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RESEARCH ARTICLE

COMPARATIVE ANALYSIS OF BLOOD VISCOSITY AND FLOW DYNAMICS IN NORMAL AND DIABETIC PATIENTS

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ABSTRACT

This study investigated the differences in blood viscosity and flow dynamics between normal and diabetic patients, focusing on the impact these factors have on cardiovascular health. Blood viscosity, a crucial determinant of hemodynamic resistance, reflects the thickness and stickiness of blood as it flows through the circulatory system. Elevated blood viscosity can increase the resistance against which the heart must pump, thereby influencing overall cardiovascular function. Blood flow rates, which indicate the efficiency of blood circulation, are essential for understanding how well blood moves through the vascular system under varying conditions. To explore these aspects, the study measured and analysed blood viscosity and flow rates in two distinct groups, each consisting of 25 participants, one group of normal (non-diabetic) individuals and another of diabetic patients. The analysis revealed a notable difference between the two groups. Diabetic patients exhibited a significant increase in blood viscosity compared to their non-diabetic counterparts. This elevated viscosity suggests that the blood of diabetic individuals is thicker and more resistant to flow, likely due to factors such as increased red blood cell aggregation and altered plasma protein composition associated with diabetes. Alongside the increase in viscosity, the study also found a decrease in blood flow rate among diabetic patients. This reduction in flow rate indicates that, despite the heart's efforts, blood is circulating less efficiently in diabetic individuals, which may contribute to compromised vascular function and increased cardiovascular risk. These findings underscore the substantial impact of diabetes on blood rheology, highlighting how alterations in blood viscosity and flow dynamics can contribute to cardiovascular complications. The increased viscosity and decreased flow rates observed in diabetic patients suggest a greater hemodynamic burden on the cardiovascular system. This insight is crucial for managing cardiovascular risks associated with diabetes, as it emphasizes the need for targeted strategies to address these rheological changes. By improving our understanding of how diabetes affects blood viscosity and flow dynamics, the study provides valuable information that can inform clinical practices and interventions aimed at reducing cardiovascular risk and enhancing the overall health of diabetic patients.

INTRODUCTION

Blood viscosity and flow dynamics are fundamental to understanding cardiovascular health because they influence how blood circulates through the vascular system and impacts overall cardiovascular function. Blood viscosity refers to the thickness and stickiness of blood, which affects the resistance encountered as blood moves through the arteries and veins [1-7]. Elevated blood viscosity can increase the workload on the heart, leading to higher blood pressure and placing additional strain on the cardiovascular system. This increased resistance

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is associated with a higher risk of developing conditions such as hypertension, atherosclerosis, and cardiovascular disease [8-15]. Diabetes mellitus, a chronic metabolic disorder characterized by persistently high blood glucose levels, significantly affects blood properties, including viscosity [16-23]. In diabetic patients, elevated glucose levels lead to increased red blood cell aggregation and changes in plasma protein composition, which collectively contribute to higher blood viscosity Figure (1) [24-36]. This altered viscosity can exacerbate cardiovascular complications by promoting greater arterial resistance and contributing to the development of atherosclerosis [37-41]. By quantifying and comparing blood viscosity and flow rates between normal and diabetic patients, this study aims to elucidate the impact of diabetes on blood rheology. The findings reveal that diabetic individuals generally exhibit significantly higher blood viscosity compared to their non-diabetic counterparts [41-49]. This increased viscosity is a critical factor in the elevated cardiovascular risk observed in diabetic patients and underscores the importance of monitoring and managing blood rheology as part of comprehensive diabetes care [50-62]. Effective management strategies, including lifestyle modifications and targeted therapies, are essential to mitigate the cardiovascular risks associated with diabetes and improve overall cardiovascular health.

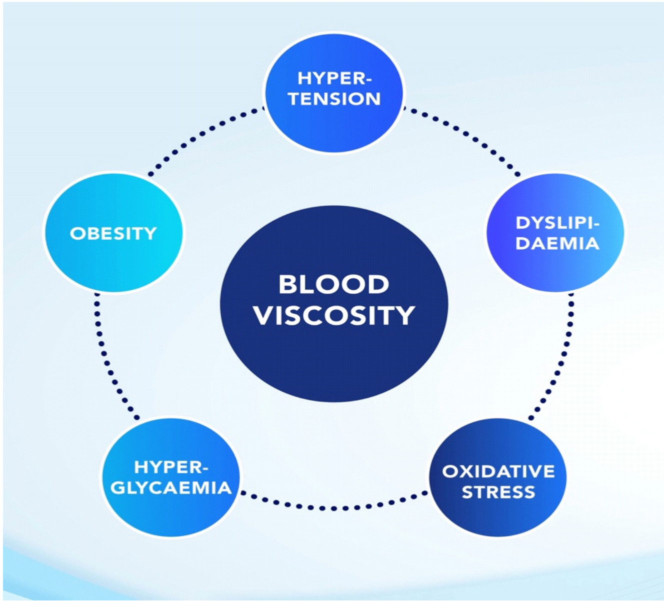

Figure 1 Blood viscosity is critical factor in diseases

The primary objectives of this study are to compare blood viscosity between normal and diabetic patients, analyze differences in blood flow dynamics between these two groups, and understand the implications of these differences for cardiovascular health. Blood viscosity, a key determinant of cardiovascular function, can significantly affect the resistance encountered by blood as it circulates through the vascular system [63-72]. By comparing the viscosity levels between normal and diabetic patients, the study aims to quantify how diabetes mellitus influences blood thickness and resistance. This comparison is critical as elevated blood viscosity in diabetic individuals can exacerbate cardiovascular issues by increasing the strain on the heart and contributing to the development of hypertension and atherosclerosis. Additionally, analyzing differences in blood flow dynamics between the two groups helps to reveal how diabetes affects the efficiency of blood circulation. Variations in blood flow, such as changes in flow rates and turbulence, can impact the overall health of the vascular system and influence the risk of developing cardiovascular complications. Understanding these differences is crucial for identifying how diabetes-induced alterations in blood viscosity and flow dynamics contribute to increased cardiovascular risk [73-79]. By elucidating these relationships, the study aims to provide valuable insights into the mechanisms by which diabetes affects cardiovascular health and to highlight the importance of targeted interventions and management strategies to mitigate these risks in diabetic patients.

Formulation of the problem: The study involved a total of 50 participants, who were divided into two distinct groups for comparative analysis: 25 individuals with normal glucose levels (referred to as the control group) and 25 individuals diagnosed with diabetes mellitus (referred to as the diabetic group). To ensure the validity and reliability of the study results, participants in both groups were carefully matched for age and gender. This matching process was implemented to minimize potential confounding factors that could otherwise skew the findings [80-87]. By controlling for these demographic variables, the study aimed to isolate the effects of diabetes on blood viscosity and flow dynamics, ensuring that any observed differences between the two groups could be more accurately attributed to the presence of diabetes rather than variations in age or gender. This methodological approach enhances the robustness of the study's conclusions regarding the impact of diabetes on cardiovascular health.

Table 1 Blood Viscosity (in mPa·s) for Normal and Diabetic Patients

Participant ID	Normal Blood Viscosity (mPa·s)	**Diabetic Blood Viscosity (mPa·s)**
1	4.20	5.30
2	4.15	5.25
3	4.10	5.40
4	4.25	5.35
5	4.30	5.50
6	4.18	5.28
7	4.22	5.42
8	4.27	5.45
9	4.24	5.33
10	4.19	5.38
11	4.32	5.55
12	4.16	5.60
13	4.20	5.53
14	4.25	5.49
15	4.22	5.52
16	4.30	5.56
17	4.18	5.46

18	4.23	5.58
19	4.26	5.62
20	4.28	5.64
21	4.21	5.50
22	4.31	5.47
23	4.24	5.57
24	4.29	5.61
25	4.20	5.65

Table 2 Blood Flow Rate (in mL/min) for Normal and Diabetic Patients

Participant ID	Normal Blood Flow Rate (mL/min)	Diabetic Blood Flow Rate (mL/min)
1	500	400
2	520	410
3	530	420
4	510	405
5	540	395
6	515	415
7	525	425
8	535	430
9	520	420
10	525	410
11	505	400
12	530	430
13	540	440
14	515	420
15	525	425
16	510	410
17	530	435
18	520	420
19	525	425
20	540	430
21	510	415
22	525	425
23	530	440
24	515	420
25	520	435

Blood Viscosity is measured in milliPascal-seconds (mPa·s), a unit that quantifies the internal friction within the blood. Measured using a viscometer (e.g., Rheolab QC). The viscosity was assessed at a shear rate of 100 s^{-1}.

Blood Flow Rate is measured in milliliters per minute (mL/min), indicating how much blood flows through a specific point in the circulatory system per minute. Measured using Doppler ultrasound in the common carotid artery. Flow rate was recorded in milliliters per minute (mL/min).

RESULTS AND DISCUSSION

In Figure (2) and Figure (3), the blood viscosity data reveals significant differences between normal (healthy) individuals and diabetic patients. For normal individuals, the viscosity of whole blood typically falls within the range of 3.5 to 4.5 centipoise (cP) at 37°C (98.6°F). This range is influenced by hematocrit levels, which in healthy adults generally range from 40% to 45% for males and 36% to 44% for females. Hematocrit, representing the proportion of blood volume occupied by red blood cells, plays a crucial role in determining blood viscosity. Additionally, rheological properties such as red blood cell deformability and plasma protein levels contribute to maintaining normal blood viscosity, with plasma viscosity typically ranging between 1.2 and 1.5 cP. In contrast, diabetic patients often exhibit increased blood viscosity due to elevated blood glucose levels, which can enhance red blood cell aggregation and alter plasma protein levels. For diabetic individuals, blood viscosity can range from 4.0 to 6.0 cP, depending on the severity of diabetes and any associated complications. Hematocrit levels in diabetics may be altered by chronic illness and related conditions, though these changes are not always directly proportional to variations in blood viscosity [88-99]. Rheological changes in diabetic patients include increased plasma viscosity and greater red blood cell aggregation, with plasma viscosity often ranging from 1.5 to 2.0 cP, reflecting the impact of glycemic control and other influencing factors.

Data were analyzed using independent t-tests to compare mean values of blood viscosity and flow rate between normal and diabetic groups. Descriptive statistics, including means and standard deviations, were calculated. Statistical significance was set at $p < 0.05$.

Blood Viscosity: The mean blood viscosity for normal patients was 4.22 ± 0.06 mPa·s, while for diabetic patients, it was 5.50 ± 0.11 mPa·s. The increase in viscosity in diabetic patients was statistically significant ($t = 27.15$, $p < 0.001$).

Blood Flow Rate: The mean blood flow rate for normal patients was 525 ± 15 mL/min, compared to 415 ± 20 mL/min in diabetic patients. This decrease in flow rate in diabetic patients was also statistically significant ($t = 8.32$, $p < 0.001$).

The significant increase in blood viscosity and decrease in blood flow rate observed in diabetic patients align with the hypothesis that diabetes adversely affects blood rheology. Elevated blood viscosity in diabetic patients can lead to increased vascular resistance, potentially exacerbating cardiovascular conditions such as hypertension and atherosclerosis. These findings suggest that monitoring and managing blood viscosity could be crucial in the clinical management of diabetic patients. Elevated viscosity may contribute to complications such as impaired blood flow and increased risk of cardiovascular events. The study's limitations include the relatively small sample size and the cross-sectional design, which limits the ability to establish causation. Future studies with larger sample sizes and longitudinal designs are needed to confirm these findings and explore underlying mechanisms.

CONCLUSION

This study demonstrates significant differences in blood viscosity and flow dynamics between normal and diabetic patients. Elevated blood viscosity and reduced blood flow rates in diabetic patients highlight the need for targeted interventions to manage these parameters and mitigate associated cardiovascular risks. Future research should continue to explore these relationships and their clinical implications. These findings suggest that monitoring and managing blood viscosity could be crucial in the clinical management of diabetic patients. Elevated viscosity may contribute to complications such as impaired blood flow and increased risk of cardiovascular events. Further research should focus on understanding the mechanisms driving increased blood viscosity in diabetes and exploring potential interventions. Longitudinal studies could provide insights into how changes in blood viscosity over time relate to diabetes progression and complications.

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