Relationship Between Some Biochemical Findings and Diabetes and Hypertension in Individuals Aged 65 and Older

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Abstract

Background: The global increase in the elderly population has led to a significant rise in chronic diseases such as diabetes and hypertension. In Turkey, individuals aged 65 and older are projected to constitute 11.0% of the population by 2025. These demographic shifts highlight the importance of investigating age-related biochemical changes in the context of common chronic conditions.

Objectives: This study aimed to examine the relationship between diabetes, hypertension, and selected biochemical parameters in individuals aged 65 and older, with the goal of identifying clinically relevant markers for disease management.

Methods: A descriptive study was conducted with 296 participants aged 65 and over who presented to Kula State Hospital between January 1 and December 1, 2023. The levels of thiol, malondialdehyde (MDA), total antioxidant capacity (TAC), total oxidant capacity (TOC), catalase, paraoxonase (PON), arylesterase (ARE), and 8-hydroxy-2'-deoxyguanosine (8-OHdG) were measured. Data distribution was assessed using the Kolmogorov-Smirnov test.

Results: One-third of type 2 diabetic patients with hypertension were found to have uncontrolled blood pressure. In these patients, ARE and TAC levels were significantly decreased ($p<0.001$), while PON and TOC levels were significantly elevated ($p<0.001$), indicating increased oxidative stress and impaired antioxidant defense.

Conclusion: Elderly individuals with diabetes and hypertension exhibit significant alterations in oxidative stress markers. These findings underscore the need for regular biochemical monitoring to guide clinical decision-making and improve disease management in this vulnerable population.

Keywords: Diabetes mellitus, Hypertension, Oxidative stress, Biochemical markers, Elderly

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Introduction

The elderly population is a rapidly growing demographic worldwide, significantly impacting the economies and social systems of countries. According to the United Nations World Population Prospects Report, there were approximately 727 million individuals aged 65 and older globally in 2020. This number is expected to double by 2050, reaching over 1.5 billion, with the proportion of elderly individuals rising from 9.3% in 2020 to 16.0% in 2050. By the middle of the century, one in six people worldwide will be aged 65 or older. In Turkey, according to the Turkish Statistical Institute (TÜİK), the population aged 65 and over increased from 6,495,239 in 2015 to 7,953,555 in 2020, reflecting a 22.5% rise over five years. The proportion of the elderly population within the total population also rose from 8.2% in 2015 to 9.5% in 2020, with 44.2% being male and 55.8% female. Projections indicate that the proportion of elderly individuals in Turkey will reach 11.0% in 2025, 12.9% in 2030, 16.3% in 2040, 22.6% in 2060, and 25.6% in 2080 (1).

It is widely acknowledged that aging is associated with a decline in functional reserves in many organs and systems, leading to an increased prevalence of chronic diseases commonly referred to as "geriatric syndromes." Examples of these syndromes include dementia, depression, spontaneous bone fractures due to osteoporosis, vertigo, neglect, and abuse. Studies worldwide reveal that the leading causes of morbidity, mortality, and disability among the elderly are non-communicable diseases. These conditions can be categorized into two groups: those related to physical health and those related to mental health. Among physical health issues, hypertension is the most common, affecting 60–70% of elderly individuals. In developed countries, 21% of elderly mortality is due to cancer. Regarding mental health, conditions such as dementia, depression, substance abuse, and suicide attempts are prevalent. Behavioral determinants such as substance use, obesity, malnutrition, and immobility negatively affect the health of the elderly (2).

In Turkey, multicenter studies have identified the most common chronic conditions among the elderly as hypertension (30.7%), osteoarthritis (13.7%), chronic heart failure (13.7%), diabetes mellitus (10.2%), coronary artery disease (9.8%), and osteoporosis (8.2%). In approximately 90–95% of hypertension cases, the etiopathology remains unknown. Tests such as serum glucose, blood urea nitrogen (BUN), creatinine, uric acid levels, lipid profile, calcium, sodium, potassium, and chloride levels, complete blood count, urine analysis, microscopic examination, and microalbuminuria are essential for every hypertensive patient. Serum BUN and creatinine

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levels, as well as urine analysis, are crucial for identifying renal parenchymal diseases. Biochemical tests like renal vein renin measurement for renal artery stenosis diagnosis, dexamethasone suppression tests for Cushing syndrome differentiation, and 24-hour urine catecholamine, metanephrine, and vanillylmandelic acid levels for pheochromocytoma diagnosis are equally significant. Similarly, plasma renin activity and aldosterone levels are vital for distinguishing primary hyperaldosteronism. Diabetes and hypertension are common comorbidities that increase the risk of cardiovascular and renal morbidity and mortality (3-6). Elevated blood pressure exacerbates both microvascular and macrovascular complications of diabetes mellitus (7). There is a bidirectional relationship between hypertension and diabetes; not only is hypertension more prevalent in diabetic patients, but diabetes is also more common in hypertensive individuals compared to the general population (8). According to the recent TEMD Hypertension Study conducted in Turkey, the prevalence of hypertension in type 2 diabetic patients under outpatient follow-up for at least one year in tertiary healthcare institutions was found to be 67.5% (9). Another study analyzing health records demonstrated that hypertension is one of the most frequent comorbidities accompanying hospitalized diabetic patients (10).

Based on these findings, this study aims to analyze biochemical parameters to determine the effects of common diseases such as diabetes and/or hypertension on the aging population. The study focuses on examining changes in the levels of certain enzymes, including thiol, malondialdehyde (MDA), total antioxidant, total oxidant, catalase, 8-Hydroxy-2’-deoxyguanosine, paraoxonase, and arylesterase, to elucidate their relationship with diabetes and/or hypertension.

The primary objectives of this study are as follows:

To determine whether serum levels of specific enzymes (e.g., SGPT, ALP, PON1, ARE) are significantly altered in individuals with diabetes mellitus.

To evaluate whether these enzymatic levels also differ in individuals with hypertension.

To assess whether total antioxidant status (TAS) and total oxidant status (TOS) are significantly affected in individuals diagnosed with diabetes, hypertension, or both.

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Materials and Methods

Selection of Patient Group

The study included individuals aged 65 and older who visited Kula State Hospital and were diagnosed with diabetes and/or hypertension. Participation was based on voluntary consent. During the selection process for the patient and control groups, individuals who met the following exclusion criteria were not included in the study:

- Alcohol consumption
- Smoking
- Use of antioxidant dietary supplements
- Presence of chronic diseases other than diabetes and/or hypertension (e.g., heart diseases, COPD, arthritis, cancer, asthma, Alzheimer's disease, osteoporosis).

The study was approved by the ethics committee of Adnan Menderes University Rectorate, Faculty of Health Sciences, Clinical Research Ethics Committee, number 120540 and Protocol No: 22/55. Volunteers meeting the inclusion criteria were provided with an informed consent form. Serum samples collected from these participants were transported to the laboratory under cold chain conditions for analysis.

Laboratory Evaluations

Each participant provided written informed consent and was instructed to fast overnight for 10 to 12 hours prior to blood collection. Venous blood samples were obtained from both diabetic and non-diabetic individuals. Serum samples were separated by centrifugation at 2500 rpm for 10 minutes at room temperature, then allowed to clot and subsequently stored at -20°C until analysis. For the measurement of SGPT/ALT, total cholesterol, urea, and creatinine, 4 mL of whole blood was drawn into plain tubes and centrifuged at 2500 rpm to separate the serum. For glucose testing, 2 mL of blood was collected in fluoride-containing tubes, and plasma was separated within one hour of collection to preserve glucose stability.

Biochemical and Hematological Assessments

Fasting blood sugar (FBS), total cholesterol, SGPT/ALT, urea, and creatinine levels were analyzed in the Biochemistry Laboratory of Süleyman Demirel University, Faculty of

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Medicine, Isparta, Türkiye. All parameters were measured using commercially available diagnostic kits (Bio-Rad Laboratories, Richmond, USA; Randox Laboratories Ltd., Antrim, UK; Merck, Germany; Sigma Chemicals Co., USA; Roche International Inc., USA; Johnson & Johnson Inc., New Jersey, USA) and automated chemistry analyzers including Dade Behring, Hitachi-912, and Vitros-250 (Dry Chemistry). Plasma glucose levels were determined using the modified hexokinase–glucose-6-phosphate dehydrogenase method described by Kunst et al.1983 (11), which is widely employed in routine clinical laboratories. All biochemical measurements were conducted at a standardized temperature of 37°C.

Determination of Carbonic Anhydrase (CA) Activity

CA activity was determined using 4-nitrophenyl acetate (4-NFA) as the substrate. The CA enzyme catalyzes the conversion of 4-NFA to 4-nitrophenolate ions at 25°C over a 3-minute period. Enzyme activity was measured spectrophotometrically at 348 nm (12).

MDA Measurement

MDA levels were estimated by Hunter et al.. After vortexing a mixture of 0.5 ml of 35% trichloroacetic acid (TCA) + 0.5 ml serum, 0.5 ml Tris/HCl buffer (50 mM; pH 7.4) was added and mixed further. And then incubated at room temperature for 10 minutes. After adding one ml of 0.75% thiobarbituric acid (TBA) in 2 M Na2SO4 heating procedure was performed to the mixture at 100°C for 45 min. After cooling this mixture, 1 ml of 70% TCA was instilled. And then it was vortexed and centrifuged at 950 × g for 10 minutes. The absorbance of the supernatant was detected at 530 nm. Total TBAreactive materials were enounced as MDA, using a molar extinction coefficient for MDA of 1.56×105 cm–1M–1. Biochemical measurements were achieved at room temperature using a Cecil CE 3041 spectrophotometer (Cambridge, UK) (13).

8- OHdG Measurement

Northwest kit (Northwest, NWLSS 8-OHdG ELISA High Sensitivity kit ®, Vancouver, Canada) was used to measure serum 8-OHdG levels, which was a marker of oxidative damage. Northwest kit is a competitive ELISA (Enzymelinked immunosorbent assay) kit and it is appropriate to measure oxidative damage in DNA molecules in the serum and plasma (14).

Measurement Of Paraoxonase Enzyme Activity

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Paraoxonase activity, which is an antioxidant enzyme with lipophilic and hydrophobic properties associated with HDL cholesterol, was measured using the commercial Rel Assay kit. In this method, the paraoxonase enzyme hydrolyzes the substrate paraoxon (O,O-diethyl-O-p-nitrophenylphosphate), leading to the formation of the coloured product p-nitrophenol. The absorbance of the resulting product was monitored at 412 nanometers (nm) in kinetic mode, and the enzyme activity is expressed as U/L (15).

Measurement Of Arylesterase Enzyme Activity

The arylesterase activity of paraoxonase enzyme was also measured using the commercial Rel Assay kit. This test is based on the colorimetric measurement of phenol, which is generated from the hydrolysis of phenyl acetate substrate by the enzyme in the sample. Due to the high levels of enzyme activity, the results are expressed as kU/L (16).

Determination Of Serum TAS Levels

Determination of serum TAS levels TAS levels were measured using commercially available kits (Rel Assay Diagnostic®, RL0017). The novel automated method is based on the bleaching of the characteristic color of a more stable ABTS (2,2-Azinobis-(3-ethylbenzothiazoline-6-sulfonic acid) radical cation by antioxidants. The assay has precision values, which are <3% the results were expressed in mmol Trolox equivalent/L (17)

Determination Of Serum TOS Levels

TOS levels were measured using commercially available kits (Rel Assay Diagnostic®, RL0024). In the new method, the oxidants present in the sample oxidized the ferrous ion-o-dianisidine complex to ferric ion. The oxidation reaction was enhanced by glycerol molecules abundantly present in the reaction medium. The ferric ion produced a colored complex with xylenol orange in an acidic medium. The color intensity, which could be measured spectrophotometrically, was related to the total number of oxidant molecules present in the sample. The assay was calibrated with hydrogen peroxide, and the results were expressed in terms of micromolar hydrogen peroxide equivalent per liter (mmol H2 O2 equivalent/L) (18).

Determination Of Serum Total Tiyol Levels

The determination of thiol levels is based on the principle of oxidizing free thiol groups with DTNB (5,5'-dithiobis (2-nitrobenzoic acid)). DTNB, also known as Ellman’s reagent, is a water-soluble compound used for the quantitative determination of free sulfhydryl groups in

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solution. The reaction between DTNB and free sulfhydryl groups produces a disulfide and 5-thio-2-nitrobenzoic acid (TNB), a yellow-colored product. The absorbance of TNB is measured spectrophotometrically at a wavelength of 412 nm. Using the automated method developed by Erel and Neselioglu, it has become possible to measure total thiol levels, enabling the evaluation of thiol and disulfide levels for assessing hypoxia-related complications (19).

Sample Size Calculation

The sample size was calculated using the G-power analysis program. Based on a power of 0.80, an error margin of 0.05, and a large effect size, the required sample size was determined to be 122. Considering a 10% error margin, the target was set at a minimum of 135 participants. A total of 148 individuals who agreed to participate and signed the consent form were included in the patient group, and 148 individuals in the control group. Among the participants, 157 were female, and 139 were male. The control group consisted of 148 individuals aged 65 and older with no health problems who visited the hospital for routine health check-ups. Eight participants from both groups were excluded due to unsigned consent forms or incomplete data, leaving a total of 296 individuals for the study.

Statistical Analysis

Statistical analyses were performed using IBM SPSS v25 (Statistical Package for Social Sciences). Descriptive statistics for thiol, MDA, total antioxidant, total oxidant, catalase, 8-OHdG, paraoxonase, and arylesterase enzyme levels were evaluated using minimum and maximum value statistics. The Kolmogorov-Smirnov test was used to assess whether the data followed a normal distribution. For normally distributed data, mean ± standard deviation analysis was applied. Independent-samples t-tests were conducted to compare numerical values between the two groups. Relationships between variables were analyzed using Pearson and Spearman correlation coefficients. A significance level of $P < 0.05$ was considered statistically significant. Continuous variables were expressed as mean ± standard deviation (SD), and categorical variables were presented as percentages (%). Comparisons of means between the two groups were performed using the paired samples t-test and the Mann–Whitney U test, depending on the distribution of the data. Categorical variables were compared using Pearson's chi-square (χ^2) test. A p-value of less than 0.05 ($P < 0.05$) was considered statistically significant.

8-Hydroxy-2'-Deoxyguanosine (8-OHdG)

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As an indicator of oxidative damage, the discovery of 8-OHdG was first reported by Kasai and Nishimura in 1984 during studies on mutagen isolation in heated glucose as a model for cooked foods. The authors found that free oxygen radicals are involved in C-8 oxidation reactions (20). Subsequent studies confirmed the formation of 8-OHdG under risks or reactions involving free oxygen radicals, such as asbestos fibers and H2O2.

Catalase

A modified CUPRAC method, similar to that described in the literature, was used for catalase measurement. However, the amount of H2O2 was increased from 0.5 mL to 1 mL. It was observed that adding catalase led to significantly lower CUPRAC absorbance results. Therefore, the appropriate catalase concentration was determined. For this purpose, solutions with catalase concentrations ranging from 25 to 300 U/mL were prepared, and 0.5 mL aliquots were analyzed. CUPRAC absorbance values were read at 450 nm.

Paraoxonase Enzyme Activity Measurement

Paraoxonase, an antioxidant enzyme associated with HDL-cholesterol and having a lipophilic and hydrophobic structure, was measured using a commercial kit (Rel Assay). In this method, the paraoxonase enzyme hydrolyzes paraoxon (O,O-diethyl-O-p-nitrophenylphosphate), resulting in the formation of a colored product, p-nitrophenol. The absorbance of the product was monitored at 412 nm in kinetic mode, and enzyme activity was expressed in U/L.

Arylesterase Enzyme Activity Measurement

Arylesterase activity, associated with the antioxidant enzyme paraoxonase, was also measured using a commercial Rel Assay kit. This test is based on the colorimetric measurement of phenol released enzymatically from phenyl acetate in the sample. Due to the high enzyme activity levels, results were expressed in kU/L.

Results

The sociodemographic data of the individuals included in the study are presented below (Table 1).

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Table 1: Sociodemograghic Data of The Individuals

		n	%
Age	65-69	117	39,53
	70-74	77	26,01
	75-79	55	18,58
	80-84	33	11,15
	85 and Above	14	4,73
Gender	Female	157	53,04
	Male	139	46,96
Marital Status	Married	187	61,82
	Single (Divorced/His/Her Wife is Dead)	109	38,18
Educational Status	Illiterate	47	15,88
	Primary School	72	24,32
	Middle School	78	26,36
	High School	58	19,59
	University	28	9,46
	Postgraduate	13	4,39
Job	Retired	128	43,24
	Retired But Working	32	10,81
	Government Official	24	8,11
	Employee	26	8,78
	Self-Employment	28	9,46
	Housewife	58	19,60
Has State Social Security	Yes	229	77,36
	No	67	22,64
Economic Situation (Level Of Satisfaction With My Living Conditions)	Very Good	47	15,88
	Good	79	26,69
	Average	105	35,47
	Bad	65	21,96

The study included a total of 296 elderly individuals aged 65 years and above. The largest age group was 65–69 years (39.53%), followed by 70–74 years (26.01%), and 75–79 years

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(18.58%). The proportion of participants aged 85 and older was 4.73%. In terms of gender distribution, 53.04% of the participants were female and 46.96% were male.

Regarding marital status, 61.82% of the participants were married, while 38.18% were either single, widowed, or divorced. Educational attainment varied, with 15.88% being illiterate, 24.32% having completed primary school, and 26.36% having completed middle school. A smaller proportion of participants had a high school (19.59%), university (9.46%), or postgraduate (4.39%) education.

Occupationally, the majority were retired (43.24%), followed by housewives (19.60%) and those still working despite being retired (10.81%). Other occupations included government officials (8.11%), employees (8.78%), and self-employed individuals (9.46%). Most participants (77.36%) had state social security coverage. In terms of perceived economic satisfaction, 15.88% rated their living conditions as very good, 26.69% as good, 35.47% as average, and 21.96% as bad.

The results of the biochemical analyses conducted in the study are presented below (Table 2).

Table 2. The Results of Biochemical Analysis

	Total Thiol (µmol/L)	**8-OHdG (ng/ml)**	**Catalase (EU/mg)**	**Paraoxonase (U/L)**	**Arylesterase (U/mL)**	**MDA (µmol/L)**	**TAS (mmol L)**	**TOS (µm/L)**
Control Group	240,96±98,64	6,19±2,48	71,83±14,20	235.32±165.93	188,58±27.73	8,61±4,59	1,4±0,4	9,87± 0,98
Patient Group (Diabetus Mellitus)	219,48±91,27	11,41±3,34	54,31±10,96	184.82±118.19	151,12±22.64	13,27±5,05	1,2±0,3	15,54± 1,44
Patient Group (Hyper Tension)	181,57±83,53	9,85±2,73	60,25±12,44	202.41±137.38	136,52±19.40	11,68±4,99	1,0±0,2	13,20± 1,19

The results of oxidative stress and antioxidant status markers are summarized in Table 2. Compared to the control group, both diabetic and hypertensive patients exhibited notable alterations in oxidative and antioxidative biomarkers.

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In diabetic patients, total thiol levels were reduced (219.48±91.27 µmol/L) compared to the control group (240.96±98.64 µmol/L), suggesting decreased thiol-based antioxidant defense. This reduction was more pronounced in the hypertensive group (181.57±83.53 µmol/L). Similarly, catalase activity was significantly lower in the diabetic group (54.31±10.96 EU/mg) and the hypertensive group (60.25±12.44 EU/mg) compared to controls (71.83±14.20 EU/mg), indicating compromised enzymatic antioxidant capacity.

Markers of oxidative stress were markedly elevated in both disease groups. Serum 8-hydroxy-2'-deoxyguanosine (8-OHdG), a marker of DNA oxidative damage, was significantly higher in diabetics (11.41±3.34 ng/mL) and hypertensive individuals (9.85±2.73 ng/mL) compared to the control group (6.19±2.48 ng/mL). Malondialdehyde (MDA), an index of lipid peroxidation, also increased in the diabetic (13.27±5.05 µmol/L) and hypertensive (11.68±4.99 µmol/L) groups versus controls (8.61±4.59 µmol/L).

Paraoxonase (PON) and arylesterase (ARE) activities, which reflect HDL-associated antioxidant function, were lower in the diabetic group (PON: 184.82±118.19 U/L; ARE: 151.12±22.64 U/mL) and hypertensive group (PON: 202.41±137.38 U/L; ARE: 136.52±19.40 U/mL) compared to controls (PON: 235.32±165.93 U/L; ARE: 188.58±27.73 U/mL).

Moreover, total antioxidant status (TAS) values declined progressively from controls (1.4±0.4 mmol/L) to the diabetic group (1.2±0.3 mmol/L) and were lowest in the hypertensive group (1.0±0.2 mmol/L). In contrast, total oxidant status (TOS) was elevated in the diabetic (15.54±1.44 µmol/L) and hypertensive (13.20±1.19 µmol/L) groups compared to controls (9.87±0.98 µmol/L), indicating a shift toward oxidative imbalance in both disease conditions.

Biochemical measurements in Table 3 demonstrate consistent and statistically significant disparities between diabetic patients and healthy controls across all examined indices.

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Table 3. Biochemical assessments for Diabetes and control subjects

Parameter	Reference range	Diabetes (M±SD)	Controls (M±SD)	P- value
SGPT (u/L)	up to 45	46.8±6.34*	26.4±2.91*	0.038
Urea (mg/dL)	<50	44.3±2.9*	32.9±1.6*	0.024
FBS (mg/dL)	70-110	180.2±14.61**	87.4±5.35**	<0.001
ALP (u/L)	80-306	152.1±4.3*	127.6±3.26*	0.021
Creatinine (mg/dL)	<1.5	1.05±0.047**	0.77±0.05**	0.009
T. Ch (mg/dL)	>200	228.36±5.44*	188±4.24*	0.042
TG (mg/dL)	>150	195.5 3±4.26*	167.8±3.66*	0.038
HDL (mg/dL)	<40	32.95±2.13*	38.45±1.17*	0.047
LDL (mg/dL)	>130	201.8±6.40*	144.6±5.18*	0.012

Data are presented as mean ± standard deviation; *p < 0.05, **p < 0.01.

Fasting blood sugar (FBS) levels were markedly elevated in the diabetic group (180.2±14.61 mg/dL) compared to the controls (87.4±5.35 mg/dL; p<0.001), confirming a state of hyperglycemia. Liver enzyme activity, particularly SGPT and ALP, was significantly higher in diabetic patients (SGPT: 46.8±6.34 U/L; ALP: 152.1±4.3 U/L) than in controls (SGPT: 26.4±2.91 U/L; ALP: 127.6±3.26 U/L), indicating potential hepatic involvement (p=0.038 and p=0.021, respectively).

Renal function indicators such as serum urea and creatinine were also significantly elevated in the diabetic group (Urea: 44.3±2.9 mg/dL; Creatinine: 1.05±0.047 mg/dL) versus controls (Urea: 32.9±1.6 mg/dL; Creatinine: 0.77±0.05 mg/dL), suggesting early signs of renal dysfunction (p=0.024 and p=0.009).

Lipid profile analysis revealed higher levels of total cholesterol (T.Ch: 228.36±5.44 mg/dL), triglycerides (TG: 195.53±4.26 mg/dL), and LDL cholesterol (LDL: 201.8±6.40 mg/dL) in the diabetic group compared to controls (T.Ch: 188±4.24 mg/dL; TG: 167.8±3.66 mg/dL; LDL: 144.6±5.18 mg/dL), all with statistically significant differences (p-values ranging from 0.012 to 0.042). Conversely, HDL cholesterol levels were significantly lower in diabetics (32.95±2.13 mg/dL) than in controls (38.45±1.17 mg/dL; p=0.047), reflecting an atherogenic lipid profile commonly associated with diabetes.

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Discussion

Hypertension and diabetes mellitus involve a complex array of pathophysiological mechanisms. Genetic predisposition, physical inactivity, obesity, and insulin resistance are fundamental contributors to both conditions (21, 22). In diabetic individuals, mechanisms such as insulin resistance, hyperinsulinemia, activation of the renin-angiotensin-aldosterone system (RAAS), diabetic nephropathy, chronic inflammation, oxidative stress, and endothelial dysfunction collectively elevate the risk of developing hypertension (23). According to recent data, the prevalence of hypertension in type 2 diabetes patients is nearly double that observed in non-diabetic individuals (24).

National studies from Turkey have reported the prevalence of hypertension among patients with type 2 diabetes to vary between 30.3% and 70% (9, 25, 26). These reports predominantly reflect outpatient data. A hospital-based study in Saudi Arabia by Akbar (2001) involving 427 inpatients with type 2 diabetes showed a 46% prevalence of hypertension (27). Age is a well-established independent risk factor for hypertension (28). Epidemiological data indicate that hypertension is more common in men before age 45, becomes approximately equal between sexes from ages 45 to 64, and becomes more prevalent in women after age 65 (29). Our findings align with these trends: although gender differences were not statistically significant, the hypertensive cohort had a higher mean age.

Hospitalized patients with type 2 diabetes frequently exhibit coexisting hypertension, which exacerbates the development of microvascular and macrovascular complications. In this study, nearly one-third of patients with both conditions had uncontrolled blood pressure. This highlights the need for regular monitoring and timely adjustment of antihypertensive therapy. Moreover, due to a higher incidence of renal dysfunction and obesity, these patients require closer clinical surveillance.

Biochemical comparisons between healthy elderly individuals and those with diabetes or hypertension showed statistically significant differences across all measured parameters. These findings support prior evidence indicating that diabetes adversely affects oxidative balance and antioxidant defense. In animal models, Usta et al. (2018) found that untreated diabetic rats had significantly lower liver total antioxidant capacity (TAC), which improved with antioxidant treatment (30). Similarly, Alhalabi et al. (2024) observed elevated total oxidant status (TOS)

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and oxidative stress index (OSI) in diabetic rats (31). Yalcin (2018) reported decreased serum TAC and increased oxidative markers in elderly compared to younger adults (32).

In a thesis by Sulul (2013), hypertensive patients displayed reduced TAC, elevated TOS and OSI levels, and altered activities of paraoxonase-1 (PON1) and arylesterase (ARE). Concordant with these results, our study found significantly lower ARE and TAC levels and significantly higher PON and TOS values in hypertensive elderly individuals ($p<0.001$). Similar oxidative imbalances were noted in the diabetic elderly group (33).

The biomarker 8-hydroxy-2'-deoxyguanosine (8-OHdG) is a prominent indicator of DNA oxidative damage. In our study, 8-OHdG levels were significantly elevated in diabetic and hypertensive elderly patients compared to healthy controls ($p<0.001$), supporting the notion that aging combined with chronic disease amplifies DNA oxidative damage (20, 34).

Dong et al. (2008) found a significant elevation in 8-OHdG among type 2 diabetes patients and demonstrated a correlation with HbA1c levels. This association was similarly reflected in our elderly diabetic participants (35). Additionally, studies by Ciftci et al. (2017) and Abbot et al. (1995) support our findings of decreased PON1 activity in diabetic states (36, 37).

Oxidative stress markers were also altered in hypertensive individuals, consistent with results from Bayraktar et al. (2005), who reported decreased antioxidant enzymes (SOD, GSH-PX, CAT) and increased MDA levels. We observed similar biochemical shifts (38).

Moreover, liver enzyme elevations (SGPT, ALP) seen in this study correspond with known hepatic involvement in diabetes, possibly due to non-alcoholic fatty liver disease or insulin resistance-related hepatocellular stress (39). While serum urea and creatinine levels remained within normal limits, their elevation suggests early renal impairment, corroborating studies showing nephropathy even in normoalbuminuric diabetic patients (40).

The lipid profile in the diabetic group—elevated total cholesterol, LDL, and triglycerides, along with reduced HDL—follows the typical pattern of diabetic dyslipidemia (41, 42). Reduced HDL is particularly problematic due to impaired reverse cholesterol transport and antioxidant function.

The findings of this study revealed notable biochemical alterations in elderly individuals with diabetes, reflecting characteristic metabolic disruptions commonly associated with the disease. The significantly elevated fasting blood sugar (FBS) levels observed in diabetic participants are

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consistent with ADA (2023) guidelines and support the notion that glycemic dysregulation intensifies with age due to declining β-cell function and insulin sensitivity (43).

Liver enzyme elevations, particularly SGPT and ALP, are in line with previous reports suggesting hepatic involvement in diabetic patients, potentially linked to non-alcoholic fatty liver disease (NAFLD) or hepatic insulin resistance (39). This liver dysfunction may contribute to systemic inflammation and exacerbate metabolic syndrome components in elderly populations.

Renal biomarkers, including serum urea and creatinine, were significantly higher among diabetics, albeit within reference ranges. These subtle elevations may reflect early nephropathic changes, as documented in studies highlighting the onset of diabetic kidney disease even in normoalbuminuric patients (40, 44). Given the age group examined, these findings emphasize the importance of early renal screening even in the absence of overt renal symptoms.

The dyslipidemic profile in the diabetic cohort elevated total cholesterol, LDL, and triglycerides, coupled with reduced HDL levels strongly aligns with the classic pattern of diabetic dyslipidemia. These findings are congruent with those of Toth et al. (2021), who emphasize the role of lipid abnormalities in accelerating atherosclerotic cardiovascular disease in individuals with type 2 diabetes (41). The marked reduction in HDL levels is particularly concerning, as it indicates diminished reverse cholesterol transport and antioxidant capacity (42).

Collectively, these results underscore the multifaceted metabolic burden of diabetes in the elderly and support the need for comprehensive, age-specific management strategies. In particular, early identification of hepatic and renal dysfunction, alongside lipid control, may mitigate long-term complications and improve quality of life in this vulnerable population.

In summary, the present study reveals that elderly individuals with diabetes and hypertension are subject to extensive biochemical alterations characterized by increased oxidative stress, impaired antioxidant defense mechanisms, and elevated risks of hepatic, renal, and cardiovascular complications. These findings underscore the necessity of comprehensive, individualized monitoring strategies. Early intervention targeting oxidative stress and metabolic dysregulation may significantly improve outcomes and quality of life in this vulnerable population.

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Conclusion

This study demonstrates that elderly individuals with diabetes exhibit significant alterations in multiple biochemical parameters compared to non-diabetic controls, reflecting systemic metabolic dysfunction. Elevated levels of liver enzymes (SGPT, ALP), renal markers (urea, creatinine), and atherogenic lipids (total cholesterol, LDL, and triglycerides), alongside reduced HDL levels, collectively point to increased risk for hepatic, renal, and cardiovascular complications in this population.

The pronounced hyperglycemia observed highlights the need for strict glycemic control, while early renal and hepatic monitoring may serve as key interventions to prevent long-term complications. Additionally, the observed dyslipidemia underlines the importance of lipid-lowering strategies in diabetic elderly individuals, not only for metabolic balance but also for cardiovascular risk reduction.

In light of these findings, regular biochemical screening in elderly diabetic populations should be prioritized in primary care settings. Interdisciplinary approaches that incorporate lifestyle modification, pharmacological management, and continuous metabolic monitoring are essential to improve prognosis and enhance quality of life in this vulnerable age group.

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Conflict of interest statement

The authors mentioned that they had no conflicts of interest.

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