Academia Open
Vol. 10 No. 2 (2025): December
DOI: 10.21070/acopen.10.2025.12245

Military Spending and Economic Growth Dynamics in Iraq, 2004–2023: Dinamika Pengeluaran Militer dan Pertumbuhan Ekonomi di Irak, 2004–2023

Huda Z. Miklif University of Karbala, College of Administration and Economics

General Background: The relationship between military spending and economic growth has long been debated, with contrasting theoretical perspectives suggesting either positive stimulus effects or harmful crowding-out impacts. **Specific Background:** Iraq represents a critical case, as the post-2003 political and security instability substantially reshaped its public expenditure structure, with military allocations absorbing significant resources. **Knowledge Gap:** While prior studies have examined this relationship in Iraq, few have applied advanced econometric approaches across the extended period of 2004–2023, leaving uncertainty regarding short- versus long-term effects. **Aims:** This study analyzes the impact of military spending on Iraq's GDP using the autoregressive distributed lag (ARDL) model to evaluate both short-run and long-run dynamics. **Results:** The findings reveal that military spending has only a short-term effect on GDP, while no significant long-term relationship exists. Moreover, excessive reliance on consumer-oriented military expenditures, coupled with weak domestic defense industries, limited Iraq's capacity to translate security outlays into sustainable economic growth. **Novelty:** By applying ARDL modeling to two decades of Iraqi data, this study provides a nuanced distinction between transitory and persistent impacts of defense spending. **Implications:** The results suggest that fiscal policies should balance security needs with investments in productive sectors, redirecting resources toward infrastructure, education, and healthcare to foster long-term stability and growth.

Highlight :

1. Military spending in Iraq was mostly consumer, not productive.
2. The ARDL model confirmed only a short-term impact on GDP.
3. High defense focus reduced resources for education, health, and infrastructure.

Keywords : Military Spending, GDP, Autoregressive Model, Iraq, Economic Growth

Introduction

The relationship between military spending and economic growth in Iraq is an important and complex issue, in which the security and political aspects overlap with the economic aspects, especially in a country like Iraq, which has suffered from wars, internal conflicts, and terrorism for many years. After 2003, Iraq witnessed radical transformations in the economic and political structure, as the military institution was reshaped. These changes were linked to the reality of the Iraqi economy, most notably unemployment and economic growth rates. Since military spending is a component of government spending, this study aims to examine the relationship between military spending and economic growth in Iraq from 2004 to 2023 in order to determine the true economic impact of this kind of spending on economic growth. The relationship between military spending and economic growth is explained by many economic theories. Some interpret this spending as having incentive effects, and some believe that it does not achieve actual growth Below is a general analysis and measurement that illustrates the relationship between military spending and economic growth in Iraq.

The Importance of Research

The importance of this research comes from the fact that it sheds light on studying the relationship between military spending and economic growth in Iraq, as it allocates a large percentage of its resources to military spending. Whether in terms of stimulating or hindering it and trying to understand whether the expansion of military spending has contributed to achieving real economic development or has constituted a burden on available economic resources, and the extent of the government's ability to balance security and defense needs on the one hand, and investment requirements in vital sectors such as education, health and infrastructure on the other hand, The results of this research could contribute to directing future economic policies towards a more efficient distribution of public spending.

Search Problem

The main problem is the following question: Does military spending in Iraq have an impact on economic growth rates during the study period? This, in turn, raises real questions about the extent to which this spending affects economic growth.

Research Hypothesis

The research hypothesis is predicated on the observation that Iraqi military spending, which was consumer rather than productive, had a detrimental effect on economic growth.

Research Objectives

Explaining the conceptual framework for spending and economic growth, analyzing the development of military spending and economic growth in Iraq, and measuring its impact on the GDP growth rate.

Research Methodology

This research is based on the standard analytical approach, supported by data from official sources such as the Iraqi Ministry of Finance and the World Bank, in addition to a review of previous studies.

Previous Studies

The results of international research on the connection between growth and military spending have clearly differed. For instance, Hartley & Sandler (1995) noted that the political and economic

climate of the nation affects the influence of military spending. While Shahin & Dibeh (2010) found in their study of the Middle East that there is a negative relationship in most Arab countries.

According to Abdul Jalil's (2017) research, there was a negative correlation between Iraq's economic growth and military spending between 2004 and 2016, as higher security expenditures resulted in lower investment spending allocations. The study recommends the necessity of restructuring the general budget to ensure a balance between security and development (Abdul Jalil, 2017, p. 89).

In another study conducted by Al-Samarrai (2020), it was found that the volatility of economic growth in Iraq is partly linked to the volatility of military spending levels, and that this effect is clearly evident in years of conflict and major military operations.

This research will measure the relationship, whether there has been a change in the state's strategy, and whether previous studies have been benefited from.

The first axis: Theoretical framework for military spending and economic growth

Firstly: The framework for concepts of public spending, military spending, and economic growth

1- The concept of public spending:

Public spending is defined as "the total expenditures made by the state or one of its institutions in order to perform its economic, social and administrative functions, whether this is represented in establishing public projects, providing services, or supporting vulnerable groups in society" (Abdul Nabi, 2016, p. 22).

Public spending is a tool of fiscal policy, and its goal is to achieve economic stability, stimulate growth, and achieve social justice. Its forms vary between current spending, such as wages and subsidies, and investment spending aimed at creating new productive capital assets.

2- The concept of military spending

Military spending is the portion of the state's general budget allocated to finance the armed forces, arm them, train them, and develop defense industries. This spending also includes expenses related to paramilitary security institutions. This concept varies from one country to another according to political orientations (Al-Tahan, 2012, p. 88).

Military spending is sometimes considered a means of strengthening national sovereignty and maintaining internal security, but at the same time it may constitute a burden on countries' budgets, especially if it comes at the expense of investment spending in sectors such as education, health, and infrastructure.

3- The concept of economic growth

A steady rise in real gross domestic product (GDP), as seen by increased levels of output, income, and employment within the economy, is referred to as economic growth. This indicator is one of the most prominent tools for measuring the economic progress of any country (Sami, 2020, p. 31).

The growth rate can usually be measured by the annual rate of change in GDP, which allows tracking the performance of the economy over time. A number of variables, such as government spending, political stability, and the effectiveness of the productive sectors, influence this growth.

Second: Economic views on the relationship between military spending and economic growth

The relationship between military spending and economic growth has been examined from a variety of angles by both classical and contemporary economic theories. While some theories argue that military spending may contribute to stimulating the economy, others suggest that it may lead to the opposite.

The Keynesian school believes that increasing government spending - including military spending - may create additional demand in the economy and stimulate growth (Keynes, 1936).

In contrast, the "displacement" theory suggests that high military spending crowds out spending on public services, negatively impacting human development (Deger & Smith, 1983).

Military-industrial complex model: suggests that an alliance between military institutions and industrial companies may lead to excessive military spending at the expense of development (Barro, 1991, p. 411).

Therefore, the impact of military spending on economic growth depends on the nature of the economy and the structure of public spending.

Third: An overview of military spending in Iraq

Iraq is one of the countries that witnessed many wars, political instability, and internal and external conflicts, during the research period 2004–2023 and before that of the 1980-1988 war and the 1991 war, which made military spending an impact on the general budget (Al-Samarrai, 2019, p. 117).

After 2003, successive Iraqi governments moved to increase defense and security allocations in the general budget. This trend came in light of the worsening security challenges and the emergence of armed organizations, which imposed a priority on security at the expense of development.

According to data from the Iraqi Ministry of Finance, the share of the Ministries of Defense and Interior in government spending exceeded 20% in some years, which is a high percentage compared to countries in the region. This trend has contributed to reducing the amounts allocated to education, health, and infrastructure projects (Al-Shammari, 2019, p. 51).

The share of military spending has risen to approximately 15% of total public expenditures in some years, particularly during periods of conflict with ISIS (2014–2017) (Ministry of Finance, 2023).

Military spending in Iraq is distributed into salaries and allowances for workers in the armed forces, armament contracts, support for security operations, and logistical and administrative expenses. The nature is usually consumer, not investment or production (Al-Naimi, 2020, p. 60).

Fourth: The development of military spending indicators and the gross domestic product in Iraq for the period 2004-2023

Economic indicators show that the Iraqi economy has not witnessed stable growth over the past two decades, but rather its performance has been characterized by volatility, especially in light of the volatility of oil prices and security conditions. One reason for this fluctuation is likely to be higher military spending versus lower investment spending.

According to a World Bank report, unproductive spending –including high military spending– is one of the most prominent factors hindering growth in rentier countries such as Iraq (World Bank, 2020). The absence of a balanced strategy for distributing resources has also weakened the economic infrastructure and, consequently, led to a decline in growth rates (Sadiq, 2021, p. 107).

Academia Open
Vol. 10 No. 2 (2025): December
DOI: 10.21070/acopen.10.2025.12245

On the other hand, directing public spending towards strengthening domestic defense industries was not a strategic option, which increased dependence on imports and contributed to the leakage of foreign exchange abroad.

From Table (1), military spending in 2004 amounted to (0.61) trillion dollars. Iraq this year is in the process of establishing a new army after changing its political system since 2003. As for the gross domestic product, it amounted to (36.63) trillion dollars.

Years	Military spending(1)	Growth %(2)	GDP (3)	Growth %(4)
2004	0.61	-	36.63	-
2005	1.12	83.6	50.07	36.7
2006	1.24	10.7	65.15	30.1
2007	1.99	60.5	88.84	36.4
2008	3.12	56.8	131.61	48.1
2009	3.24	3.8	111.66	-15.2
2010	3.75	15.7	138.52	24.1
2011	4.28	14.1	185.75	34.1
2012	4.14	-3.3	218.01	17.4
2013	7.78	87.9	234.64	7.6
2014	6.92	-11.1	228.42	-2.7
2015	9.6	38.7	166.77	-27.0
2016	5.97	-37.8	166.74	0.0
2017	7.42	24.3	187.22	12.3
2018	6.32	-14.8	227.37	21.4
2019	7.6	20.3	233.64	2.8
2020	5.65	-25.7	180.9	-22.6
2021	4.77	-15.6	209.69	15.9
2022	4.68	-1.9	286.64	36.7
2023	5.11	9.2	250.84	-12.5
Full duration		Compound growth		
2023-2004		11.2		10.1

Table 1. *Military spending and GDP in Iraq for the period 2004-2023 (trillion US dollars)*

Source: -

1. https://www.macrotrends.net

https://ar.tradingeconomics.com -

2. Columns (2), (4) Calculated by the researcher

- Simple growth rate calculated according to the following formula:- $R = \frac{P_t - P_{t-1}}{P_{t-1}} * 100$
- The composite growth rate is calculated according to the following formula :-

$$R = \left[\left(PT/P0\right)^{\wedge}(1/N)\right) - 1\right] * 100$$

Figure 1.

We note in the table above that in the years 2005 – 2007, military spending witnessed an increase year after year at a positive growth rate for these years, and the gross domestic product also witnessed a growing increase due to the lifting of sanctions on Iraq and the export of crude oil, which is the main resource for financing spending in Iraq In the years after 2007, there was a

general increase in military spending with fluctuations in percentages. The gross domestic product also witnessed a fluctuating increase, but the growth rate was negative and military expenditures increased in 2008 due to the agreement on the withdrawal of American forces, which requires preparation to equip the Iraqi army and security forces with equipment. In 2014 and 2015, there were military crises, and after 2019 due to Corona and in 2023 as a result of the exacerbation of geopolitical conflicts in Middle East region.

The second axis: Measuring the relationship between military spending and GDP using the autoregressive model of distributed slowdown in Iraq for the period (2004 – 2023)

First: Research variables and functional description

The independent variable military spending and the dependent GDP were established as follows in order to test the research hypothesis and accomplish its goals:

MS: Military Spending Independent Variable

GDP: dependent variable

The following test of functional relationships is presumed by the research's theoretical framework:-

GDP =a-b MS +ui

(MS) stands for military spending, while (GDP) stands for gross domestic product (UI), which stands for random error. Using the (13 Eviews) program, we will use the (ARDL) model, This is regarded as a contemporary standard model.

Second: Test results

1. **Unit root test**

Academia Open
Vol. 10 No. 2 (2025): December
DOI: 10.21070/acopen.10.2025.12245

UNIT ROOT TEST RESULTS TABLE (ADF) Null Hypothesis: the variable has a unit root			
At Level			
		GDP	MS
With Constant	t-Statistic	-1.7094	-2.0028
	Prob.	0.4109	0.2829
		n0	n0
With Constant & Trend	t-Statistic	-2.2746	-0.4485
	Prob.	0.4263	0.9761
		n0	n0
Without Constant & Trend	t-Statistic	0.6608	-0.1923
	Prob.	0.85	0.6022
		n0	n0
At First Difference			
		d(GDP)	d(MS)
With Constant	t-Statistic	-4.4457	-7.2199
	Prob.	0.0033	0
		***	***
With Constant & Trend	t-Statistic	-4.7246	-8.1634
	Prob.	0.0082	0
		***	***
Without Constant & Trend	t-Statistic	-3.8544	-2.1346
	Prob.	0.0007	0.0351
		***	**

Figure 2. *Unit root test (DKI-Fuller)*

The table was prepared by the researcher based on the analysis results of the program (EViews13).

We determine the ideal slowdown period as follows after running the unit root test for the search variables and looking at Table (2). It is evident that the variable GDP did not settle at the level but rather settled at the first difference, and the variable MS did not settle at the level but also settled at the first difference with a breaker or breaker and a general trend:-

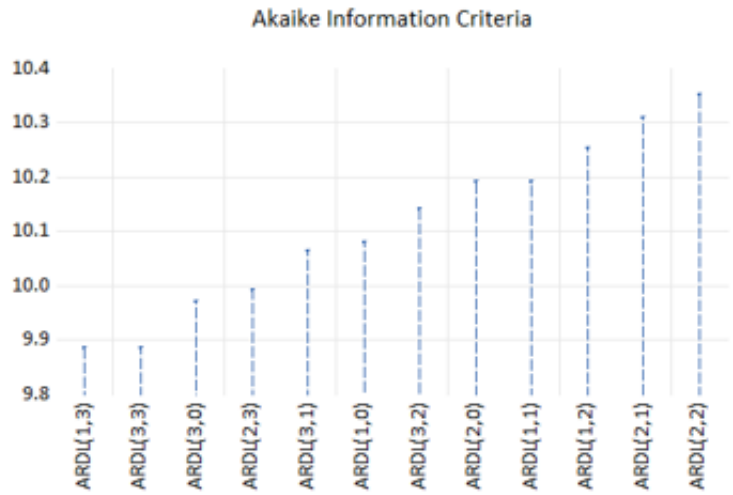

Figure 3. *Determining the Slowdown Period*

The form was prepared by the researcher based on the analysis results of the program (EViews13).

Academia Open
Vol. 10 No. 2 (2025): December
DOI: 10.21070/acopen.10.2025.12245

From Figure (1) it becomes clear to us that the optimal slowdown period for the model is Lag 3.

2. ARDL model of cointegration

المتغير	Coefficient	Std. Error	t-Statistic	Prob.*
MS(-1)	-13.44208	6.458244	-2.081384	0.0616
MS(-2)	-5.945734	6.702180	-0.887134	0.3940
MS(-3)	16.21346	6.168443	2.628452	0.0235
MS	4.848089	7.550085	0.642124	0.5339
GDP(-1)	0.612853	0.193482	3.167497	0.0090
C	76.94900	24.94848	3.084316	0.0104
R-squared	0.78	**Adjusted R-squared**		0.68
F-statistic	7.984532	**Durbin-Watson stat**		2.208320

Figure 4. *Results of the ARDL Cointegration Model*

The table was prepared by the researcher based on the analysis results of the program (EViews13).

Table (3) shows us the results of the autoregressive model of distributed deceleration and shows that the explanatory power R-squared was (78R2=0.) That is, 78% of the variations in the dependent variable are explained by the independent variable in the estimated model, with 22% coming from variables not included in the model. The value of Adjusted R-squared was (0.68), and the calculated value of F-statistic was (7.984532), which is significant at the level of 5%. In other words, we accept the alternative hypothesis and reject the null hypothesis because the model is significant.

3. Boundary test

Test Stat.	Value	K
F- Stat	3.867716	1
Signi.	I0 Bound	I1 Bound
5%	4.94	5.73

Table 2. *Boundary Test (Bounds Test)*

The table was prepared by the researcher based on the analysis results of the program (EViews13).

The computed value of (F-statistics) was 3.867716, which is below the minimum and maximum values at a significance level of 5%, according to Table (4), which displays the results of the boundary test. This suggests that the variables do not have a long-term equilibrium connection.

4. Testing the problem of autocorrelation and heterogeneity of variance

Breusch-Godfrey Serial Correlation LM Test			
F- statistic	0.429470	Prop . F	0.7375
Obs*R-squared	٢.٣٥٨٠٩٦	Prob. Chi-Square	٠.٥٠١٥
Heteroskedasticity Test: ARCH			
F-statistic	0.932667	Prob. F	0.3506
Obs*R-squared	0.999331	Prob. Chi-Square	0.3175

Figure 5. *Serial Correlation and Heterogeneity Test*

The table was prepared by the researcher based on the analysis results of the program (EViews13).

Academia Open
Vol. 10 No. 2 (2025): December
DOI: 10.21070/acopen.10.2025.12245

Since the Chi-Square value is not significant at the 5% level, we can conclude from Table (5) and the results of the Breusch-Godfrey Serial Correlation LM Test that the model is sound and free of the autocorrelation issue. Additionally, the Heteroskedasticity Test: ARCH revealed that the model is free of the heterogeneity of variance issue, which was likewise not significant at the 5% level.

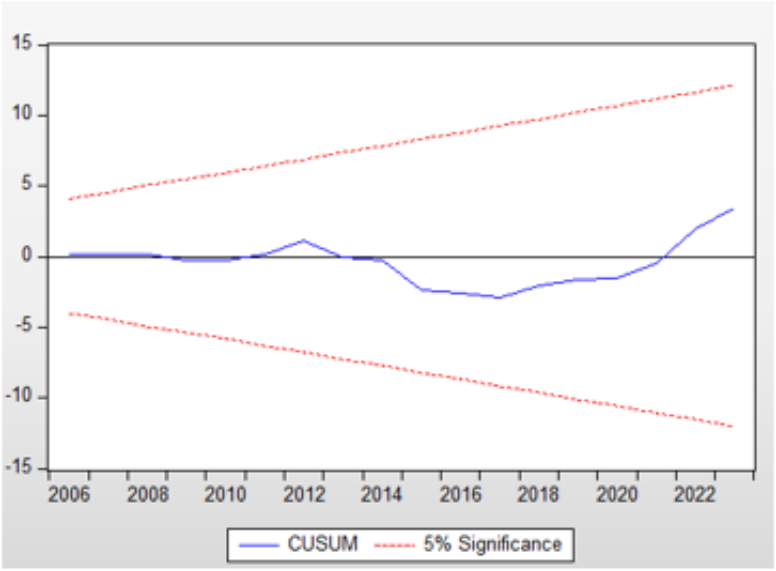

Figure 6. *Exclusivity Test*

The form was prepared by the researcher based on the analysis results of the program (EViews13).

Through Figure (2), it becomes clear to us that the model is stable because the graph lies within the upper and lower limits.

5. ECM Error Correction Model Estimation

ECM Short-Term Error Correction Model				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
D(MS)	4.848089	7.550085	0.642124	0.5339
D(MS(-1))	5.945734	6.702180	0.887134	0.3940
D(MS(-2))	-16.213457	6.168443	-2.628452	0.0235
CointEq(-1)	-0.387147	0.193482	-2.000951	0.0707
CM Long Term Error Correction Form				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
MS	4.323232	13.700166	0.315561	0.7582
C	198.758943	89.817233	2.212927	0.0490

Figure 7. *Error Correction Form*

The table was prepared by the researcher based on the analysis results of the program (EViews13).

Only the second shift, D(MS(-2)), had a significant impact, according to Table (6), which displays the short-term adjustment between changes in military spending and GDP. Despite the statistical significance of the long-term association, military spending (MS) does not seem to have a substantial long-term effect on GDP. This suggests that changes in military spending may not be related to a strong long-term relationship with GDP within the sample used and these results are consistent with the research hypothesis that there is a short-term relationship between the two

variables over the research period.

Conclusions

1. The explanatory power R-squared was (78R2=0.) That is, 78% of the variations in the dependent variable are explained by the independent variable in the estimated model, with 22% coming from variables not included in the model. The value of Adjusted R-squared was (0.68), and the calculated value of F-statistic was (7.984532), which is significant at the level of 5%. In other words, we accept the alternative hypothesis and reject the null hypothesis because the model is significant.

2. In other words, a study of the correlation between Iraq's military spending and economic growth reveals that it was negative in the majority of the years due to an imbalance in overall government spending. Although maintaining security is important, continuing to prioritize the military aspect over development requirements may weaken the economy's ability to achieve growth and stability.

3. Military spending was not a catalyst for economic growth because it was consumer rather than productive, the lack of military manufacturing infrastructure, weak encouragement of local defense industries, and there was no efficient use of resources due to administrative and economic corruption.

4. Directing public spending towards strengthening domestic defense industries was not a strategic option, which increased dependence on imports and contributed to the leakage of foreign exchange abroad and thus the trade balance deficit.

5. Military spending (MS) does not appear to have a significant impact on GDP in the long term. This indicates that changes in military spending may not be linked to a strong long-term relationship with GDP within the sample used. These results are consistent with the research hypothesis, which states a short-term relationship between the two variables during the research period.

Recommendations

Based on the study’s findings, the following recommendations are proposed:

1. Adopt a balanced fiscal policy that ensures national security without compromising the trajectory of economic development and growth. Public spending should be more strategically allocated to serve both security and development objectives.

2. Reevaluate the structure of the public budget by increasing allocations to productive and service sectors, particularly in areas such as infrastructure, education, and healthcare. Efforts should also focus on reducing the fiscal deficit through more efficient expenditure.

3. Develop a local defense industry to reduce dependence on imports and preserve foreign currency reserves. This would help retain financial resources within the national economy and potentially generate employment and technological advancement.

4. Integrate military spending into a comprehensive national development strategy, rather than treating it as a separate or exceptional category. Defense spending should contribute to broader goals of economic diversification and sustainability.

References

1. S. Siddiqui, et al., “A Brief Insight into the Etiology, Genetics, and Immunology of Polycystic Ovarian Syndrome (PCOS),” Journal of Assisted Reproduction and Genetics, vol. 39, no. 11,

pp. 2439–2473, 2022, doi: 10.1007/s10815-022-02671-3.
2. A. E. Joham, et al., “Polycystic Ovary Syndrome,” The Lancet Diabetes & Endocrinology, vol. 10, no. 9, pp. 668–680, 2022, doi: 10.1016/S2213-8587(22)00142-0.
3. Y. Xu and J. Qiao, “Association of Insulin Resistance and Elevated Androgen Levels with Polycystic Ovarian Syndrome (PCOS): A Review of Literature,” Journal of Healthcare Engineering, vol. 2022, pp. 1–9, 2022, doi: 10.1155/2022/9240569.
4. S. K. Masenga, et al., “Mechanisms of Oxidative Stress in Metabolic Syndrome,” International Journal of Molecular Sciences, vol. 24, no. 9, p. 7898, 2023, doi: 10.3390/ijms24097898.
5. A. Allameh, et al., “Oxidative Stress in Liver Pathophysiology and Disease,” Antioxidants, vol. 12, no. 9, p. 1653, 2023, doi: 10.3390/antiox12091653.
6. A. K. Aranda-Rivera, et al., “RONS and Oxidative Stress: An Overview of Basic Concepts,” Oxygen, vol. 2, no. 4, pp. 437–478, 2022, doi: 10.3390/oxygen2040032.
7. P. Sengupta, S. Dutta, and M. F. Hassan, “Polycystic Ovary Syndrome (PCOS) and Oxidative Stress,” Journal of Integrated Science and Technology, vol. 12, no. 3, p. 752, 2024.
8. E. Rudnicka, et al., “Oxidative Stress and Reproductive Function: Oxidative Stress in Polycystic Ovary Syndrome,” Reproduction, vol. 164, no. 6, pp. F145–F154, 2022, doi: 10.1530/REP-21-0633.
9. A. Mancini, et al., “Oxidative Stress and Low-Grade Inflammation in Polycystic Ovary Syndrome: Controversies and New Insights,” International Journal of Molecular Sciences, vol. 22, no. 4, p. 1667, 2021, doi: 10.3390/ijms22041667.
10. J. Nawrocka-Rutkowska, et al., “Assessment of the Parameters of Oxidative Stress Depending on the Metabolic and Anthropometric Status Indicators in Women with PCOS,” Life, vol. 12, no. 2, p. 225, 2022, doi: 10.3390/life12020225.
11. N. A. Abdulmuttaleb, M. Q. Mohammed, and O. A. Mohsein, “The Impact of Adipocytokines on Thyroid Function and Obesity: A Narrative Review,” Development, vol. 8, pp. 9–15, 2021.
12. Y. Liu, et al., “Oxidative Stress Markers in the Follicular Fluid of Patients with Polycystic Ovary Syndrome Correlate with a Decrease in Embryo Quality,” Journal of Assisted Reproduction and Genetics, vol. 38, no. 2, pp. 471–477, 2021, doi: 10.1007/s10815-020-01988-0.
13. A. Naigaonkar, et al., “Altered Redox Status May Contribute to Aberrant Folliculogenesis and Poor Reproductive Outcomes in Women with Polycystic Ovary Syndrome,” Journal of Assisted Reproduction and Genetics, vol. 38, no. 10, pp. 2609–2623, 2021, doi: 10.1007/s10815-021-02255-7.
14. N. H. Naif, et al., “The Impact of Inflammatory and Adipokine Biomarkers on Breast Cancer Progression and Patient Outcomes,” Bulletin of Pharmaceutical Sciences, Assiut University, vol. 48, no. 1, pp. 511–522, 2025, doi: 10.21608/bfsa.2025.267356.
15. P. Sharma, et al., “Assessment of Serum Elements Concentration and Polycystic Ovary Syndrome (PCOS): Systematic Review and Meta-Analysis,” Biological Trace Element Research, vol. 200, no. 11, pp. 4582–4593, 2022, doi: 10.1007/s12011-021-03015-3.
16. S. Mohammad, A. Mohsen, and I. Jalil, “Assessing the Prevalence of Bacterial Vaginosis among Infertile Women in Thi-Qar Province, Iraq,” Infection Epidemiology and Microbiology, vol. 10, no. 4, pp. 233–240, 2024.
17. K. Uçkan, et al., “Role of Oxidative Stress in Obese and Nonobese PCOS Patients,” International Journal of Clinical Practice, vol. 2022, p. 4579831, 2022, doi: 10.1155/2022/4579831.
18. E. Rudnicka, et al., “Oxidative Stress and Reproductive Function: Oxidative Stress in Polycystic Ovary Syndrome,” Reproduction, vol. 164, no. 6, pp. F145–F154, 2022, doi: 10.1530/REP-21-0633.
19. P. Sengupta, S. Dutta, and M. F. Hassan, “Polycystic Ovary Syndrome (PCOS) and Oxidative Stress,” Journal of Integrated Science and Technology, vol. 12, no. 3, p. 752, 2024.
20. A. A. Mahmud, et al., “Elevated Serum Malondialdehyde (MDA), Insulin, Follicle-Stimulating Hormone (FSH), Luteinizing Hormone (LH), and Thyroid-Stimulating Hormone (TSH), and Reduced Antioxidant Vitamins in Polycystic Ovarian Syndrome Patients,” Narra J, vol. 2, no. 1, p. e56, 2022, doi: 10.52225/narraj.v2i1.56.

21. L. Rahmatnezhad, et al., “Free Androgen Index (FAI)’s Relations with Oxidative Stress and Insulin Resistance in Polycystic Ovary Syndrome,” Scientific Reports, vol. 13, no. 1, p. 5118, 2023, doi: 10.1038/s41598-023-32062-9.
22. A. A. Shenta and A. D. M. Al-Maliki, “Clinical Assessment of Female Sexual Hormones and Some Antioxidant Vitamins in Iraqi Women with Polycystic Ovary Syndrome According to Body Mass Index and Blood Group Variables,” Romanian Journal of Medical Practice, vol. 19, no. 3, pp. 272–278, 2024, doi: 10.37897/RJMP.2024.3.9.
23. K. Bhattacharya, et al., “Polycystic Ovary Syndrome and Its Management: In View of Oxidative Stress,” Biomolecular Concepts, vol. 15, no. 1, p. 20220038, 2024, doi: 10.1515/bmc-2022-0038.
24. S. Lu, et al., “Sedentary Leisure Behaviour, Physical Activity, and Gastroesophageal Reflux Disease: Evidence from a Mendelian Randomization Analysis,” Health Science Reports, vol. 8, no. 3, p. e70479, 2025, doi: 10.1002/hsr.7047.
25. M. Zaki, et al., “Total Antioxidant Capacity Status in Non-Obese Adolescent Females with PCOS: A Cross-Section Study,” Middle East Fertility Society Journal, vol. 29, no. 1, p. 51, 2024, doi: 10.1186/s43043-024-00151-0.
26. J. Liang, et al., “Reactive Oxygen Species and Ovarian Diseases: Antioxidant Strategies,” Redox Biology, vol. 62, p. 102659, 2023, doi: 10.1016/j.redox.2023.102659.