BMC Endocrine Disorders

SYSTEMATIC REVIEW

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Predictor factors of uncontrolled diabetes

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Abstract

Objective The most significant challenge faced by individuals with diabetes is poor blood sugar control. The objective of this review is to identify the most crucial predictors of poor glycemic control among patients with diabetes.

Materials This review employed a comprehensive approach, utilizing all available analytical cross-sectional, case control and cohort studies to ascertain the pooled odds ratio/risk ratio of uncontrolled diabetes. The review encompassed articles from international databases, including Web of Science, PubMed, Scopus, and Google Scholar without restrictions on publication date or language. Data extraction was conducted until May 11, 2024, with statistical analyses performed using Stata 17 software, employing a random effects model at a 95% confidence level.

Results Out of 157,841 records, a total of 59 cross-sectional studies, 4 case-control studies, and 3 cohort studies were included, comprising 284,558 participants with a mean age of 53.78 years (SD = 6.33). There was no statistically significant association between the seven factors analyzed—age, gender, smoking status, education level, systolic blood pressure, diastolic blood pressure, and BMI. However, we observed a significant decrease in the likelihood of poor glycemic control with each unit increase in physical activity. Specifically, as physical activity levels increased, the likelihood of poor glycemic control decreased (adjusted OR 0.41; 95% CI: 0.24, 0.72; *p*-value = 0.02).

Conclusion Our systematic review and meta-analysis study showed that increased levels of physical activity in individuals with type 2 diabetes enhance the chances of achieving better glycemic control.

Keywords Type 2 diabetes mellitus, Glycemic control, Predictor factors, Systematic review and meta-analysis

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Introduction

Diabetes mellitus is a chronic metabolic disorder characterized by persistently elevated blood glucose levels. In the absence of adequate management, the condition can result in significant complications, including cardiovascular disease, renal failure and neuropathy [1]. Despite recent advances in the management of diabetes, many individuals continue to experience difficulties in controlling their blood glucose levels [2, 3]. According to a report by the World Health Organization (WHO), the number of individuals living with diabetes increased from 200 million in 1990 to 830 million in 2022. The prevalence of diabetes has been rising at a faster rate in low- and middle income countries compared to high-income countries [4]. Previous studies showed that 40–60% of patients diagnosed with diabetes have been unable to adequately manage their condition [5–8].

A number of factors, including socioeconomic status, the presence of comorbid conditions, lifestyle choices and psychological aspects, have been identified as having the potential to exert a significant influence on the management of diabetes and its related outcomes, such as health results, improved quality of life, and reduced healthcare costs [8, 9].

As the global prevalence of diabetes rises, addressing uncontrolled diabetes has become a public health priority. This systematic review and meta-analysis aim to enhance understanding of the factors associated with uncontrolled diabetes and provide a foundation for future research on improving management strategies and outcomes. -.

Method

Search strategy

A comprehensive search was conducted on international databases, including PubMed, Web of Science, Scopus and Google Scholar up until May 11, 2024. The search was not restricted by time, country, age, gender, or ethnicity or language. Additionally, the reference lists of relevant studies were reviewed. The search was performed using this strategy (“uncontrolled Diabetes Mellitus” OR “poor diabetes management” OR ‘’Poor glycemic control”) AND (“predictor factors” OR “risk factors”).

Eligibility criteria

This systematic review focuses on analytical observational studies that employ cross-sectional, case-control, and cohort designs to investigate the associated risk/preventive factors of poor glycemic control. We include only those studies that provide sufficient data to report effect sizes as relative risk (RR) or odds ratio (OR). The primary outcome of this review was type 2 diabetes, which must be confirmed through medical diagnosis and validated according to the International Classification of Diseases (ICD-10-CM) criteria (E11.9).

Study selection

After importing the search results into EndNote and removing duplicate records, two investigators, Z. Ch. and M. O., independently and concurrently screened the titles and abstracts of the identified studies. In cases of disagreement, consensus was reached through discussions with a third investigator, A. DI. The agreement between the two researchers was evaluated using the kappa index, which indicated substantial agreement with a value of 0.88.

To ensure a thorough review, the full texts of the selected studies were downloaded and evaluated based on pre-defined inclusion criteria. Only those studies that met the specified criteria were included in the final review.

Data extraction

We conducted a comprehensive review of eligible studies and extracted relevant information, which was then recorded in a datasheet. This included details like the authors, publication year, study location, participant demographics, sample size, crude and adjusted odds ratios, as well as the upper and lower limits of these odds ratios and group sizes.

Quality assessment

The quality of the included studies was assessed using the Newcastle-Ottawa Scale (NOS) [10]. The NOS evaluates several aspects, including outcome assessment, exposure ascertainment, control definition and selection, and the precision of outcome reporting.

Heterogeneity and publication bias

To evaluate statistical heterogeneity, we conducted a chi-square test with a significance level of 10%. We also utilized the I^2 statistic to measure the degree of heterogeneity, while estimating the between-study variance using tau-squared (τ^2). To address the observed heterogeneity, we implemented several approaches. First, we thoroughly reviewed the extracted data for accuracy. Additionally, we created a funnel plot to visually assess publication bias, and performed Egger’s tests at a significance level of 0.05 for a statistical evaluation of publication bias.

Data synthesis

In order to calculate the odds ratios, we used the formula: $(a \times d) / (b \times c)$, where a represents the number of cases exposed, b represents the number of controls unexposed, c represents the number of cases unexposed, and d represents the number of controls exposed. To calculate the standard error of the odds ratios in logarithm scale, we used the formula: 1 / √a + 1 / √b + 1 / √c + 1 / √d. For studies that did not report the number of cases and controls by exposure level, we calculated the standard error at logarithm scale using the 95% confidence interval with the formula: log (upper limit - lower limit) / (2 × 1.96).

The inverse variance method was employed to obtain the pooled odds ratios/risk ratio, and the results were reported at a 95% confidence interval using the random effects model. Data analysis was conducted using Stata 11 (Stata Corp, College Station, TX, USA) with a 95% confidence interval.

Results

A comprehensive search in international databases resulted in a total of 157,841 articles. After removing 349 duplicate articles, the number of articles reduced to 157,492. Following the screening of titles and abstracts, an additional 157,173 articles were excluded. In the next stage, a reevaluation was conducted on the remaining 319 articles, which led to the exclusion of 253 articles due to non-compliance with entry criteria or lack of access to the full text. Ultimately, 59 cross-sectional studies [5–7, 11–66], 4 case-control studies [67–70] and 3 cohort studies [71–73] were added to the study collection (see Fig. 1 and appendix 1). The total sample size across all studies was 284, 558 individuals, with a mean age (standard deviation) of 53.78 (6.33) years. The characteristics of the included studies are presented in Appendix 2.

Heterogeneity and publication bias

To evaluate both quantitative and qualitative heterogeneity among the studies, we used the I^2 and Chi-squared tests, with a significance level of 0.05. Additionally, the tau-squared test was employed to estimate the variances among the studies. Low heterogeneity was observed in four subgroups including: systolic blood pressure, diastolic blood pressure, and education. Considerable heterogeneity was observed for remained exposers including smoking, gender, physical activity, BMI and age (Appendix 3). A visual inspection of the funnel plot and Begg's test for asymmetry revealed no significant publication bias (P_value: 0.714) (Fig. 2).

Risk of bias assessment

In the current study 16.67% of studies ($n = 11$), had very good (7 stars) reporting quality, while 42.42% studies ($n = 28$), had acceptable (5–6 stars) quality, and 40.91% ($n = 27$) had low quality (Appendix 4).

Pooled adjusted OR

Among cross-sectional studies, Smokers had a higher odd of having uncontrolled diabetes compared to non-smokers, but it isn't statistically significant, adjusted OR 1.41. (95% CI: 0.76, 2.61, p-value = 0.273). With each unit increase in systolic blood pressure, the likelihood of uncontrolled diabetes increases, but it isn't statistically significant, adjusted OR 1.35. (95% CI: 0.89, 2.04, p-value = 0.159). With each unit increase in diastolic blood pressure, the likelihood of uncontrolled diabetes increases, but it isn't statistically significant, adjusted OR 1.02. (95% CI: 0.96, 1.08, p-value = 0.510). With each unit increase in level of education, the likelihood of uncontrolled diabetes decreased, but it isn't statistically significant, adjusted OR 0.59. (95% CI: 0.34, 1.102, p-value = 0.059). With each unit increase in level of physical activity, the likelihood of uncontrolled diabetes decreased, and this association was statistically significant, adjusted OR 0.41. (95% CI: 0.24, 0.72, p-value = 0.02).

With each unit increase in BMI, the likelihood of uncontrolled diabetes increases, and this association was statistically significant, adjusted OR 1.83. (95% CI: 0.54, 6.22, p-value = 0.333) (See Fig. 3).

In other hand among case-control studies, with each unit increase in level of education, the likelihood of uncontrolled diabetes decreased, but it isn't statistically significant, adjusted OR 0.85. (95% CI: 0.50, 1.10, p-value = 0.137). With each unit increase in level of physical activity, the likelihood of uncontrolled diabetes decreased, and this association was statistically significant, adjusted OR 0.30. (95% CI: 0.03, 2.88, p-value = 298) (See Fig. 4).

Finally, one cohort study was identified in the comprehensive search, this subgroup was not included in the meta-analysis.

Discussion

In this study, we investigated the impact of both modifiable and non-modifiable factors on diabetes control. The included studies presented various indices; some reported crude odds ratios, while others provided adjusted odds ratios, and some presented both. To account for the influence of confounding factors (such as age, gender, smoking status, education level, systolic blood pressure, diastolic blood pressure, and BMI), we chose to report our findings separately based on the type of index used. - The adjusted odds ratio (AOR) is preferred over the crude odds ratio (COR) because it accounts for confounding variables that could distort the observed relationship between exposure and outcome. While the COR measures the direct association without considering other factors, the AOR provides a clearer understanding by controlling for these extraneous influences. This allows researchers to isolate the primary exposure's effect and draw more accurate conclusions about the relationship being studied. Although the crude analysis revealed significant effects from several variables, our final analysis and conclusions were based on

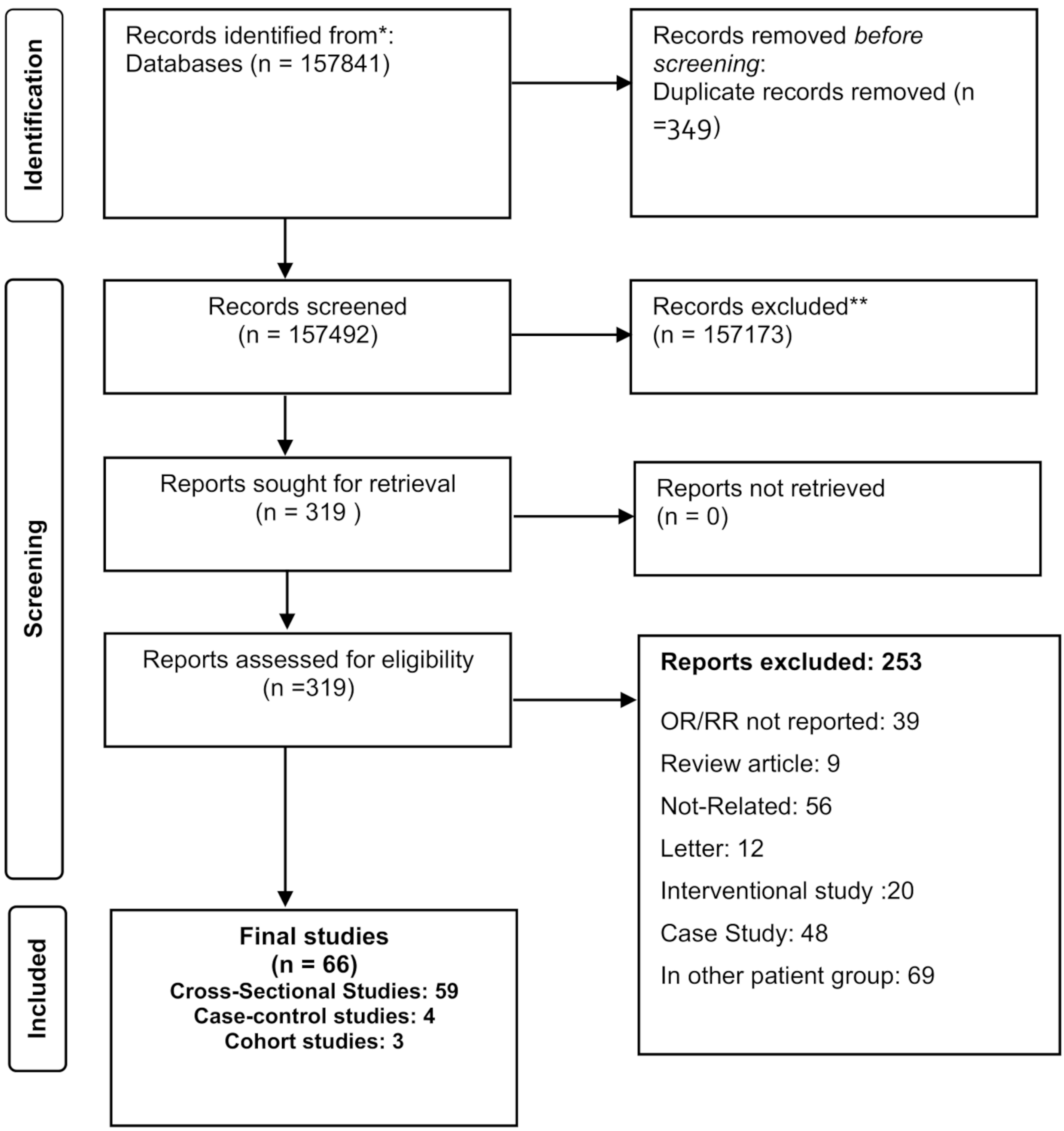

Fig. 1 A flow diagram depicting the phases of retrieving articles, checking eligibility criteria, and including the articles into the meta-analysis

the adjusted indices. Crude analyses offer a preliminary look at relationships, revealing raw associations without accounting for confounding factors. In contrast, adjusted analyses control for the confounders, providing more reliable estimates of true effects. Differences between the two types of analyses can indicate the impact of confounders, highlighting the significance of context in data interpretation. Ultimately, adjusted results clarify causal relationships, leading to more informed recommendations and policy decisions.

The present review study employed a combination of cross-sectional, case-control, and cohort studies. Combining results from various study designs in review studies and meta-analyses can lead to complications due to differences in methodologies, objectives, and potential biases. Each study design possesses distinct strengths and weaknesses that impact data interpretation, validity, and

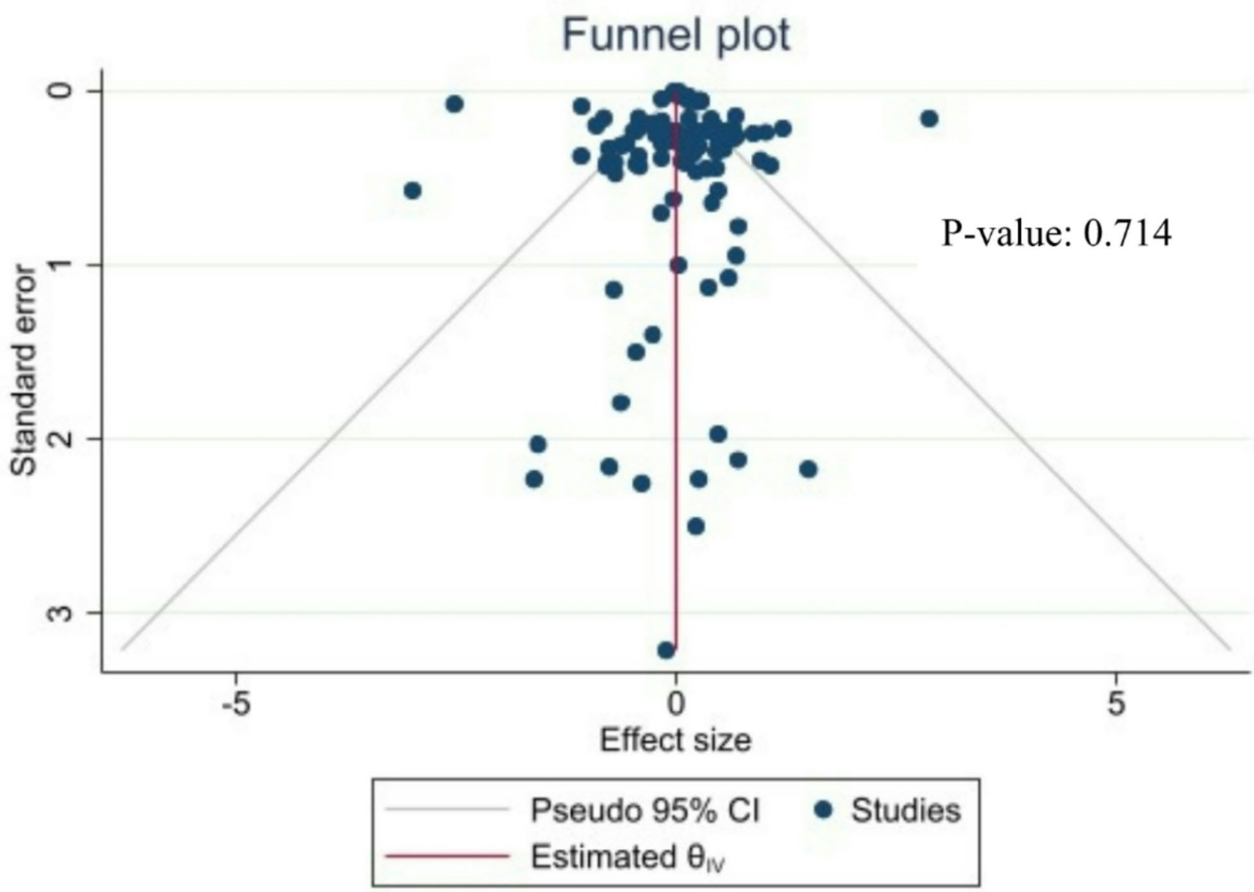

Fig. 2 funnel plot for assessing the publication bias

generalizability. Consequently, the results were reported separately based on the study designs.

In this study, we examined the impact of eight variables on uncontrolled diabetes. Of these, seven showed no statistically significant relationships, while only one variable—physical activity—demonstrated a significant adjusted effect. We indicated with each unit increase in level of physical activity, the likelihood of uncontrolled diabetes decreased, and this association was statistically significant.

Regular exercise improves insulin sensitivity, aiding in better blood sugar control, especially for those with insulin resistance. It helps manage blood sugar spikes after meals and contributes to weight management, which is crucial since excess weight is a key risk factor for type 2 diabetes [74], recent meta-analysis showed regular exercise greatly enhances insulin sensitivity in adults with type 2 diabetes mellitus (T2DM), and these benefits may continue for more than 72 h after the last exercise session [75]. Additionally, exercise promotes cardiovascular health by lowering blood pressure and improving cholesterol levels, benefiting individuals with diabetes who have a higher risk of heart disease. It also positively affects mental health by reducing stress and anxiety, which can further influence blood sugar levels. Overall, physical activity enhances muscle strength, flexibility, and endurance, reducing the likelihood of diabetes-related complications [76].

The American Diabetes Association (ADA) recommends that individuals with diabetes should aim to engage in at least 150 min of moderate-intensity aerobic activity each week, complemented by resistance training on two or more days [77]. A comprehensive exercise programmed that incorporates aerobic activities, strength training and flexibility exercises can markedly improve diabetes management.

Strengths and weaknesses

The present systematic review was conducted with a large sample size, which was the desired number of included studies. Although we had some significant limitations as well. The relationship identified in this review is based on cross-sectional studies, which limits our ability to draw definitive conclusions about causality due to unclear

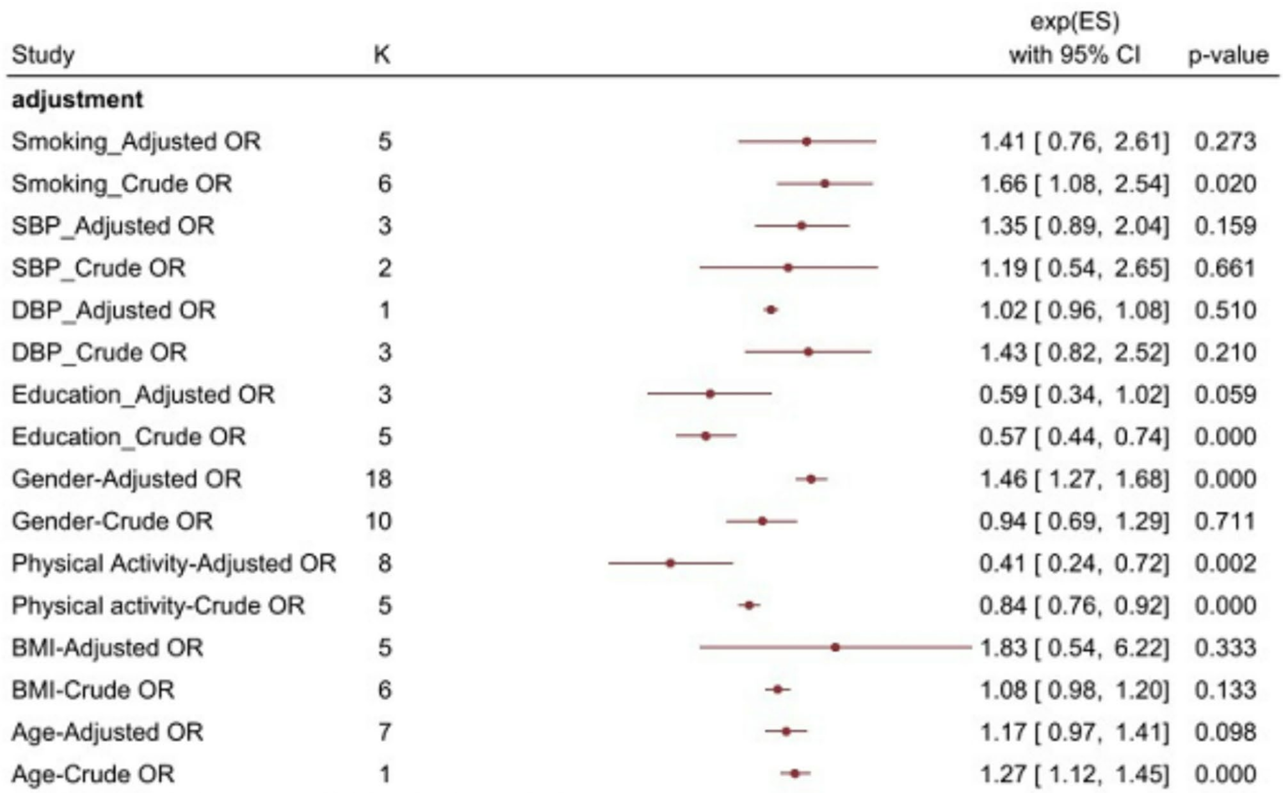

Fig. 3 Forrest plot of pooled odds ratio of risk factor/preventive factor of poor glycemic control in cross-sectional studies

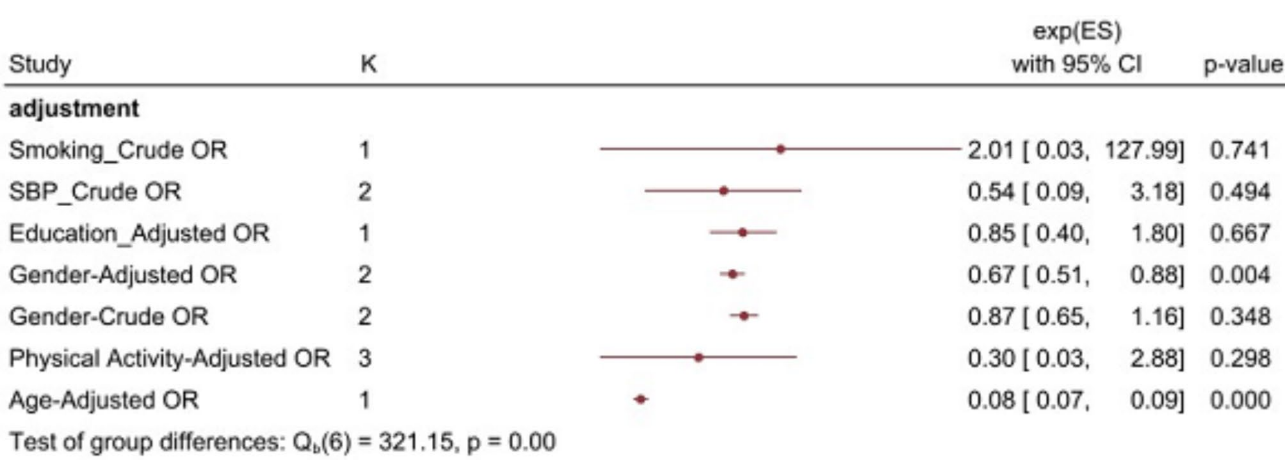

Fig. 4 Forrest plot of pooled odds ratio of risk factor/preventive factor of poor glycemic control in case-control studies

temporal precedence. Another major limitation is the lack of robust observational studies, such as case-control and cohort studies; our conclusions were therefore drawn solely from cross-sectional analytical studies. In order to achieve a more precise identification of preventive and risk factors for effective diabetes management, the implementation of more robust studies, such as case-control and cohort studies, is recommended. The relationships identified in these studies are closer to causality due to reduced bias due to temporal precedence (temporal bias).

Conclusion

Our systematic review and meta-analysis study showed that increased levels of physical activity in individuals with type 2 diabetes enhance the chances of achieving better glycemic control.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12902-025-01906-3.

Supplementary Material 1

Supplementary Material 2

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None.

Author contributions
Conceptualization, N.M, Z.Ch.; methodology, N.M, Z. Ch and A.DI; formalanalysis, Z. Ch and A.DI.; investigation, N.M, Z.Ch.; data collection: N.M, writing—original draft preparation, N.M and Z.Ch. writing, review and editing, N.M, Z.Ch. All authors have read and agreed to the published version of the manuscript.

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Data availability
Tha Data available on request.

Declarations

Ethics approval and consent to participate
The Institutional Review Board and the Ethics Committee of Hamadan University of Medical Sciences, Hamadan, Iran, approved this study (IR.UMSHA.REC.1401.636).

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Clinical trial number
Not applicable.

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