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Clinical study of oxidative stress, antioxidant status and trace elements in patients with chronic asthma in Al-Muthanna Governorate/Iraq: a cross-sectional study

Ali Adil Ajeel[1,*]

[1] Department of Chemistry. General Directorate of Education Al-Muthanna, Al-Muthanna, Iraq.

*Corresponding author: Ali Adil Ajeel.
Department of Chemistry. General Directorate of
Education Al-Muthanna, Al-Muthanna, Iraq.
E-mail: ali.ad_ch@utq.edu.iq
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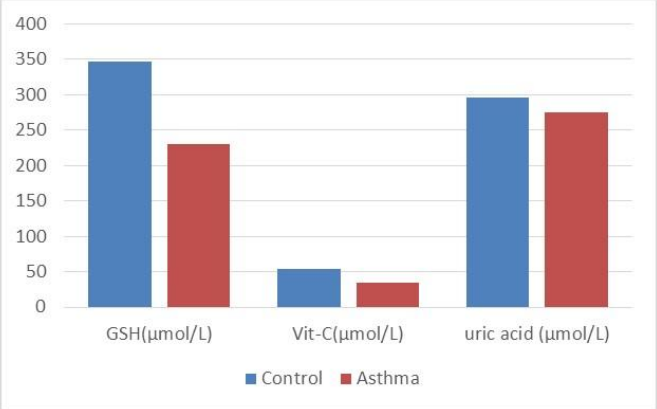
Abstract

Introduction: Oxidative stress, altered antioxidant status, and serum trace elements are all linked to chronic asthma. **Objective:** The study involved determination the levels of some clinical markers in serum of patient with chronic asthma relative to healthy people aiming at clarifying the relation among these changes. **Methods:** Serum levels of malondialdehyde MDA, glutathione (GSH), vitamin C, uric acid, total protein, albumin, globulin and trace elements chromium Cr and selenium Se were measured in (200 asthma and 200 supposed healthy subjects) sex (100 male, 100 female). **Results:** Statistical data analysis revealed a significant elevation in the levels of malondialdehyde in serum of patients with chronic asthma relative to control group. The study also showed a signification decrease in glutathione, chromium, selenium in serum of patients in comparison to control groups for both sexes. On the other hand, signification decrease was observed in uric acid, vitamin C, total protein and albumin and no signification deferent in globulin in serum of patients with chronic asthma in comparison to control group and for both sexes. **Conclusion:** There was no effect of sex on the studied markers.

Keywords: Asthma. Malondialdehyde. Vitamin C. Glutathione. Chromium. Selenium.

Graphical Abstract



Source: Own authorship.

Introduction

About 260 million people worldwide, of all ages, suffer from asthma, a common chronic airway illness that significantly increases mortality, morbidity, and financial burden [1]. Asthma is a noninfectious chronic inflammatory disease that targets the airways. patients with asthma, a complex inter-play of several types of lung structural cells together and immune cells leads to excessive mucus production, bronchial hyper reactivity and airway narrowing. These symptoms can cause shortness of breath, repeated periods of wheezing and tightness of the chest [2]. One common long-term inflammatory condition of the airways is asthma. Many individuals arrive with asthma that is resistant to acute

treatment [3], Asthma can be categorized based on age into Late and Early Onset asthma [4]. Approximately 300 million individuals worldwide suffer with asthma, and the figure is continually rising.

Asthma has a significant socioeconomic cost in terms of healthcare spending and morbidity due to its chronic nature and prevalence. In America, the total yearly medical expenses for treating asthma were estimated to be $50 billion in (2013) [5], with forecasts for the period (2019 to 2038) indicating a substantial rise in costs [6]. Asthma is marked by airway hyperresponsiveness (AHR) and variable airflow obstruction, causing an increased airway-narrowing reaction to several environmental cues, which results in episodic and reversible bronchoconstriction, for example allergens. customarily, the illness is categorized into two groups: intrinsic and extrinsic asthma. Intrinsic asthma (non - allergic) is triggered by several factors, for example pulmonary infection, aspirin, cold, exercise, obesity, stress, etc. Allergens cause extrinsic asthma, commonly referred to as allergic asthma, which is primarily caused by aberrant T helper T2 inflammation [7,8].

Oxidative stress is a significant contributor to the development of neurological disorders, which is an imbalance between the body's natural defensive systems and the generation of reactive oxygen species (ROS). The brain is especially susceptible to oxidative stress because of its high metabolic rate and oxygen intake [9]. Oxidative stress is key factors in the progression and pathogenesis of many chronic diseases, for example cancers of the breast, lung, kidney, cardiovascular diseases (atherosclerosis, hypertension, arrhythmia), autoimmune diseases (rheumatoid arthritis), neurodegenerative diseases (Parkinson's disease, Alzheimer's disease, Huntington's disease), gastrointestinal disorders (colorectal cancer, inflammatory bowel disease), mental disorders (schizophrenia, depression, bipolar disorder) [10].

Typical, numerous conditions can lead to increased oxidative stress at the cellular level such as infections, medications, poor diet, toxins, trauma, radiation and cigarette smoke [11]. ROS and ROS attack polyunsaturated fatty acids (PUFA) to cause lipid peroxidation (LPO), a chain of processes that damages cell membranes and ultimately results in cell death [12]. As illustrated in Figure 1, the three stages of lipid peroxidation are initiation, propagation, and termination.

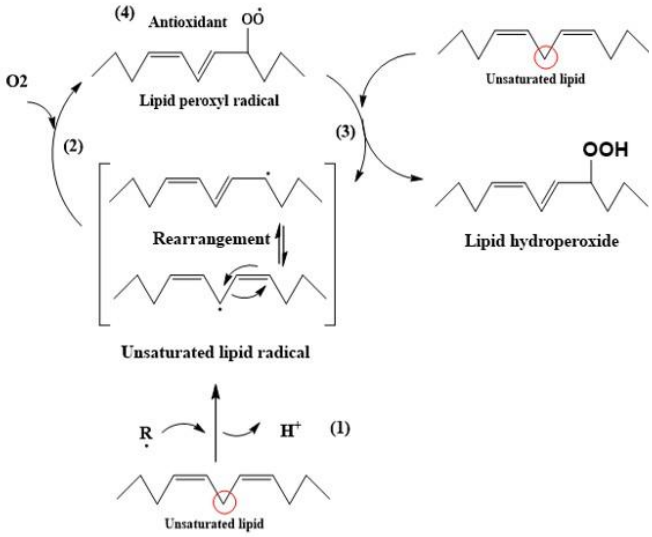


Figure 1. Lipid peroxidation process [13].

The first step is the initiation of the carbon-centered lipid radical (L·), which is produced when prooxidants such hydroxyl radicals extract the allylic hydrogen [12]. Step 2: Propagation phase: (L·) rapidly combines with oxygen to form lipid hydroperoxide (LOOH) and a lipid peroxyl radical (LOO·), which extracts a hydrogen atom from another lipid molecule to form a new L· (which continues the chain reaction [12]. Step 3: Termination reaction: A comparable vitamin C radical is created when antioxidants such as vitamin C give a hydrogen atom to the LOO· species. This radical then combines with another LOO· to make non-radical products [12]. Primary products of LPO are unstable hydro peroxides that decompose to several secondary products, among which are malondialdehyde (MDA), stable aldehydes, acrolein and 4-hydroxy-2-nonenal (HNE) [12].

The primary source of MDA in biological samples is the peroxidation of polyunsaturated fatty acids, which makes it a useful indicator of oxidative stress and damage caused by free radicals [14]. Through its propensity to react with molecules like DNA and proteins, MDA can affect a number of physiological processes in the human body. Therefore, it is crucial to think about this molecule as more than just a result of lipid peroxidation [15].

Method and Materials

Study Design

This study followed STROBE checklist for a cross-sectional study. Abailable on: https://www.strobe-statement.org/. Accessed on: March 10, 2026.

Ethical Approval

The study was approved by the institutional ethics committee in Department of Chemistry, General Directorate of Education Al-Muthanna, Al-Muthanna, Iraq, and adheres to the ethical principles outlined in the declaration of General Directorate of Education Al-Muthanna, Al-Muthanna, Iraq 2026.

Informed Consent

Informed consent was obtained from all participants involved in the study, with all procedures explained in detail before participation.

Laboratorial Analysis

Determination of MDA Concentration: an enzyme-linked immunosorbent test (ELISA) kit from China was utilized by Sunlong. Determination of Glutathione Concentration: using a modified method **[16]**. Determination of Vitamin C Concentration: using the (2,4-dinitrophenylhydrazine) method **[17]**. Determination of Uric acid Concentration: using the enzymatic method, by kit from France, Biolabo **[18]**. Determination of Total Protein Concentration: using the Biuret method **[17]**, by kit from France, Biolabo. Determination of Albumin level: using the Bromocresol Green Method **[19]**, by kit from France, Biolabo. Determination of Globulin: The following formula was used to estimate the amount of globulin in blood serum **[17]**.

$$Conc.\ Globulin = Conc.\ Total\ prptein - Conc.\ Albumin$$

- Concentrations of chromium and selenium : The flame atomic absorption method was used to determine the elemental concentrations in serum samples.
- BioChemical study: This study carried out AL-Hussein Educational Hospital in Al-Muthanna - Iraq in Biochemistry Laboratory at 1/1/2023 to 1/1/2025.

The study includes 200 subjects, 100 control and 100 patients with Asthma (They were identified by a professional medical angel), Blood samples was conducted with the consent of the patients in collaboration with the laboratory

- Asthma group: 100 patients with Asthma [50 males and 50 females] with aged (20-60) years
- NOT: Patients excluded from this study, Patients with diabetes, Patients with cardiovascular disease, Patients with hypo- or hyperthyroidism and pregnant women.
- Control group: 100 supposed healthy subjects [50 males and 50 females] at aged (20 - 60) years
- Blood Collection: Five mL were put into a plain tube, allowed to clot at room temperature, and then centrifuged for 10 minutes at 3000 rpm to extract the serum. The serum was then stored at -20°C for future clinical marker measurements, if not utilized right away.

Statistical Analysis

Used in statistical analyzed with Microsoft Excel 2021, the measured markers were expressed as mean ± standard deviations (mean ± SD). Two-way ANOVA - test was employed to compare markers in different studied groups. P - values ($p \leq 0.05$) were deemed statistically significant.

Results

Statistical data analysis revealed a significant elevation in the levels of malondialdehyde in serum of patients with chronic asthma relative to control group. The study also showed a signification decrease in Glutathione, chromium, selenium in serum of patients in comparison to control groups for both sexes. On the other hand, signification decrease was observed in uric acid, vitamin C, total protein and albumin and no signification deferent in globulin in serum of patients with chronic asthma in comparison to control group and for both sexes (Tables 1-4 and Figures 2-9).

Table 1. MDA, Alb and Globulin for studied groups (p≤ 0.05).

Group	n	MDA (µmol/L)	Alb (g/dL)	Globulin (g/dL)
		mean ± SD	mean ± SD	mean ± SD
control	100	1.59±0.42[b]	4.43±0.21[a]	2.28±0.57[a]
Asthma	100	2.06±0.71[a]	3.46±0.18[b]	2.15±0.34[a]
LSD		0.33	0.19	0.61

Source: Own authorship.

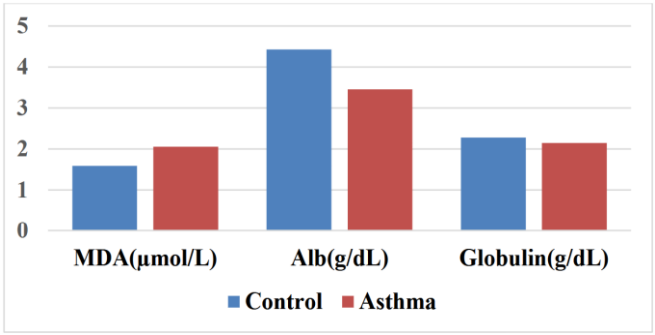


Figure 2. MDA, Alb and Globulin for studied groups. Source: Own authorship.

Table 2. GSH, Vit-c and uric acid for studied groups (p ≤ 0.05).

Group	n	GSH (µmol/L) mean ± SD	Vit-c (µmol/L) mean ± SD	uric acid (µmol/L) mean ± SD
control	100	346.29±30.48[a]	54.02±2.32[a]	295.59±31.05[a]
Asthma	100	230.84±17.43[b]	34.53±1.58[b]	274.70±25.31[b]
LSD		15.32	1.18	13.40

Source: Own authorship.

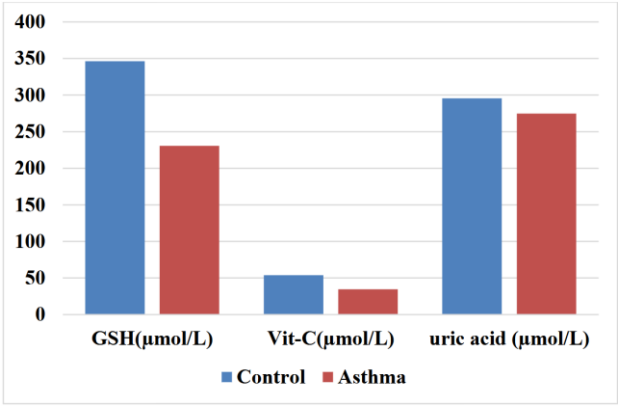


Figure 3. GSH, Vit-C and uric acid for studied groups. Source: Own authorship.

Table 3. Trace elements concentrations for studied groups (p≤ 0.05).

Group	n	Chromium(µg/L) mean ± SD	Selenium(µg/L) mean ± SD
control	100	0.57±0.09[a]	135.76±13.42[a]
Asthma	100	0.44±0.12[b]	106.44±12.75[b]
LSD		0.07	8.56

Source: Own authorship.

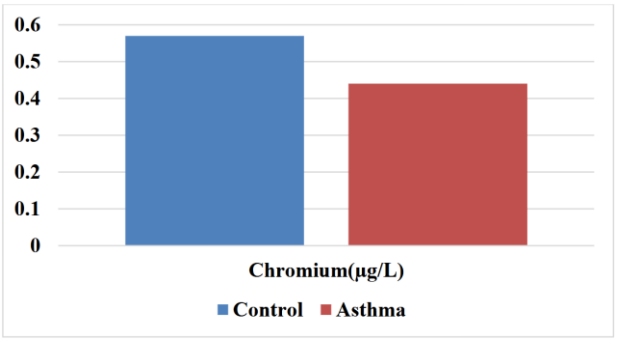


Figure 4. Chromium constrations for studied groups. Source: Own authorship.

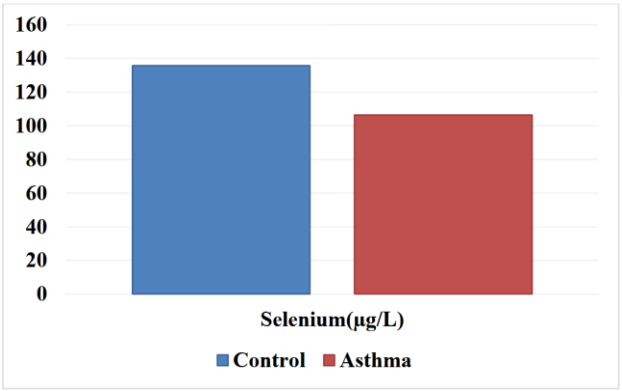


Figure 5. Selenium constrations for studied groups. Source: Own authorship. Table 4. All parameter concentrations of sex groups (p ≤ 0.05).

concentration	N		Control mean ± SD	Asthma mean ± SD	LSD
		Male	n= 50	n= 50	
		Female	n= 50	n= 50	
MDA (µmol/L)	Male		1.55±0.68[b]	2.11±0.63[a]	0.37
	Female		1.62±0.83[b]	2.02±0.78[a]	0.32
	LSD		0.51	0.64	
Alb (g/dL)	Male		4.21±0.46[a]	3.32±0.22[b]	0.31
	Female		4.64±0.43[a]	3.59±0.29[b]	0.30
	LSD		0.43	0.49	
GSH (µmol/L)	Male		350.21±28.81[a]	229.95±21.59[b]	21.01
	Female		342.37±29.53[a]	231.73±18.67[b]	18.24
	LSD		12.71	13.39	
Globulin (g/dL)	Male		2.21±0.91[a]	2.37±0.42[a]	0.32
	Female		2.34±0.52[a]	1.92±0.71 [a]	0.55
	LSD		0.17	0.12	
Vit-c (µmol/L)	Male		54.91±4.68[a]	33.92±4.01[b]	1.64
	Female		53.12±3.13[a]	35.13±6.34[b]	1.07
	LSD		1.18	1.28	
uric acid (µmol/L)	Male		310.98±19.47[a*]	283.98±15.82[b*]	3.85
	Female		280.19±17.45[a]	265.41±14.38[b]	5.13
	LSD		4.26	5.24	
Chromium (µg/L)	Male		0.55±0.18[a]	0.45±0.13[b]	0.12
	Female		0.59±0.11[a]	0.42±0.16[b]	0.14
	LSD		0.13	0.16	
Selenium (µg/L)	Male		134.71±9.98[a]	103.74±7.55[b]	12.98
	Female		136.86±14.43[a]	109.15±9.07[b]	11.84
	LSD		13.28	13.27	

Source: Own authorship.

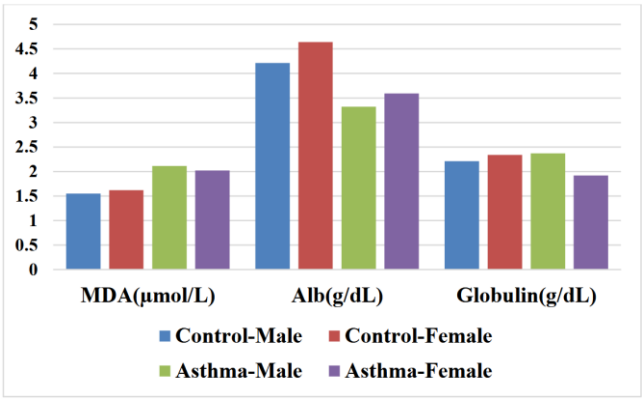


Figure 6. MDA, Alb and Globulin for studied groups. Source: Own authorship.

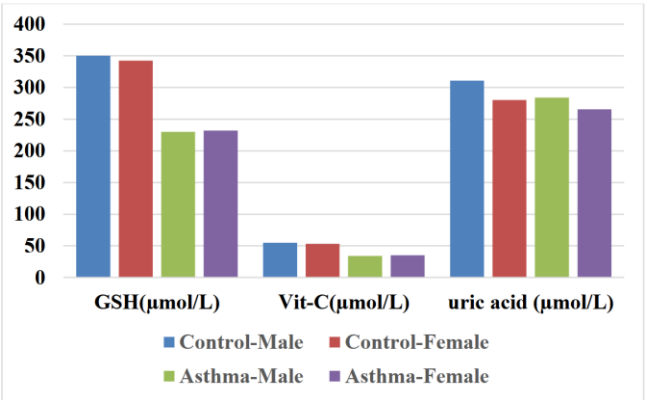


Figure 7. GSH, Vit-C and uric acid for studied groups. Source: Own authorship.

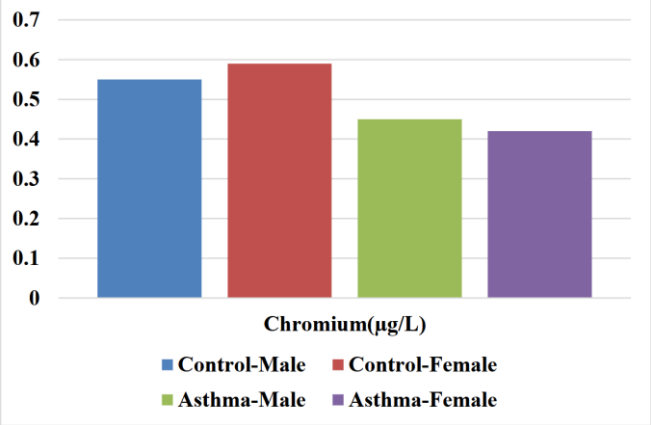


Figure 8. Chromium constration for studied groups. Source: Own authorship.

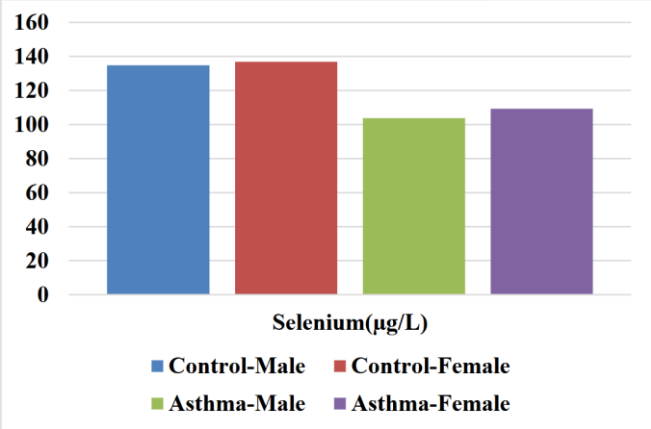


Figure 9. Selenium constration for studied groups. Source: Own authorship.

Discussion

High MDA reflects intensified lipid peroxidation caused by ROS generated in inflamed asthmatic airways **[20,21]**, high levels of ROS are linked to the development of several pathological changes that are related to bronchial asthma, for example increased lipid peroxidation, and that free radicals of oxygen work to attack cellular membranes and damage their components, which accelerates the process of e-transfer and peroxidation of fats, thereby causing the production of multiple compounds, such as MDA **[22]**.

Many studies show significantly higher MDA and lower GSH in asthmatics, especially in uncontrolled or more severe disease, confirming oxidative stress and consumption of antioxidants, reduced GSH and lower GSH/GSSG ratio are markers of a shifted redox state toward oxidation in asthma **[23]**. Selenium is an essential cofactor of glutathione peroxidase (GPx), a key enzyme that detoxifies peroxides. Multiple recent and older studies report significantly reduced serum Se and GPx activity in adults and children with asthma, independent of sex, and associated with poorer control **[24– 26]**, Reduced selenium (Se) levels in the patient group may compromise glutathione peroxidase (GPx) activity, thereby enhancing lipid peroxidation—as evidenced by elevated malondialdehyde (MDA)—and promoting increased consumption of reduced glutathione (GSH) **[25]**.

The trace elements in general (Zn, Cu, Se, Fe, Mg) are often reduced in asthmatic patients and correlate with airway inflammation and poor control **[26]**, Lower chromium (Cr) levels in the study cohort may reflect a broader deficiency in micronutrients and antioxidant capacity, These two elements play a pivotal role in mediating tissue remodeling within the respiratory tract of asthma, through their pivotal involvement in oxidative processes. They contribute to the mitigation of free radical-induced damage, either by inhibiting the production of free radicals, promoting their degradation or attenuating their activity.

Uric acid, vitamin C and albumin are major circulating antioxidants; several studies show lower plasma ascorbic acid, uric acid, and albumin in more severe or uncontrolled asthma **[23]**, reduced levels observed in the patient group suggest chronic utilization of these antioxidants in response to excessive reactive oxygen species (ROS) and/or an underlying impairment in nutritional status **[23]**.

Vitamin C is an antioxidant that works to neutralize free radicals and ROS. Hence, the levels of this vitamin C in the blood decrease, leading to increased oxidative stress in patients and hence damaging cellular components. Since asthma results in elevated levels of oxidants within the patient's body, there is an increased need for vitamin C to counteract this rise in oxidative stress levels, causing a decrease in the levels of vitamin C in the blood serum **[27]**. Uric acid is an antioxidant that has the capacity to inhibit the lipid peroxidation process (Lipid Peroxidation), by binding to copper and iron and thus inhibiting the creation of free radicals for example ($O\dot{H}$, $O\dot{R}$)) this produces a relatively stable uric acid radical, thereby inhibiting the free radical generation reaction and reducing the oxidative stress that takes place in bronchial asthma **[28]**.

Total protein and albumin declines with unchanged globulin fit a pattern where nutritional/oxidative stress affects visceral protein synthesis more than immunoglobulin production **[29]**, low albumin in asthma has been linked to greater airway inflammation, higher eosinophil counts, and worse outcomes **[30,31]**.

The reduced total serum protein levels observed in asthmatic patients compared with the control group may be attributed to decreased albumin concentrations, this is due to Alb constitutes 60% of the T. protein in the blood. The lower serum Alb levels in asthma group relative to control group may be due

to Alb is a plasma protein containing a thiol group (-SH). As an antioxidant, it protects the body from the effects of ROS and free radicals. Therefore, it inhibits lipid peroxidation, causing damage to cellular components. Consequently, a decrease in Alb levels causes reduced free radical scavenging and, therefore, increased lipid peroxidation **[32,33]**.

Study Limitations

There are a number of limitations to this study. First, because of its cross-sectional design, it is difficult to determine the causal links between oxidative stress markers, antioxidant status, trace elements, and chronic asthma. Second, the study was limited to one governorate (Al-Muthanna), which would limit how broadly the results can be applied to other parts of Iraq or to other demographics. Third, while we examined a number of clinical markers, we did not include additional potentially important biomarkers. Lastly, there was insufficient control over lifestyle factors that could affect oxidative stress and antioxidant status, such as nutrition, exercise, and exposure to the environment.

Conclusion

This study is consistent with accumulating evidence indicating that chronic asthma is characterized by increased oxidative stress (elevated MDA) accompanied by depletion of both enzymatic and non-enzymatic antioxidants (reduced GSH, Se, uric acid, vitamin C, and albumin), while globulin levels remain relatively preserved. This redox imbalance likely contributes to airway inflammation, greater disease severity, and suboptimal asthma control. In chronic asthma, the disease process itself appears strong enough to produce similar oxidative stress and antioxidant depletion in men and women, so no statistically significant sex effect is seen on your measured serum markers.

CRediT

Author contributions: Methodology, Project Administration, Supervision, Writing, Review & Editing all done by Ali Adil Ajeel.

Acknowledgment

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Ethical Approval

The study was approved by the institutional ethics committee in Department of Chemistry, General Directorate of Education Al-Muthanna, Al-Muthanna, Iraq, and adheres to the ethical principles outlined in the declaration of General Directorate of Education Al-Muthanna, Al-Muthanna, Iraq 2026.

Informed Consent

Informed consent was obtained from all participants involved in the study, with all procedures explained in detail before participation.

Funding

Not applicable.

Data Sharing Statement

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request, and all data is stored following privacy and ethical guidelines.

Conflict of Interest

The authors declare no conflict of interest.

Similarity Check

It was applied by Ithenticate@.

Application of Artificial Intelligence (AI)

Not applicable.

Peer Review Process

It was performed.

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