International Journal of Biomedicine 14(2) (2024) 265-269
http://dx.doi.org/10.21103/Article14(2)_OA4

ORIGINAL ARTICLE

Diabetes Mellitus

INTERNATIONAL JOURNAL OF BIOMEDICINE

Evaluation of Serum Visfatin and Chemerin Levels in Diabetes Patients in Mosul City

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Abstract

Background: Diabetes mellitus is a major public health concern worldwide. Although there are many possible causes of diabetes, the three most prevalent ones are insulin resistance, pancreatic cell damage, and insulin insufficiency. Visfatin, an adipocytokine with insulin-mimicking characteristics, and chemerin, an adipokine responsible for maintaining normal cholesterol and glucose levels, are linked to inflammation and immunological dysfunction in metabolic illnesses. Hence, in this study, we aimed to evaluate the possible association between type 2 diabetes mellitus (T2DM) and the adipokines visfatin and chemerin.

Methods and Results: This study was conducted at the Al-Salam Teaching Hospital in Mosul from December 1, 2022, to the end of June 2023. The study included 65 patients of both sexes with T2DM aged between 35 and 80. Twenty-five healthy individuals of both sexes were chosen for a control group. Visfatin and chemerin levels in the serum were measured using an ELISA kit (Koma biotech, ELISA, USA) per the manufacturer's instructions.

The levels of visfatin and chemerin in T2DM patients were significantly higher than in controls (1.478±0.631 ng/ml and 158.768±36.941 pg/ml vs. 0.538±0.151 ng/ml and 71.272±12.994 pg/ml, respectively, P=0.000 in both cases). The study showed no significant difference in the levels of chemerin and visfatin between females and males in T2DM patients. Among men, the visfatin levels were significantly higher in T2DM patients with diabetic retinopathy than in T2DM patients with such complications as cardiovascular disease and diabetic nephropathy. These features also occurred among women. Men and women with T2DM did not differ in the chemerin levels, depending on the nature of the diabetes complication.

Conclusion: T2DM patients are characterized by significantly higher visfatin and chemerin levels than healthy controls. No differences in the levels of these adipokines that depend on the gender of diabetic patients have been found. **(International Journal of Biomedicine. 2024;14(2):265-269.)**

Keywords: type 2 diabetes mellitus • visfatin • chemerin • insulin resistance

For citation: Khalil RI, Mohsin SN, Nayyef SH. Evaluation of Serum Visfatin and Chemerin Levels in Diabetes Patients in Mosul City. International Journal of Biomedicine. 2024;14(2):265-269. doi:10.21103/Article14(2)_OA4

Abbreviations

CVD, cardiovascular disease; **DN**, diabetic nephropathy; **DR**, diabetic retinopathy; **IR**, insulin resistance; **T2DM**, type 2 diabetes mellitus; **VSMCs**, vascular smooth muscle cells.

Introduction

Diabetes mellitus is a major public health concern, affecting over 400 million individuals throughout the world. The number of individuals with diabetes is rising, and by 2030, it is projected that 366 million people aged 65 and more will have the disease. Diabetes has been associated with several factors, including insulin deficiency, pancreatic cell injury, and insulin resistance. Nephropathy, neuropathy, cardiovascular disease, and diabetic retinopathy are only a few of the many complications of diabetes.[1] Constant microvascular and macrovascular problems could develop due to this metabolic disorder. The inability of the pancreas to produce enough insulin and a lifetime of poor dietary and lifestyle choices contribute to the development of insulin resistance and type 2 diabetes mellitus (T2DM).

The molecular mechanisms involved in insulin generation, release, and response in tissues must be tightly

regulated to ensure that insulin activity precisely matches metabolic demand. The pathophysiology of T2DM may be affected by defects in any of these systems, leading to a metabolic imbalance.[2] Adipokines regulate hunger, energy expenditure and storage, insulin secretion and sensitivity, blood pressure, endothelial function, and homeostasis. Adipokines have several systemic effects on the liver, brain, muscle, heart, arteries, and immune system.[3] The visceral adipose tissue produces the proinflammatory adipokine visfatin, a 52-kDa protein. Visfatin increases cytokine production, and elevated levels are linked to inflammation and endothelial dysfunction in metabolic illness. Visfatin has been linked to many different types of brain and heart damage in clinical investigations. Evidence suggests it has various harmful long-term effects and a regulatory function in the heart, neurons, and mitochondria. There is a need for more excellent research into the impact of adipocytokine on critically sick individuals.[4]

The newly discovered adipokine chemerin possesses endocrine, paracrine, and autocrine functions, making it crucial for maintaining normal cholesterol and glucose levels. It is generated mainly by white adipose tissue, the liver, and the placenta, with some also coming from brown adipose tissue, skeletal muscles, and other organs, such as kidneys, adrenal glands, lungs, ovaries, and the heart. In addition to its role in blood pressure control, chemerin may have a role in angiogenesis, inflammation, immunological modulation, and other processes. Some research has shown that chemerin levels are more significant in diabetic patients than in healthy controls, while others have shown no significant differences.[5] In this case-control and exploratory investigation, we examined a group of diabetic patients in Mosul (Iraq) for a possible association between T2DM and visfatin and chemerin.

Materials and Methods

This study was conducted at the Al-Salam Teaching Hospital in Mosul from December 1, 2022, to the end of June 2023. The study included 65 patients of both sexes with T2DM aged between 35 and 80. Twenty-five healthy individuals of both sexes were chosen for a control group. Venous blood was collected from patients and controls after an 8-hour fasting. The blood was allowed to rest for 20 minutes at room temperature. The serum separated was centrifuged at 3000rpm for 15 minutes and transferred to fresh tubes for further analysis. Fasting blood glucose was estimated using Glucose Reagent Kit (Biomerieux, France). Visfatin and chemerin levels in the serum were measured using an ELISA kit (Koma biotech, ELISA, USA) per the manufacturer's instructions.

Statistical analysis was performed using the statistical software package SPSS version 25.0 (SPSS Inc, Armonk, NY: IBM Corp). For the descriptive analysis, results are presented as mean (M) ± standard deviation (SD). For data with normal distribution, inter-group comparisons were performed using Student's t-test. Multiple comparisons were performed with one-way ANOVA and Tukey HSD post-hoc test. A value of $P<0.05$ was considered significant.

Results and Discussion

We found significantly higher levels of visfatin and chemerin in T2DM patients than in controls (1.478±0.631 ng/ml and 158.768±36.941 pg/ml vs. 0.538±0.151 ng/ml and 71.272±12.994 pg/ml, respectively, P=0.000 in both cases) (Table 1). The study showed no significant difference in the levels of chemerin and visfatin between females and males in T2DM patients (Table 2). The patients were divided into groups according to the T2DM complications, and the level of visfatin was compared between these groups and for each sex separately. Among men, the visfatin levels were significantly higher in T2DM patients with diabetic retinopathy than in T2DM patients with such complications as cardiovascular disease and diabetic nephropathy. These features also occurred among women (Table 3). Men and women with T2DM did not differ in the chemerin levels, depending on the nature of the diabetes complication (Table 4).

Table 1.

The levels of visfatin and chemerin in controls and T2DM patients.

Variable	Control group (n=25)	T2DM patients (n=65)	*P*-value
Visfatin (ng/mL)	0.538 ± 0.151	1.478 ± 0.631	0.000
Chemerin (pg/mL)	71.272±12.994	158.768 ± 36.941	0.000

Table 2.

Levels of chemerin and visfatin in T2DM patients depending on gender.

Variable	Female (n=25)	Male (n=40)	*P*- value
Visfatin (ng/ml)	1.546 ± 0.671	1.436± 0 .609	0.499
Chemerin (pg/ml)	157.122 ±43.678	159.797 ± 32.598	0.779

Table 3.

The visfatin levels according to the T2DM complications.

Gender	Group	n	Visfatin (ng/mL)	ANOVA
Males T2DM complication	Control group[1]	11	0.609±0.098	F=11.7128 P=0.0000 P_{1-2}=0.0036 P_{1-3}=0.0224 P_{1-4}=0.0000 P_{2-3}=0.9690 P_{2-4}=0.0372 P_{3-4}=0.0212
	CVD[2]	15	1.424± 0.587	
	DN[3]	11	1.324±0.565	
	DR[4]	9	2.083±0.789	
Females T2DM complication	Control group[1]	14	0.483±0.164	F=7.5841 P=0.0001 P_{1-2}=0.0016 P_{1-3}=0.0222 P_{1-4}=0.0044 P_{1-5}=0.0011 P_{2-3}=0.9942 P_{2-4}=0.9966 P_{2-5}=0.9269 P_{3-4}=0.9616 P_{3-5}=0.8124
	CVD[2]	11	1.487±0.836	
	DN3	7	1.370±0.796	
	DR[4]	6	1.594±0.400	
	Other complications[5]	6	1.733±0.652	

Table 4.

The chemerin levels according to the T2DM complications.

Gender	Group	n	Chemerin (pg/ml)	ANOVA
Males T2DM complication	Control group[1]	11	68.941 ±11.304	F=43.2797 P=0.000 P_{1-2}=0.0000 P_{1-3}=0.0000 P_{1-4}=0.0000 P_{2-3}=0.9579 P_{2-4}=0.5114 P_{3-4}=0.8246
	CVD[2]	15	159.127 ±35.327	
	DN[3]	11	164.001 ±15.726	
	DR[4]	9	173.449 ±21.770	
Females T2DM complication	Control group[1]	14	73.103 ±14.325	F=23.4721 P=0.0000 P_{1-2}=0.0011 P_{1-3}=0.0120 P_{1-4}=0.5790 P_{1-5}=0.0000 P_{2-3}=0.9988 P_{2-4}=0.3076 P_{2-5}=0.0000 P_{3-4}=0.5383 P_{3-5}=0.0000
	CVD[2]	11	139.765 ±49.931	
	DN[3]	7	134.732 ±57.010	
	DR[4]	6	101.291 ±38.130	
	Other complications[5]	6	252.693 ±29.641	

Adipokines play a critical role in maintaining systemic energy homeostasis, and the impaired adipokine production observed in obesity contributes to diabetes pathogenesis. Visfatin was first discovered as an adipocytokine with insulin-mimicking characteristics.[6] Chemerin is a recently discovered adipokine that regulates adipocyte differentiation and modulates chemotaxis and the activation of dendritic cells and macrophages.[7] Susairaj et al.[8] found that chemerin was associated with BMI and fat components but is not an independent risk factor for T2DM.

In our study, the levels of visfatin and chemerin in T2DM patients were significantly higher than in controls. These results are consistent with those of Sulaiman et al.,[9] who showed elevated levels of visfatin and chemerin in T2DM patients and showed that serum visfatin plays an important role in many pathological processes in T2DM.

Our study showed no differences in the levels of chemerin and visfatin regardless of the gender of patients with diabetes, which is consistent with the data of Tabandeh et al.[10] and Mir et al.[11] but disagrees with Lehrke et al.,[7] who found that the blood chemerin levels were significantly higher in females than in males. In addition, the researchers found that chemerin was strongly associated with markers of inflammation and components of metabolic syndrome (body mass index, triglycerides, HDL-cholesterol, and hypertension).

Diabetic microvascular complications (retinopathy, nephropathy, neuropathy) and macrovascular complications (ischemic heart disease, peripheral vascular disease, and cerebrovascular disease) result in organ and tissue damage in approximately one-third to one-half of people with diabetes. Akbarian et al.[12] showed high levels of visfatin and NO metabolites in patients with diabetic nephropathy. In addition, there was a positive correlation between visfatin and NO metabolite levels in nephropathic and non-nephropathic diabetic patients. The results of a study by Al Obaidi et al.[13] showed that serum visfatin levels were significantly correlated with CRP in patients with chronic kidney disease and with deterioration of kidney function.

Besides, Wang et al.[14] found that serum and vitreous visfatin levels were associated with the presence and severity of diabetic retinopathy, which is consistent with our results, indicating that diabetic retinopathy, among other complications of diabetes, was characterized by high values of this adipokine. In a study by Yasir et al.,[15] linear regression data showed that chemerin was also an independent predictor of diabetic retinopathy severity.

Kärberg et al.[16] found that visfatin could be used as a marker of subclinical atherosclerosis in patients with T2DM, especially in males. In particular, visfatin positively correlated with intima-media thickness ≥1.0 mm or plaque (P=0.008). According to research findings, visfatin has a strong connection to cardiovascular disease.

Several studies have shown a connection between chemerin and endothelial dysfunction in pathological conditions such as obesity, DM, and hypertension.[17-19] Neves et al.[20] found that chemerin induces endothelial dysfunction by downregulating endothelial nitric oxide synthase and decreasing NO production in endothelial cells. Chemerin is also associated with excessive ROS accumulation in endothelial cells, contributing to endothelial dysfunction.[18,20] Increased ROS accumulation and elevated expressions of inflammatory cytokines such as IL-1β, IL-6, and monocyte chemoattractant protein-1 were observed in chemerin-treated vascular smooth muscle cells, suggesting that chemerin can induce vascular smooth muscle cell dysfunction by augmenting oxidative stress and promoting inflammation.[21-24] Chemerin may contribute to the development of atherosclerosis by promoting the formation of vascular inflammation by recruiting macrophages to inflamed blood vessels.[25] Gasbarino et al.[26] showed circulating chemerin is associated with carotid plaque instability.

A prospective cohort study by Zhou et al.,[27] which included 834 patients with chronic heart failure, investigated the association between serum chemerin and clinical outcomes. Cox regression analysis showed that chemerin significantly predicted major adverse cardiac events after adjustment for conventional risk factors. In addition, chemerin was an independent predictor of all-cause mortality after multivariable adjustment. The authors concluded that chemerin may be a novel serum marker for predicting major adverse cardiac events in patients with chronic heart failure. Chemerin can also potentially be used as a biomarker in chronic kidney disease, which is common in people with diabetes.[28]

Conclusion

T2DM patients are characterized by significantly higher visfatin and chemerin levels than healthy controls. No differences in the levels of these adipokines that depend on

the gender of diabetic patients have been found. The level of visfatin has been significantly higher in patients with diabetic retinopathy than in such diabetes complications as cardiovascular disease and diabetic nephropathy. Elevated chemerin levels in T2DM patients do not depend on the type of diabetes complication.

Ethical Considerations

The study was conducted in accordance with ethical principles of the WMA Declaration of Helsinki (1964, ed. 2013). Written informed consent was obtained from all participants according to Administrative Order No. 3/7/107 dated 18/1/2022.

Competing Interests

The authors declare that they have no competing interests.

References

1. Padhi S, Nayak AK, Behera A. Type II diabetes mellitus: a review on recent drug based therapeutics. Biomed Pharmacother. 2020 Nov;131:110708. doi: 10.1016/j.biopha.2020.110708. Epub 2020 Sep 11. PMID: 32927252.
2. Galicia-Garcia U, Benito-Vicente A, Jebari S, Larrea-Sebal A, Siddiqi H, Uribe KB, Ostolaza H, Martín C. Pathophysiology of Type 2 Diabetes Mellitus. Int J Mol Sci. 2020 Aug 30;21(17):6275. doi: 10.3390/ijms21176275. PMID: 32872570; PMCID: PMC7503727.
3. Lelis DF, Freitas DF, Machado AS, Crespo TS, Santos SHS. Angiotensin-(1-7), Adipokines and Inflammation. Metabolism. 2019 Jun;95:36-45. doi: 10.1016/j.metabol.2019.03.006. Epub 2019 Mar 21. PMID: 30905634.
4. Hajri T, Gharib M, Kaul S, Karpeh MS Jr. Association between adipokines and critical illness outcomes. J Trauma Acute Care Surg. 2017 Sep;83(3):507-519. doi: 10.1097/TA.0000000000001610. PMID: 28697011.
5. Ashraf H, Soltani D, Sobh-Rakhshankhah A, Jafari S, Boroumand MA, Goudarzi V, Vasheghani Farahani A, Masoudkabir F. Visfatin as marker of isolated coronary artery ectasia and its severity. Cytokine. 2019 Jan;113:216-220. doi: 10.1016/j.cyto.2018.07.007. Epub 2018 Jul 9. PMID: 30001864.
6. Yu PL, Wang C, Li W, Zhang FX. Visfatin Level and The Risk of Hypertension and Cerebrovascular Accident: A Systematic Review and Meta-Analysis. Horm Metab Res. 2019 Apr;51(4):220-229. doi: 10.1055/a-0867-1333. Epub 2019 Apr 25. PMID: 31022738.
7. Lehrke M, Becker A, Greif M, Stark R, Laubender RP, von Ziegler F, Lebherz C, Tittus J, Reiser M, Becker C, Göke B, Leber AW, Parhofer KG, Broedl UC. Chemerin is associated with markers of inflammation and components of the metabolic syndrome but does not predict coronary atherosclerosis. Eur J Endocrinol. 2009 Aug;161(2):339-44. doi: 10.1530/EJE-09-0380. Epub 2009 Jun 4. PMID: 19497986.
8. Susairaj P, Snehalatha C, Nanditha A, Satheesh K, Raghavan A, Vinitha R, Ramachandran A. Analysis of an Indian diabetes prevention programme on association of adipokines and a hepatokine with incident diabetes. Sci Rep. 2021 Oct 13;11(1):20327. doi: 10.1038/s41598-021-99784-x. PMID: 34645898; PMCID: PMC8514464.
9. Sulaiman MM, Salih KN, Alazzawy MA. Role of Visfatin Chemerin with Type Two Diabetes Mellitus. Al-Kufa University Journal for Biology. 2019;11(1).
10. Tabandeh MR, Taha AS, Addai Ali H, Razijalali M, Mohammadtaghvaei N. Type 2 Diabetes Mellitus Coincident with Clinical and Subclinical Thyroid Dysfunctions Results in Dysregulation of Circulating Chemerin, Resistin and Visfatin. Biomedicines. 2023 Jan 25;11(2):346. doi: 10.3390/biomedicines11020346. PMID: 36830883; PMCID: PMC9952980.
11. Mir MM, Mir R, Alghamdi MAA, Wani JI, Sabah ZU, Jeelani M, Marakala V, Sohail SK, O'haj M, Alharthi MH, Alamri MMS. Differential Association of Selected Adipocytokines, Adiponectin, Leptin, Resistin, Visfatin and Chemerin, with the Pathogenesis and Progression of Type 2 Diabetes Mellitus (T2DM) in the Asir Region of Saudi Arabia: A Case Control Study. J Pers Med. 2022 May 1;12(5):735. doi: 10.3390/jpm12050735. PMID: 35629157; PMCID: PMC9143828.
12. Akbarian N, Zarghami N, Mota A, Abediazar S, Abroon S, Mihanfar A, Amanzadeh M, Darbin A, Bannazadeh Baghi H, Rahmati-Yamchi M. Correlation Between Circulating Visfatin and Nitric Oxide Metabolites Levels in Patients With Diabetic Nephropathy. Iran J Kidney Dis. 2018 May;12(3):163-168. PMID: 29891746.
13. Muayad Shukur Al Obaidi R. The Physiological Effects of Visfatin on Immune Response and Inflammatory Impacts on Nephropathy. Arch Razi Inst. 2021 Sep 1;76(3):639-647. doi: 10.22092/ari.2021.355463.1688. PMID: 34824756; PMCID: PMC8605846.
14. Wang Y, Yuan Y, Jiang H. Serum and vitreous levels of visfatin in patients with diabetic retinopathy. Med Sci Monit. 2014 Dec 19;20:2729-32. doi: 10.12659/MSM.891292. PMID: 25524991; PMCID: PMC4280054.
15. Yasir M, Senthilkumar GP, Jayashree K, Ramesh Babu K, Vadivelan M, Palanivel C. Association of serum omentin-1, apelin and chemerin concentrations with the presence and severity of diabetic retinopathy in type 2 diabetes mellitus patients. Arch Physiol Biochem. 2022 Apr;128(2):313-320. doi: 10.1080/13813455.2019.1680698. Epub 2019 Nov 5. PMID: 31686535.
16. Kärberg K, Forbes A, Lember M. Visfatin and Subclinical Atherosclerosis in Type 2 Diabetes: Impact of Cardiovascular Drugs. Medicina (Kaunas). 2023 Jul 18;59(7):1324. doi: 10.3390/medicina59071324. PMID: 37512134; PMCID: PMC10386106.
17. Gu P, Cheng M, Hui X, Lu B, Jiang W, Shi Z. Elevating circulation chemerin level is associated with endothelial dysfunction and early atherosclerotic changes in essential hypertensive patients. J Hypertens. 2015 Aug;33(8):1624-32. doi: 10.1097/HJH.0000000000000588. PMID: 26136068.
18. Haybar H, Shahrabi S, Rezaeeyan H, Shirzad R, Saki N. Endothelial Cells: From Dysfunction Mechanism to

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Pharmacological Effect in Cardiovascular Disease. Cardiovasc Toxicol. 2019 Feb;19(1):13-22. doi: 10.1007/s12012-018-9493-8. PMID: 30506414.
19. Macvanin MT, Rizzo M, Radovanovic J, Sonmez A, Paneni F, Isenovic ER. Role of Chemerin in Cardiovascular Diseases. Biomedicines. 2022 Nov 18;10(11):2970. doi: 10.3390/biomedicines10112970. PMID: 36428537; PMCID: PMC9687862.
20. Neves KB, Lobato NS, Lopes RA, Filgueira FP, Zanotto CZ, Oliveira AM, Tostes RC. Chemerin reduces vascular nitric oxide/cGMP signalling in rat aorta: a link to vascular dysfunction in obesity? Clin Sci (Lond). 2014 Jul;127(2):111-22. doi: 10.1042/CS20130286. PMID: 24498891.
21. Satoh K, Nigro P, Berk BC. Oxidative stress and vascular smooth muscle cell growth: a mechanistic linkage by cyclophilin A. Antioxid Redox Signal. 2010 Mar 1;12(5):675-82. doi: 10.1089/ars.2009.2875. PMID: 19747062; PMCID: PMC2861539.
22. Das S, Zhang E, Senapati P, Amaram V, Reddy MA, Stapleton K, Leung A, Lanting L, Wang M, Chen Z, Kato M, Oh HJ, Guo Q, Zhang X, Zhang B, Zhang H, Zhao Q, Wang W, Wu Y, Natarajan R. A Novel Angiotensin II-Induced Long Noncoding RNA Giver Regulates Oxidative Stress, Inflammation, and Proliferation in Vascular Smooth Muscle Cells. Circ Res. 2018 Dec 7;123(12):1298-1312. doi: 10.1161/CIRCRESAHA.118.313207. Erratum in: Circ Res. 2019 Dec 6;125(12):e112. PMID: 30566058; PMCID: PMC6309807.
23. Cui L, Zhou Q, Zheng X, Sun B, Zhao S. Mitoquinone attenuates vascular calcification by suppressing oxidative stress and reducing apoptosis of vascular smooth muscle cells via the Keap1/Nrf2 pathway. Free Radic Biol Med. 2020 Dec;161:23-31. doi: 10.1016/j.freeradbiomed.2020.09.028. Epub 2020 Oct 2. PMID: 33011276.
24. Dai L, Schurgers LJ, Shiels PG, Stenvinkel P. Early vascular ageing in chronic kidney disease: impact of inflammation, vitamin K, senescence and genomic damage. Nephrol Dial Transplant. 2020 Mar 1;35(Suppl 2):ii31-ii37. doi: 10.1093/ndt/gfaa006. PMID: 32162665; PMCID: PMC7066546.
25. Hart R, Greaves DR. Chemerin contributes to inflammation by promoting macrophage adhesion to VCAM-1 and fibronectin through clustering of VLA-4 and VLA-5. J Immunol. 2010 Sep 15;185(6):3728-39. doi: 10.4049/jimmunol.0902154. Epub 2010 Aug 18. PMID: 20720202.
26. Gasbarrino K, Mantzoros C, Gorgui J, Veinot JP, Lai C, Daskalopoulou SS. Circulating Chemerin Is Associated With Carotid Plaque Instability, Whereas Resistin Is Related to Cerebrovascular Symptomatology. Arterioscler Thromb Vasc Biol. 2016 Aug;36(8):1670-8. doi: 10.1161/ATVBAHA.115.306741. Epub 2016 Jun 16. PMID: 27312219.
27. Zhou X, Tao Y, Chen Y, Xu W, Qian Z, Lu X. Serum Chemerin as a Novel Prognostic Indicator in Chronic Heart Failure. J Am Heart Assoc. 2019 Aug 6;8(15):e012091. doi: 10.1161/JAHA.119.012091. Epub 2019 Jul 23. PMID: 31333053; PMCID: PMC6761658.
28. Behnoush AH, Shobeiri P, Bahiraie P, Amirkhani N, Khalaji A, Peiman S. Chemerin levels in chronic kidney disease: A systematic review and meta-analysis. Front Endocrinol (Lausanne). 2023 Jan 25;14:1120774. doi: 10.3389/fendo.2023.1120774.