designs to better understand the dynamic interplay between lipid and glucose metabolism.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare no conflict of interest regarding the publication of this study. All funding sources, if any, were independent of the research objectives, and no external parties influenced the design, data collection, analysis, or interpretation of the results.

Statement of ethical approval

This study followed the WHO ethical principles established in 2011 and received ethical approval from the Ethics Committee of the Health Polytechnic of the Ministry of Health Manado, with the approval reference number KEPK.01/12/502/2024. This process confirmed that the study adhered to ethical guidelines for medical research involving patient data.

Statement of informed consent

This study was retrospective and used secondary data from patients' medical records at ODSK Hospital; the ethics committee did not require informed consent. Furthermore, patient data was anonymized and handled confidentially to protect privacy and ensure compliance with ethical standards.

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