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Oxidative stress in acne vulgaris of varying severities in India

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Background: Acne vulgaris is a common inflammatory skin disease with a multifactorial pathogenesis. Although the pathophysiology of acne has been linked to free radical-mediated responses, it is still unknown how these reactions trigger the disease's progression.

Objective: This study aimed to evaluate the status and role of oxidative stress in patients with acne vulgaris, and to find a potential correlation with varying clinical severities.

Methods: An observational cross-sectional study was conducted amongst 200 subjects (50 in each grade of acne vulgaris: Grades 1, 2, 3, and 4) and 50 controls aged 18 to 45 years, between 01 July 2023 and 30 June 2024 at SGT University, Faculty of Medicine and Health Sciences, Gurugram, India. The analysis included superoxide dismutase (SOD), catalase (CAT), glutathione (GSH) and malondialdehyde (MDA) by using enzyme-linked immunosorbent assay kits. A Student's *t*-test and Pearson's correlation were applied, and a p-value of < 0.05 is considered statistically significant.

Results: The present study included 50 healthy controls: 29 women and 21 men, with a mean age of 25.80 ± 5.45 years, while the mean age of the cases was 26.24 ± 6.56 years, with 121 women and 79 men. Acne patients had considerably higher serum MDA levels than healthy controls ($p < 0.001$). Malondialdehyde was highest in Grade 4 patients (10.61 nmol/mL ± 1.75 nmol/mL), while lowest MDA levels were observed in Grade 1 acne (5.83 nmol/mL ± 0.60 nmol/mL). Superoxide dismutase, CAT and GSH activities were significantly lower in acne patients in comparison to healthy controls ($p < 0.001$). The levels of SOD, CAT and GSH decreased as the severity of disease increased, indicative of antioxidant defence system damage.

Conclusion: These findings provide credence to the link between acne and oxidative stress, which suggests that oxidative stress markers could be helpful in assessing the course of acne, and in outlining the patho-physiological support of the condition.

What this study adds: The study suggests that levels of SOD, CAT, GSH and MDA differ significantly in patients with acne vulgaris, adding region-specific evidence from the Indian population, addressing a gap in the literature on oxidative stress in dermatological conditions in this demographic.

Keywords: acne vulgaris; biomarkers; lipid peroxidation; oxidative stress; superoxide dismutase.

Introduction

Acne vulgaris (AV) is a chronic skin disease with an inflammatory condition caused by changes in pilosebaceous units. It is by far the most common of the several cutaneous disorders that affect people.[1] It is common, not only in teenagers, but also in the adult population. The Global Burden of Disease estimates that 85% of young adults aged between 12 and 25 years suffer from acne, which can occur in individuals of any age, race, or sex or gender.[2,3] Approximately 20% of the individuals who develop severe acne end up with scarring. While white people are more likely to have mild acne, Asian and African people are more likely to acquire severe forms. Generally, hyperpigmentation is more common in darker-skinned individuals.[4]

Four key interrelated concepts of pathogenesis that lead to the formation of AV are: increased sebaceous gland activity, keratinisation of the middle part of the infundibulum, bacterial colonisation, and inflammation of the follicle.[5] The most common clinical signs of AV include papules, pustules, nodules, cysts, open and closed comedones, and sometimes, scarring.[6] The genetic component of acne has been supported by numerous studies. Acne risk can be up to three times higher for those with afflicted first-degree family members than for those who do not have a family history.[7]

Despite studies, no single primary cause has been identified and the aetiology and pathogenesis of acne remain unclear.[8,9] It has been suggested that one of the pathogenic conditions in AV is the generation of ROS (reactive oxygen species) by neutrophils, resulting in tissue injury and inhibition of ROS production can be beneficial from a therapeutic standpoint.[10,11] The ROS system includes free radicals such as the superoxide ion radical, the hydroxyl radical, and the nitric oxide radical, as well as non-radicals such as hydrogen peroxide and ozone. These have been linked to processes of mutagenesis, tumorigenesis, inflammatory responses, and senescence.[12,13] Acne is characterised by changes in sebum composition, and neutrophil-produced ROS contribute to follicular wall irritation and destruction, which in turn fuels the inflammatory course of acne.[14] Moreover, the reactions between lipidic structures and ROS can result in the peroxidation of polyunsaturated fatty acid and the production of toxic compounds such as malondialdehyde (MDA), which can be used as markers to assess oxidative damage in cells.[15]

Enzymatic and non-enzymatic antioxidant defence mechanisms are both present in human cells. As the first line of defence against oxygen-derived free radicals, the SOD–CAT (superoxide dismutase–catalase) system is a key enzymatic system that catalyses the dismutation of superoxide into hydrogen peroxide, which subsequently converts into water by catalase. This process regulates the production of ROS and is therefore essential for preserving a proper cellular redox balance.[16] Oxidative stress can result from changes in this natural balance, which can be brought on by increased ROS generation and/or decreased antioxidant levels.[17,18]

A few studies have reported the increased oxidative stress in AV.[19,20] However, the disturbance in oxidants–antioxidant systems in the disease progression has not been studied extensively in the Indian regional setting. Therefore, we measured the levels of biochemical indicators of oxidative stress in patients of AV, and compared their relationship to the severity of disease activity (Grades 1, 2, 3, and 4) in the Indian population. Our results not only support an association between oxidative stress and acne; they show that it may be used as a biomarker index for evaluating the activity of the disease and to monitor the course of treatment.

Methods

Ethical considerations

The study was carried out in compliance with the Declaration of Helsinki and approved by the Institution Ethics Committee of SGT University, Faculty of Medicine and Health Sciences, with vide letter number IEC/FMHS/MD/MS/2023-29 dated 03/06/2023. Written and informed consent was obtained after explaining the purpose and details of the study to all of the subjects. Protocol numbers were assigned for reference, and participant personal information was kept private and used only for research. Data security measures included password protection of the computer and data storage in a safe physical location.

Study design and settings

This observational cross-sectional study was carried out in the Department of Biochemistry of the Faculty of Medicine and Health Sciences at SGT University, Gurugram, India, from 01 July 2023 to 30 June 2024.

Sample size

Acne severity was assessed by a single experienced dermatologist using a simple grading system by Tutakne and Chari,[21] to ensure consistency and avoid interrater variability:

- Grade 1: Comedones, occasional papules
- Grade 2: Papules, comedones, few pustules
- Grade 3: Prominent pustules, nodules and abscesses
- Grade 4: Mainly cysts, abscesses, widespread scarring

By keeping the confidence level at 95% (1.96), prevalence (85%),[22] and maximum allowance of error (5%) in the Cochran's formula ($n = Z^2pq/e^2$), a sample size of 196 subjects was established. We rounded up to 200 to account for potential exclusions. Therefore, 200 subjects (50 in each grade of AV: Grades 1, 2, 3, and 4) and 50 healthy controls were selected. For sub-group comparison, a post-hoc power calculation was performed in acne grades. By keeping alpha = 0.05, power (1-β) comes as: for SOD, large effect size (Cohen's d = 1.14) and power = 1.0. Malondialdehyde and GSH (glutathione) comparisons demonstrated high power, whereas CAT comparisons had smaller effect sizes and slightly lower power (0.85).

Eligibility criteria

The cross-sectional study included patients with AV, who did not receive any topical or systemic treatment in the previous four weeks, were aged between 18 and 45 years, were from both genders, and were willing to participate. However, the study excluded patients on immune-suppressive therapy such as corticosteroids, regular analgaesic intake, and hormonal therapy; patients with any systemic disease (diabetes mellitus, liver disease, thyroid disorders, cardiovascular events, known cases of malignancy); patients with any dermatological disorder other than AV; patients taking any vitamin supplementation; pregnant and lactating women; and smoking and/or alcohol abusers. The information on social demographics and disease duration was collected by directly interviewing study participants in the local language using a semi-structured questionnaire.

Sample collection and equipment

Using aseptic technique, 5 mL of venous blood was taken in dry sterile red top (serum) vacutainers from each participant after gaining written consent. Serum was separated by centrifugation at 3500 revolutions per minute (rpm) for 10 min. Serum SOD, CAT, GSH and MDA were measured using the ERBA Lisa Scan EM analyser (ERBA Diagnostics Mannheim GmbH, Mannheim, Germany) via an enzyme-linked immunosorbent assay kit. Calibration and quality control of this analyser were performed

before the samples were run. The manufacturer's instructions for the machine and the reagents were strictly followed. Standard curves were generated for each biomarker (SOD, CAT, GSH, MDA) using the calibrators provided in the enzyme-linked immunosorbent assay kits, and sample concentrations were calculated from these curves. To reduce the analytical variation, all samples were analysed using the same lots of reagent kits, and intra-assay coefficient of variation values remained within acceptable limits. (Table 1).

Statistical analysis

Data and various parameters were analysed on IBM® SPSS® Statistics (SPSS®) version 24 (IBM Corporation, Armonk, New York, United States). The Shapiro-Wilk test was applied for assessing the normal distribution of the dataset and was found to be normally distributed. Mean and standard deviation of all parameters were calculated. A Student's *t*-test (unpaired) was used to compare two groups while a one-way analysis of variance test was applied to compare the various parameters in three or more groups. A post-hoc test was conducted to determine pair-wise differences between groups. Pearson's correlation coefficient (*r*-value) was applied to find the correlation. The $p < 0.05$ was considered as statistically significant, and $p < 0.001$, highly significant.

Results

General characteristics of study population

The present study included 50 healthy controls: 29 women and 21 men with a mean age of 25.80 ± 5.45 years. Two hundred patients with AV—121 females and 79 males—were also enrolled (Figure 1). The mean age and gender distribution of each grade of AV is expressed in Table 2, with $p = 0.0007$. The distribution of patients according to duration of acne is shown in Table 3. Over 31.4% of the women had struggled with AV for 2–5 years, while a higher number of men (50.6%) had acne for a similar time period, followed by 34.2% who had acne for more than five years ($p < 0.0001$).

Table 4 shows a comparison of SOD, CAT, GSH and MDA levels between controls and severity grades of acne. The serum levels of SOD were lowest in severe cases (Grade 4) and highest in mild cases (Grade 1), when compared with controls with a mean ± standard deviation of 5.68 U/mL ± 1.95 U/mL, 11.71 U/mL ± 2.12 U/mL, and 89.39 U/mL ± 9.91 U/mL ($p < 0.0001$). Similarly, the serum levels of CAT and GSH were markedly decreased in Grade 4 acne patients versus individuals in any other grades. Meanwhile, a comparison of MDA levels across the four grades revealed a substantial difference. Malondialdehyde levels were significantly lower in Grade 1, and higher in Grades 3 and 4 ($p < 0.0001$). Post-hoc pair-wise comparisons between acne severity grades revealed significant differences for most oxidative stress markers. Superoxide dismutase levels showed highly significant reductions across all grade comparisons ($p \leq 0.0001$). Catalase levels were comparable between Grades 1 and 2 ($p = 0.0703$), but significantly lower from Grade 2 onwards ($p \leq 0.0001$). Glutathione levels demonstrated an early decline, with a significant difference observed between Grades 1 and 2 ($p = 0.0161$), and highly significant differences in subsequent grade comparisons ($p < 0.0001$). Malondialdehyde levels were significantly elevated across all inter-grade comparisons ($p < 0.0001$), confirming progressive oxidative damage with increasing acne severity (Table 5).

To adjust for potential confounding variables and to explore the combined effect of oxidative stress markers, a multiple linear regression analysis was performed. Acne severity was used as the dependent variable, with serum levels of SOD, CAT, GSH, MDA, and patient age as independent predictor variables. As shown in Table 6, MDA was a significant positive predictor ($B = 0.232$,

TABLE 1: Different parameters with method, cut-off range and coefficient of variation, Gurugram, India, from 01 July 2023 to 30 June 2024.

Serial no.	Parameters	Method	Cut-off value	CV
1.	Serum SOD	Sandwich ELISA[23]	15.6 U/mL – 500 U/mL	7.0
2.	Serum CAT	Sandwich ELISA[24]	0.312 ng/mL – 20 ng/mL	5.6
3.	Serum GSH	Competitive ELISA[25]	1.25 ng/mL – 80.0 ng/mL	6.1
4.	Serum MDA	Double-antibody sandwich ELISA[26]	1.42 nmol/mL – 4.48 nmol/mL	4.9

Note: Please see the full reference list of this article for details on the articles cited: Goyal A, Bansal SK, Ganjoo S. Oxidative stress in acne vulgaris of varying severities in India. Afr J Lab Med. 2025;14(1), a2912. https://doi.org/10.4102/ajlm.v14i1.2912

SOD, Superoxide dismutase; CAT, Catalase; GSH, Glutathione; MDA, Malondialdehyde; ELISA, Enzyme-linked immunosorbent assay; CV, Coefficient of Variation.

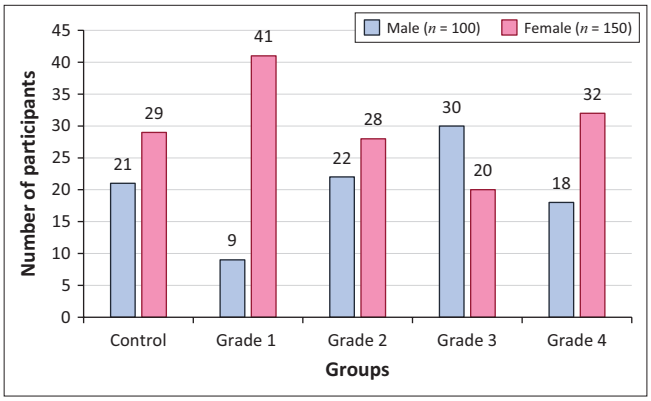


FIGURE 1: A bar graph showing number of male and female participants in control and acne patients, Gurugram, India, from 01 July 2023 to 30 June 2024.

TABLE 2: Demographic data of controls and cases, Gurugram, India, from 01 July 2023 to 30 June 2024.

Variable	Control (n = 50)		Grade 1 (n = 50)		Grade 2 (n = 50)		Grade 3 (n = 50)		Grade 4 (n = 50)	
	n	Mean ± s.d.	n	Mean ± s.d.	n	Mean ± s.d.	n	Mean ± s.d.	n	Mean ± s.d.
Male	21	-	9	-	22	-	30	-	18	-
Female	29	-	41	-	28	-	20	-	32	-
Age (years)	-	25.80 ± 5.45	-	24.74 ± 4.68	-	25.44 ± 5.81	-	25.18 ± 6.61	-	29.60 ± 7.74

s.d., standard deviation.

$p < 0.0001$), while SOD (B = −0.125, $p < 0.0001$), CAT (B = −1.920, $p = 0.0004$), and GSH (B = −0.839, $p < 0.0001$) were significant negative predictors. Age was not a significant predictor ($p = 0.311$). Overall, these findings indicate that oxidative stress markers independently contribute to acne severity, with higher oxidative damage (MDA) and lower antioxidants (SOD, CAT, GSH) predicting more severe disease.

Table 7, Table 8, Table 9, Table 10, Figure 2, Figure 3, Figure 4 and Figure 5 displays the correlation between acne severity and levels of oxidative and antioxidative biomarkers. A significant negative correlation was observed between MDA levels and CAT activity in the serum of Grade 4 acne patients ($r = –0.403$, $p = 0.0037$). However, no significant correlation was found in the other acne subgroups.

TABLE 3: Disease duration of acne vulgaris patients, Gurugram, India, from 01 July 2023 to 30 June 2024.

Duration (years)	Men		Women	
	n	%	*n*	%
< 2	12	15.2	59	48.7
2–5	40	50.6	38	31.4
> 5	27	34.2	24	19.9
Total	**79**	**100**	**121**	**100**

TABLE 4: Oxidative biomarkers levels in controls and acne patients of varying severity, Gurugram, India, from 01 July 2023 to 30 June 2024.

Parameters	Mean ± standard deviation					*p*-value
	Controls (*n* = 50)	Grade 1 (*n* = 50)	Grade 2 (*n* = 50)	Grade 3 (*n* = 50)	Grade 4 (*n* = 50)	
SOD (U/mL)	89.39 ± 9.91	11.71 ± 2.12	9.54 ± 1.68	8.06 ± 1.97	5.68 ± 1.95	< 0.0001*
CAT (ng/mL)	8.99 ± 4.02	0.27 ± 0.10	0.24 ± 0.05	0.20 ± 0.06	0.15 ± 0.04	< 0.0001*
GSH (ng/mL)	18.77 ± 6.50	0.80 ± 0.21	0.71 ± 0.16	0.57 ± 0.19	0.35 ± 0.17	< 0.0001*
MDA (nmol/mL)	2.51 ± 0.97	5.83 ± 0.60	6.70 ± 0.78	7.76 ± 0.93	10.61 ± 1.75	< 0.0001*

SOD, Superoxide dismutase; CAT, Catalase; GSH, Glutathione; MDA, Malondialdehyde.
*, When controls were compared to Grades 1, 2, 3 and 4 acne subgroups ($p < 0.0001$).

TABLE 5: Post-hoc multiple comparisons of oxidative stress markers between acne severity grades, Gurugram, India, from 01 July 2023 to 30 June 2024.

Grades	*p*-value			
	SOD	CAT	GSH	MDA
G1 and G2	< 0.0001	0.0703	0.0161	< 0.0001
G1 and G3	< 0.0001	< 0.0001	< 0.0001	< 0.0001
G1 and G4	< 0.0001	< 0.0001	< 0.0001	< 0.0001
G2 and G3	0.0001	0.0001	0.0001	< 0.0001
G2 and G4	< 0.0001	< 0.0001	< 0.0001	< 0.0001
G3 and G4	< 0.0001	< 0.0001	< 0.0001	< 0.0001

G, Grade; SOD, Superoxide dismutase; CAT, Catalase; GSH, Glutathione; MDA, Malondialdehyde.

TABLE 6: Multiple linear regression analysis of oxidative stress markers and age as predictors of acne severity, Gurugram, India, from 01 July 2023 to 30 June 2024.

Parameters	*B*	s.e.	Sig.
Age	0.005538	0.005452	0.311
SOD	-0.125	0.01552	< 0.0001
CAT	-1.9202	0.5324	0.0004
GSH	-0.8391	0.1836	< 0.0001
MDA	0.2323	0.02312	< 0.0001

s.e., standard error; B, Unstandardised Coefficient; Sig., Significance; SOD, Superoxide dismutase; CAT, Catalase; GSH, Glutathione; MDA, Malondialdehyde.

Discussion

The current study's findings showed that lipid peroxide levels in patients of AV were much higher than those of healthy controls. On the other hand, the activities of serum SOD and CAT as well as the levels of GSH were statistically reduced in acne patients. Prior research has demonstrated that in inflammatory diseases, the level of lipid peroxidation increases. Furthermore, MDA is thought to be a sign of oxidative stress within cells.[27] Therefore, the elevated serum MDA levels in this study could be the consequence of cellular damage caused by ROS. These findings imply that acne is mediated by the increased ROS production, which can be linked to a decrease in antioxidant enzyme levels, such as SOD or CAT. It has been noted that the SOD-CAT system increases or decreases or goes in two different directions in a variety of disorders.[15] On the other hand, there are some studies that do not agree with the current study.

According to a study by Mahmoud et al.,[28] higher levels of SOD and MDA were found in acne patients than in controls ($p < 0.001$).[28] In their study, 37 patients were divided into two groups. Group I (the patient group) included 27 patients (21 women and six men) with acne; and Group II (the control group) included 10 age-matched and sex-matched healthy individuals as controls; there were eight women and two men. Similarly, in another study conducted by El Garem

TABLE 7: Correlation analysis of oxidative markers in Grade 1 acne patients, Gurugram, India, from 01 July 2023 to 30 June 2024.

Variable Y	Variable X	Correlation coefficient (*r*)	Significance level (*p*)	95% Confidence interval for *r*
MDA	SOD	-0.1352	0.3491	-0.3986 to 0.1487
	CAT	0.0044	0.9753	-0.2742 to 0.2825
	GSH	-0.0610	0.6738	-0.3337 to 0.2211

SOD, Superoxide dismutase; CAT, Catalase; GSH, Glutathione; MDA, Malondialdehyde.

TABLE 8: Correlation analysis of oxidative markers in Grade 2 acne patients, Gurugram, India, from 01 July 2023 to 30 June 2024.

Variable Y	Variable X	Correlation coefficient (*r*)	Significance level (*p*)	95% Confidence interval for *r*
MDA	SOD	0.0010	0.9943	-0.2774 to 0.2793
	CAT	0.1141	0.4299	-0.1696 to 0.3804
	GSH	0.0538	0.7104	-0.2279 to 0.3273

SOD, Superoxide dismutase; CAT, Catalase; GSH, Glutathione; MDA, Malondialdehyde.

TABLE 9: Correlation analysis of oxidative markers in Grade 3 acne patients, Gurugram, India, from 01 July 2023 to 30 June 2024.

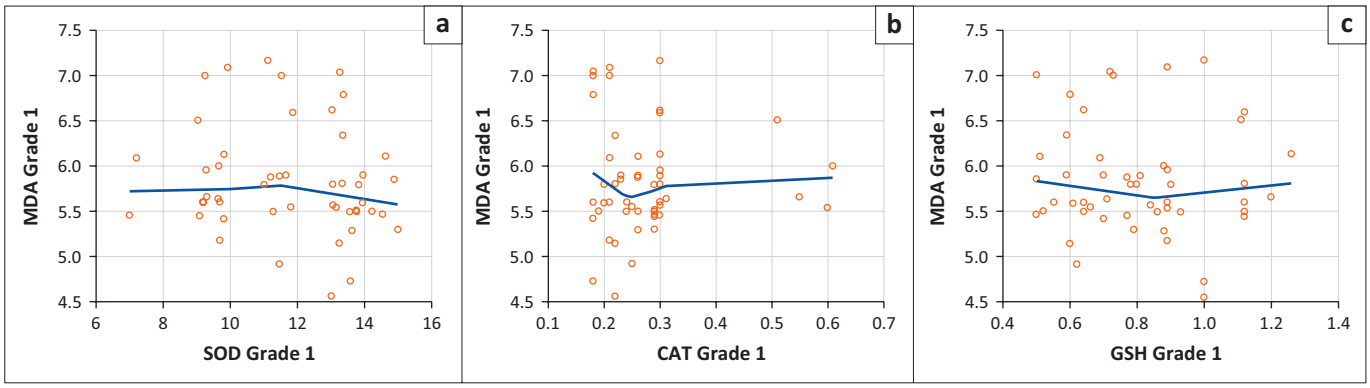
Variable Y	Variable X	Correlation coefficient (*r*)	Significance level (*p*)	95% Confidence interval for *r*
MDA	SOD	0.1140	0.4306	-0.1698 to 0.3803
	CAT	0.1802	0.2106	-0.1034 to 0.4366
	GSH	-0.0570	0.6938	-0.3302 to 0.2249

SOD, Superoxide dismutase; CAT, Catalase; GSH, Glutathione; MDA, Malondialdehyde.

TABLE 10: Correlation analysis of oxidative markers in Grade 4 acne patients, Gurugram, India, from 01 July 2023 to 30 June 2024.

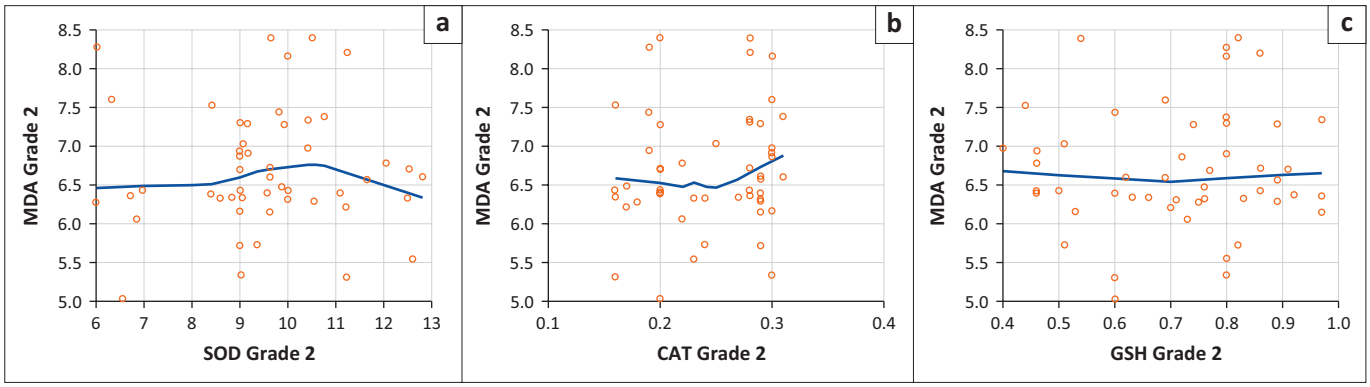
Variable Y	Variable X	Correlation coefficient (*r*)	Significance level (*p*)	95% Confidence interval for *r*
MDA	SOD	0.0204	0.0888	-0.2594 to 0.2971
	CAT	-0.4035	0.0037*	-0.6130 to 0.1410
	GSH	0.1166	0.4202	-0.1672 to 0.3825

SOD, Superoxide dismutase; CAT, Catalase; GSH, Glutathione; MDA, Malondialdehyde.
*, statistically significant at < 0.05.



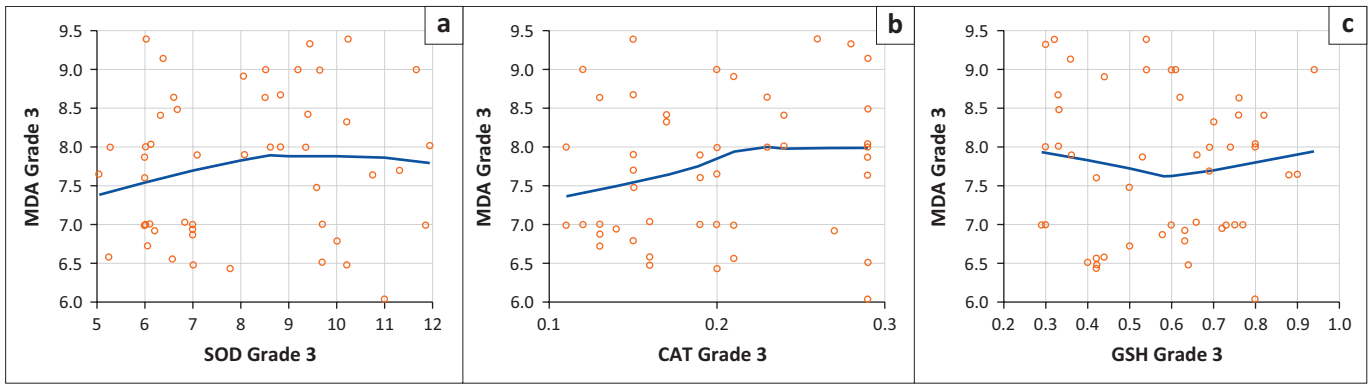
SOD, Superoxide dismutase; CAT, Catalase; GSH, Glutathione; MDA, Malondialdehyde.

FIGURE 2: Correlation between oxidative stress biomarker and antioxidants in Grade 1 acne patients, Gurugram, India, from 01 July 2023 to 30 June 2024. Correlation between (a) MDA and SOD (non-significant, $p = 0.3491$, $r = -0.1352$); (b) MDA and CAT (non-significant, $p = 0.9753$, $r = 0.0044$); and (c) MDA and GSH (non-significant, $p = 0.6738$, $r = -0.0610$).



SOD, Superoxide dismutase; CAT, Catalase; GSH, Glutathione; MDA, Malondialdehyde.

FIGURE 3: Correlation between oxidative stress biomarker and antioxidants in Grade 2 acne patients, Gurugram, India, from 01 July 2023 to 30 June 2024. Correlation between (a) MDA and SOD (non-significant, $p = 0.9943$, $r = 0.0010$); (b) MDA and CAT (non-significant, $p = 0.4299$, $r = 0.1141$); and (c) MDA and GSH (non-significant, $p = 0.7104$, $r = 0.0538$).

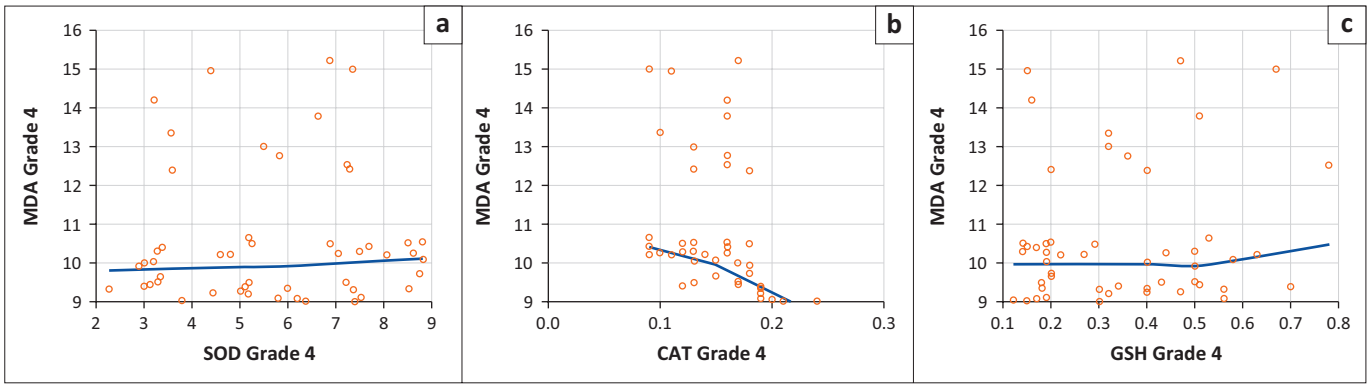


SOD, Superoxide dismutase; CAT, Catalase; GSH, Glutathione; MDA, Malondialdehyde.

FIGURE 4: Correlation between oxidative stress biomarker and antioxidants in Grade 3 acne patients, Gurugram, India, from 01 July 2023 to 30 June 2024. Correlation between (a) MDA and SOD (non-significant, $p = 0.4306$, $r = 0.1140$); (b) MDA and CAT (non-significant, $p = 0.2106$, $r = 0.1802$); and (c) MDA and GSH (non-significant, $p = 0.6938$, $r = -0.0570$).

et al., 50 acne patients and 20 healthy controls were compared, and results showed higher SOD in acne patients, which was statistically non-significant.[14] A study conducted by Arican, Kurutas, and Sasmaz, who investigated 43 acne patients, including 30 women and 13 men, and 46 healthy controls, including 28 women and 18 men, came up with the result of elevated SOD and MDA in patients compared to the control ($p < 0.001$).[20] They proposed that the imbalance between oxidants and antioxidants in the cells caused oxidative stress, which in turn led to an increase in SOD levels.

Additionally, our results showed a correlation between the higher levels of oxidative stress biomarkers and the severity of acne patients. Patients with Grade 4 acne had noticeably higher serum MDA levels than those in patients with Grade 1, Grade 2, or Grade 3 acne. Moreover, SOD–CAT activity and GSH levels were significantly decreased in Grade 4 patients compared to the levels of patients with other grades of acne. The increase in SOD activities in Grade 1 acne patients indicates that the antioxidant defence system is responding appropriately to oxidative stress, which keeps



SOD, Superoxide dismutase; CAT, Catalase; GSH, Glutathione; MDA, Malondialdehyde.

FIGURE 5: Correlation between oxidative stress biomarker and antioxidants in Grade 4 acne patients, Gurugram, India, from 01 July 2023 to 30 June 2024. Correlation between (a) MDA and SOD (non-significant, $p = 0.8880$, $r = 0.0204$); (b) MDA and CAT (significant, $p = 0.0037$, $r = -0.4035$); and (c) MDA and GSH (non-significant, $p = 0.4202$, $r = 0.1166$).

MDA levels within the normal range. This adaptive response protects the cells from the harmful products of free radical reactions. Membrane lipids and other tissue lipids may peroxide as a result of the increased production of ROS, which can start the lipid peroxidation chain reaction, when the disease process becomes more severe and the protective mechanism is no longer sufficient. This is shown with the decreased SOD activities and increased MDA levels observed in patients with Grade 2 and Grade 3 acne. In patients with Grade 4 acne, SOD activities were significantly decreased, and the substantial increase in MDA levels suggests that an increase in ROS production has outpaced the antioxidant capability.

Contrary to the current findings, Basak et al. did not find any correlation between acne severity and antioxidant enzymes levels or MDA in the leukocytes.[11] According to them, this proved that while each patient's oxidant and/or antioxidant balance may be impacted to a certain degree, the total number of factors or agents involved in each case could not affect the enzyme levels. We reasoned that this disagreement was most likely caused by the samples used for measuring oxidative biomarkers coming from different sources. The levels of these markers do not indicate the origin of their production in plasma.[29]

In the present study, data showed that patients with Grade 4 acne had a strong negative association between their CAT and MDA levels (Figure 5b), whereas patients with other grades did not show this correlation. Furthermore, regardless of the severity of the condition, no discernible relationship between SOD activity, GSH levels, and MDA levels was found in acne patients. These results have unequivocally shown that oxidative stress contributes to acne and may be a significant factor in its aetiology and progression.[30]

However, the origin of these enzymes cannot be ascertained. Whether aberrant antioxidant enzymes are the famous 'egg or chicken dilemma' in acne is still up for debate. It is likely that these alterations are a result of cutaneous inflammation, such as acne, rather than the cause.

Limitations of the study

The limitations of the study were as follows:

- The study design is cross-sectional, which limits the ability to establish a causal relationship between biomarkers and acne severity.
- The study does not account for lifestyle and environmental factors, such as diet, stress, pollution exposure, and genetic predisposition, all of which can influence oxidative stress levels.
- The effects of oxidative stress markers after treatment with antioxidants were not measured in this study.

Future scope

Future research should involve lesion-level assays–such as quantification of squalene peroxides in sebum, punch biopsy, or scraping of skin surface by a dermatologist for correlating serum and local cutaneous oxidative stress directly.

Conclusion

According to the present results, statistically high levels of MDA in patients with AV is evidence of the existence of oxidative stress which can cause cell injury and inflammation. Furthermore, low levels of SOD, CAT and GSH enzyme in acne clearly indicate that the antioxidant defence system is damaged, irrespective of the degree of severity, and thereby antioxidant drugs can be indicated for the treatment of acne. However, it is still unclear whether oxidative stress is a cause or an outcome of inflammation. Combining antioxidants drugs with other treatment modalities of acne might be beneficial in treating patients, especially those with inflammatory acne lesions, or their effects may be mitigated.

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Competing interests

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

Authors' contributions

Astha Goyal conceived and designed the study, collected and analysed the data and drafted the manuscript. Dr. Sanjiv K. Bansal reviewed and revised the final article and contributed to the visualization of the manuscript. Dr. Shikhar Ganjoo contributed to the study methodology, and assisted in manuscript editing.

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Data availability

The data that support the findings of this study are available on request from the corresponding author, Astha Goyal upon reasonable request.

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