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ЕЖЕМЕСЯЧНЫЙ НАУЧНЫЙ ЖУРНАЛ

Медицинские новости Грузии

საქართველოს სამედიცინო სიახლენი

GEORGIAN MEDICAL NEWS

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GMN: Georgian Medical News is peer-reviewed, published monthly journal committed to promoting the science and art of medicine and the betterment of public health, published by the GMN Editorial Board since 1994. GMN carries original scientific articles on medicine, biology and pharmacy, which are of experimental, theoretical and practical character; publishes original research, reviews, commentaries, editorials, essays, medical news, and correspondence in English and Russian.

GMN is indexed in MEDLINE, SCOPUS, PubMed and VINITI Russian Academy of Sciences. The full text content is available through EBSCO databases.

GMN: Медицинские новости Грузии - ежемесячный рецензируемый научный журнал, издаётся Редакционной коллегией с 1994 года на русском и английском языках в целях поддержки медицинской науки и улучшения здравоохранения. В журнале публикуются оригинальные научные статьи в области медицины, биологии и фармации, статьи обзорного характера, научные сообщения, новости медицины и здравоохранения. Журнал индексируется в MEDLINE, отражён в базе данных SCOPUS, PubMed и ВИНИТИ РАН. Полнотекстовые статьи журнала доступны через БД EBSCO.

GMN: Georgian Medical News – საქართველოს სამედიცინო სიახლენი – არის ყოველთვიური სამეცნიერო სამედიცინო რეცენზირებადი ჟურნალი, გამოიცემა 1994 წლიდან, წარმოადგენს სარედაქციო კოლეგიისა და აშშ-ის მეცნიერების, განათლების, ინდუსტრიის, ხელოვნებისა და ბუნებისმეტყველების საერთაშორისო აკადემიის ერთობლივ გამოცემას. GMN-ში რუსულ და ინგლისურ ენებზე ქვეყნდება ექსპერიმენტული, თეორიული და პრაქტიკული ხასიათის ორიგინალური სამეცნიერო სტატიები მედიცინის, ბიოლოგიისა და ფარმაციის სფეროში, მიმოხილვითი ხასიათის სტატიები.

ჟურნალი ინდექსირებულია MEDLINE-ის საერთაშორისო სისტემაში, ასახულია SCOPUS-ის, PubMed-ის და ВИНИТИ РАН-ის მონაცემთა ბაზებში. სტატიების სრული ტექსტი ხელმისაწვდომია EBSCO-ს მონაცემთა ბაზებიდან.

WEBSITE

www.geomednews.com

К СВЕДЕНИЮ АВТОРОВ!

При направлении статьи в редакцию необходимо соблюдать следующие правила:

1. Статья должна быть представлена в двух экземплярах, на русском или английском языках, напечатанная через **полтора интервала на одной стороне стандартного листа с шириной левого поля в три сантиметра**. Используемый компьютерный шрифт для текста на русском и английском языках - **Times New Roman** (**Кириллица**), для текста на грузинском языке следует использовать **AcadNusx.** Размер шрифта - **12**. К рукописи, напечатанной на компьютере, должен быть приложен CD со статьей.

2. Размер статьи должен быть не менее десяти и не более двадцати страниц машинописи, включая указатель литературы и резюме на английском, русском и грузинском языках.

3. В статье должны быть освещены актуальность данного материала, методы и результаты исследования и их обсуждение.

При представлении в печать научных экспериментальных работ авторы должны указывать вид и количество экспериментальных животных, применявшиеся методы обезболивания и усыпления (в ходе острых опытов).

4. К статье должны быть приложены краткое (на полстраницы) резюме на английском, русском и грузинском языках (включающее следующие разделы: цель исследования, материал и методы, результаты и заключение) и список ключевых слов (key words).

5. Таблицы необходимо представлять в печатной форме. Фотокопии не принимаются. **Все цифровые, итоговые и процентные данные в таблицах должны соответствовать таковым в тексте статьи**. Таблицы и графики должны быть озаглавлены.

6. Фотографии должны быть контрастными, фотокопии с рентгенограмм - в позитивном изображении. Рисунки, чертежи и диаграммы следует озаглавить, пронумеровать и вставить в соответствующее место текста **в tiff формате**.

В подписях к микрофотографиям следует указывать степень увеличения через окуляр или объектив и метод окраски или импрегнации срезов.

7. Фамилии отечественных авторов приводятся в оригинальной транскрипции.

8. При оформлении и направлении статей в журнал МНГ просим авторов соблюдать правила, изложенные в «Единых требованиях к рукописям, представляемым в биомедицинские журналы», принятых Международным комитетом редакторов медицинских журналов - http://www.spinesurgery.ru/files/publish.pdf и http://www.nlm.nih.gov/bsd/uniform_requirements.html
В конце каждой оригинальной статьи приводится библиографический список. В список литературы включаются все материалы, на которые имеются ссылки в тексте. Список составляется в алфавитном порядке и нумеруется. Литературный источник приводится на языке оригинала. В списке литературы сначала приводятся работы, написанные знаками грузинского алфавита, затем кириллицей и латиницей. Ссылки на цитируемые работы в тексте статьи даются в квадратных скобках в виде номера, соответствующего номеру данной работы в списке литературы. Большинство цитированных источников должны быть за последние 5-7 лет.

9. Для получения права на публикацию статья должна иметь от руководителя работы или учреждения визу и сопроводительное отношение, написанные или напечатанные на бланке и заверенные подписью и печатью.

10. В конце статьи должны быть подписи всех авторов, полностью приведены их фамилии, имена и отчества, указаны служебный и домашний номера телефонов и адреса или иные координаты. Количество авторов (соавторов) не должно превышать пяти человек.

11. Редакция оставляет за собой право сокращать и исправлять статьи. Корректура авторам не высылается, вся работа и сверка проводится по авторскому оригиналу.

12. Недопустимо направление в редакцию работ, представленных к печати в иных издательствах или опубликованных в других изданиях.

При нарушении указанных правил статьи не рассматриваются.

REQUIREMENTS

Please note, materials submitted to the Editorial Office Staff are supposed to meet the following requirements:

1. Articles must be provided with a double copy, in English or Russian languages and typed or compu-ter-printed on a single side of standard typing paper, with the left margin of **3** centimeters width, and **1.5** spacing between the lines, typeface - **Times New Roman** (**Cyrillic**), print size - **12** (referring to Georgian and Russian materials). With computer-printed texts please enclose a CD carrying the same file titled with Latin symbols.

2. Size of the article, including index and resume in English, Russian and Georgian languages must be at least 10 pages and not exceed the limit of 20 pages of typed or computer-printed text.

3. Submitted material must include a coverage of a topical subject, research methods, results, and review.

Authors of the scientific-research works must indicate the number of experimental biological species drawn in, list the employed methods of anesthetization and soporific means used during acute tests.

4. Articles must have a short (half page) abstract in English, Russian and Georgian (including the following sections: aim of study, material and methods, results and conclusions) and a list of key words.

5. Tables must be presented in an original typed or computer-printed form, instead of a photocopied version. **Numbers, totals, percentile data on the tables must coincide with those in the texts of the articles.** Tables and graphs must be headed.

6. Photographs are required to be contrasted and must be submitted with doubles. Please number each photograph with a pencil on its back, indicate author's name, title of the article (short version), and mark out its top and bottom parts. Drawings must be accurate, drafts and diagrams drawn in Indian ink (or black ink). Photocopies of the X-ray photographs must be presented in a positive image in **tiff format**.

Accurately numbered subtitles for each illustration must be listed on a separate sheet of paper. In the subtitles for the microphotographs please indicate the ocular and objective lens magnification power, method of coloring or impregnation of the microscopic sections (preparations).

7. Please indicate last names, first and middle initials of the native authors, present names and initials of the foreign authors in the transcription of the original language, enclose in parenthesis corresponding number under which the author is listed in the reference materials.

8. Please follow guidance offered to authors by The International Committee of Medical Journal Editors guidance in its Uniform Requirements for Manuscripts Submitted to Biomedical Journals publication available online at: http://www.nlm.nih.gov/bsd/uniform_requirements.html
http://www.icmje.org/urm_full.pdf
In GMN style for each work cited in the text, a bibliographic reference is given, and this is located at the end of the article under the title "References". All references cited in the text must be listed. The list of references should be arranged alphabetically and then numbered. References are numbered in the text [numbers in square brackets] and in the reference list and numbers are repeated throughout the text as needed. The bibliographic description is given in the language of publication (citations in Georgian script are followed by Cyrillic and Latin).

9. To obtain the rights of publication articles must be accompanied by a visa from the project instructor or the establishment, where the work has been performed, and a reference letter, both written or typed on a special signed form, certified by a stamp or a seal.

10. Articles must be signed by all of the authors at the end, and they must be provided with a list of full names, office and home phone numbers and addresses or other non-office locations where the authors could be reached. The number of the authors (co-authors) must not exceed the limit of 5 people.

11. Editorial Staff reserves the rights to cut down in size and correct the articles. Proof-sheets are not sent out to the authors. The entire editorial and collation work is performed according to the author's original text.

12. Sending in the works that have already been assigned to the press by other Editorial Staffs or have been printed by other publishers is not permissible.

Articles that Fail to Meet the Aforementioned Requirements are not Assigned to be Reviewed.

ავტორთა საყურადღებოდ!

რედაქციაში სტატიის წარმოდგენისას საჭიროა დავიცვათ შემდეგი წესები:

1. სტატია უნდა წარმოადგინოთ 2 ცალად, რუსულ ან ინგლისურ ენებზე,დაბეჭდილი სტანდარტული ფურცლის 1 გვერდზე, 3 სმ სიგანის მარცხენა ველისა და სტრიქონებს შორის 1,5 ინტერვალის დაცვით. გამოყენებული კომპიუტერული შრიფტი რუსულ და ინგლისურენოვან ტექსტებში - **Times New Roman (Кириллица)**, ხოლო ქართულენოვან ტექსტში საჭიროა გამოვიყენოთ **AcadNusx.** შრიფტის ზომა – 12. სტატიას თან უნდა ახლდეს CD სტატიით.

2. სტატიის მოცულობა არ უნდა შეადგენდეს 10 გვერდზე ნაკლებს და 20 გვერდზე მეტს ლიტერატურის სიის და რეზიუმეების (ინგლისურ, რუსულ და ქართულ ენებზე) ჩათვლით.

3. სტატიაში საჭიროა გაშუქდეს: საკითხის აქტუალობა; კვლევის მიზანი; საკვლევი მასალა და გამოყენებული მეთოდები; მიღებული შედეგები და მათი განსჯა. ექსპერიმენტული ხასიათის სტატიების წარმოდგენისას ავტორებმა უნდა მიუთითონ საექსპერიმენტო ცხოველების სახეობა და რაოდენობა; გაუტკივარებისა და დაძინების მეთოდები (მწვავე ცდების პირობებში).

4. სტატიას თან უნდა ახლდეს რეზიუმე ინგლისურ, რუსულ და ქართულ ენებზე არანაკლებ ნახევარი გვერდის მოცულობისა (სათაურის, ავტორების, დაწესებულების მითითებით და უნდა შეიცავდეს შემდეგ განყოფილებებს: მიზანი, მასალა და მეთოდები, შედეგები და დასკვნები; ტექსტუალური ნაწილი არ უნდა იყოს 15 სტრიქონზე ნაკლები) და საკვანძო სიტყვების ჩამონათვალი (key words).

5. ცხრილები საჭიროა წარმოადგინოთ ნაბეჭდი სახით. ყველა ციფრული, შემაჯამებელი და პროცენტული მონაცემები უნდა შეესაბამებოდეს ტექსტში მოყვანილს.

6. ფოტოსურათები უნდა იყოს კონტრასტული; სურათები, ნახაზები, დიაგრამები - დასათაურებული, დანომრილი და სათანადო ადგილას ჩასმული. რენტგენოგრამების ფოტოასლები წარმოადგინეთ პოზიტიური გამოსახულებით **tiff** ფორმატში. მიკროფოტოსურათების წარწერებში საჭიროა მიუთითოთ ოკულარის ან ობიექტივის საშუალებით გადიდების ხარისხი, ანათალების შეღებვის ან იმპრეგნაციის მეთოდი და აღნიშნოთ სურათის ზედა და ქვედა ნაწილები.

7. სამამულო ავტორების გვარები სტატიაში აღინიშნება ინიციალების თანდართვით, უცხოურისა – უცხოური ტრანსკრიპციით.

8. სტატიას თან უნდა ახლდეს ავტორის მიერ გამოყენებული სამამულო და უცხოური შრომების ბიბლიოგრაფიული სია (ბოლო 5-8 წლის სიღრმით). ანბანური წყობით წარმოდგენილ ბიბლიოგრაფიულ სიაში მიუთითეთ ჯერ სამამულო, შემდეგ უცხოელი ავტორები (გვარი, ინიციალები, სტატიის სათაური, ჟურნალის დასახელება, გამოცემის ადგილი, წელი, ჟურნალის №, პირველი და ბოლო გვერდები). მონოგრაფიის შემთხვევაში მიუთითეთ გამოცემის წელი, ადგილი და გვერდების საერთო რაოდენობა. ტექსტში კვადრატულ ფჩხილებში უნდა მიუთითოთ ავტორის შესაბამისი N ლიტერატურის სიის მიხედვით. მიზანშეწონილია, რომ ციტირებული წყაროების უმეტესი ნაწილი იყოს 5-6 წლის სიღრმის.

9. სტატიას თან უნდა ახლდეს: ა) დაწესებულების ან სამეცნიერო ხელმძღვანელის წარდგინება, დამოწმებული ხელმოწერითა და ბეჭდით; ბ) დარგის სპეციალისტის დამოწმებული რეცენზია, რომელშიც მითითებული იქნება საკითხის აქტუალობა, მასალის საკმაობა, მეთოდის სანდოობა, შედეგების სამეცნიერო-პრაქტიკული მნიშვნელობა.

10. სტატიის ბოლოს საჭიროა ყველა ავტორის ხელმოწერა, რომელთა რაოდენობა არ უნდა აღემატებოდეს 5-ს.

11. რედაქცია იტოვებს უფლებას შეასწოროს სტატია. ტექსტზე მუშაობა და შეჯერება ხდება საავტორო ორიგინალის მიხედვით.

12. დაუშვებელია რედაქციაში ისეთი სტატიის წარდგენა, რომელიც დასაბეჭდად წარდგენილი იყო სხვა რედაქციაში ან გამოქვეყნებული იყო სხვა გამოცემებში.

აღნიშნული წესების დარღვევის შემთხვევაში სტატიები არ განიხილება.

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Содержание:

RELATIONSHIP BETWEEN LIPID PROFILES AND RISK OF HYPERGLYCEMIA IN HYPERTENSIVE AND OBESITY PATIENTS: A MULTIVARIATE ANALYSIS

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Abstract.

Objective: To investigate the correlation between hyperglycemia and lipid indicators under different Body Mass Index (BMI) and hypertension prevalence.

Method: 1585 subjects (367 hyperglycemic patients and 1218 controls) were selected from the First Affiliated Hospital of Wannan Medical College. Lipid indicators included total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), remnant cholesterol (RC), low-density lipoprotein/ high-density lipoprotein cholesterol ratio (LHR) and triglycerides/high-density lipoprotein cholesterol ratio (THR). Multivariate logistic regression analysis was used.

Results: TG, TC, RC, LHR, and THR were higher in the hyperglycemia group ($p<0.05$), while HDL-C was lower ($p<0.05$). FBG correlated positively with TC, TG, RC, and THR ($p<0.05$). Logistic regression showed TG (OR=1.163, p=0.001), RC (OR=1.295, p=0.030), and THR (OR=1.172, p=0.001) as hyperglycemia risk factors. In normotensive patients, TC and LDL-C increased hyperglycemia risk, while in hypertensive patients, TG, THR, and RC did ($p<0.05$). When BMI≥24, TG (OR=1.190, p=0.001), THR (OR=1.193, p=0.001), and RC (OR=1.364, p=0.035) increased hyperglycemia risk, but HDL-C (OR=0.412, p=0.008) was protective.

Conclusion: TG, RC, and THR are significantly related to hyperglycemia in hypertensive, overweight, and obese patients. Lipid indicators associated with hyperglycemia risk differ by blood pressure level, providing a basis for evaluating and treating these conditions.

Key words. Lipid indicators, hyperglycemia, hypertension, obesity, multivariate analysis.

Introduction.

Diabetes is a metabolic disease characterized by long-term hyperglycemia due to impairment of insulin secretion or utilization, leading to functional decline and failure of multiple tissue and organ systems. With the change of social nutrition structure and lifestyle, people's blood sugar level has gradually changed. The prevalence of type 2 diabetes has been increasing globally over the past 40 years [1,2]. China is no exception. As of 2017, the prevalence of diabetes among people aged 18 and above in China has reached 11.2%, with a high proportion of undiagnosed diabetes [3]. Prediabetes is characterized by impaired glucose tolerance, impaired blood sugar regulation, and higher than normal blood sugar levels, but does not reach the level for a diagnosis of diabetes [4]. It is a transitional stage in the development of diabetes and is reversible. Prediabetes is associated with increased diabetes, cardiovascular events, and mortality [5]. The prevalence of prediabetes in China is as high as 35.2% [6]. Therefore, hyperglycemia, as a common feature of prediabetes and diabetes, plays an important role in the occurrence and development of the disease.

Overweight and obesity is one of the main factors affecting the formation of diabetes [7]. Among the patients with diabetes from 1980 to 2020, more than 36% of the incidence of diabetes is related to obesity, and the risk of diabetes in overweight or obese people is 2 to 6 times that of the normal population [8]. Obesity is closely related to blood lipids, and effective control of blood lipids is a powerful measure for the prevention and control of cardiovascular diseases [9]. In addition, during the occurrence and development of diabetes, the abnormal occurrence time of lipid metabolism is earlier than the occurrence time of hyperglycemia, which can induce the disorder of glucose metabolism in patients [10]. Lipid indicators are divided into individual lipid indicators and lipid ratios. Individual lipid indicators include total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C) low-density lipoprotein cholesterol (LDL-C), remnant cholesterol (RC), etc. The lipid ratio includes low-density lipoprotein/high-density lipoprotein cholesterol ratio (LHR), triglycerides/high-density lipoprotein cholesterol ratio (THR), etc. Blood lipid is an important indicator in the occurrence and development of diabetes [11]. Among them, elevated levels of TC and LDL-C have been recognized as the main risk factors for CVD [12], and RC was listed as a newly discovered risk factor of atherosclerosis by the American Heart Association in 2001 [13].

The risk of obesity-related cardiovascular disease varied between blood pressure levels. People with a history of hypertension have a higher risk of cardiovascular disease than those without a history of hypertension [14,15]. Therefore, this study analyzed the relationship between lipid indexes and high blood glucose levels by stratification according to the presence or absence of hypertension. Other studies have shown that obesity and dyslipidemia are risk factors for cardiovascular disease, and the two have a positive additive interaction in the occurrence and development of the disease [16]. In the process of mutual influence between lipid indicators and Body Mass Index (BMI), some lipid indicators change before BMI [17]. This indicates that maintaining lipid indicators within the reference range is relatively more important than maintaining a normal BMI. Therefore, in the context of obesity, simply focusing on BMI is not enough, and lipid indicators are more worthy of attention.

This study analyzed the relationship between lipid indexes and high blood sugar level under different conditions, and provided scientific basis for clinical diagnosis, treatment and prevention of diabetes in the course of occurrence and development.

Materials and Methods.

Study participants: A total of 1585 subjects were included in this study, including 906 males with a median age of 47.5 years and 579 females with a median age of 46.8 years. According to the Standards of Medical Care in Diabetes 2020 issued by the ADA [18]. The inclusion criteria for hyperglycemia were fasting blood glucose (FBG) ≥ 5.6 mmol/L, oral hypoglycemic drugs, or diagnosed T2DM. The inclusion criteria of the controls were fasting blood glucose < 5.6 mmol/L, no oral hypoglycemic drugs, and no history of T2DM. The inclusion criteria of hypertensive were according to the Chinese Guidelines for the prevention and treatment of Hypertension (2018 revision) [19], systolic blood pressure ≥ 140 and/or diastolic blood pressure ≥ 90mmhg, or a history of hypertension. The inclusion criteria for the controls were an average systolic blood pressure < 140 mmHg and diastolic blood pressure < 90 mmHg three times, no history of hypertension, and no cardiovascular or cerebrovascular disease. The exclusion criteria were as follows: (1) history of cardiovascular and cerebrovascular diseases, history of infectious diseases, and history of malignant tumors; (2) Have lost weight or taken diet pills within the last 6 months; (3) Data loss. This study was approved by the institutional Ethics Committee (Ethics number:2022099), and all subjects gave informed consent.

Clinical data collection:

All participants were investigated by questionnaire, physical examination, and laboratory test. Smoking history (≥ 1 cigarette per day in the previous 6 months) and drinking history (≥ 30 g of alcohol consumed per week in the previous 6 months) of the individuals were obtained by questionnaire. Body mass index (BMI), systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured by trained and qualified medical personnel. The classification criteria of BMI are: underweight (BMI<18.5 kg/m^2), normal weight (BMI: 18.5-23.9 kg/m^2), overweight and obesity (BMI≥24.0 kg/m^2) [20].

Lipid parameters Measurements:

Venous blood was drawn in the morning on an empty stomach, and the laboratory used 7060 (Hitachi, Japan) automatic biochemistry instrument to measure blood biochemical indexes, including FBG, TG, and HDL-C, LDL-C, TC. RC levels are calculated by subtracting HDL-C and LDL-C from TC [21]. LHR is calculated by dividing LDL-C by HDL-C. THR is calculated by dividing TG by HDL-C.

Statistical analysis.

For baseline information, measurement data that followed a normal distribution were expressed as the mean ± standard deviation (SD), and intergroup comparisons were performed using an independent sample t test. Measurement data that did not conform to the normal distribution were expressed as the median (P_{25}, P_{75}), and the Mann Whitney U test was used for intergroup comparison. Classification data was described using composition ratio, and the $\chi 2$ test was used to compare the differences between cases and controls. The Spearman correlation coefficient was used to assess the correlation between lipid parameters and hyperglycemia. The odds ratio (OR) and 95% confidence interval (CI) from binary logistic regression analyses were calculated to test the association between different stratification levels and the risk of hyperglycemia.

All data analyses were conducted using the SPSS 26.0 software, and the results showed a statistically significant difference of $p < 0.05$ on both sides.

Results.

Demographic and clinical characteristics of the subjects:

A total of 367 hyperglycemia patients (271 males and 96 females, respectively) and 1218 controls (735 males and 483 females, respectively) were included in the study. As shown in Table 1, Uric acid (UA) and LDL-C levels were similar in the hyperglycemia group and the control group, and the difference was not statistically significant (p>0.05). The percentage of males, the smoking rate, the drinking rate and the prevalence of hypertension in the hyperglycemia group were 73.8%, 36.0%, 27.8% and 85.0%, respectively, which were higher than those of the controls (60.3%, 25.9%, 20.2% and 59.9%), and the difference was statistically significant (p<0.05). Age, BMI, SBP, DBP, FBG, UA, TG, TC, RC LHR and THR levels were significantly higher in the hyperglycemia group than in the control group. HDL-C levels were significantly lower in the hyperglycemia group than in the control group(p<0.05).

Analysis of lipid parameters in hyperglycemia and control groups stratified by hypertensive status:

As shown in Table 2, TC, TG, LDL-C, RC, LHR, and THR parameters in the normotensive hyperglycemia group were higher than those in the control group, while TG, RC, and THR parameters in the hypertensive hyperglycemia group were higher than those in the control group (all $p < 0.05$).

Analysis of lipid parameters in hyperglycemia and control groups stratified by BMI:

As shown in Table 3, TC, TG, RC, and THR parameters were higher in the 18.5≤BMI<24 and BMI≥24 hyperglycemia groups than in the control groups, but LDL-C of the control group was higher than that of the hyperglycemia group when BMI<18.5 (all p<0.05).

Correlation of TC, TG, HDL-C, LDL-C, RC, and LHR with FBG: Spearman's correlation analysis showed a positive correlation between FBG and TC, TG, RC, THR(p<0.05); meanwhile, TC, TG, LDL-C, RC, LHR, THR in normotensive group and TG, RC, THR in hypertensive group were positively associated with FBG (p<0.05, Table 4).

Multifactorial regression analysis of hyperglycemia and lipid parameters by hypertensive status:

Univariate logistic regression analysis showed that TC (*OR*=1.223, 95%*CI*=1.090-1.373, p=0.001), TG (*OR*=1.290, 95%*CI*=1.187-1.403, p<0.001), RC (*OR*=1.926, 95%*CI*=1.546-2.399, p<0.001), LHR (*OR*=1.372, 95%*CI*=1.121-1.679, p=0.002), and THR (*OR*=1.287, 95%*CI*=1.177-1.407, p<0.001) were risk factors for hyperglycemia, while HDL-C (*OR*=0.570, 95%*CI*=0.395-0.823, p=0.003) was protective factor. After

Table 1. *Demographic and clinical characteristics of the subjects.*

Characteristic	Control(n=1218)	Hyperglycemia(n=367)	t/Z/χ^2	p
Age, years	45.40(39.00,52.00)	53.30(44.00,59.00)	11.982	<0.001
BMI, kg/m^2	23.82±3.12	25.10±3.00	6.976	<0.001
Gender, n (%)				
Males	735(60.30)	271(73.80)	22.159	<0.001
Females	483(39.70)	96(26.20)		
Smoking, n (%)				
Yes	316(25.90)	132(36.00)	13.974	<0.001
No	902(70.50)	235(64.00)		
Drinking, n (%)				
Yes	246(20.20)	102(27.80)	9.496	0.002
No	972(79.80)	265(72.20)		
Hypertension, n (%)				
Yes	730(59.90)	312(85.00)	78.760	<0.001
No	488(40.10)	55(15.00)		
SBP, mmHg	131.42(118.00,142.25)	142.86(130.00,155.00)	9.906	<0.001
DBP, mmHg	83.64(75.00,90.25)	88.52(81.00,96.00)	7.216	<0.001
FBG, mmol/L	4.90(4.66,5.17)	6.78(5.79,7.14)	28.602	<0.001
UA, μmol/L	68.99 (56.58,79.83)	70.29(59.50,78.80)	0.746	0.456
TC, mmol/L	4.84(4.17,5.39)	5.05(4.32,5.68)	3.439	0.001
TG, mmol/L	1.15(0.82,1.85)	2.06(1.11,2.42)	6.765	<0.001
HDL-C, mmol/L	1.55(1.32,1.76)	1.49(1.26,1.68)	3.193	<0.001
LDL-C, mmol/L	2.71(2.22,3.14)	2.79(2.26,3.28)	1.506	0.132
RC, mmol/L	0.58(0.30,0.71)	0.76(0.41,0.91)	6.606	<0.001
LHR, mmol/L	1.82±0.57	1.92±0.60	3.090	0.002
THR, mmol/L	1.10(0.49,1.29)	1.58(0.68,1.79)	6.478	<0.001

BMI: Body Mass Index; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; FBG: Fasting Blood Glucose; TC: Total Cholesterol; TG: Triglycerides; HDL-C: High-Density Lipoprotein Cholesterol; LDL-C: Low-Density Lipoprotein Cholesterol; RC: Remnant Cholesterol; LHR: LDL / HDL Cholesterol Ratio; THR: TG / HDL Cholesterol Ratio.

Table 2. *Analysis of lipid parameters in hyperglycemia and control groups stratified by hypertensive status.*

Characteristic	Normotensive				Hypertensive			
	Control (n=488)	Hyperglycemia (n=55)	t/Z	p	Control (n=730)	Hyperglycemia (n=312)	t/Z	p
TC, mmol/L	4.77±0.95	5.29±1.15	3.791	<0.001	4.89(4.24,5.44)	5.00(4.27,5.66)	1.704	0.088
TG, mmol/L	1.22(0.72,1.48)	1.76(0.91,1.83)	3.577	<0.001	1.74(0.96,2.11)	2.12(1.12,2.47)	3.376	0.001
HDL-C, mmol/L	1.63±0.35	1.58±0.35	1.058	0.290	1.50(1.28,1.71)	1.48(1.26,1.64)	1.419	0.156
LDL-C, mmol/L	2.64±0.69	3.10±0.92	3.540	0.001	2.76(2.28,3.19)	2.74(2.21,3.21)	0.635	0.525
RC, mmol/L	0.49(0.25,0.63)	0.61(0.32,0.80)	2.206	0.027	0.63(0.34,0.76)	0.79(0.43,0.93)	4.644	<0.001
LHR, mmol/L	1.70±0.57	2.02±0.59	3.989	<0.001	1.90±0.55	1.91±0.60	0.216	0.829
THR, mmol/L	0.82(0.41,0.97)	1.36(0.60,1.30)	3.241	0.001	1.29(0.59,1.53)	1.62(0.70,1.85)	3.148	0.002

Table 3. *Analysis of lipid parameters in hyperglycemia and control groups stratified by BMI.*

Characteristic	BMI<18.5				18.5≤BMI<24				BMI≥24			
	Control (n=27)	Hyperglycemia (n=3)	t/Z	p	Control (n=630)	Hyperglycemia (n=126)	t/Z	p	Control (n=561)	Hyperglycemia (n=238)	t/Z	p
TC, mmol/L	4.72(3.92,5.24)	3.99(3.85,4.24)	1.279	0.201	4.81(4.12,5.39)	5.12(4.38,5.67)	2.901	0.004	4.88(4.28,5.42)	5.02(4.268,5.72)	1.989	0.047
TG, mmol/L	0.96(0.74,1.18	1.97(0.63,2.01)	2.837	0.863	1.29(0.72,1.52)	1.60(0.91,1.77)	3.837	<0.001	1.84(1.04,2.21)	2.31(1.23,2.71)	3.542	<0.001
HDL-C, mmol/L	1.85(1.65,2.06)	1.78(1.63,2.01)	0.257	0.782	1.65(1.40,1.84)	1.67(1.42,1.87)	0.257	0.797	1.44(1.23,1.60)	1.40(1.22,1.54)	1.362	0.173
LDL-C, mmol/L	2.40(1.80,2.97)	1.58(1.27,1.79)	1.552	0.035	2.64±0.71	2.77±0.87	1.552	0.123	2.81±0.66	2.82±0.83	0.200	0.842
RC, mmol/L	0.48(0.27,0.64)	0.62(0.36,0.97)	4.285	0.489	0.52(0.26,0.64)	0.69(0.36,0.83)	4.285	<0.001	0.64(0.34,0.77)	0.80(0.42,1.00)	4.022	<0.001
LHR, mmol/L	1.32(1.09,1.58)	0.89(0.78,1.05)	0.895	0.057	1.67±0.54	1.72±0.57	0.895	0.371	2.01±0.54	2.05±0.58	0.89	0.374
THR, mmol/L	0.55(0.40,0.60)	1.18(0.31,2.69)	0.380	0.704	0.86(0.41,1.00)	1.08(0.54,1.12)	2.972	0.003	1.40(0.68,1.68)	1.85(0.82,2.05)	3.455	0.001

Table 4. *Correlation of TC, TG, HDL-C, LDL-C, RC and LHR with FBG.*

Characteristic	All subjects [a]		Normotensive [b]		Hypertensive [b]	
	r	p	r	p	r	p
TC, mmol/L	0.056	0.025	0.132	0.002	0.044	0.153
TG, mmol/L	0.143	<0.001	0.136	0.002	0.146	<0.001
HDL-C, mmol/L	-0.023	0.364	0.007	0.877	-0.030	0.327
LDL-C, mmol/L	0.007	0.794	0.121	0.005	-0.018	0.553
RC, mmol/L	0.116	<0.001	0.096	0.026	0.123	<0.001
LHR, mmol/L	0.011	0.651	0.088	0.040	-0.004	0.903
THR, mmol/L	0.135	<0.001	0.103	0.017	0.143	<0.001

[a] Controlled for age, BMI, gender, smoking, drinking and hypertension.
[b] Controlled for age, BMI, gender, smoking, and drinking.

Table 5. *Multifactorial regression analysis of hyperglycemia and lipid parameters by hypertensive status.*

Characteristic	Crude *OR* (95%*CI)*	p	Adjusted *OR* (95%*CI)*	p
All subjects [a]				
TC, mmol/L	1.223 (1.090,1.373)	0.001	1.083 (0.953,1.230)	0.222
TG, mmol/L	1.290 (1.187,1.403)	<0.001	1.163 (1.067,1.269)	0.001
HDL-C, mmol/L	0.570 (0.395,0.823)	0.003	0.700 (0.440,1.113)	0.132
LDL-C, mmol/L	1.156 (0.987,1.353)	0.072	1.059 (0.894,1.255)	0.508
RC, mmol/L	1.926 (1.546,2.399)	<0.001	1.295 (1.025,1.637)	0.030
LHR, mmol/L	1.372 (1.121,1.679)	0.002	1.169 (0.923,1.481)	0.195
THR, mmol/L	1.287(1.177,1.407)	<0.001	1.172 (1.069,1.285)	0.001
Normotensive [b]				
TC, mmol/L	1.632 (1.256,2.121)	<0.001	1.416 (1.063,1.886)	0.017
TG, mmol/L	1.506 (1.165,1.946)	0.002	1.265 (0.954,1.676)	0.102
HDL-C, mmol/L	0.642 (0.282,1.459)	0.290	1.391 (0.519,3.733)	0.512
LDL-C, mmol/L	2.201 (1.527,3.172)	<0.001	1.742 (1.187,2.557)	0.005
RC, mmol/L	1.880 (1.044,3.388)	0.036	1.034 (0.510,2.098)	0.926
LHR, mmol/L	2.524 (1.575,4.047)	<0.001	1.639 (0.934,2.874)	0.085
THR, mmol/L	1.486 (1.086,2.033)	0.013	1.217 (0.898,1.650)	0.206
Hypertensive [b]				
TC, mmol/L	1.115 (0.977,1.273)	0.107	1.020 (0.885,1.176)	0.783
TG, mmol/L	1.173 (1.075,1.279)	<0.001	1.147 (1.047,1.257)	0.003
HDL-C, mmol/L	0.789 (0.513,1.213)	0.280	0.616 (0.363,1.046)	0.073
LDL-C, mmol/L	0.961 (0.802,1.151)	0.665	0.940 (0.778,1.137)	0.526
RC, mmol/L	1.654 (1.298,2.106)	<0.001	1.331 (1.037,1.708)	0.025
LHR, mmol/L	1.026 (0.812,1.296)	0.812	1.065 (0.819,1.386)	0.638
THR, mmol/L	1.173 (1.070,1.286)	0.001	1.163 (1.054,1.283)	0.003

[a] Adjusted for age, BMI, gender, smoking, drinking and hypertension.
[b] Adjusted for age, BMI, smoking and drinking.

adjusting for covariates, the difference of TG (*OR*=1.163, 95%*CI*=1.067-1.269, *p*=0.001), RC (*OR*=1.295, 95%*CI*=1.025-1.637, *p*=0.030) and THR (*OR*=1.172, 95%*CI*=1.069-1.285, *p*=0.001) were still statistically significant. The TC (*OR*=1.632, *p*<0.001), LDL-C (*OR*=2.201, *p*<0.001) in the normotensive group and the TG (*OR*=1.173, *p*<0.001), AC (*OR*=1.654, *p*<0.001), THR (*OR*=1.173, *p*=0.001) in the hypertensive group were associated with an increased risk of hyperglycemia, and the differences remained significant after adjustment (*p*>0.05). In addition, TG (*OR*=1.506, *p*=0.002), LHR (*OR*=2.524, *p*<0.001) and THR (*OR*=1.486, *p*=0.013) in the normotensive group also showed an increased risk of hyperglycemia, but the differences disappeared after adjusted for covariates (*p*>0.05). It is worth mentioning that RC was associated with an increased risk of hyperglycemia in both hypertensive (*OR*=1.654, *p*<0.001) and normotensive (*OR*=1.880, *p*=0.036) groups, but only the difference in hypertensive groups remained significant after adjustment (*OR*=1.331, *p*=0.025).

Multifactorial regression analysis of hyperglycemia and lipid parameters at different BMIs:

18.5≤BMI<24 group TC (*OR*=1.330, *p*=0.002), TG (*OR*=1.224, *p*=0.009), RC (*OR*=1.860, *p*=0.001), THR (*OR*=1.223, *p*=0.022) were associated with increased risk of hyperglycemia, but the differences disappeared after adjusted for covariates, while BMI≥24, the results showed that TG and RC were associated with increased risk of hyperglycemia (TG *OR*=1.219, *p*<0.001; RC *OR*=1.717, *p*<0.001; THR *OR*=1.207, *p*<0.001) and the

Table 6. *Multifactorial regression analysis of hyperglycemia and lipid parameters at different BMIs.*

Characteristic	Crude *OR* (95%*CI)*	p	Adjusted *OR* (95%*CI)*	p
BMI<18.5*				
TC, mmol/L	1.223(1.090,1.373)	0.270	0.218(0.011,4.472)	0.323
TG, mmol/L	3.095(0.800,11.976)	0.102	0.022(0.000,118.485)	0.385
HDL-C, mmol/L	0.592(0.018,19.572)	0.769	1.130(0.011,117.816)	0.959
LDL-C, mmol/L	0.081(0.004,1.730)	0.108	0.015(0.000,6.137)	0.170
RC, mmol/L	4.775(0.112,204.266)	0.415	0.0.269(0.000,496.981)	0.732
LHR, mmol/L	0.018(0.000,2.600)	0.113	0.001(0.000,25.014)	0.172
THR, mmol/L	5.039(0.755, 33.608)	0.095	0.001(0.000,24873.192)	0.431
18.5≤BMI<24*				
TC, mmol/L	1.330 (1.108,1.596)	0.002	1.151 (0.938,1.413)	0.179
TG, mmol/L	1.224 (1.053,1.422)	0.009	1.113 (0.947,1.308)	0.193
HDL-C, mmol/L	1.164 (0.666,2.036)	0.593	1.102 (0.567,2.140)	0.774
LDL-C, mmol/L	1.253 (0.975,1.612)	0.078	1.156 (0.885,1.509)	0.288
RC, mmol/L	1.860 (1.289,2.685)	0.001	1.214 (0.805,1.830)	0.356
LHR, mmol/L	1.173 (0.827,1.663)	0.371	1.108 (0.759,1.616)	0.596
THR, mmol/L	1.223(1.029, 1.454)	0.022	1.135 (0.941,1.370)	0.186
BMI≥24*				
TC, mmol/L	1.157 (0.991,1.351)	0.065	1.076 (0.913,1.269)	0.381
TG, mmol/L	1.219 (1.102,1.347)	<0.001	1.190 (1.072,1.322)	0.001
HDL-C, mmol/L	0.627 (0.362,1.088)	0.097	0.412 (0.214,0.794)	0.008
LDL-C, mmol/L	1.024 (0.828,1.266)	0.827	1.058 (0.849,1.319)	0.617
RC, mmol/L	1.717 (1.302,2.265)	<0.001	1.364 (1.023,1.818)	0.035
LHR, mmol/L	1.132 (0.861,1.489)	0.373	1.321 (0.978,1.786)	0.070
THR, mmol/L	1.207(1.089, 1.338)	<0.001	1.193 (1.071,1.329)	0.001
*Adjusted for age, smoking, drinking and hypertension.				

differences were still statistically significant after adjustment (TG *OR*=1.190, *p*=0.001; RC *OR*=1.364, *p*=0.035; THR *OR*=1.193, *p*=0.001). It is worth noting that HDL-C, after adjusting for covariates, suggests a protective effect in reducing the risk of hyperglycemia (*OR*=0.412, *p*=0.008) (Table 6).

Discussion.

Cardiovascular and cerebrovascular diseases are an important cause of death in elderly patients in China. According to statistics, more than 300 million people suffer from cardiovascular and cerebrovascular diseases, and abnormal blood lipids are an important risk factor for diabetes and various cardiovascular and cerebrovascular diseases [22,23]. Abnormal blood lipids are a common factor affecting blood sugar control [24]. Research shows that people with prediabetes and newly diagnosed diabetes are more likely to have dyslipidemia than normal people [25].

In this study, the TC, TG, RC, LHR, and THR of the hyperglycemic group were significantly higher than those of the control group, and lipid indicators showed a significant correlation with the risk of elevated blood sugar. Abnormal blood lipids are a susceptible factor to hyperglycemia. In individuals with dyslipidemia, peripheral target organs are less sensitive to insulin due to dyslipidemia, leading to insulin resistance [26]. Insulin resistance can promote the induction of upregulation of ApoC3 and ANGPTL8, thereby inhibiting the activity of lipoprotein esterase and slowing down TG metabolism [27]. Insulin resistance is an important mechanism in prediabetes and pathophysiological process of diabetes [28].

THR and RC can increase the risk of hyperglycemia through multiple pathways. When THR increases, high triglycerides prompt adipose tissue to release free fatty acids [29] interfere with insulin signals and trigger inflammation [30]. At the same time, it leads to an increase in liver gluconeogenesis [31], lipid accumulation [32], and also affects glucose uptake in skeletal muscle [33]. Low HDL-C levels weaken anti-inflammatory and vascular protective functions and aggravate insulin resistance [34]. RC accumulates in pancreatic β cells, triggering oxidative stress and inflammation and damaging insulin secretion [35]. In peripheral tissues, it promotes the release of insulin resistance-related factors and interferes with metabolic signals [36]. In addition, it can cause endothelial dysfunction, reduce tissue blood supply, and ultimately lead to an increased risk of insulin resistance and hyperglycemia [37].

TC, TG, RC, and THR are all positively correlated with FBG, which is consistent with Wang's research [38]. Among them, TG has the strongest correlation, followed by THR and RC, Ketut Suastika's study also pointed out this point [39]. The level of TG can effectively affect the regulation of blood sugar, thereby altering insulin sensitivity [40]. Another study has pointed out that the increase in the ratio of THR can be used as one of the surrogate indicators of insulin resistance, which is positively correlated with the incidence of prediabetes [41]. RC regulates blood sugar through insulin resistance and mediating pro-inflammatory symptom states [36]. A national longitudinal retrospective study of adults in South Korea showed that RC was an independent predictor of type 2 diabetes [42].

After adjusting for age, BMI, smoking, and alcohol consumption, the correlation between TG, THR, RC and increased risk of hyperglycemia in hypertensive patients was stronger than in normotensive patients. To some extent, it may be related to the changes in blood lipid indicators after the onset of hypertension. Excessive levels of blood lipids promote the release of free radicals and increase oxidative stress damage to blood vessel walls [43]. One of the reasons for the increased risk of hypertension is the increased fragility and weakened elasticity of blood vessels [44]. The results of this study indicate that TG, THR, RC and TC, LDL-C are risk factors for elevated blood glucose levels in hypertensive and normotensive patients, respectively. This further confirms the conclusion that changes in blood pressure are important factors affecting blood glucose regulation [45]. It is worth noting that this study found that TC and LDL-C in the normal population were associated with an increased risk of hyperglycemia, while TG, THR and RC in patients with hypertension were associated with an increased risk of hyperglycemia, suggesting that in clinical work, medical staff can pay targeted attention to the lipid indexes of people with different blood pressure levels. Therefore, evaluating these potential biomarkers in routine clinical examinations may be helpful for timely intervention in hypertension.

When BMI ≥ 24, TG, THR, and RC are risk factors for elevated blood sugar, while HDL-C is a protective factor for elevated blood sugar. This is consistent with the conclusion that the decrease in HDL-C levels and the increase in TG rich lipoprotein levels are clinical manifestations of obesity and dyslipidemia [46]. The reason may be an increase in the secretion of TG rich lipoproteins, insulin resistance caused by obesity, and pro-inflammatory status leading to more free fatty acids being transported to the liver, promoting the secretion of TG rich LDL-C and HDL-C by the liver. As both are easily hydrolyzed by lipase, HDL-C is metabolized by the kidneys due to particle size reduction. Manifested as an increase in fasting TG levels and a decrease in HDL-C levels [47-49]. Insulin resistance promote the progression of obesity and is also the pathological core of obesity [50]. This shows that those hypertensive patients with body mass index≥24 need to pay more attention to the changes of lipid indicators, reduce hyperglycemia, and then develop the risk of diabetes.

To the best of our knowledge, this study is the first to categorize the relationship between different lipid markers, especially residual cholesterol, and high blood glucose levels in the Chinese population according to different BMI levels and hypertension. However, there are some limitations to this study. Because BMI, blood pressure, and lipids were assessed only once in clinical testing, we were unable to assess the effect of changes in BMI, blood pressure, and lipids before and after testing on the risk of hyperglycemia. In addition, there was a significant age difference between the hyperglycemic group and the group with normal blood sugar, so a potential confounding bias due to age could be present even after adjusting for age. BMI bias is also possible because individuals with abnormal body markers detected may be able to control their weight during the test period. In addition, all participants in our study were from Anhui Province, so the results are not representative of the overall situation in the country. And there may be uncontrolled confounding effects caused by unmeasured confounding factors.

Conclusion.

In conclusion, lipid indicators are important indicators that need close attention when assessing the condition and treatment effect of hypertension, overweight and obesity, prediabetes and diabetes patients. TG, RC and THR are significantly related to the level of hyperglycemia in patients with hypertension, overweight and obesity. Maintaining these indicators within the normal range will not only help reduce the risk of cardiovascular disease in patients with hypertension, overweight and obesity, but also effectively prevent the occurrence and development of diabetes. The correlation between TC, LDL-C, and hyperglycemia varies depending on whether they have hypertension, indicating that in the daily physical examination of non hypertensive patients, it is important to pay special attention to whether these two indicators have abnormal values, and then take corresponding primary prevention measures. People with abnormal TG, THR, and RC indicators in overweight and obese patients are more likely to experience hyperglycemia, indicating that it is crucial to pay attention to and improve TG, THR, and RC indicators for overweight and obese patients.

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Author contributions.

ZJ and JYL designed the study. SLX, WY, CX, and ZPP contributed to literature searching, data collection and analysis. ZJ and JYL assessed study quality. SLX and WY wrote the manuscript. YHQ and XMC revised the manuscript. All authors read and approved the final manuscript.

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