GEORGIAN MEDICAL NEWS

ISSN 1512-0112

NO 6 (375) Июнь 2026

ТБИЛИСИ - NEW YORK

ЕЖЕМЕСЯЧНЫЙ НАУЧНЫЙ ЖУРНАЛ

Медицинские новости Грузии

საქართველოს სამედიცინო სიახლენი

GEORGIAN MEDICAL NEWS

Monthly Georgia-US joint scientific journal published both in electronic and paper formats of the Agency of Medical Information of the Georgian Association of Business Press. Published since 1994. Distributed in NIS, EU and USA.

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:

GEORGIAN MEDICAL NEWS
No 6 (375) 2026

ASSESSING THE EFFECTIVENESS OF LIFESTYLE CLINIC INTERVENTIONS ON CARDIOMETABOLIC RISK FACTORS: A RETROSPECTIVE STUDY

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Abstract.

Background: Cardiometabolic disorders, including diabetes mellitus, hypertension, dyslipidemia, and obesity, represent a significant global health burden. While lifestyle interventions are recommended, evidence from real-world clinical settings in Saudi Arabia remains limited.

Objective: To evaluate the association between participation in a comprehensive lifestyle clinic intervention on cardiometabolic risk factors among adult patients in Saudi Arabia over a six-month period.

Methods: This retrospective cohort study analyzed data from 281 participants enrolled at the Lifestyle Clinic of King Abdulaziz Medical City, Jeddah. Participants were categorized into metabolic (n=137) and smoking cessation (n=144) cohorts. Longitudinal changes in BMI, systolic blood pressure, HbA1c, and total cholesterol were assessed at baseline, 3 months, and 6 months using linear mixed-effects models. Smoking cessation outcomes were evaluated using generalized estimating equations.

Results: At 6 months, participants demonstrated significant reductions in BMI (−0.92 kg/m², 95% CI −1.79 to −0.05; p=0.036) and total cholesterol (−0.25 mmol/L, 95% CI −0.48 to −0.03; p=0.022) in adjusted analyses. Among active smokers at baseline, 24.1% had quit smoking at 6 months. No significant changes were observed in systolic blood pressure or HbA1c levels.

Conclusion: Participation in a structured lifestyle clinic program was associated with improvements in BMI and lipid profile among Saudi adults with cardiometabolic risk factors over 6 months. These findings support the potential role of comprehensive lifestyle programs in routine clinical practice to address the growing burden of metabolic diseases in Saudi Arabia.

Key words. Behavioral intervention, cardiovascular prevention, health promotion, obesity management, preventive medicine, primary care.

Introduction.

Cardiometabolic disorders including obesity, hypertension, dyslipidemia, and type 2 diabetes, frequently coexist as part of metabolic syndrome and constitute a significant global health burden [1]. These interrelated conditions are responsible for a substantial proportion of mortality worldwide and incur considerable healthcare costs, with diabetes alone accounting for approximately 11% of global healthcare expenditure [2-4]. Several modifiable lifestyle factors play a central role in the development and progression of cardiometabolic diseases. [5,6]. Unhealthy lifestyle behaviors such as poor diet, physical inactivity, and tobacco use account for a large proportion of this burden. In 2021 alone, dietary risks contributed to an estimated 6.6 million cardiovascular deaths globally [7]. Consequently, international guidelines emphasize lifestyle modification as first-line therapy for preventing and managing cardiometabolic conditions [8,9]. Comprehensive lifestyle interventions typically include dietary modification, regular physical activity, behavioral counseling, and smoking cessation. Evidence from large international studies has demonstrated that structured lifestyle programs can lead to meaningful improvements in cardiometabolic risk factors such as body weight, blood pressure, and glycemic control. Moreover, such interventions have been shown to reduce the incidence of type 2 diabetes by approximately 50-60% among high-risk individuals [10,11]. Despite this, such interventions are underutilized, necessitating more aggressive implementation to mitigate the escalating epidemic of metabolic syndrome [12,13].

In Saudi Arabia, rapid urbanization and lifestyle transitions, characterized by sedentary behavior and high-calorie diets, have contributed to increasing prevalence rates of obesity, diabetes, and associated risk factors [2]. Current estimates indicate that the prevalence of type 2 diabetes among patients with established cardiovascular diseases in Saudi Arabia ranges from 51.4% to 72.8% of highlighting a concerning burden within the region [14]. Saudi Arabia also has one of the highest rates of obesity and metabolic syndrome globally [15]. Over 60% of adults are overweight or obese, and 69% are insufficiently active [16]. A lifestyle survey conducted in the Makkah region by Alsulami et al. reported an obesity prevalence of 23% and an additional 33% classified as overweight, with clear associations between unhealthy lifestyle behaviors and increased adiposity [17]. Although lifestyle interventions are widely recommended for the prevention and management of cardiometabolic diseases, evidence from intervention studies conducted in Saudi Arabia remains limited. However, available studies have reported promising results. Al-Hamdan et al. evaluated a six-month lifestyle intervention program among Saudi women with prediabetes and found significant reductions in glycated hemoglobin across all intervention groups. Participants who received in-person lifestyle counseling showed greater improvements in weight and lipid profiles than those who participated in remote interventions [18].

While global evidence supports lifestyle modification, local Saudi data remain sparse, especially from real-world clinical settings. Most studies are short-term, small-scale, or targeted to specific groups, including women and individuals with prediabetes. This study addresses a critical gap by evaluating the association between participation in a comprehensive lifestyle clinic intervention on cardiometabolic risk factors among adult patients in Saudi Arabia, aiming to inform scalable, evidence-based interventions.

Materials and Methods.

Study design:

This retrospective cohort study was conducted at the Lifestyle Clinic of King Abdulaziz Medical City, Jeddah, Saudi Arabia. The study evaluated the effectiveness of structured lifestyle interventions on cardiometabolic risk factors through review and analysis of electronic medical records. Participants were followed longitudinally with repeated clinical and laboratory assessments at baseline, 3 months, and 6 months.

Study Population:

The study population comprised adult patients (≥18 years) who were enrolled in the lifestyle modification program and had at least one documented follow-up visit within six months of enrollment. Patients were managed either for cardiometabolic risk reduction (metabolic cohort) or for structured smoking cessation (smoking cohort).

Inclusion criteria for the metabolic cohort included documented cardiometabolic risk factors such as hypertension, dyslipidemia, impaired glucose tolerance, obesity (BMI ≥30 kg/m²), or established type 2 diabetes mellitus. The smoking cessation cohort consisted of patients enrolled specifically for behavioral and medical smoking cessation support. Patients with severe cardiovascular disease requiring advanced management, active malignancy, pregnancy, or incomplete baseline medical records were excluded.

The initial dataset included 342 patients. Prior to analysis, data were cleaned and screened for completeness. Prior to analysis, the dataset underwent data cleaning and eligibility assessment. Records with insufficient longitudinal data, excessive missing repeated measurements, or non-analyzable cohort-specific outcome data were excluded. To maximize retention in longitudinal analyses, participants with partially incomplete baseline measurements but available repeated follow-up observations were retained when sufficient data were available for mixed-effects modeling. The final analytic sample included 281 participants, comprising 137 individuals in the metabolic cohort and 144 in the smoking cessation cohort.

Sample size estimation was performed using G*Power software, assuming an effect size of 0.3, alpha of 0.05, and statistical power of 0.80, yielding a required minimum sample size of 278 participants. Consecutive sampling of eligible patients was performed retrospectively until the available dataset met this requirement. Although the overall analytic sample met the prespecified sample size requirement, subsequent division into metabolic and smoking cessation cohorts may have reduced statistical power for certain subgroup and secondary analyses, particularly analyses based on complete-case follow-up data.

Lifestyle interventions.

The Lifestyle Clinic delivered routine, multidisciplinary care guided by established principles of lifestyle medicine. Clinical management was primarily informed by the six core pillars described by the American College of Lifestyle Medicine, which include a healthy dietary pattern, regular physical activity, restorative sleep, stress management, avoidance of risky substances, and positive social connections [19]. These domains provided a general framework for patient counseling and follow-up within the clinic.

Interventions were individualized according to patient needs and clinical indications rather than following a standardized research protocol. Patients in the metabolic cohort received counseling focused on improving dietary habits, increasing physical activity, and addressing modifiable cardiometabolic risk factors. Patients in the smoking cessation cohort received behavioral support aimed at reducing and quitting tobacco use. The type of intervention and number of sessions attended were recorded as part of routine clinical documentation. All care was delivered as part of usual clinical practice, and follow-up visits were scheduled according to clinical need, typically at baseline, 3 months, and 6 months. Participants continued routine pharmacological management prescribed by their primary treating clinics throughout follow-up. The Lifestyle Clinic itself did not modify chronic disease medications; however, medication changes initiated by external clinics during the study period could not be reliably extracted from the medical records and therefore could not be adjusted for analytically. Intervention intensity varied according to individual clinical needs and patient engagement. The median number of attended sessions was 3 (interquartile range [IQR]: 1–6), while the median number of scheduled sessions was 6 (IQR: 3–9).

Data Collection.

Data were extracted from electronic medical records using a standardized data abstraction form. Variables collected included demographic characteristics (age and gender), anthropometric measurements (height, weight, BMI, and waist circumference), clinical parameters (systolic and diastolic blood pressure), and laboratory values (HbA1c and lipid profile).

Statistical Analysis.

All statistical analyses were performed using R (R Foundation for Statistical Computing, Vienna, Austria). The original dataset comprised 342 participants. After data cleaning and eligibility assessment, records with insufficient longitudinal data, excessive missing repeated measurements, or non-analyzable cohort-specific outcome data were excluded, yielding a final analytic sample of 281 participants. Participants with partially incomplete baseline measurements but available repeated follow-up observations were retained when sufficient data were available for mixed-effects modeling. Continuous variables were summarized as mean ± standard deviation (SD), and categorical variables as frequencies and percentages. Baseline characteristics were described separately for the metabolic and smoking cohorts. The number and proportion of observed measurements at each timepoint were reported.

Longitudinal changes in metabolic outcomes (BMI, systolic blood pressure, HbA1c, and total cholesterol) were evaluated

using linear mixed-effects models with random intercepts to account for within-subject correlation. Timepoint (baseline, 3 months, and 6 months) was modeled as a categorical fixed effect with baseline as the reference. Overall time effects were assessed using Type III tests, and pairwise comparisons with baseline were conducted using Dunnett-adjusted contrasts. Prespecified adjusted models included age, gender, and diabetes status as covariates. For the smoking cessation cohort, participants who had quit at baseline were excluded from longitudinal modeling. Smoking status at follow-up was dichotomized as quit versus not quit. Changes between 3 and 6 months were analyzed using generalized estimating equations with a binomial distribution and exchangeable correlation structure, and results were reported as odds ratios (ORs) with 95% confidence intervals. Exploratory multivariable linear regression analyses were additionally performed within the metabolic cohort to evaluate whether intervention engagement intensity, measured by the number of attended sessions, was associated with 6-month changes in BMI, HbA1c, systolic blood pressure, and total cholesterol after adjustment for demographic and baseline clinical covariates.

Sensitivity analyses included complete-case linear mixed-effects models and logistic regression models evaluating baseline predictors of missingness at 6 months. Statistical significance was defined as a two-sided p-value <0.05.

Ethical Considerations.

The study protocol was approved by the Institutional Review Board of King Abdullah International Medical Research Center (KAIMRC). Given the retrospective nature of the study and use of de-identified data, the requirement for informed consent was waived. Patient confidentiality was maintained through removal of identifiable information and use of coded identifiers. The study was conducted in accordance with the Declaration of Helsinki and institutional research ethics guidelines.

Results.

A total of 342 records were initially assessed for eligibility. Following data cleaning and eligibility assessment, 61 records were excluded because of insufficient longitudinal data, excessive missing repeated measurements, or non-analyzable cohort-specific outcome data, yielding a final analytic sample of 281 participants. The participant selection process, exclusions, cohort allocation, and follow-up retention are summarized in (Figure 1). A total of 281 participants were included in the analysis. The study population comprised two distinct cohorts derived from a lifestyle clinic program. The metabolic cohort (n=137) included patients enrolled for management of metabolic conditions, including weight management, pre-diabetes, dyslipidemia, uncontrolled diabetes mellitus, and hypertension. The smoking cessation cohort (n=144) consisted of patients enrolled specifically for structured smoking cessation support. Participants in both cohorts underwent repeated assessments at baseline, 3 months, and 6 months, and analyses were conducted separately for each cohort according to predefined outcomes.

The overall mean age of participants was 47.9 years (SD 14.4), with metabolic participants being slightly older than smoking participants (49.2 [15.3] vs 46.7 [13.4] years). Females constituted 31.3% of the total sample, with a markedly higher proportion in the metabolic cohort compared with the smoking cohort. The prevalence of diabetes was 39.5% overall. At baseline, the mean BMI was 31.7 kg/m² (SD 6.9), mean systolic blood pressure was 125.6 mmHg (SD 13.4), mean HbA1c was 6.3% (SD 1.5), and mean total cholesterol was 4.9 mmol/L (SD 1.2). Baseline metabolic parameters were generally higher in the metabolic cohort compared with the smoking cohort (Table 1).

Longitudinal changes in metabolic outcomes were evaluated using linear mixed-effects models. BMI decreased significantly at 6 months compared with baseline in unadjusted analyses (−1.01 kg/m²; p=0.020), with a significant overall time effect (p=0.034). After adjustment for age, gender, and diabetes status, the reduction at 6 months remained statistically significant (−0.92 kg/m², 95% CI −1.79 to −0.05; p=0.036), although the overall time effect became borderline (p=0.058). Total cholesterol also decreased significantly at 6 months in both unadjusted and adjusted models. In the adjusted analysis, total cholesterol decreased by 0.26 mmol/L (95% CI −0.48 to −0.03; p=0.022), with a significant overall time effect (p=0.026). No significant longitudinal changes were observed for systolic blood pressure. HbA1c showed a modest decline over time, with a non-significant trend toward reduction after adjustment (overall p=0.054). Detailed longitudinal model estimates are presented in Table 2. The percentage change from baseline across follow-up timepoints illustrates a progressive reduction in BMI and total cholesterol, while systolic blood pressure remained relatively stable and HbA1c demonstrated only minor variation over time (Figure 2).

Among participants who were active smokers at baseline (n=118), 22.0% had quit smoking at 3 months and 24.1% at 6 months. The proportion reporting no change in smoking status decreased from 100% at baseline to 35.2% at 3 months and 49.4% at 6 months, while the proportion reporting reduced smoking was 42.9% at 3 months and 26.6% at 6 months. In a generalized estimating equation model comparing 6 months with 3 months, the odds of quitting were not significantly different (OR 1.24, 95% CI 0.81–1.90; p=0.314) (Table 3).

Sensitivity analyses were conducted to evaluate the impact of missing data. In complete-case analyses including participants with measurements at all three timepoints, the reduction in BMI at 6 months remained statistically significant (p=0.032). Logistic regression models examining predictors of missingness at 6 months demonstrated that younger age was associated with a higher likelihood of missing data, whereas baseline BMI and baseline total cholesterol were not associated with missingness. These findings support the assumption of missing at random and suggest that the primary longitudinal results are robust to incomplete follow-up.

Exploratory multivariable regression analyses were performed within the metabolic cohort to evaluate whether intervention engagement intensity, measured by the number of attended sessions, was associated with 6-month changes in metabolic outcomes. After adjustment for age, gender, diabetes status, and baseline outcome values, the number of attended sessions was not independently associated with changes in BMI, HbA1c, systolic blood pressure, or total cholesterol. Higher baseline BMI, baseline HbA1c, baseline systolic blood pressure, and

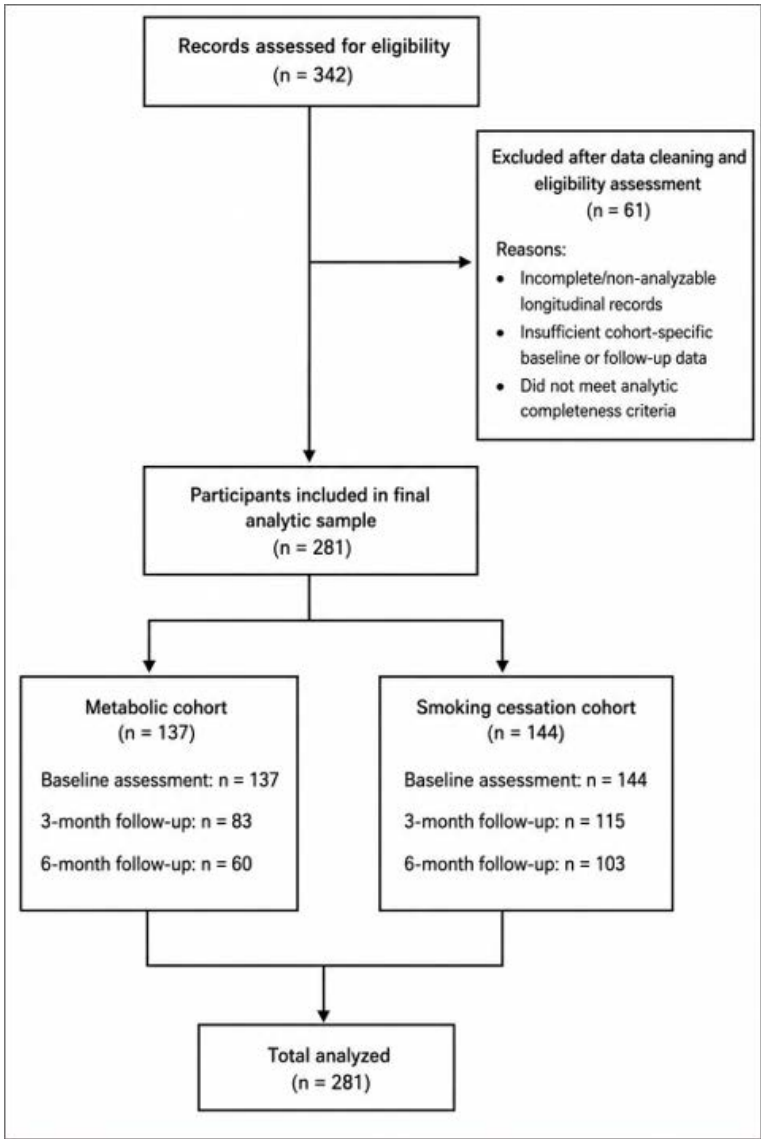

Figure 1. *STROBE-style flow diagram illustrating participant inclusion, exclusions, cohort allocation, and follow-up retention throughout the study.*

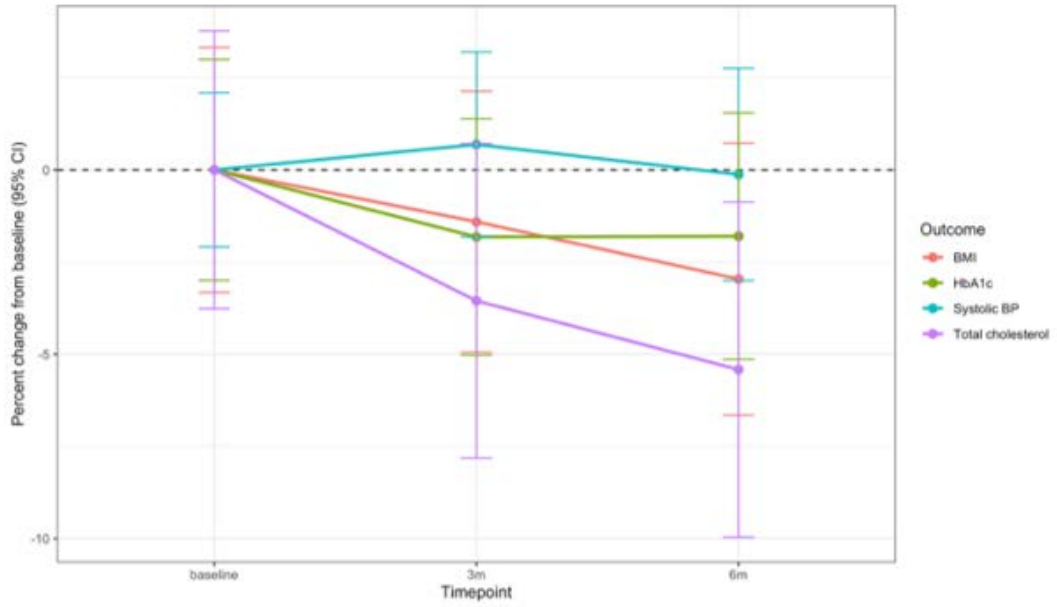

Figure 2. *Illustration of percentage change from baseline in metabolic outcomes over 6 months in the metabolic cohort. BMI is expressed in kg/m², systolic blood pressure in mmHg, HbA1c in percent (%), and total cholesterol in mmol/L.*

Table 1. *Baseline demographic and clinical characteristics of the study population according to cohort.*

Variable	Total		Metabolic		Smoking (n)	
	(n)	Mean ± SD / (%)	(n)	Mean ± SD / (%)	(n)	Mean ± SD / (%)
N	281	100%	137	48.8%	144	51.2%
Age (years)	281	47.9±14.4	137	49.2±15.3	144	46.7±13.4
Female, n (%)	88	31.3%	80	28.5%	8	2.8%
Diabetes, n (%)	111	39.5%	54	19.2%	57	20.3%
BMI	224	31.7±6.9	137	34±6.7	87	28.2±5.5
Systolic BP	216	125.6±13.4	124	126.3±13.2	92	124.6±13.6
HbA1c	189	6.3±1.5	117	6±1	72	6.6±2.1
Total cholesterol	186	4.9±1.2	116	5±1.1	70	4.6±1.4

SD = standard deviation, BMI = body mass index (kg/m²); BP = blood pressure (mmHg); HbA1c = glycated hemoglobin (%); total cholesterol reported in mmol/L.

Table 2. *Longitudinal changes in metabolic outcomes estimated using linear mixed-effects models.*

Outcome	Model (LMM)	Baseline mean (95% CI)	3-month mean (95% CI)	6-month mean (95% CI)	Change at 6 months vs baseline	P value (6 month*	Overall P value^
BMI	Unadjusted	33.9 (32.8, 35.1)	33.5 (32.3, 34.7)	32.9 (31.7, 34.2)	-1 (-1.88, -0.13)	0.021	0.034
BMI	Adjusted	33.4 (32.3, 34.5)	33 (31.8, 34.2)	32.5 (31.3, 33.7)	-0.92 (-1.79, -0.05)	0.036	0.058
HbA1c	Unadjusted	6 (5.8, 6.2)	5.9 (5.7, 6.1)	5.9 (5.7, 6.1)	-0.11 (-0.26, 0.04)	0.196	0.119
HbA1c	Adjusted	6.1 (5.9, 6.3)	6 (5.8, 6.2)	6 (5.8, 6.2)	-0.13 (-0.28, 0.02)	0.115	0.054
Systolic BP	Unadjusted	126 (124, 129)	127 (124, 130)	126 (122, 129)	-0.16 (-4.4, 4.1)	0.991	0.829
Systolic BP	Adjusted	127 (124, 130)	127 (124, 130)	126 (122, 130)	-0.93 (-5.2, 3.3)	0.829	0.819
Total cholesterol	Unadjusted	5 (4.8, 5.2)	4.8 (4.6, 5.1)	4.8 (4.5, 5)	-0.27 (-0.49, -0.05)	0.013	0.015
Total cholesterol	Adjusted	4.9 (4.8, 5.2)	4.8 (4.6, 5.)	4.7 (4.5, 4.9)	-0.25 (-0.48, -0.03)	0.022	0.026

BMI is expressed in kg/m²; systolic blood pressure (BP) in mmHg; HbA1c in percent (%); and total cholesterol in mmol/L.
**Dunnett-adjusted p-value for comparison of 6 months versus baseline.*
^Global test for timepoint from the Type III ANOVA.

Table 3. *Smoking status over time among participants actively smoking at baseline.*

	Baseline (n=118)	3 Months (n=91)	6 Months (n=79)
No change	118 (100%)	32 (35.2%)	39 (49.4%)
Reduced	0 (0%)	39 (42.9%)	21 (26.6%)
Quit	0 (0%)	20 (22.0%)	19 (24.1%)
GEE: 6m vs 3m (Quit vs Not quit)	-	OR 1.24 (0.81–1.90), p=0.314	

OR = odds ratio; CI = confidence interval; GEE = generalized estimating equation.

baseline total cholesterol were independently associated with greater subsequent reductions in their respective outcomes.

Discussion.

Participation in the lifestyle clinic program was associated with improvements in BMI and total cholesterol levels at 6-month follow-up. Similarly, 24.1% had quit smoking during this period. However, no significant impact was seen in the levels of systolic blood pressure and HbA1c. The findings of the present study align with previous studies which have shown that lifestyle interventions have positive impact on cardiometabolic risk factors [20,21].

In the present study, average BMI reduction was 1 kg/m^2 after 6 months. Similarly, a large randomized trial of digital behavioral interventions in emerging adults (mean baseline BMI 33.5) reported mean 6-month weight loss of 3-3.5 kg [22]. In their study, all intervention arms produced weight losses exceeding 3% of body weight. They further reported that 40-44% of participants achieved ≥5% weight loss across groups. Similar to present study, they also did not observe significant reductions in blood pressure [22]. A newly-published randomized controlled trial showed that a behavioral nutrition program led to over 3% average weight loss and corresponding cardiometabolic improvements [23]. Although in the present study no reduction in blood pressure was detected despite a significant reduction in BMI, guidelines emphasize that even small weight reductions are beneficial. According to the 2025 AHA/ACC guidelines, each kilogram of weight loss lowers systolic blood pressure by roughly 1 mmHg [24]. Some other estimates report that even modest weight loss of 5-10% improves blood pressure and lipid profiles, with every kilogram of weight lost reducing systolic blood pressure by approximately 0.4 mmHg [25,26]. In patients with hypertension, greater weight loss is typically needed to achieve meaningful blood pressure reductions. However, lifestyle modifications when combined with medication management has been shown to reduce blood pressure. A meta-analysis of 16 studies by Abate et al. involving 4450 participants reported that lifestyle interventions with or without medication optimization reduced systolic blood pressure ($P < 0.001$), diastolic blood pressure ($P < 0.001$), and total cholesterol ($P = 0.009$) [27]. Although not statistically significant, our lipid findings support a beneficial effect of lifestyle change. Total

cholesterol decreased by 0.25 mmol/L at 6 months, consistent with prior evidence. For context, a meta-analysis of high-fiber (≥3 g oat β-glucan) dietary interventions found total cholesterol reductions of 0.30 mmol/L [28].

Similar evidence has been presented in other studies as well. Recent meta-analyses confirmed that low-carbohydrate and DASH-style diets significantly reduced body weight, systolic blood pressure, and LDL cholesterol [29]. Physical activity has also been shown to improve cardiometabolic risk factors. Aerobic physical activity (30-40 min, 3-5 times/week) significantly lowers resting BP, heart rate, and triglycerides [30]. Structured exercise interventions reduced systolic blood pressure by approximately 5 mmHg and diastolic blood pressure by approximately 3 mmHg in previously sedentary adults [30]. While weight loss may be modest, improvements in fitness, lipid profiles, and glycemic control were consistent. Habitual activity reduced cardiovascular disease risk by up to 21%, and combined diet-exercise interventions yield synergistic benefits [31]. Behavioral support, goal setting, self-monitoring, and motivational interviewing are vital to sustaining change. A recent study reported significant reductions in waist circumference, blood pressure, and insulin resistance among young adults receiving structured behavioral therapy [22]. Meta-analyses showed that such programs maintained cardiometabolic improvements in HbA1c and high-density lipid levels up to 5 years, even with partial weight regain [32]. Digital interventions, including mobile apps and online coaching, are increasingly effective; one 2023 meta-analysis found that eHealth tools matched human-guided programs in improving weight and blood glucose levels [33].

The trend toward lower HbA1c in our cohort did not reach statistical significance, indicating a relatively small glycemic impact of the intervention. This may reflect the population mix and intervention scope. About 40% of participants had diagnosed diabetes, but many had relatively well-controlled or prediabetic glycemia. In trials specifically targeting glycemic control, larger HbA1c reductions are often achieved. For instance, a pooled analysis of 30 RCTs in overweight adults with T2DM found a mean HbA1c decrease of 0.48%-0.59% over 3-6 months [34]. A meta-analysis in South Asian T2DM patients reported an average reduction of 0.86%, with greater improvements over longer (≥6 month) interventions [35]. Consistent with this, a U.S. trial of a low-carbohydrate diet in prediabetic adults achieved a 0.23% greater HbA1c drop than a usual diet at 6 months [36]. That very targeted dietary intervention significantly lowered HbA1c compared to control, whereas our broader counseling may have had more diffuse effects. More intensive or sustained interventions may be needed to achieve clinically significant HbA1c reduction in a largely normoglycemic/pre-diabetic clinic population. For example, intermittent fasting achieved superior short-term glycemic control compared to standard pharmacotherapy in prediabetic patients [23].

Among active smokers at baseline, roughly one-quarter reported quitting by 6 months. This abstinence rate is comparable to real-world cessation programs. For example, a large Chinese hospital-based smoking cessation clinic reported 31.7% of smokers remained quit at 6 months [37]. Similarly, a cross-sectional study conducted at a smoking cessation clinic in Makkah included 340 smokers enrolled in the Saudi national tobacco control program. The smoking cessation success rate was 27.4%. Determination and strong personal motivation were the most commonly reported reasons for successful cessation (53.8%), followed by participation in the anti-smoking program (21.5%) and use of anti-smoking therapy (10.8%) [38]. In patients with type 2 diabetes, cessation interventions led to significant reductions in HbA1c, BP, and cholesterol within three months [39]. Longitudinal studies show that former heavy smokers (>20 pack-years) reduce CVD risk by 39% within 5 years of quitting, though normalization to non-smoker levels may take 10-15 years [40]. Light smokers (<8 pack-years) regain normal risk profiles faster [41]. Thus, smoking cessation, like dietary and exercise changes, yields substantial cardiometabolic benefit.

Several limitations should be considered when interpreting the findings of this study. First, the duration of follow-up was limited to 3 and 6 months, which may not fully capture the longer-term sustainability of changes in cardiometabolic risk factors and smoking behavior. Second, incomplete follow-up and variable data availability across outcomes resulted in reduced sample sizes at later assessment intervals, which may have introduced attrition bias and reduced statistical power for some subgroup and secondary analyses. Although sensitivity analyses suggested that missingness was primarily associated with demographic factors rather than baseline outcome severity, residual bias related to incomplete follow-up cannot be fully excluded. Third, because this was a real-world retrospective study without a parallel control group receiving standard care, causal inferences regarding the observed improvements cannot be definitively established. The observed changes may have been influenced by external factors, regression to the mean, concurrent medical care, or behavioral changes related to study participation. Fourth, participants continued routine pharmacological management through their primary treating clinics during follow-up. Although the Lifestyle Clinic itself did not modify chronic disease medications, medication changes initiated by external clinics could not be reliably extracted from the medical records and therefore could not be adjusted for analytically. Finally, intervention intensity and patient engagement varied substantially across participants. Exploratory analyses evaluating the association between the number of attended sessions and changes in metabolic outcomes did not demonstrate a significant independent dose-response relationship after multivariable adjustment, although the study may have been underpowered to detect modest associations in complete-case subgroup analyses. Despite these limitations, the study has several notable strengths. The use of longitudinal repeated measurements allowed assessment of within-individual changes over time under real-world clinical conditions. The inclusion of both metabolic and smoking cessation cohorts enhances the clinical relevance of the findings and reflects implementation of a comprehensive lifestyle clinic model in routine practice. Additionally, mixed-effects modeling enabled inclusion of participants with partially incomplete repeated measurements while accounting for within-subject correlation, thereby improving analytical robustness.

Conclusion.

This retrospective study demonstrated an association between participation in a lifestyle clinic program and improvements in BMI (mean reduction 1.0 kg/m²) and total cholesterol (mean reduction 0.25 mmol/L) over 6 months, with 24.1% of baseline smokers achieving smoking cessation. No significant changes were observed in systolic blood pressure or HbA1c, suggesting that more intensive or prolonged interventions may be necessary for these outcomes. The findings support the role of multicomponent lifestyle modification in reducing cardiometabolic risk factors in the Saudi Arabian population. Future studies should extend follow-up duration beyond 6 months to assess long-term sustainability, incorporate more structured exercise and dietary protocols, and employ randomized controlled trial designs to strengthen causal inference. Integration of digital health tools and targeted interventions for high-risk subgroups may further enhance program effectiveness and scalability.

REFERENCES

1. Wang Q, Chair SY, Wong EML, et al. Actively incorporating lifestyle modifications into daily life: The key to adherence in a lifestyle intervention programme for metabolic syndrome. Front Public Health. 2022;10:929043.
2. Alhabib KF, Batais MA, Almigbal TH, et al. Demographic, behavioral, and cardiovascular disease risk factors in the Saudi population: results from the Prospective Urban Rural Epidemiology study (PURE-Saudi). BMC Public Health. 2020;20:1213.
3. Caswell A, Kenkre J. Primary healthcare in Saudi Arabia: an evaluation of emergent health trends. Global Journal on Quality and Safety in Healthcare. 2021;4:96-104.
4. Zhang P, Zhang X, Brown J, et al. Global healthcare expenditure on diabetes for 2010 and 2030. Diabetes Res Clin Pract. 2010;87:293-301.
5. López-Bueno R, Núñez-Cortés R, Calatayud J, et al. Global prevalence of cardiovascular risk factors based on the Life's Essential 8 score: an overview of systematic reviews and meta-analysis. Cardiovasc Res. 2024;120:13-33.
6. Barbosa AR, Pais S, Marreiros A, et al. Impact of a Mediterranean-Inspired Diet on Cardiovascular Disease Risk Factors: A Randomized Clinical Trial. Nutrients. 2024:16.
7. Vaduganathan M, Mensah GA, Turco JV, et al. The global burden of cardiovascular diseases and risk: a compass for future health. American College of Cardiology Foundation Washington DC; 2022;80:2361-2371.
8. Kim HL, Chung J, Kim KJ, et al. Lifestyle Modification in the Management of Metabolic Syndrome: Statement from Korean Society of CardioMetabolic Syndrome (KSCMS). Korean Circ J. 2022;52:93-109.
9. Virani SS, Morris PB, Agarwala A, et al. 2021 ACC Expert Consensus Decision Pathway on the Management of ASCVD Risk Reduction in Patients with Persistent Hypertriglyceridemia: A Report of the American College of Cardiology Solution Set Oversight Committee. J Am Coll Cardiol. 2021;78:960-993.
10. Alberti KG, Eckel RH, Grundy SM, et al. Harmonizing the metabolic syndrome: a joint interim statement of the International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Atherosclerosis Society; and International Association for the Study of Obesity. Circulation. 2009;120:1640-1645.
11. Ukke GG, Boyle JA, Reja A, et al. A Systematic Review and Meta-Analysis of Type 2 Diabetes Prevention Through Lifestyle Interventions in Women with a History of Gestational Diabetes-A Summary of Participant and Intervention Characteristics. Nutrients. 2024;16.
12. Tariq MNM, Stojanovska L, Dhaheri ASA, et al. Lifestyle Interventions for Prevention and Management of Diet-Linked Non-Communicable Diseases among Adults in Arab Countries. Healthcare (Basel). 2022;11.
13. Noubiap JJ, Nansseu JR, Lontchi-Yimagou E, et al. Geographic distribution of metabolic syndrome and its components in the general adult population: A meta-analysis of global data from 28 million individuals. Diabetes Res Clin Pract. 2022;188:109924.
14. Alhabeeb W, Elasfar A, Kinsara AJ, et al. A Saudi Heart Association Position Statement on Cardiovascular Diseases and Diabetes Mellitus. J Saudi Heart Assoc. 2024;36:385-407.
15. Salem V, AlHusseini N, Abdul Razack HI, et al. Prevalence, risk factors, and interventions for obesity in Saudi Arabia: A systematic review. Obes Rev. 2022;23:e13448.
16. Almubark RA, Alqahtani SA. Epidemiology of obesity and control interventions in Saudi Arabia. East Mediterr Health J. 2023;29:987-994.
17. Alsulami S, Baig M, Ahmad T, et al. Obesity prevalence, physical activity, and dietary practices among adults in Saudi Arabia. Front Public Health. 2023;11:1124051.
18. Al-Hamdan R, Avery A, Al-Disi D, et al. Efficacy of lifestyle intervention program for Arab women with prediabetes using social media as an alternative platform of delivery. J Diabetes Investig. 2021;12:1872-1880.
19. Lippman D, Stump M, Veazey E, et al. Foundations of Lifestyle Medicine and its Evolution. Mayo Clin Proc Inn Qual Out. 2024;19:209-211.
20. Vetter ML, Wadden TA, Chittams J, et al. Effect of lifestyle intervention on cardiometabolic risk factors: results of the POWER-UP trial. Int J Obes (Lond). 2013;37:S19-24.
21. Faiz U, Atiq Ur R, Khan RD, et al. Impact of Lifestyle Interventions on Cardiovascular Risk Factors in Patients with Metabolic Syndrome. Indus Journal of Bioscience Research. 2025;3:210-215.
22. LaRose JG, Leahey TM, Lanoye A, et al. Effect of a Lifestyle Intervention on Cardiometabolic Health Among Emerging Adults: A Randomized Clinical Trial. JAMA Network Open. 2022;5:e2231903-e2231903.
23. Guo L, Xi Y, Jin W, et al. A 5:2 Intermittent Fasting Meal Replacement Diet and Glycemic Control for Adults with Diabetes: The EARLY Randomized Clinical Trial. JAMA Netw Open. 2024;7:e2416786.
24. Han B, Lee GB, Yoon J, et al. Lifestyle interventions for hypertension management in primary care: a narrative review. Ewha Med J. 2025;48:e56.
25. Brown JD, Buscemi J, Milsom V, et al. Effects on cardiovascular risk factors of weight losses limited to 5-10. Transl Behav Med. 2016;6:339-346.

26. Morris E, Jebb SA, Oke J, et al. Effect of weight loss on cardiometabolic risk: observational analysis of two randomised controlled trials of community weight-loss programmes. Br J Gen Pract. 2021;71:e312-e319.
27. Abate SM, Thanigaimani S, Sinha M, et al. A systematic review and meta-analysis testing the effect of lifestyle modification and medication optimization programs on cholesterol and blood pressure in patients with cardiovascular disease. Syst Rev. 2025;14:153.
28. Whitehead A, Beck EJ, Tosh S, et al. Cholesterol-lowering effects of oat β-glucan: a meta-analysis of randomized controlled trials. Am J Clin Nutr. 2014;100:1413-1421.
29. Chatzi CA, Basios A, Markozannes G, et al. Effect of Different Dietary Patterns on Cardiometabolic Risk Factors: An Umbrella Review of Systematic Reviews and Meta-Analyses. Nutrients. 2024;16.
30. Guo L, Wang C. The effect of exercise on cardiovascular disease risk factors in sedentary population: a systematic review and meta-analysis. Front Public Health. 2025;13:1470947.
31. Barone Gibbs B, Hivert MF, Jerome GJ, et al. Physical Activity as a Critical Component of First-Line Treatment for Elevated Blood Pressure or Cholesterol: Who, What, and How?: A Scientific Statement from the American Heart Association. Hypertension. 2021;78:e26-e37.
32. Hartmann-Boyce J, Theodoulou A, Oke JL, et al. Long-Term Effect of Weight Regain Following Behavioral Weight Management Programs on Cardiometabolic Disease Incidence and Risk: Systematic Review and Meta-Analysis. Circ Cardiovasc Qual Outcomes. 2023;16:e009348.
33. Cohen Rodrigues TR, Breeman LD, Kinik A, et al. Effectiveness of Human-Supported and Self-Help eHealth Lifestyle Interventions for Patients with Cardiometabolic Risk Factors: A Meta-Analysis. Psychosom Med. 2023;85:795-804.
34. Yang J, Xia Y, Sun Y, et al. Effect of lifestyle intervention on HbA1c levels in overweight and obese adults with type 2 diabetes across ethnicities: A systematic review and meta-analysis of randomized controlled trials. Diabetes Research and Clinical Practice. 2023;199:110662.
35. Ahmad I, Taimur H, Poduri GV, et al. A Systematic Review and Meta-Analysis of RCTs Assessing Efficacy of Lifestyle Interventions on Glycemic Control in South Asian Adults with Type 2 Diabetes. Med Sci (Basel). 2026;14.
36. Dorans KS, Bazzano LA, Qi L, et al. Effects of a Low-Carbohydrate Dietary Intervention on Hemoglobin A1c: A Randomized Clinical Trial. JAMA Network Open. 2022;5:e2238645-e2238645.
37. Xie J, Zhong R, Zhu L, et al. Smoking cessation rate and factors affecting the success of quitting in a smoking cessation clinic using telephone follow-up. Tobacco Induced Diseases. 2021;19:1-11.
38. Falemban A, Kofi M. Success Rate of Smoking Quitting in those who Attends Smoking Cessation Clinic: A Cross Sectional Study. Acta Scientific Medical Sciences. 2022:6.
39. Chen HJ, Huang WH, Chan HL, et al. Improvement in Cardiometabolic Risk Factors During Smoking Cessation Treatment in Patients with Type 2 Diabetes: A Retrospective Cohort Study. Diabetes Metab Syndr Obes. 2021;14:1695-1702.
40. Gallucci G, Tartarone A, Lerose R, et al. Cardiovascular risk of smoking and benefits of smoking cessation. Journal of Thoracic Disease. 2020;12:3866.
41. Cho JH, Shin SY, Kim H, et al. Smoking Cessation and Incident Cardiovascular Disease. JAMA Netw Open. 2024;7:e2442639.

Appendices.

Table S1 presents the results of multivariable logistic regression models evaluating baseline predictors of missing outcome data at 6 months for BMI and total cholesterol in the metabolic cohort. Younger age was significantly associated with higher odds of missingness for both outcomes, whereas gender, diabetes status, and the corresponding baseline outcome values were not significantly associated with loss to follow-up. These findings suggest that missingness at 6 months was primarily related to demographic factors rather than baseline metabolic severity. The absence of associations between baseline outcome levels and subsequent missingness supports the plausibility of the missing at random (MAR) assumption underlying the primary linear mixed-effects analyses.

Table S1. *Logistic regression models evaluating baseline predictors of missingness at 6 months for primary metabolic outcomes.*

Missingness model	Predictor variable	Odds ratio (95% CI)	P value
Missing BMI at 6m	Intercept	85.24 (4.02, 1806.47)	0.004
Missing BMI at 6m	Age (years)	0.95 (0.92, 0.98)	<0.001
Missing BMI at 6m	Male (vs Female)	1.01 (0.47, 2.15)	0.986
Missing BMI at 6m	Diabetes: Yes (vs No)	0.68 (0.31, 1.50)	0.337
Missing BMI at 6m	Baseline BMI	0.96 (0.91, 1.02)	0.215
Missing Total cholesterol at 6m	Intercept	61.11 (3.65, 1022.83)	0.004
Missing Total cholesterol at 6m	Age (years)	0.95 (0.92, 0.98)	0.001
Missing Total cholesterol at 6m	Male (vs Female)	1.14 (0.51, 2.54)	0.748
Missing Total cholesterol at 6m	Diabetes: Yes (vs No)	0.56 (0.24, 1.31)	0.182
Missing Total cholesterol at 6m	Baseline total cholesterol	0.79 (0.54, 1.17)	0.235

OR = odds ratio; CI = confidence interval.