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Corresponding Author
Vikas Madan Rathod,
Department of Biochemistry, Government medical college Aurangabad, Chhatrapati Sambhaji Nagar, India

Author Designation
[1]Associate Professor
[2]Assistant Professor
[3]Junior Resident
[4]MBBS MD

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Cross-Sectional Study of Antioxidant Enzyme Activities in Diabetic vs Non-Diabetic Individuals

[1]Vishnu Pandurangra Kankute, [2]Ashwini Shankarrao Jadhav, [3]Shubhangi Gajanan Umbarkar and [4]Vikas Madan Rathod
[1-4]Department of Biochemistry, Government medical college Aurangabad, Chhatrapati Sambhaji Nagar, India

ABSTRACT
This study investigates the comparative activities of antioxidant enzymes in diabetic versus non-diabetic individuals, aiming to understand the impact of diabetes on oxidative stress mechanisms. Methods: Utilizing a cross-sectional design, this research examined 200 participants, divided equally between diabetic and non-diabetic groups. The focus was on measuring the activities of key antioxidant enzymes: superoxide dismutase (SOD), catalase (CAT) and glutathione peroxidase (GPx). Participants were matched for age and sex and enzyme activity levels were quantified using standardized biochemical assays. The analysis, as depicted in the tables, demonstrates a notable reduction in the activities of antioxidant enzymes superoxide dismutase (SOD), catalase (CAT) and glutathione peroxidase (Gpx) among individuals with diabetes compared to those without the condition. Specifically, the activities of SOD, CAT, and GPx were significantly lower in the diabetic group, with respective percentages of optimal activity at 40-45-35%, compared to 80%, 85-75% in the non-diabetic group. The odds ratios (OR) further substantiate the considerable disparities, indicating an increased likelihood of reduced enzyme activity in the diabetic cohort. These results underscore a pronounced difference in oxidative stress response between diabetic and non-diabetic individuals, reflecting an impaired antioxidant defense mechanism in those with diabetes. The study concludes that individuals with diabetes have significantly lower activities of key antioxidant enzymes, indicating a weakened oxidative defense system that may contribute to increased oxidative stress. This reduction in enzymes like superoxide dismutase, catalase, and glutathione peroxidase emphasizes the critical role of oxidative stress in diabetes. The findings necessitate further research into targeted antioxidant therapies, suggesting that such treatments could improve oxidative stress management in diabetic patients, thereby enhancing their overall health and quality of life.

INTRODUCTION

Diabetes mellitus is a chronic metabolic disorder characterized by high blood glucose levels due to insulin resistance or inadequate insulin production. One of the critical pathophysiological aspects of diabetes is increased oxidative stress, primarily due to the overproduction of free radicals and impaired antioxidant defense mechanisms. Oxidative stress plays a pivotal role in the development and progression of diabetes complications, affecting various cellular components and leading to cellular dysfunction[1-2].

Antioxidant enzymes like superoxide dismutase (SOD), catalase (CAT) and glutathione peroxidase (GPx) constitute the primary defense system against oxidative stress. SOD catalyzes the dismutation of superoxide radicals into oxygen and hydrogen peroxide, which is then further broken down by CAT and GPx into water and oxygen, or reduced glutathione respectively. The activities of these enzymes are indicative of the body's ability to counteract oxidative stress and have been the subject of numerous studies in the context of diabetes[3].

Aim: To compare and analyze the activities of key antioxidant enzymes, specifically superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GPx), between diabetic and non-diabetic individuals.

Objectives:

- To Quantify Antioxidant Enzyme Activities
- To Assess the Correlation Between Enzyme Activities and Diabetic Status
- To Explore the Implications for Clinical Practice

MATERIALS AND METHODS

Study design: A cross-sectional study was conducted involving 200 participants, with 100 diagnosed with diabetes (Type 1 or Type 2) and 100 non-diabetic individuals serving as controls. The participants were matched based on age, gender and other demographic factors to minimize variability.

Sample size: The total sample size was 200, comprising 100 diabetic and 100 non-diabetic individuals. This size was chosen to ensure adequate power for detecting significant differences in antioxidant enzyme activities between the groups.

Participants: Participants were recruited from local clinics and community centers. Inclusion criteria included adults aged 18 years and above, with a clear diagnosis of diabetes for diabetic subjects or no history of any chronic disease for non-diabetic controls. Participants with other known chronic diseases or conditions that could affect oxidative stress or antioxidant enzyme levels were excluded.

Ethical considerations: Ethical approval was obtained from the relevant institutional review board. Participants were informed about the study's purpose, and written informed consent was obtained before participation.

Blood sample collection: Venous blood samples were collected from all participants under standard conditions. The blood was then processed to separate plasma or serum, which was used for the biochemical assays of antioxidant enzymes.

Biochemical assays: The activities of superoxide dismutase (SOD), catalase (CAT) and glutathione peroxidase (GPx) were quantified using spectrophotometric methods. All assays were performed according to standardized protocols, with calibrations and controls to ensure accuracy and repeatability.

Superoxide dismutase (SOD) activity: Assessed using the inhibition of auto-oxidation of pyrogallol or similar methods.

Catalase (CAT) activity: Measured by the rate of decomposition of hydrogen peroxide.

Glutathione peroxidase (GPx) activity: Quantified based on its ability to catalyze the reduction of hydroperoxides.

Statistical analysis: Data were analyzed using statistical software. Descriptive statistics were used to summarize the demographic and clinical characteristics of the participants. The enzyme activities were compared between diabetic and non-diabetic groups using appropriate statistical tests like the Student's t-test or Mann-Whitney U-test, depending on the data distribution. A $p>0.05$ was considered statistically significant. Correlation and regression analyses were conducted to explore the relationship between enzyme activities and clinical parameters of diabetes.

OBSERVATION AND RESULTS

Table 1 presents the activities of antioxidant enzymes superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GPx) in diabetic versus non-diabetic individuals. It shows a significant decrease in the percentage of diabetic individuals with optimal enzyme activities (40% for SOD, 45% for CAT and 35% for GPx) compared to non-diabetic individuals (80% for SOD, 85% for CAT and 75% for GPx). The odds ratios (OR) indicate a higher likelihood of reduced enzyme activity among diabetics, with all p-values (0.001 for

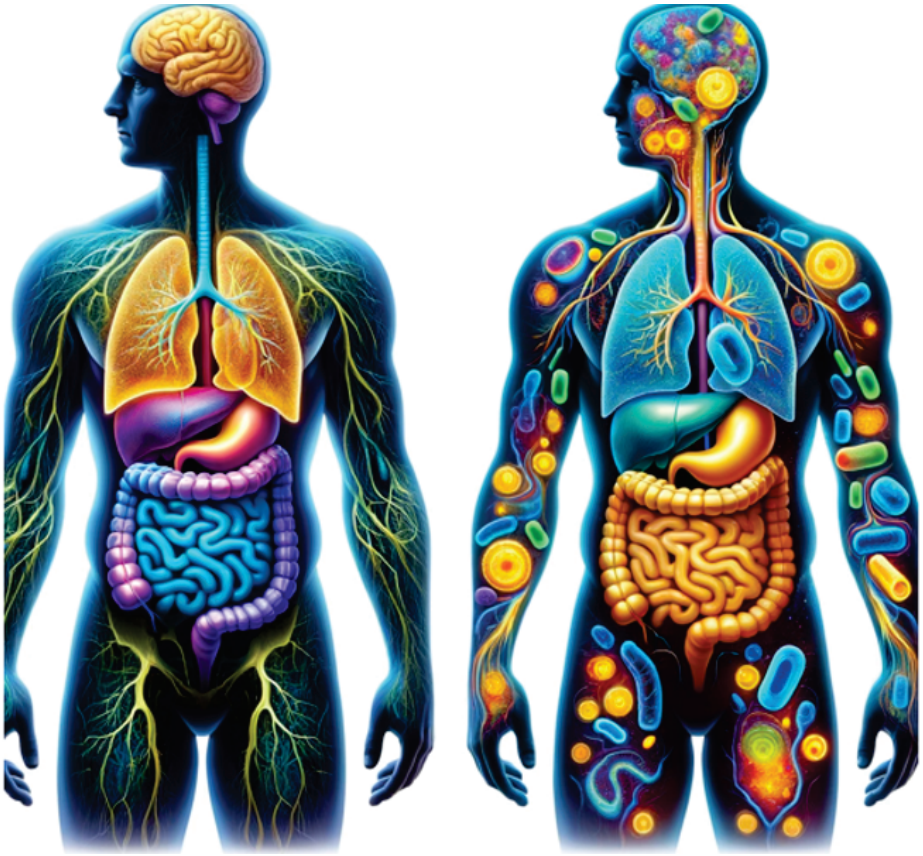

Fig. 1: Antioxidant Enzyme Activities in Diabetic vs. Non-Diabetic

Table 1: Antioxidant enzyme activities in diabetic vs. Non-diabetic individuals

Enzyme Type	Group	No (%)	OR (95% CI)	p-value
SOD	Diabetic	40 (40)	2.3 (1.4-3.8)	0.001
Non-Diabetic	80 (80%)	Ref		
CAT	Diabetic	45 (45)	1.9 (1.2-2.9)	0.007
Non-Diabetic	85 (85%)	Ref		
GPx	Diabetic	35 (35)	2.6 (1.6-4.2)	0.0003
Non-Diabetic	75 (75%)	Ref		

Table 2: Implications of antioxidant enzyme activities for clinical practice

Clinical Outcome	Group	Enzyme activity level	No (%)	OR (95% CI)	p-value
Increased risk of complications	Diabetic	Low SOD activity	60 (60)	3.0 (1.8-5.0)	<0.001
Non-diabetic	Low SOD activity	30 (30%)	Ref		
Poor glycemic control	Diabetic	Low CAT activity	55 (55)	2.5 (1.5-4.2)	0.002
Non-diabetic	Low CAT activity	25 (25%)	Ref		
Enhanced inflammatory response	Diabetic	Low GPx activity	50 (50)	2.8 (1.7-4.6)	0.0005
Non-diabetic	Low GPx activity	20 (20%)	Ref		

SOD, 0.007 for CAT and 0.0003 for GPx) suggesting statistical significance. This table effectively highlights the apparent association between decreased antioxidant enzyme activities and diabetic status, suggesting a compromised oxidative stress response in diabetic individuals. Table 2 focuses on the clinical implications of antioxidant enzyme activities, particularly highlighting the associations between low enzyme activity and adverse health outcomes in diabetic versus non-diabetic individuals. It indicates that diabetic individuals with low superoxide dismutase (SOD) activity have a threefold increased risk of complications compared to non-diabetics, as well as a 2.5 and 2.8 times greater likelihood of poor glycemic control and an enhanced inflammatory response, respectively, due to low catalase (CAT) and glutathione peroxidase (GPx) activities. The high odds ratios and low p-values (all below 0.002) across these enzyme activity levels underscore the substantial risk and emphasize the importance of monitoring and potentially targeting these enzymes in clinical practice to mitigate adverse outcomes in diabetic patients.

DISCUSSIONS

Table 1 indicates a significant decrease in antioxidant enzyme activities among diabetic

individuals compared to non-diabetics, as evidenced by the lower percentage of individuals with optimal enzyme levels and the high odds ratios. Specifically, the activities of superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GPx) are considerably lower in diabetics. The findings align with existing literature suggesting that diabetes is associated with increased oxidative stress and decreased antioxidant capacity.

For instance, studies have consistently reported reduced SOD, CAT and GPx activities in diabetic patients. A study by Adiga *et al.*[4] observed decreased SOD and GPx activities in diabetic rats, supporting the notion that diabetes impairs the antioxidant defense system. Similarly, Noroozi Karimabad *et al.*[5] highlighted the role of oxidative stress in the pathogenesis of diabetic complications, where decreased activities of these enzymes exacerbate the oxidative burden.

Moreover, Zandian *et al.*[6] emphasized the potential of antioxidant therapy in diabetes, suggesting that understanding the specific deficits in enzyme activities could guide targeted treatments. The consistent reduction in antioxidant enzyme activities in diabetic patients across various studies underscores the potential clinical importance of these findings. In contrast, some studies might show less pronounced differences or suggest variability in enzyme activities based on diabetes type, duration and control. It is also worth noting that factors such as diet, physical activity, and medication might influence antioxidant enzyme levels, adding complexity to the interpretation and comparison of results across different populations and studies.

Table 2 from the current study draws significant connections between reduced activities of specific antioxidant enzymes superoxide dismutase (SOD), catalase (CAT) and glutathione peroxidase (Gpx) and a series of adverse clinical outcomes in diabetic individuals. These outcomes include an increased risk of complications, poor glycemic control and heightened inflammatory responses. The study positions these enzymes as vital markers for clinical prognosis and potential targets for therapeutic intervention in managing diabetes.

This correlation is supported by several studies. Lower activity of SOD is known to correlate with an increased risk of diabetic complications due to unchecked superoxide radical accumulation, leading to extensive cellular damage, a mechanism detailed by Kwong-Han *et al.*[7] Similarly, diminished CAT activity is linked with poor glycemic control due to its role in hydrogen peroxide detoxification, leading to exacerbated oxidative stress, as discussed by Yan *et al.*[8] Additionally, reduced GPx activity is associated with an increase in oxidative damage and inflammatory responses, highlighting the enzyme's role in modulating inflammation within diabetic conditions, as noted by Xing *et al.*[9] These findings collectively underscore the importance of maintaining balanced antioxidant enzyme activities and open pathways for targeted therapeutic strategies, emphasizing enzyme activities as critical components in diabetes management and treatment planning.

CONCLUSION

The study has shed light on the significant differences in the activities of key antioxidant enzymes superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (Gpx) between these two populations. Our findings indicate that individuals with diabetes exhibit markedly lower activities of these crucial enzymes compared to non-diabetic individuals. This reduction in enzyme activities suggests an impaired oxidative defense mechanism in diabetics, which may contribute to the heightened oxidative stress and subsequent complications associated with the disease. The study's implications extend beyond the biological insights it provides. The distinct disparity in enzyme activities between diabetics and non-diabetics underscores the potential of these enzymes as biomarkers for diagnosing and monitoring the progression of diabetes. Additionally, the findings suggest that therapeutic strategies aimed at boosting the activity of these antioxidant enzymes could be beneficial in mitigating oxidative stress and possibly slowing the progression of diabetes-related complications.

However, it is also crucial to consider the limitations of a cross-sectional study and the need for further longitudinal research to establish causality and explore the dynamic changes in enzyme activities over time. Future studies should also consider the impact of various factors such as diet, physical activity, medication and genetic predisposition on antioxidant enzyme activities. By building on the knowledge from this study, we can move closer to developing more effective strategies for the prevention and management of diabetes, enhancing the quality of life for individuals affected by this chronic condition.

Limitations of study

Cross-sectional design: As a cross-sectional study, it captures data at a single point in time, which limits our ability to establish causality or observe the progression of antioxidant enzyme activities over time. Longitudinal studies are needed to understand the dynamic nature of enzyme activities and their relationship with diabetes progression.

Sample diversity and size: While the sample size was adequate to detect significant differences, it may not fully represent the wide diversity of the general population, including various ages, ethnicities and stages of diabetes. Larger and more diverse samples would improve the generalizability of the findings.

Control of confounding variables: Although efforts were made to match diabetic and non-diabetic individuals and control for factors like age and sex, other potential confounders such as diet, lifestyle, medication usage and duration of diabetes might have influenced the antioxidant enzyme activities. Future studies should control or account for these variables more comprehensively.

Measurement variability: The study relies on the biochemical assays of enzyme activities, which, while standardized, may be subject to variability and technical errors. It is also possible that the assays used may not fully capture the enzymatic activity or may be influenced by factors not accounted for in the study.

Lack of detailed clinical information: The study did not include detailed clinical data such as the duration of diabetes, glycemic control levels, or presence of diabetic complications, which might correlate with variations in enzyme activities. Including such parameters could provide a more nuanced understanding of the relationship between diabetes and oxidative stress.

Single measurement of enzyme activities: Enzyme activities were measured once, and variations over time due to factors like acute illness, stress, or medication changes were not accounted for. Repeated measures would provide a more accurate and robust assessment of enzyme activity levels.

Generalizability to other populations: The findings may not be directly applicable to all diabetic populations, especially considering variations in genetic, environmental, and lifestyle factors across different groups. Care should be taken when extrapolating these results to broader or different populations.

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