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Evaluation of Sirtuin 3 level and some biochemical parameters in people with Parkinson's disease

Noor Abdulsatar Majeed[1*], Mohammed Bahry Hassin [2]
[1,2] Chemistry Department, College of Science, University of Mosul, Mosul, Iraq

[*]*Corresponding author:* *nour.21scp58@student.uomosul.edu.iq*

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Abstract
The study aimed to evaluate the levels of Sirtuin 3 (SIRT3), along with various biochemical parameters, in individuals diagnosed with Parkinson's disease. Additionally, the potential relationship between these parameters and factors such as age, gender, and blood group. The findings of the study indicated significant variations in SIRT3 levels among individuals with Parkinson's disease. Moreover, observed correlations between SIRT3 levels and certain biochemical parameters. These parameters included markers of oxidative stress, inflammation, and neurodegeneration, which are commonly associated with Parkinson's disease. The study was conducted on (50) healthy and Parkinson's patients, their ages ranged between (30–80) years, and the study indicated that there was a significant decrease in the probability level ($P \leq 0.05$) for the level of SIRT3 in the blood serum of the patients with Parkinson's disease of both genders. It also aimed to study the impact of oxidative stress on patients with Parkinson's disease and compare it with the healthy ones, by measuring (17) variables of oxidation and antioxidants. The results showed that there was a significant decrease at the probability level ($p \leq 0.05$) in the level of SIRT3 at the probability level ($p \leq 0.05$) and a significant increase at the probability level ($p \leq 0.05$) in the level of malondialdehyde, glucose, and copper in comparison with healthy people. The results showed a significant decrease in the patients with Parkinson's disease in all antioxidants (vitamin C - bilirubin - albumin - Ceruloplasmin- glutathione - iron) compared to healthy people because of the increased oxidative stress. As for lipid profile, the results indicate a significant decrease in levels of (TC, TG, HDL-C, LDL-C, and VLDL-C). Also, the results showed a significant decrease in the concentration of (uric acid, zinc, and lipid profile).

Keywords: Parkinson's disease, blood serum, Sirtuin 3, lipid profile

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تقييم مستوى السرتوين 3 وبعض المتغيرات البيوكيميائية الدى الأشخاص المصابين بداء باركنسون

نور عبد الستار مجيد [1*]، محمد بحري حسن [2]
[1،2] قسم الكيمياء، كلية العلوم، جامعة الموصل، الموصل، العراق

الملخص: تهدف الدراسة إلى تقييم مستويات Sirtuin 3، إلى جانب المعلمات البيوكيميائية المختلفة، لدى الأفراد الذين تم تشخيص إصابتهم بمرض باركنسون. بالإضافة إلى ذلك، العلاقة المحتملة بين هذه المعلمات والعوامل مثل العمر والجنس

وفصيلة الدم. أشارت نتائج الدراسة إلى اختلافات كبيرة في مستويات SIRT3 بين الأفراد المصابين بمرض باركنسون. علاوة على ذلك، لوحظ وجود ارتباطات بين مستويات SIRT3 وبعض المعلمات البيوكيميائية. تضمنت هذه المعلمات علامات الإجهاد التأكسدي والالتهاب والتنكس العصبي، والتي ترتبط عادة بمرض باركنسون. أجريت الدراسة على (50) مريضا سليما ومرضى باركنسون، تراوحت أعمارهم بين (30-80) سنة، وأشارت الدراسة إلى وجود انخفاض معنوي في مستوى الاحتمال ($P \leq 0.05$) لمستوى SIRT3 في مصل الدم لمرضى مرض باركنسون من كلا الجنسين. كما هدفت إلى دراسة تأثير الإجهاد التأكسدي على مرضى باركنسون ومقارنته مع الأصحاء، وذلك بقياس (17) متغيرا من متغيرات الأكسدة ومضادات الأكسدة. أظهرت النتائج أن هناك انخفاضا معنويا عند مستوى الاحتمال ($p \leq 0.05$) في مستوى SIRT3 عند مستوى الاحتمال ($p \leq 0.05$) وزيادة معنوية عند مستوى الاحتمال ($p \leq 0.05$) في مستوى malondialdehyde والجلوكوز والنحاس مقارنة بالأشخاص الأصحاء. أظهرت النتائج انخفاضا معنويا في مرضى مرض باركنسون في جميع مضادات الأكسدة (فيتامين ج - البيليروبين - الألبومين - سيرولوبلازمين - جلوتاثيون - حديد) مقارنة بالأشخاص الأصحاء بسبب زيادة الإجهاد التأكسدي. أما بالنسبة لملف الدهون، فقد أشارت النتائج إلى انخفاض معنوي في مستويات (TC وTG و HDL-C و LDL-C و VLDL-C). كما أظهرت النتائج انخفاضا معنويا في تركيز (حمض اليوريك، الزنك، والدهون).

الكلمات المفتاحية: مرض باركنسون، فصيلة الدم،SIRT3 ، مستويات الدهون

Introduction

Parkinson's disease (PD) is the second most common neurodegenerative disorder, surpassed only by Alzheimer's disease. PD is a chronic and progressive condition that primarily affects movement but can also cause non-motor symptoms [1]. The disease occurs due to the loss of dopamine-producing cells in a specific brain region called the substantia nigra (SNpc). This leads to a shortage of dopamine, a neurotransmitter that plays a crucial role in controlling movement and influencing the central nervous system (CNS), which includes the brain and spinal cord. As a result, PD interferes with the control of movement and emotions in affected individuals. The loss of dopamine in the brain is responsible for the characteristic motor symptoms of PD, such as tremors, rigidity, bradykinesia (slowness of movement), and postural instability [2]. PD is a complex and progressive neurodegenerative condition that typically manifests around the age of sixty. The typical age for PD diagnosis is in the late 50s, and the likelihood of receiving a PD diagnosis increases with age, with men being more susceptible than women. Most neurological movement disorders, including 1-2% of people over 65 and 4-5% of people over 85, are attributed to Parkinson's disease (PD). Furthermore, between 5-10% of individuals may experience the disease at an early stage, with symptoms appearing before the age of 50, and the incidence rate is 0.5 per 100,000 for those under the age of 40 [3]. Young-onset Parkinson’s disease affects individuals between the ages of 21 and 40, and it is believed to be caused by genetic factors rather than environmental influences [4]. The exact cause of PD is still unknown, except for cases linked to inherited DNA mutations. However, in addition to age, several other factors have been identified as significant risk factors, such as family history, exposure to toxic metals or pesticides, mitochondrial dysfunction, and oxidative stress [5].

2. The aim of this study:

The aims of this research were a biochemical study of Parkinson’s disease patients and its effect on age, gender, and blood type.

3. Materials and methods:

3.1. The Subjects:

50 blood samples were collected for people with Parkinson’s disease who were diagnosed by specialized doctors in cooperation with several Hospitals, whose ages ranged from (30-80) years. The study included 21 females and 29 males, which were divided into three age groups, (30-45) years), (46-60 years) and (more than 60 years).

3.2. Preparation of blood serum:

Blood samples were collected from patients with Parkinson’s disease (10ml), then the serum samples were separated and divided into four parts in small dry plastic tubes and kept in covered tubes at a temperature of (-20ºc) until it is used in measuring the specified variables in the research.

3.3. Measurement of some biochemical variables in blood serum:

1.3.3. Determination of the Sirtuin 3 (SIRT3):

The level of (SIRT3) was determined based on using the ready-made analysis kit (Kit) from the Chinese company (YL Biont) and based on (Enzyme-Linked Immunosorbent Assay, ELISA technique). Based on the Biotin double antibody sandwich technology to assay the Human (SIRT3).

3.3.2. Determination of Albumin:
Albumin was determined using the bromocresol green method, which is a ready-made standard analysis kit from the French company (BIOLABO) [6].

3.3.3 Determination of Total Bilirubin:
The level of bilirubin concentration in the blood serum was measured using the determination kit produced by the French company (BIOLABO) [7].

3.3.4. Determination of Glucose:
The concentration of glucose in the blood serum was estimated according to the enzymatic method, the Trinder method, using the ready-made analysis kit [8].

3.3.5. Determination of Ceruloplasmin (Cp):
The method depends on the activity of (Cp) on the oxidation of Para-phenylenediamine (PPD) to a blue-violet solution, and the speed of product formation depends on the concentration of ceruloplasmin in serum [9].

3.3.6. Determination of Uric acid:
The uric acid concentration was estimated using the Uricase Enzyme method, and a ready-made analysis (Kit) from the French company (BIOLABO) was used [10].

3.3.7. Determination of the level of Triglyceride (TG):
The level of Triglyceride in the blood serum was estimated using the ready-made analysis kit from the French company (BIOLABO) [11].

3.3.8. Determination of Total Cholesterol (TC):
The level of total cholesterol in the blood serum was estimated using the ready-made analysis kit from the French company (BIOLABO) [12].

3.3.9. Determination of the level of a High-Density Lipoprotein Cholesterol (HDL-C):
The level of high-density lipoprotein-cholesterol (HDL-C) in the blood serum was estimated depending on the enzymatic method using a ready-made analysis kit from the French company BIOLABO [13].

3.3.10. Determination of Serum Low-Density Lipoprotein-Cholesterol (LDL–C) and Serum Very Low-Density Lipoprotein-Cholesterol (VLDL-C) Levels:
Low-density lipoprotein has been calculated using Friedewald's [14] formula:
LDL-C (mg/dL) =Total cholesterol- [HDL-C + TG/5] While VLDL-C concentration is estimated as 20% of total TG concentrations from the following equation:
VLDL = TG/5

3.3.11. Determination of Glutathione (GSH):
The concentration of glutathione in blood serum was estimated based on the modified method used by the researchers [15], which is based on the use of (Ellman's reagent).

3.3.12. Determination of oxidant marker, malondialdehyde (MDA) level in blood serum:
The method used by the researcher [16] was used to estimate the level of malondialdehyde concentration in blood serum.

3.3.13. Determination of Zinc:
The level of zinc in the blood serum was estimated depending on the colorimetric method using a ready-made analysis kit from the Egyptian company (Spectrum) [17].

3.3.14. Determination of Copper:
The level of copper in the blood serum was estimated depending on the colorimetric method using a ready-made analysis kit from the Egyptian company (Spectrum) [18].

3.3.14. Determination of Iron:

The concentration of iron in the blood serum was determined by following the colorimetric method, in which a ready-made analysis kit was used from the French company BIOLABO [19].

3.4.15. Determination of Vitamin C concentration:
Vitamin C concentration has been determined by the researchers [20].

4. Statistical analysis
The results were statistically analyzed using the statistical program 18SPSS [21], and the data were statistically analyzed using the Analysis of Variance (ANOVA) test and Duncan test to compare more than two variables and find the difference at the level of probability $p \leq 0.05$.

5. Results and discussion:

5.1. The results of the biochemical study

The study included in Table (1), the impact of oxidation and antioxidants on patients with Parkinson's disease and levels of body fat (lipid profile) by measuring (17) variables, which was conducted on (50) samples of patients and healthy people, their ages ranged from (30–80) years. The results indicated a correlation between oxidation and the development of PD. Regarding the levels of body fat (lipid profile), changes were observed in Parkinson's patients. The results showed a significant decrease in the probability of ($p \leq 0.05$) in the level of SIRT3 compared to healthy people. This may be attributed to dysregulated cellular signaling, SIRT3 is involved in regulating various cellular signaling pathways that impact cellular metabolism, stress response, and longevity. The level of SIRT3 and its concentration decrease according to Chronic inflammation. Inflammation may affect SIRT3 expression and activity, leading to reduced levels of SIRT3 in the serum [22]. Also, the results showed a significant decrease in patients with Parkinson's disease in all antioxidants (vitamin C - bilirubin - albumin - glutathione - iron - ceruloplasmin) compared to healthy people because of the increased oxidative stress. attributed to their increased depletion in combating and removing free radicals resulting from the oxidative process occurring in dopaminergic neurons. Free radicals can overwhelm the antioxidant defense mechanisms, leading to oxidative stress. Reduced antioxidant enzyme activity, such as superoxide dismutase (SOD), catalase, and glutathione peroxidase. These enzymes neutralize free radicals and maintain a balanced antioxidant status. When their activity decreases, the capacity to counteract oxidative stress diminishes [23]. Also, a decrease in lipid profile (TC, TG, HDL-C, LDL-C, and VLDL-C) was observed in patients with PD compared to healthy people. This reason is attributed to dopamine deficiency; PD is characterized by a loss of dopamine-producing cells in the brain. Dopamine is involved in regulating lipid metabolism, and its deficiency may disrupt lipid homeostasis, leading to decreased lipid levels [24]. The results also showed there was a significant increase in the concentration of copper in patients compared to healthy. The reason for this increase can be attributed to impaired copper metabolism [25]. As for MDA, there was a significant increase in the probability of ($p \leq 0.05$). The reason for this increase can be attributed to oxidative stress, which refers to an imbalance between the production of reactive oxygen species (ROS) and the body's ability to neutralize them [26]. The result also indicates a significant increase in glucose levels in patients. The reason for this can be attributed to could be related to the dysregulation of glucose metabolism in PD [27].

Table 1. The levels of some biochemical variables in the blood serum of people with Parkinson's disease compared to the control group.

Biochemical variables	Mean ± SE	
	patient group (n= 50)	control group (n= 50)
Sirtuin 3 (ng/ml)	2.38 ± 0.070 b	7.61 ± 0.076 a
Albumin (g/dl)	2.89 ± 0.050 b	4.58 ± 0.020 a
Total Bilirubin (mg/dl)	0.27 ± 0.020 b	0.43 ± 0.024 a
Glucose (mg/dl)	129.11 ± 0.065 a	91.45 ± 0.025 b
Ceruloplasmin (g/L)	0.54 ± 0.016 b	1.02 ± 0.075 a
Uric acid (mg/dl)	3.61 ± 0.021	5.38 ± 0.016

	b	a
Triglyceride (mg/dl)	119.70 ± 0.083 b	148.62 ± 0.034 a
Total Cholesterol (mg/dl)	111.79 ± 0.082 b	154.02 ± 0.031 a
High-density lipoprotein (mg/dl)	20.66 ± 0.018 b	38.60 ± 0.011 a
Low-density lipoprotein (mg/dl)	68.47 ± 0.057 b	87.88 ± 0.026 a
Very-low-density lipoprotein (mg/dl)	23.94 ± 0.022 b	27.80 ± 0.017 a
Glutathione (µmol/L)	14.24 ± 0.012 b	18.14 ± 0.016 a
Malondialdehyde (µmol/L)	1.76 ± 0.018 a	0.57 ± 0.017 b
Zinc (µg/dl)	76.00 ± 0.044 b	84.27 ± 0.025 a
Copper (µg/dl)	172.60 ± 0.069 a	106.74 ± 0.030 b
Iron (µg/dl)	59.11 ± 0.052 b	102.47 ± 0.072 a
Vitamin C (mg/100ml)	0.18 ± 0.018 b	0.29 ± 0.020 a

Different letters horizontally indicate a significant difference at the probability level (P≤0.05).

6. Study of some factors affecting the biochemical variables measured in the blood serum of people with Parkinson's disease and healthy people

6.1. Effect of Gender:

The effect of gender on all the measured biochemical variables in the patient group and the healthy group was studied, as well as studying the effect of gender on the group of patients with PD. The results shown in Tables (2) and (3) indicate a significant decrease in the concentration of (SIRT3) in the male patient group compared to males in the healthy group, and the concentration of SIRT3 in male patients with Parkinson's disease was also higher than that in healthy females. This means that the level of SIRT3 significantly decrease in the male and female patient groups with PD compared to the healthy group, and the results also showed that gender plays a significant role in Parkinson's disease as the level of SIRT3 decreased in female patients and controls compared to male patients and controls. This result is consistent with studies that have concluded that males are more susceptible to the risk of PD when various factors, including genetic and hormonal differences between the sexes. Hormones like testosterone and estrogen play a role in gene regulation, which can impact the expression of SIRT3. Additionally, variations in lifestyle, diet, and environmental factors may also contribute to the observed differences [28]. The results also indicated that levels of oxidation and antioxidants (albumin, total bilirubin, vitamin C, iron, ceruloplasmin, and glutathione) significantly decreased in the patient group (males and females) compared to the control group (males and females), attributed to their increased depletion in combating and removing free radicals resulting from the oxidative process occurring in dopaminergic neurons, as we age, our bodies naturally produce more free radicals, which are reactive molecules that can cause cellular damage. Free radicals can overwhelm the antioxidant defense mechanisms, leading to oxidative stress. Reduced antioxidant enzyme activity, such as SOD, catalase, and glutathione peroxidase. These enzymes neutralize free radicals and maintain a balanced antioxidant status. When their activity decreases, the capacity to counteract oxidative stress diminishes [23]. As for uric acid, the results indicate a significant and noticeable decrease in its concentration in the patient group (males and females) compared to the control group (males and females). This can be attributed to oxidative stress, Oxidative stress plays an important role in PD, especially in the dopaminergic neurons of the substantia nigra, whose degeneration is responsible for the onset and progression of Parkinson's disease. There is evidence indicating a significant association between lower serum UA levels and the severity of motor impairment in PD [29]. Regarding (zinc and copper) the results indicate a significant increase in the concentration of copper in the patient group (males and females) compared to the control group (males and females) and no significant difference in concentration of zinc. This increase in concentration leads to the binding of copper to alpha-synuclein is a crucial event in the development of the disease as it leads to

several interrelated consequences. Firstly, it induces a conformational change in alpha-synuclein, promoting fibrillation and aggregation. The copper-alpha-synuclein complex alters copper's redox properties, which have been linked to increased production of H2O2 through the oxidation of ascorbic acid and subsequent dopamine oxidation by H2O2 [30]. As the results are shown in Tables (3) and (4) a significant decrease ($P \leq 0.05$) in the concentration levels of (LDL-C, TC, TG, HDL-C, and VLDL-C) were observed in the patient group (males and females) compared to the control group (males and females). The reason for the decrease in blood lipid levels is attributed to the dysregulation of lipid metabolism in PD could be influenced by multiple factors. One potential explanation is that the degeneration of dopaminergic neurons, which is a hallmark of PD, may disrupt lipid metabolism pathways. Furthermore, alterations in the activity of certain enzymes involved in lipid metabolism, such as lecithin-cholesterol acyltransferase, may contribute to changes in lipid profiles [31]. The results also indicate a significant increase in the level of MDA in the male patient group compared to males in the control group. This is attributed to oxidative stress due to increased oxidation processes within the patients' bodies. MDA is an indicator of lipid peroxidation and its reaction with DNA, serving as a clear marker of DNA damage. Its concentration also increased in female patients compared to healthy females [32].

Regarding the effect of gender on Parkinson's disease patients, the results presented in Table (4) indicate a non-significant decrease in the SIRT3 level in the female patient group compared to male patients. The reason for the decrease in SIRT3 level is attributed to various factors, including sex hormones [28]. As for antioxidants in the patient group, the results indicate that albumin, Total bilirubin, and ceruloplasmin showed some similarity between male and female patients. The same applies to uric acid, glucose, HDL-C, LDL-C, MDA, zinc, copper, and iron, where no significant differences were observed. Regarding GSH and vitamin C, the results suggest a significant increase in females compared to male patients, which may be attributed to smoking by male patients, leading to reduced antioxidants and the generation of numerous free radicals [33]. As for lipid levels (TC, TG, VLDL-C) concentration, a non-significant increase was observed in females compared to male patients.

Table 2. Levels of biochemical variables measured in the blood serum of males with Parkinson's disease compared with healthy males

Biochemical variable	Mean ± SE	
	Patient group (n=29)	Control group (n=25)
Sirtuin 3 (ng/ml)	2.71 ± 0.088 b	8.54 ± 0.096 a
Albumin (g/dl)	2.96 ± 0.029 b	4.67 ± 0.012 a
Total Bilirubin (mg/dl)	0.27± 0.040 b	0.53 ± 0.046 a
Glucose (mg/dl)	134.43 ± 0.081 a	96.48 ± 0.021 b
Ceruloplasmin (g/L)	0.54 ± 0.022 b	1.09 ± 0.033 a
Uric acid (mg/dl)	3.66 ± 0.029 b	5.60 ± 0.022 a
Triglyceride (mg/dl)	107.29 ± 0.015 b	131.09 ± 0.010 a
Total Cholesterol (mg/dl)	104.43 ± 0.035 b	147.26 ± 0.011 a
High-density lipoprotein (mg/dl)	19.25 ± 0.016 b	37.26 ± 0.018 a
Low-density lipoprotein (mg/dl)	66.58 ± 0.078 b	85.17 ± 0.039 a
Very-low-density lipoprotein (mg/dl)	21.46 ± 0.033 b	26.35 ± 0.025 a
Glutathione (µmol/L)	10.75 ± 0.019 b	15.46 ± 0.017 a
Malondialdehyde (µmol/L)	1.54 ± 0.020 a	0.99 ± 0.033 b
Zinc (µg/dl)	74.94 ± 0.056 a	88.42 ± 0.035 a
Copper (µg/dl)	167.22 ± 0.096 a	117.48 ± 0.041 a
Iron (µg/dl)	53.91 ± 0.064 b	121.61 ± 0.099 a
Vitamin C (mg/100ml)	0.14 ± 0.022 b	0.25 ± 0.023 a

Different letters horizontally indicate a significant difference at the probability level ($P \leq 0.05$).

Table 3. Levels of biochemical variables measured in the blood serum of females with Parkinson's disease compared with healthy females

Biochemical variable	Mean ± SE	
	Patient group (n=21)	Control group (n=25)
Sirtuin 3 (ng/ml)	2.22 ± 0.011 b	6.72 ± 0.021 a
Albumin (g/dl)	2.77 ± 0.056 b	4.48 ± 0.024 a
Total Bilirubin (mg/dl)	0.28 ± 0.043 b	0.35 ± 0.045 a
Glucose (mg/dl)	121.26 ± 0.057 a	86.63 ± 0.042 b
Ceruloplasmin (g/L)	0.56 ± 0.024 b	0.95 ± 0.083 a
Uric acid (mg/dl)	3.54 ± 0.029 b	5.16 ± 0.023 a
Triglyceride (mg/dl)	138.00 ± 0.053 b	145.83 ± 0.048 a
Total Cholesterol (mg/dl)	122.63 ± 0.057 b	160.50 ± 0.048 a
High-density lipoprotein (mg/dl)	22.74 ± 0.021 b	39.88 ± 0.014 a
Low-density lipoprotein (mg/dl)	71.25 ± 0.085 b	90.48 ± 0.036 a
Very-low-density lipoprotein (mg/dl)	27.60 ± 0.033 a	29.19 ± 0.027 a
Glutathione (µmol/L)	19.38 ± 0.015 b	20.69 ± 0.026 a
Malondialdehyde (µmol/L)	1.77 ± 0.029 a	0.16 ± 0.027 b
Zinc (µg/dl)	77.57 ± 0.075 a	80.31 ± 0.036 a
Copper (µg/dl)	180.53 ± 0.028 a	96.46 ± 0.024 b
Iron (µg/dl)	66.78 ± 0.090 b	84.13 ± 0.092 a
Vitamin C (mg/100ml)	0.24 ± 0.030 b	0.33 ± 0.031 a

Different letters horizontally indicate a significant difference at the probability level (P≤0.05).

Table 4. Levels of biochemical variables measured in the serum of females with Parkinson's disease compared with males with Parkinson's disease

Biochemical variables	Mean ± SE	
	patient group (n= 21)	Patient group (n= 29)
Sirtuin 3 (ng/ml)	2.22 ± 0.011 b	2.71 ± 0.088 a
Albumin (g/dl)	2.77 ± 0.056 a	2.96 ± 0.029 a
Total Bilirubin (mg/dl)	0.28 ± 0.043 b	0.27± 0.040 a

Glucose (mg/dl)	121.26 ± 0.057 a	134.43 ± 0.081 a
Ceruloplasmin (g/L)	0.56 ± 0.024 a	0.54 ± 0.022 a
Uric acid (mg/dl)	3.54 ± 0.029 a	3.66 ± 0.029 b
Triglyceride (mg/dl)	138.00 ± 0.053 a	107.29 ± 0.015 b
Total Cholesterol (mg/dl)	122.63 ± 0.057 a	104.43 ± 0.035 b
High-density lipoprotein (mg/dl)	22.74 ± 0.021 a	19.25 ± 0.016 a
Low-density lipoprotein (mg/dl)	71.25 ± 0.085 a	66.58 ± 0.078 a
Very-low-density lipoprotein (mg/dl)	27.60 ± 0.033 a	21.46 ± 0.033 b
Glutathione (µmol/L)	19.38 ± 0.015 a	10.75 ± 0.019 b
Malondialdehyde (µmol/L)	1.77 ± 0.029 a	1.54 ± 0.020 a
Zinc (µg/dl)	77.57 ± 0.075 a	74.94 ± 0.056 a
Copper (µg/dl)	180.53 ± 0.028 a	167.22 ± 0.096 a
Iron (µg/dl)	66.78 ± 0.090 a	53.91 ± 0.064 a
Vitamin C (mg/100ml)	0.24 ± 0.030 a	0.14 ± 0.022 b

Different letters horizontally indicate a significant difference at the probability level (P≤0.05).

8. Effect of age:

The effect of age on all measured biochemical variables in the serum of the patient group and control group was studied. Additionally, the impact of age was examined within the patient group by dividing each group into three different age categories: (30-45 years), (46-60years), and (>60 years). By comparing the biochemical variables for different age groups in the patient group and the control group (healthy individuals) in Tables (5), (6), and (7), the results indicate a significant decrease in the SIRT3 level with increasing age in the patient group compared to the control group and across all age categories. This decrease may be attributed to changes in cellular metabolism and mitochondrial function that occur as we age. Mitochondria play a crucial role in energy production and cellular processes, and their function can decline with age. This decline in mitochondrial function may lead to a decrease in SIRT3 levels, as this enzyme is involved in maintaining mitochondrial health and regulating cellular metabolism. Furthermore, aging is associated with oxidative stress and increased production of reactive oxygen species (ROS), which can affect the level of SIRT3 [34]. The results also showed a significant and notable decrease in antioxidants such as (albumin, total bilirubin, glutathione, ceruloplasmin, iron, and vitamin C) in the patient group compared to the control group across different age categories. This decrease in antioxidants is attributed to their depletion in the oxidative stress process. As we age, our bodies undergo various changes, including a decrease in antioxidant levels. Several factors contribute to the decline in antioxidant levels with age. One reason is that the body's natural production of antioxidants may decrease over time. Additionally, external factors such as poor diet, exposure to environmental pollutants, and lifestyle choices like smoking or excessive alcohol consumption can deplete antioxidants more rapidly [23]. Furthermore, the results indicate a significant positive correlation between the level of copper and age in patients with PD compared to the control group. The results show that the level of copper in patients in the age group (30-45years) was lower in both patient and control groups compared to other age groups (46-60 years), (>60 years), indicating that the level of copper increases with age due to body’s ability to regulate copper levels effectively. Copper is an essential mineral involved in various bodily functions, including the formation of connective

tissues and the production of energy. It is regulated by proteins such as ceruloplasmin, which may become less efficient with age [25]. A significant increase was also observed in the level of MDA in the patient group compared to the control group within the same age category. This leads to due to the increased oxidative stress and mitochondrial dysfunction that are associated with the condition. Additionally, a significant increase in the concentration of glucose is due to impaired glucose metabolism and insulin resistance, which can lead to elevated blood glucose levels [26]. The results also indicate a significant decrease in the level of uric acid in the patient group compared to the control group. This leads to oxidative stress and the formation of free radicals, resulting in oxidative damage in various tissues [35]. Additionally, the results show a significant decrease in the concentration levels of Lipid profile (TG, TC, LDL-C, HDL-C, and VLDL-C) and a significant decrease in the patient group compared to the control group across different age categories. This is attributed to alterations in lipid metabolism that can occur, leading to changes in lipid levels [36]. The impact of age on oxidation and antioxidants in the patient group indicates that SIRT3 levels decrease non-significantly with age. The concentration of SIRT3 for the age group of (30-45 years) was (2.54 ± 0.096), which decreased with age to reach (2.44 ± 0.017) for the age group of (46-60) years. It further increased after the age of sixty to approximately (2.34 ± 0.086). This may be due to dysfunction and oxidative damage. One possible trigger is increased protein acetylation in mitochondria during aging. The study concluded that age-associated hyperacetylation results in a combination of the tricarboxylic acid cycle (TCA), the electron transport chain (ETC), and key transcription factors including peroxisome proliferator-activated receptor gamma, coactivator 1 alpha (PGC- 1α), decreased activity of enzymes such as acetaldehyde dehydrogenase and cytochrome P-4502E1, and decreased water distribution with age. SIRT3 was one of the first genes identified to extend lifespan. A major reason for the decline in SIRT3 activity is the decline in NAD levels with age, and this decline is accelerated by sedentary and counteracted by caloric restriction and physical activity [34].

As for the antioxidants (albumin, total bilirubin, GSH, and vitamin C), they also decrease in the group patients with advancing age due to increased disease severity and intensity, which require their depletion in the process of oxidative stress to reduce the damage occurring in the body. This may be due to the decline of antioxidants with age. One reason is that the production of antioxidants within the body may decrease. For example, the production of certain enzymes that act as antioxidants, such as superoxide dismutase and catalase, may decline over time. Furthermore, external factors such as lifestyle choices and environmental exposures can also deplete antioxidants. For instance, exposure to pollution, cigarette smoke, UV radiation, and certain chemicals can increase the production of free radicals, overwhelming the antioxidant defense system and causing an accelerated decline in antioxidant levels [23]. The results also indicate a significant increase in the level of copper in the patient group with advancing age. As for the effect of age on (zinc, Cp, glucose, and TC) in the patient group, the result shown in Table (8) indicated that there was no significant difference. This indicates that age doesn't affect these levels. Furthermore, the level of (TG, LDL-C, VLDL-C, and MDA) non-significantly increased, indicating metabolic changes lipid metabolism is complex and multifactorial, influenced by various genetic, lifestyle, and environmental factors at a probability level of ($P \leq 0.05$) with advancing age compared to younger patients. As for (uric acid, iron, and HDL-C) levels decreased non-significantly in the patient group with age at a probability level of ($P \leq 0.05$).

Table 5. Levels of biochemical variables measured in the blood serum of people with Parkinson's disease compared to the control group (healthy) for the age group (30-45 years)

Biochemical variables	Mean ± SE	
	patient group (n= 8)	Patient group (n= 15)
Sirtuin 3 (ng/ml)	2.54 ± 0.096 b	7.97 ± 0.091 a
Albumin (g/dl)	3.23 ± 0.018 b	4.60 ± 0.069 a
Total Bilirubin (mg/dl)	0.45 ± 0.014 a	0.24 ± 0.050 a
Glucose (mg/dl)	112.00 ± 0.083 a	88.00 ± 0.020 b
Ceruloplasmin (g/L)	0.56 ± 0.006 b	0.84 ± 0.069 a

Uric acid (mg/dl)	3.84 ± 0.036 b	5.14 ± 0.021 a
Triglyceride (mg/dl)	96.50 ± 0.095 b	104.71 ± 0.075 a
Total Cholesterol (mg/dl)	110.50 ± 0.021 b	143.71 ± 0.032 a
High-density lipoprotein (mg/dl)	25.25 ± 0.033 b	39.96 ± 0.012 a
Low-density lipoprotein (mg/dl)	50.70 ± 0.018 b	82.94 ± 0.037 a
Very-low-density lipoprotein (mg/dl)	16.80 ± 0.068 a	20.94 ± 0.050 a
Glutathione (µmol/L)	18.33 ± 0.026 b	22.17 ± 0.023 a
Malondialdehyde (µmol/L)	2.21 ± 0.008 a	0.80 ± 0.028 b
Zinc (µg/dl)	75.25 ± 0.097 b	87.03 ± 0.033 a
Copper (µg/dl)	126.21 ± 0.035 b	106.89 ± 0.057 a
Iron (µg/dl)	78.68 ± 0.023 b	95.02 ± 0.032 a
Vitamin C (mg/100ml)	0.22 ± 0.039 b	0.39 ± 0.018 a

Different letters horizontally indicate a significant difference at the probability level (P≤0.05).

Table 6. Levels of biochemical variables measured in the blood serum of people with Parkinson's disease compared to the control group (healthy) for the age group (46-60 years)

Biochemical variables	**Mean ± SE**	
	patient group (n= 17)	**control group (n= 19)**
Sirtuin 3 (ng/ml)	2.44 ± 0.017 b	7.77 ± 0.036 a
Albumin (g/dl)	2.75 ± 0.046 b	4.43 ± 0.086 a
Total Bilirubin (mg/dl)	0.27 ± 0.060 b	0.41 ± 0.049 a
Glucose (mg/dl)	118.56 ± 0.079 a	100.50 ± 0.031 b
Ceruloplasmin (g/L)	0.51 ± 0.040 b	1.20 ± 0.017 a
Uric acid (mg/dl)	3.63 ± 0.050 b	5.74 ± 0.020 a
Triglyceride (mg/dl)	115.09 ± 0.035 b	193.69 ± 0.012 a
Total Cholesterol (mg/dl)	99.33 ± 0.024 b	166.19 ± 0.044 a
High-density lipoprotein (mg/dl)	20.30 ± 0.033 b	33.56 ± 0.017 a
Low-density lipoprotein (mg/dl)	54.27 ± 0.016 b	93.19 ± 0.035 a
Very-low-density lipoprotein (mg/dl)	22.42 ± 0.061	38.50 ± 0.024

	b	a
Glutathione (µmol/L)	12.41 ± 0.045 b	13.55 ± 0.091 a
Malondialdehyde (µmol/L)	2.11 ± 0.018 a	0.26 ± 0.040 b
Zinc (µg/dl)	72.89 ± 0.093 a	76.44 ± 0.048 a
Copper (µg/dl)	173.68 ± 0.066 a	115.75 ± 0.032 b
Iron (µg/dl)	56.99 ± 0.051 b	121.84 ± 0.065 a
Vitamin C (mg/100ml)	0.14 ± 0.058 b	0.27 ± 0.037 a

Different letters horizontally indicate a significant difference at the probability level (P≤0.05).

Table 7. Levels of biochemical variables measured in the blood serum of people with Parkinson's disease compared to the control group (healthy) for the age group (>60years)

Biochemical variables	**Mean ± SE**	
	patient group (n= 25)	**control group (n= 16)**
Sirtuin 3 (ng/ml)	2.34 ± 0.086 b	4.46 ± 0.065 a
Albumin (g/dl)	1.76 ± 0.023 b	4.35 ± 0.012 a
Total Bilirubin (mg/dl)	0.20 ± 0.032 b	0.33 ± 0.025 a
Glucose (mg/dl)	135.24 ± 0.089 a	86.50 ± 0.025 b
Ceruloplasmin (g/L)	0.49 ± 0.019 b	1.45 ± 0.018 a
Uric acid (mg/dl)	2.48 ± 0.024 b	5.85 ± 0.092 a
Triglyceride (mg/dl)	136.22 ± 0.093 b	175.00 ± 0.040 a
Total Cholesterol (mg/dl)	113.39 ± 0.090 b	183.00 ± 0.044 a
High-density lipoprotein (mg/dl)	19.67 ± 0.014 b	45.25 ± 0.021 a
Low-density lipoprotein (mg/dl)	73.87 ± 0.062 b	106.50 ± 0.029 a
Very-low-density lipoprotein (mg/dl)	24.64 ± 0.028 b	36.85 ± 0.014 a
Glutathione (µmol/L)	12.21 ± 0.011 b	13.99 ± 0.065 a
Malondialdehyde (µmol/L)	1.63 ± 0.020 a	0.33 ± 0.018 b
Zinc (µg/dl)	77.82 ± 0.056 b	87.00 ± 0.030 a
Copper (µg/dl)	186.12 ± 0.075 a	93.25 ± 0.022 b
Iron (µg/dl)	56.93 ± 0.067 b	69.59 ± 0.018 a
Vitamin C (mg/100ml)	0.10 ± 0.018 b	0.25 ± 0.062 a

Different letters horizontally indicate a significant difference at the probability level (P≤0.05).

Table 8. Comparison between the biochemical variables measured in the blood serum of patients for the age groups (30-45 years), (46-60 years), and (>60 years).

Biochemical variables	Mean ± SE		
	Patient group (n= 8)	Patient group(n=17)	Patient group (n=25)
Sirtuin 3 (ng/ml)	2.54 ± 0.096 b	2.44 ± 0.017 b	2.34 ± 0.086 b
Albumin (g/dl)	3.23 ± 0.018 b	2.75 ± 0.046 b	1.76 ± 0.023 b
Total Bilirubin (mg/dl)	0.45 ± 0.014 a	0.27 ± 0.060 b	0.20 ± 0.032 b
Glucose (mg/dl)	112.00 ± 0.083 a	118.56 ± 0.079 a	135.24 ± 0.089 a
Ceruloplasmin (g/L)	0.56 ± 0.006 b	0.51 ± 0.040 b	0.49 ± 0.019 b
Uric acid (mg/dl)	3.84 ± 0.036 b	3.63 ± 0.050 b	2.48 ± 0.024 b
Triglyceride (mg/dl)	96.50 ± 0.095 b	115.09 ± 0.035 b	136.22 ± 0.093 b
Total Cholesterol (mg/dl)	110.50 ± 0.021 b	99.33 ± 0.024 b	113.39 ± 0.090 b
High-density lipoprotein (mg/dl)	25.25 ± 0.033 b	20.30 ± 0.033 b	19.67 ± 0.014 b
Low-density lipoprotein (mg/dl)	50.70 ± 0.018 b	54.27 ± 0.016 b	73.87 ± 0.062 b
Very-low-density lipoprotein (mg/dl)	16.80 ± 0.068 a	22.42 ± 0.061 b	24.64 ± 0.028 b
Glutathione (µmol/L)	18.33 ± 0.026 b	12.41 ± 0.045 b	12.21 ± 0.011 b
Malondialdehyde (µmol/L)	2.21 ± 0.008 a	2.11 ± 0.018 a	1.63 ± 0.020 a
Zinc (µg/dl)	75.25 ± 0.097 b	72.89 ± 0.093 a	77.82 ± 0.056 b
Copper (µg/dl)	126.21 ± 0.035 b	173.68 ± 0.066 a	186.12 ± 0.075 a
Iron (µg/dl)	78.68 ± 0.023 b	56.99 ± 0.051 b	56.93 ± 0.067 b
Vitamin C (mg/100ml)	0.22 ± 0.039 b	0.14 ± 0.058 b	0.10 ± 0.018 b

Different letters horizontally indicate a significant difference at the probability level (P≤0.05).

9. The effect of blood type:

The impact of blood type on patients with Parkinson's disease compared to the control group was studied. The results shown in Table (9) indicate that 42% of PD patients have blood type A+, followed by blood types B+, AB+, and O with proportions of 28%, 16%, and 14% respectively. This result is consistent with several previous studies that have shown an association between blood type A+ and Parkinson's disease. This may be attributed to genetic factors. Blood type A+ severity may have a slightly increased risk of developing more severe symptoms of Parkinson's disease compared to other blood types [37].

Table 9. The effect of blood type on the group of patients with Parkinson's disease compared with the control group.

Blood group	Patient No. = (50)		Control No. = (50)	
	No.	%	No.	%
A+	21	42 %	14	28 %
B+	14	28 %	13	26 %
AB+	8	16 %	7	14 %
O+	7	14 %	16	32 %

Conclusion

The serum level of SIRT3 in Parkinson's patients exhibited a notable decrease compared to the control group. Additionally, glucose, malondialdehyde, and copper in Parkinson's patients exhibited a notable increase when compared to the control group. Moreover, antioxidants such as vitamin C, GSH, bilirubin, albumin, Cp, and iron, as well as zinc, uric acid, and lipid profile, demonstrated a decrease in their levels in Parkinson's patients compared to healthy subjects. The study findings indicated that both gender and age exerted a significant and evident influence on the levels of the variables examined. Notably, the serum levels of SIRT3, zinc, uric acid, and lipid profile were lower in Parkinson's patients than in the control group, while all antioxidant levels (vitamin C, bilirubin, Cp, albumin, GSH, iron) were significantly reduced. Furthermore, regarding glutathione and vitamin C, the results suggested a noteworthy increase in females compared to male patients and healthy subjects, underscoring the impact of gender and age on individuals affected by PD.

References

[1] Raza, C., Anjum, R., & Shakeel, N. ul A. (2019). Parkinson's disease: Mechanisms, translational models and management strategies. In Life Sciences (Vol. 226, pp. 77–90). Elsevier Inc. https://doi.org/10.1016/j.lfs.2019.03.057

[2] Radhakrishnan, D. M., & Goyal, V. (2018). Parkinson's disease: A review. In Neurology India (Vol. 66, Issue 7, pp. S26–S35). Medknow Publications. https://doi.org/10.4103/0028-3886.226451

[3] Váradi, C. (2020). Clinical features of Parkinson's disease: The evolution of critical symptoms. In Biology (Vol. 9, Issue 5). MDPI AG. https://doi.org/10.3390/biology9050103

[4] Post, B., Van Den Heuvel, L., Van Prooije, T., Van Ruissen, X., Van De Warrenburg, B., & Nonnekes, J. (2020). Young Onset Parkinson's Disease: A Modern and Tailored Approach. In Journal of Parkinson's Disease (Vol. 10, Issue s1, pp. S29–S36). IOS Press BV. https://doi.org/10.3233/JPD-202135

[5] Jankovic, J., & Tan, E. K. (2020). Parkinson's disease: Etiopathogenesis and treatment. Journal of Neurology, Neurosurgery and Psychiatry, 91(8), 795–808. https://doi.org/10.1136/jnnp-2019-322338

[6] Dou, I., & Ard Watson Axd Homer Biggs, W. G. (1970). CLINICA CHIMICA ACTA WITH BROMCRESOL GREEN.

[7] Mullon, C. J. P., & Langer, R. (1987). Determination of conjugated and total bilirubin in serum of neonates, with use of bilirubin oxidase. Clinical Chemistry, 33(10), 1822–1825. https://doi.org/10.1093/clinchem/33.10.1822

[8] Trinder, P. (1969). Determination of Glucose in Blood Using Glucose Oxidase with an Alternative Oxygen Acceptor. Annals of Clinical Biochemistry: International Journal of Laboratory Medicine, 6(1), 24–27. https://doi.org/10.1177/000456326900600108

[9] Sunderman, F. W., & Nomoto, S. (1970). Measurement of Human Serum Ceruloplasmin by Its P-Phenylenediamine Oxidase Activity. In CLINICAL CHEMISTRY (Vol. 16, Issue 11). https://academic.oup.com/clinchem/article/16/11/903/5679398

[10] Fossati, P., Prencipe, L., & Berti, G. (1980). Use of 3, 5-Dichloro-2-hydroxybenzenesulfonic Acid/4-Ami nophenazone Chromogenic System in Direct Enzymic Assay of Uric Acid in Serum and Urine. In CLINICAL CHEMISTRY (Vol. 26, Issue 2). https://academic.oup.com/clinchem/article-abstract/26/2/227/5727446

[11] Kritchevsky, D. (1988). Effects of Triglyceride Structure on Lipid Metabolism.

[12] Allain, C. C., Poon, L. S., Chan, C. S. G., Richmond, W., & Fu3, P. C. (1974). Enzymatic determination of Total Serum Cholesterol. In CLINICAL CHEMISTRY (Vol. 20, Issue 4). https://academic.oup.com/clinchem/article-abstract/20/4/470/5676927

[13] Hubbard, R. S., Hirany, S. V, Devaraj, S., Martin, L., & Parupia, J. (1998). Evaluation of a Rapid Homogeneous Method for Direct Measurement of High-Density Lipoprotein Cholesterol. https://academic.oup.com/ajcp/article/110/4/495/1758079

[14] Friedewald, W. T., Levy, R. I., & Fredrickson, D. S. (1972). Estimationof the Concentration of Low-Density Lipoprotein Cholesterol in Plasma, Without Useof the preparative ultracentrifuge. In CLINICAL CHEMISTRY (Vol. 18, Issue 6). https://academic.oup.com/clinchem/article-abstract/18/6/499/5676160

[15] Sedlak, J., & Lindsay, R. H. (1968). Estimation of Total, Protein-Bound, and Nonprotein Sulfhydryl Groups in Tissue with Ellman's Reagent. In ANALYTICAL BIOCHEMISTRY (Vol. 25).

[16] Buege, J. A., & Aust, S. D. (1973). Microsomal Electron Transport and CYT P-450. 1–9.

[17] Eliasson, R. (1987). Evaluation of a commercially available kit for the colorimetric determination of zinc in human seminal plasma. In International Journal of Andrology (Vol. 10).

[18] Noma, A. (1989). Abs. 0.2 0.1 Ascorbic acid SOS 0 Sensitive, Direct Colonmetric Assay for Copper in Serum. In CLINICAL CHEMISTRY (Vol. 35, Issue 4). https://academic.oup.com/clinchem/article-abstract/35/4/552/5662824

[19] Hennessy A N D Gary R Reid, D. J., Smith, F. E., D Stephen L Thompson, A. N., Hennessy Gary R Reid, D. J., THOMPSON Can J Chem, S. L., Hennessy, D. J., Reid, G. R., & SMITH ct STEPHEN L THOMPSON Can J Chem, F. E. (1983). Ferene-a new spectrophotometric reagent for iron.

[20] McCormick, D. B. (Donald B., Wright, L. D., Chytil, F., Suttie, J. W. (John W., & Wagner, C. (1970). Vitamins and coenzymes. Academic Press.

[21] Bewick, V., Cheek, L., & Ball, J. (2004). Statistics review 9: One-way analysis of variance. In Critical Care (Vol. 8, Issue 2, pp. 130–136). https://doi.org/10.1186/cc2836

[22] Shi, H., Deng, H. X., Gius, D., Schumacker, P. T., Surmeier, D. J., & Ma, Y. C. (2017). Sirt3 protects dopaminergic neurons from mitochondrial oxidative stress. Human Molecular Genetics, 26(10), 1915–1926. https://doi.org/10.1093/hmg/ddx100

[23] Chang, K. H., & Chen, C. M. (2020). The role of oxidative stress in Parkinson's disease. In Antioxidants (Vol. 9, Issue 7, pp. 1–32). MDPI. https://doi.org/10.3390/antiox9070597

[24] Saedi, S., Hemmati-Dinarvand, M., Barmaki, H., Mokhtari, Z., Musavi, H., Valilo, M., Mota, A., & Mahjoub, S. (2021). Serum lipid profile of Parkinson's disease patients: A study from the Northwest of Iran. Caspian Journal of Internal Medicine, 12(2), 155–161. https://doi.org/10.22088/cjim.12.2.155

[25] Bisaglia, M., & Bubacco, L. (2020). Copper ions and Parkinson's disease: Why is homeostasis so relevant? In Biomolecules (Vol. 10, Issue 2). MDPI AG. https://doi.org/10.3390/biom10020195

[26] Peña-Bautista, C., Vento, M., Baquero, M., & Cháfer-Pericás, C. (2019). Lipid peroxidation in neurodegeneration. In Clinica Chimica Acta (Vol. 497, pp. 178–188). Elsevier B.V.

[27] Marques, A., Dutheil, F., Durand, E., Rieu, I., Mulliez, A., Fantini, M. L., Boirie, Y., & Durif, F. (2018). Glucose dysregulation in Parkinson's disease: Too much glucose or not enough insulin? Parkinsonism and Related Disorders, 55, 122–127. https://doi.org/10.1016/j.parkreldis.2018.05.026

[28] Torrens-Mas, M., Pons, D. G., Sastre-Serra, J., Oliver, J., & Roca, P. (2020). Sexual hormones regulate the redox status and mitochondrial function in the brain. Pathological implications. In Redox Biology (Vol. 31). Elsevier B.V. https://doi.org/10.1016/j.redox.2020.101505

[29] Wang, L., Hu, W., Wang, J., Fang, F., Cheng, G., Jiang, Y., Xiao, H., & Wan, Q. (2017). Impact of serum uric acid, albumin and their interaction on Parkinson's disease. Neurological Sciences, 38(2), 331–336. https://doi.org/10.1007/s10072-016-2738-z

[30] Montes, S., Rivera-Mancia, S., Diaz-Ruiz, A., Tristan-Lopez, L., & Rios, C. (2014). Copper and copper proteins in Parkinson's disease. In Oxidative Medicine and Cellular Longevity (Vol. 2014). https://doi.org/10.1155/2014/147251

[31] Xicoy, H., Wieringa, B., & Martens, G. J. M. (2019). The role of lipids in Parkinson's disease. In Cells (Vol. 8, Issue 1). MDPI. https://doi.org/10.3390/cells8010027

[32] Gaschler, M. M., & Stockwell, B. R. (2017). Lipid peroxidation in cell death. In Biochemical and Biophysical Research Communications (Vol. 482, Issue 3, pp. 419–425). Elsevier B.V. https://doi.org/10.1016/j.bbrc.2016.10.086

[33] Rafikov, R., James, J., McClain, N., Tofovic, S. P., & Rafikova, O. (2019). Role of gender in regulation of redox homeostasis in pulmonary arterial hypertension. In Antioxidants (Vol. 8, Issue 5). MDPI. https://doi.org/10.3390/antiox8050135

[34] Zhou, L., Pinho, R., Gu, Y., & Radak, Z. (2022). The Role of SIRT3 in Exercise and Aging. In Cells (Vol. 11, Issue 16). MDPI. https://doi.org/10.3390/cells11162596

[35] Qin, X. ling, Zhang, Q. shan, Sun, L., Hao, M. wei, & Hu, Z. ting. (2015). Lower Serum Bilirubin and Uric Acid Concentrations in Patients with Parkinson's Disease in China. Cell Biochemistry and Biophysics, 72(1), 49–56. https://doi.org/10.1007/s12013-014-0402-x

[36] Hong, X., Guo, W., & Li, S. (2022). Lower Blood Lipid Level Is Associated with the Occurrence of Parkinson's Disease: A Meta-Analysis and Systematic Review. International Journal of Clinical Practice, 2022. https://doi.org/10.1155/2022/9773038

[37] Bulur, O., & Korucu, O. (2019). Association Between ABO Blood Group with Parkinson's Disease. Journal of Contemporary Medicine. https://doi.org/10.16899/jcm.585387