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Impact of gestational diabetes mellitus on women's sexual function: a systematic review and meta-analysis

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Abstract

Background Gestational diabetes mellitus (GDM) is a prevalent pregnancy complication with well-established adverse effects on maternal and fetal health. However, research on its impact on sexual health is inconsistent. Currently, there is no comprehensive review on sexual function in pregnant women with GDM. The purpose of this study is to systematically gather and synthesize the available evidence, addressing this important research gap.

Methods This systematic review and meta-analysis utilized a comprehensive literature search strategy and incorporated the following databases: the Cochrane Library, Scopus, PubMed, Web of Science, SID, and Google Scholar. The search was conducted until February 21, 2024. The quality of the cross-sectional and case–control studies included in the current study was evaluated via the modified and standard Newcastle–Ottawa scale. The certainty of the evidence was evaluated via the Grading of Recommendations, Assessment, Development, and Evaluations (GRADE) framework. A meta-regression was conducted to examine the variables that influence total sexual function. Additionally, sequential analysis was performed to determine the required information size for the meta-analysis.

Results The systematic search process yielded a total of 370 studies. The final analysis included six studies. The meta-analysis findings revealed that compared with controls, women with GDM had significantly lower total scores for sexual function (SMD − 1.80, 95% CI -3.44 to -0.15, $p = 0.03$), sexual desire (SMD − 5.14, 95% CI -8.14 to -2.14, $p < 0.001$), arousal (SMD − 0.58, 95% CI -0.95 to -0.21, $p = 0.002$), lubrication (MD -0.41, 95% CI -0.59 to -0.22, $p < 0.001$) and satisfaction (SMD − 3.82, 95% CI -6.08 to -1.57, $p < 0.001$). However, the analysis did not reveal statistically significant differences in sexual pain, or orgasm between the GDM and control groups. The meta-regression analysis revealed that older age in the control group was associated with poorer sexual function.

Conclusion Compared with control women, pregnant women diagnosed with GDM have lower sexual function. Further research with larger sample sizes is necessary to enhance the robustness of the evidence, given the low level of certainty. Healthcare providers should focus on the sexual well-being of women with GDM and create tailored interventions to address their specific needs.

Keywords Diabetes, Pregnancy, Sexual dysfunction, Hyperglycemia

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Background

According to the World Health Organization (WHO), the concept of sexual health goes beyond simply the absence of issues or dysfunction. Instead, the WHO defines sexual health as a broader state of overall well-being related to one's sexuality and intimate life. It necessitates a positive and respectful approach to sexuality and relationships, facilitating pleasurable and safe sexual experiences devoid of coercion, discrimination, and violence [1]. Sexuality is a fundamental aspect of the human experience and is significantly shaped by the intricate interplay of cultural, legal, economic, environmental, and interpersonal factors [2].

Sexual function encompasses the capacity to experience and progress through various phases of arousal, desire, and orgasm, as well as the mental satisfaction derived from the frequency and outcomes of one's individual and interpersonal sexual activities [3]. Factors that can affect sexual functioning include poor physical and mental health, stress, negative body image, and reproductive system problems [4]. Furthermore, certain diseases, such as diabetes, can contribute to sexual dysfunction in both pregnant and nonpregnant women [5, 6].

The existing review studies and meta-analyses have typically concentrated more on sexual dysfunction linked to established cases of type 1 or type 2 diabetes. These comprehensive analyses shed light on the significant prevalence and underlying factors of sexual problems in individuals living with these more apparent forms of the disease. Sexual dysfunction affects approximately 61.4% of people with overt diabetes globally [7, 8]. The development of sexual disorders in individuals with diabetes is complex, with various contributing factors, including metabolic, vascular, neurological, hormonal, and psychological mechanisms [7, 8]. For women with overt diabetes, common sexual difficulties include low sexual desire, reduced arousal, difficulty achieving orgasm, and painful intercourse. The physiological factors related to diabetes can significantly impact sexual function and intimate relationships in many individuals living with this chronic condition [9]. Diabetes encompasses a wide range of reproductive health concerns [10], and research has shown that women with diabetes experience disruptions across various stages of the sexual response cycle [11]. In men with overt diabetes, erectile dysfunction is highly prevalent and can be an early indicator of worsening cardiovascular health [12, 13]. The physiological and psychological impacts of overt diabetes appear to significantly impair sexual function and intimate relationships for many individuals living with this chronic condition [8, 12, 14].

Pregnancy, a period characterized by significant physiological and psychological changes, substantially impacts women's sexual function [15]. Research has shown that women are more likely to experience sexual dysfunction and distress during the third trimester of pregnancy [15, 16]. Several factors contribute to these disturbances, such as concerns from their partners, worries about potential harm to the fetus, and the perceived risk to the pregnancy [16, 17]. Women with high-risk pregnancies experience a reduction in their quality of sexual life, including sexual dissatisfaction, sexual aversion, and dyspareunia [18].

Gestational diabetes mellitus (GDM) is a highly prevalent health condition that can arise during pregnancy. It represents one of the more common complications that pregnant women may face, with global estimates indicating that it affects approximately 14% of all pregnancies. This poses a significant challenge for healthcare providers tasked with managing and treating GDM effectively [19, 20]. The pathways by which diabetes can lead to adverse outcomes during pregnancy are linked to factors such as high maternal and fetal blood sugar levels, epigenetic changes, elevated oxidative stress, and other underlying mechanisms [21]. GDM can lead to adverse outcomes, including an elevated frequency of cesarean sections, fetal overgrowth, preterm births, and an increased likelihood of the mother subsequently developing type 2 diabetes [19, 22]. The purpose of this study was to systematically gather and synthesize existing evidence on how GDM affects the sexual function of pregnant women. Despite the potential adverse effects of GDM on women, fetuses, and their sexual function, the current body of observational studies has yielded inconsistent findings. While some studies have reported no significant differences in sexual function between pregnant women with and without GDM [23–25], others have reported more sexual problems in those with GDM [26–28]. Additionally, prior reviews have only examined sexual function in pregnant women without diabetes [21, 29–31], overlooking the unique challenges faced by those with GDM. Filling this knowledge gap is important, as it can inform healthcare providers, researchers, and pregnant women themselves about the potential sexual health impacts of GDM during pregnancy.

Methods

This study was conducted in alignment with the guidelines specified in the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) reporting checklist [32]. Additionally, as of February 8, 2024, this study has been registered in the PROSPERO database under the registration ID CRD42024507098. (https://www.crd.york.ac.uk/prospero display record.php? Record ID = 507098).

Inclusion and exclusion criteria

Types of studies

The review included all observational study designs, including cohort, case–control, descriptive, and analytical descriptive approaches. In contrast, the researchers excluded other types of publications, such as editorials, case reports, intervention studies, review articles, conference proceedings, and studies examining sexual dysfunction in the postpartum period or in nondiabetic or nonpregnant populations.

Participant type

The eligible participants for the study were women who met the following criteria: had singleton pregnancies in either the second or third trimester, were aged 18 years or older, had been in a sexually active relationship with the same partner for a minimum duration of 6 months, and did not have any known pregnancy-related complications or were not taking any medications that could affect their sexual function. GDM was identified between 24 and 28 weeks of pregnancy through a 75-gram oral glucose tolerance assessment.

Control group

Studies that included a control group of healthy pregnant women without any complications, such as gestational diabetes, were eligible for inclusion. Studies without a control group were excluded.

Outcomes of the study

The primary endpoint of this study was the participants' total score on the sexual function assessment. The secondary endpoients assessed the specific dimensions of sexual function, such as sexual desire, sexual arousal, vaginal lubrication, ability to reach orgasm, sexual satisfaction, and sexual pain.

Outcome measures

The systematic review and meta-analysis included studies that utilized validated instruments to assess sexual function, such as the Female Sexual Function Index (FSFI), Pregnancy Sexual Response Inventory (PSRI), or Golombok-Rust Inventory of Sexual Satisfaction Female Questionnaire (GRISS).

The FSFI is a 19-item questionnaire that covers six areas of sexual function: arousal, desire, lubrication, satisfaction, orgasm, and pain. Scores range from 2 to 36, with higher scores indicating better sexual function. A score of 26.55 or lower is indicative of sexual dysfunction [33].

The PSRI is a 26-item instrument that encompasses ten dimensions, including the ability to reach orgas, female sexual difficulties, frequency of sexual activity, initiation of sexual encounters, male sexual challenges, male sexual fulfillment, overall sexual satisfaction, pain during intercourse, sexual arousal, and sexual desire. Scores range from 0 to 100, with 75–100 indicating excellent sexual function, 50–75 indicating good sexual function, 25–50 indicating poor sexual function, and below 25 indicating very poor sexual function [34, 35].

The GRISS is a 28-item assessment tool that evaluates seven dimensions of sexual function: anorgasmia, avoidance, communication, frequency of relations, satisfaction, touch, and vaginismus. The participants rated each item on a 5-point scale from 0 to 4. Higher total scores (out of a maximum of 112) reflect greater sexual quality and functioning [36].

Search methods

Search methods

Two researchers (MMa and MMi) independently systematically searched several electronic databases, including the Cochrane Library, Scopus, PubMed, Web of Science, the Persian database SID, and Google Scholar, with searches covering studies published up to February 21, 2024. Furthermore, the researchers reviewed the reference lists of the included articles to identify any further relevant studies that may have been missed.

The search terms used to find relevant literature included both free-text keywords and controlled vocabulary such as MeSH terms. These covered concepts related to "women", "pregnancy", "sexual function", "sexual dysfunction", and "gestational diabetes mellitus". The full search strategies used across the different electronic databases are included in the supplementary materials.

Screening and inclusion of relevant studies

The researchers (MMa and MMi) took a rigorous and diligent approach to selecting the data for this study. Two researchers independently conducted the literature search via EndNote X19 reference management software. They began by removing any duplicate or repetitive studies from the initial pool of literature. The two researchers independently reviewed the titles and abstracts of all potentially relevant studies. The authors subsequently conducted a thorough full-text review of the eligible studies [13, 37].

During the full-text review stage, the researchers closely examined the complete text of each potentially relevant reference to assess whether it aligned with the predetermined inclusion criteria for this study. For any studies that did not satisfy the inclusion criteria, the researchers meticulously documented the specific reason(s) why they were excluded. Any discrepancies between MMa and MMi concerning which studies to include or exclude were settled through discussion and reached an agreement with a senior reviewer (S.MA.) [37].

Data collection

Two researchers (MMa and MMi) independently conducted a manual review and data extraction process via a Microsoft Word 2016 document. The information extracted from the included studies included BMI (body mass index), country of origin, first author's name, gestational age, mean age of participants, publication date, race, reported outcomes, results, sample size for each group, and tools used to measure sexual function. Any issues that arose during the data extraction were worked through collaboratively with a senior reviewer (S.MA.) until a mutually agreed-upon resolution was reached [37].

Assessment of study quality

Two researchers (MMa and MMi) utilized the modified Newcastle-Ottawa Scale (NOS) to evaluate cross-sectional studies and the standard NOS for case-control studies included in the current investigation. Any discrepancies that arose during the quality assessment process were worked through collaboratively with a more experienced reviewer (S.MA.) until a mutually agreed-upon resolution was reached [37].

The NOS is a tool used to assess the methodological quality of observational studies. It has a maximum possible score of 9 points. Studies that earned a score between 7 and 9 points were considered to have high methodological quality. On the other hand, scores ranging from 0 to 3 were indicative of low methodological quality. Studies that scored between 4 and 6 points were categorized as having moderate methodological quality [38, 39].

Statistical analysis

The statistical analysis was conducted via RevMan version 5.4 software. When a consistent measurement tool was available for the desired outcome, the mean difference (MD) was calculated. In cases where different measurement tools were used, the standardized mean difference (SMD) with a 95% confidence interval (CI) was utilized. The degree of heterogeneity across the studies was quantified via the I^2 metric and evaluated for statistical significance via the chi-square test. Values ranging from 30 to 60% indicated moderate heterogeneity, whereas values between 50% and 90% suggested substantial heterogeneity. Significant heterogeneity was considered when the I^2 statistic ranged from 75 to 100% [40]. When the level of heterogeneity exceeded the 30% threshold, a random effects model was applied rather than a fixed effects model [41].

The primary outcome was further analyzed through subgroup comparisons based on study design (cross-sectional vs. case–control). Additionally, comprehensive meta-analysis version 3 software was employed to conduct meta-regression analysis on the total sexual function score. The analysis considered variables such as the mean ages of participants in the intervention and control groups, the mean gestational age, the total sample size, the percentage of married women, the study type, and the proportion of women with at least a high school level of education. Given the relatively small number of studies included (fewer than ten), an evaluation of potential publication bias was not performed.

We conducted a sensitivity analysis using Stata version 17 to assess the robustness of our findings. This analysis included a leave-one-out approach, in which individual studies were systematically removed to evaluate their effect on the overall results.

Trial sequential analysis (TSA) was performed via TSA software version 0.9.5.10 Beta to control the risk of type I and II errors and determine the required information size (RIS) for the primary endpoint via the random effects model. Assuming a statistical power of 80% and a type I error rate of 5%, the Z-curve analysis would yield conclusive evidence regarding the outcome of interest if it crossed the prespecified trial sequential monitoring boundaries or reached the RIS [42].

The level of confidence in the evidence was determined through the application of the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) framework.

The quality rating assigned to a study was fundamentally determined through a comprehensive assessment of several critical factors, with this evaluation process allowing for potential upward or downward adjustments to the initial rating. On the downgrade side, the quality rating could be lowered if concerns were identified regarding the risk of bias present in the study, any inconsistencies in the findings, issues related to indirectness, problems with the overall precision of the data, or evidence suggestive of publication bias. Conversely, the rating could be upgraded if the study demonstrated a large magnitude of effect, a dose–response relationship, and appropriate consideration of any residual confounding variables that may have influenced the outcomes. Ultimately, the final quality rating reflects the careful balance and weighing of this multifaceted evaluative criterion [43, 44]. The resulting confidence ratings were categorized into one of four qualitative levels: high, moderate, low, or very low.

Results

Search results

A total of 370 studies were obtained through systematic searches of databases and the Google Scholar search engine. After removing duplicate studies and excluding them for other reasons, 226 articles were evaluated for screening. Among these, 211 studies were removed because of irrelevance. The remaining 15 studies were assessed for eligibility, of which three studies [44–47]

were excluded because of study design, one study [48] focused on investigating sexual function in women with a history of gestational diabetes during the postpartum period, and three studies [49–51] were excluded because of irrelevant outcomes or participants under investigation. One study [52] was excluded because of duplicate published results. One study [53] was excluded from the current study because it involved participants with GDM who were examined on the basis of their BMI categories, specifically normal BMI and overweight. The qualitative synthesis included data from six studies [23–28], whereas the meta-analysis was based on data from five studies. One study [25] was omitted from the meta-analysis because it did not provide sexual function scores for the different treatment groups (Fig. 1).

Study characteristics

Three studies were conducted in Brazil [23, 24, 26], one study in Turkey [28], and two studies in Iran [25, 27]. The publication year of the included articles varied between 2012 and 2021. The study included a total of 881 women. There were 400 participants in the GDM group and 481 participants in the non-GDM group. Five studies were conducted with a cross-sectional design [23–25, 27, 28], and one was a case–control study [26]. The study enrolled pregnant women who were all at least 18 years old. The mean age was 29.67 years in the control group and 30.97 years in the GDM group.

The diagnosis of diabetes in all women with GDM was evaluated via a 75-gram GTT, and the control group in all studies consisted of healthy or low-risk pregnant women. The included studies evaluated sexual function via different assessment tools, such as the GRISS, FSFI, and PSRI questionnaires. Specifically, the FSFI was employed in 4 studies [23–25, 27], the PSRI was used in the study by Nunes et al. [24], and the GRISS questionnaire was utilized in the study conducted by Ozcan et al. [28] (Table 1).

Assessment of the quality of the included studies

Most included studies received a score of 7 or higher on the modified NOS, suggesting a low risk of bias.

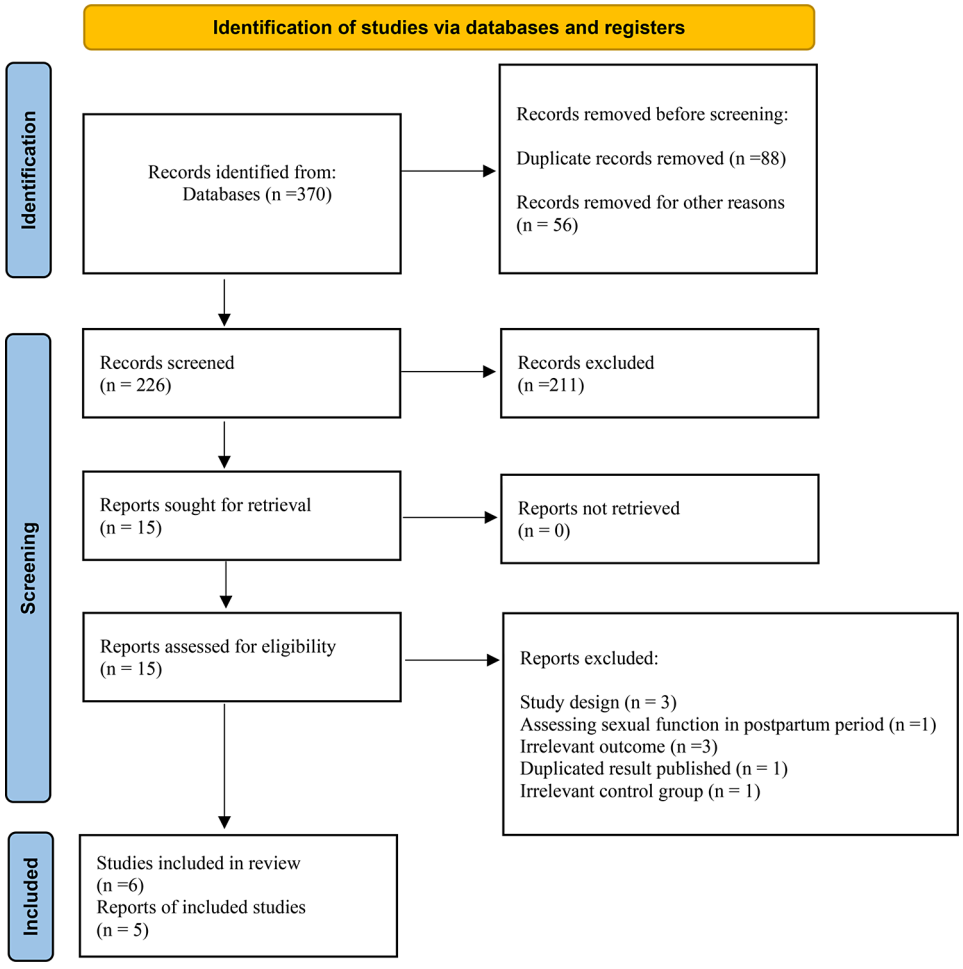

Fig. 1 Flow diagram of the systematic literature search

Table 1 Characteristics of the included studies

First author/date of publication/country	Type of studies	Sample size	Age of participants (years)	Gestational age (weeks)	Race	BMI (kg/m2)	Comparison	Outcome measurements	Outcome	Results	NOS
Souza et al. [23]/Brazil	Cross-Sectional	GDM group: 33 Control group: 55	GDM group: 30.94 ± 6.2 Control group: 26.1 ± 6.0	20 to 25 weeks	GDM group: White = 32% Non-white = 68% Control group: White = 45% Non-white = 55%	NR	Low-risk pregnancy	FSFI	Total score of Sexual Function Prevalence of sexual dysfunction Sexual function domains (sexual desire, arousal, lubrication, orgasm, satisfaction, and pain)	There was no statistically significant difference in the total score of sexual function, orgasm, and satisfaction scores between the groups with GDM and the control groups.	7
Ribeiro et al. [24]/Brazil	Cross-Sectional	GDM group: 44 Control group: 43	GDM group: 30.8 ± 5.2 Control group: 29.2 ± 5.5	GDM group: 33.8 ± 3.0 Control group: 33.9 ± 3.6	GDM group: White = 54.5% Non-white = 45.5% Control group: White = 53.5% Non-white = 46.5%	NR	Healthy Pregnancy	FSFI	Total score of Sexual Function Sexual function domains (sexual desire, arousal, lubrication, orgasm, satisfaction, and pain)	There was no statistically significant difference observed in the total score of sexual function ($P = 0.523$), sexual desire ($P = 0.775$), arousal ($P = 0.407$), lubrication ($P = 0.749$), orgasm ($P = 0.655$), satisfaction ($P = 0.956$), and pain ($P = 0.571$) scores between the groups diagnosed with GDM and the control groups.	7
Nunes et al. [26]/ Brazil	CCase-Control	GDM group: 108 Control group: 168	GDM group: 28.9 ± 4.7 Control group: 25.1 ± 5.3	GDM group: 37.0 ± 2.7 Control group: 35.4 ± 3.2	NR	GDM group: 33.25 ± 5.44 Control group: 30.22 ± 5.45	Healthy Pregnancy	PSRI	Total score of Sexual Function Prevalence of sexual dysfunction Sexual function domains (sexual desire, arousal, orgasm, satisfaction, pain, and frequency of sexual relations)	There was a statistically significant difference in the prevalence of sexual dysfunction ($P < 0.0001$), total score of sexual function ($P < 0.0001$), frequency, arousal, orgasm, satisfaction, pain, and female difficulties score ($P < 0.0001$) between the groups diagnosed with GDM and the control groups.	6

Table 1 (continued)

First author/date of publication/country	Type of studies	Sample size	Age of participants (years)	Gestational age (weeks)	Race	BMI (kg/m2)	Comparison	Outcome measurements	Outcome	Results	NOS
Zare et al. [27]/Iran	Cross-Sectional	GDM group: 150 Control group: 150	GDM group: 31.31 ± 0.46 Control group: 28.73 ± 0.41	GDM group: 34.38 ± 0.18 Control group: 34.78 ± 0.2	GDM and control groups = White 100% (Persian)	NR	low-risk pregnancy	FSFI	Total score of Sexual Function Sexual function domains (sexual desire, arousal, lubrication, orgasm, satisfaction, and pain)	There was a statistically significant difference in the total score of sexual function ($P = 0.001$), sexual desire ($P = 0.001$), lubrication ($P = 0.003$), satisfaction ($P = 0.001$), and pain ($P = 0.004$) scores between the groups diagnosed with GDM and the control groups.	9
Ozcan et al. [28]/Turkey	Cross-Sectional	GDM group: 65 Control group: 65	GDM group: 31.68 ± 3.23 Control group: 29.48 ± 4.06	GDM group: 32.14 ± 3.96 Control group: 31.35 ± 6.08	GDM and control groups = White 100% (Turkish)	NR	Healthy Pregnancy	GRISS	Total score of sexual function Sexual function domains (Satisfaction and frequency of sexual relations)	There was a statistically significant difference in the total score of sexual function ($P < 0.0001$) and sexual satisfaction ($P < 0.0001$) between the groups diagnosed with GDM and the control groups.	7
Tabande et al. [25]/Iran	Cross-Sectional	GDM group: 75 Control group: 75	27.8 ± 5.7	NR	GDM and control groups = White 100% (Persian)	NR	Healthy Pregnancy	FSFI	Total score of Sexual Function Sexual function domains (sexual desire, arousal, lubrication, orgasm, satisfaction, and pain)	There was no statistically significant difference in the total score and domain-specific scores of sexual function between the groups diagnosed with GDM and the control groups.	5

FSFI = Female Sexual Function Index, PSRI = Pregnancy Sexual Response Inventory, GRISS = Golombok-Rust Inventory of Sexual Satisfaction Female Questionnaire, GDM = Gestational Diabetes Mellitus, BMI = Body Mass Index, NR = Not Reported

However, two studies [25, 26] received scores of 6 and 5, respectively, suggesting a moderate risk of bias (Supplementary File, Table 1).

Meta-analysis

Primary outcomes

Total score of sexual function

The results of the meta-analysis revealed a statistically significant reduction in the total sexual function score for women with GDM compared with non-GDM women (SMD −1.80, 95% CI -3.44, -0.15; 5 studies, 884 women; $p=0.03$; random effects; low-certainty evidence). The heterogeneity was considerable ($p<0.0001$, $I^2=99\%$).

The subgroup analysis, stratified by study design, revealed that the type of study design—either cross-sectional ($I^2=99\%$) or case–control ($I^2=$ not applicable)—did not significantly affect the overall sexual function scores reported across the different studies ($p=0.31$) (Fig. 2).

Secondary outcomes

The meta-analysis results demonstrated a statistically significant decrease in sexual desire (SMD −5.14, 95% CI -8.14 to -2.14, 4 studies, 751 women; $p<0.001$; random effects; low-certainty evidence; $I^2=99\%$), arousal (-0.58, 95% CI -0.95 to -0.21, 4 studies, 751 women; $p=0.002$; random effects; low-certainty evidence; $I^2=81\%$), lubrication (MD -0.41, 95% CI -0.59 to -0.22, 3 studies, 475 women; $p=0.31$; fixed effects; low-certainty evidence; $I^2=0\%$), and satisfaction (SMD −3.82, 95% CI -6.08 to -1.57, 5 studies, 881 women; $p<0.001$; random effects; low-certainty evidence; $I^2=99\%$) among women with GDM compared with the control groups. However, the analysis did not reveal any statistically significant differences in sexual pain (SMD 0.99, 95% CI -1.25 to 3.22, 4 studies, 751 women; $p=0.39$; random effects; low-certainty evidence; $I^2=99\%$), or orgasm (SMD −0.74, 95% CI -1.52 to 0.05, 4 studies, 751 women; $p=0.07$; random effects; low-certainty evidence; $I^2=96\%$) between the GDM and control groups (Supplementary File, Table 2; Fig. 1).

Meta-regression

Meta-regression analyses using a random-effects model indicated that studies with older control groups had lower sexual function scores than those with younger control groups.

Specifically, the beta coefficient for this association was −0.532, and it was statistically significant, with a p value of 0.002. However, the analysis did not find any significant associations between sexual function and the mean age of the intervention group ($p=0.437$), percentage of married women ($p=0.554$), mean gestational age ($p=0.395$), study type ($p=0.647$), total sample size ($p=0.128$), or percentage of women with a high school education or higher ($p=0.414$) (Supplementary File, Table 3).

Trial sequential analysis

TSA was performed on the total sexual function score (primary outcome), with a variance of 0.711, a two-sided α of 5%, a β of 20%, an I^2 of 99.6%, and an RIS of 2300. The Z-curve did not reach the trial sequential monitoring boundaries or the RIS The results from the TSA suggest that the current data are insufficient and lack the necessary statistical power. Consequently, further studies are required to draw a definitive conclusion (Fig. 3).

The overall level of certainty regarding the evidence

The evidence for all outcomes was assessed to have low certainty due to issues with inconsistency and

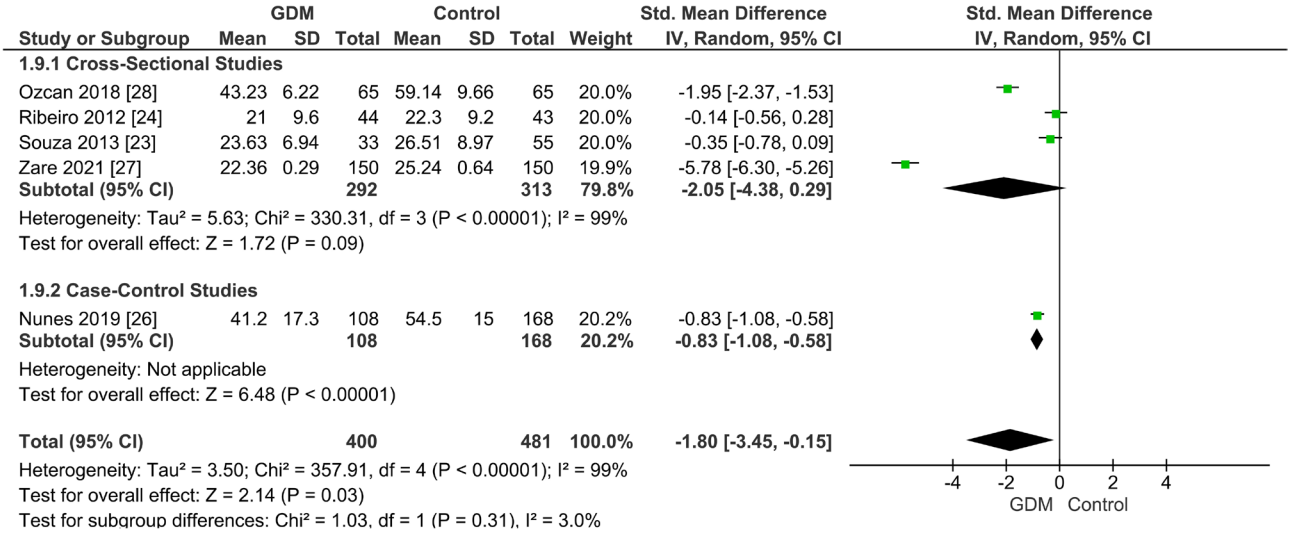

Fig. 2 Forest plot of the total score of sexual function in women with gestational diabetes mellitus (GDM) compared with non-GDM women

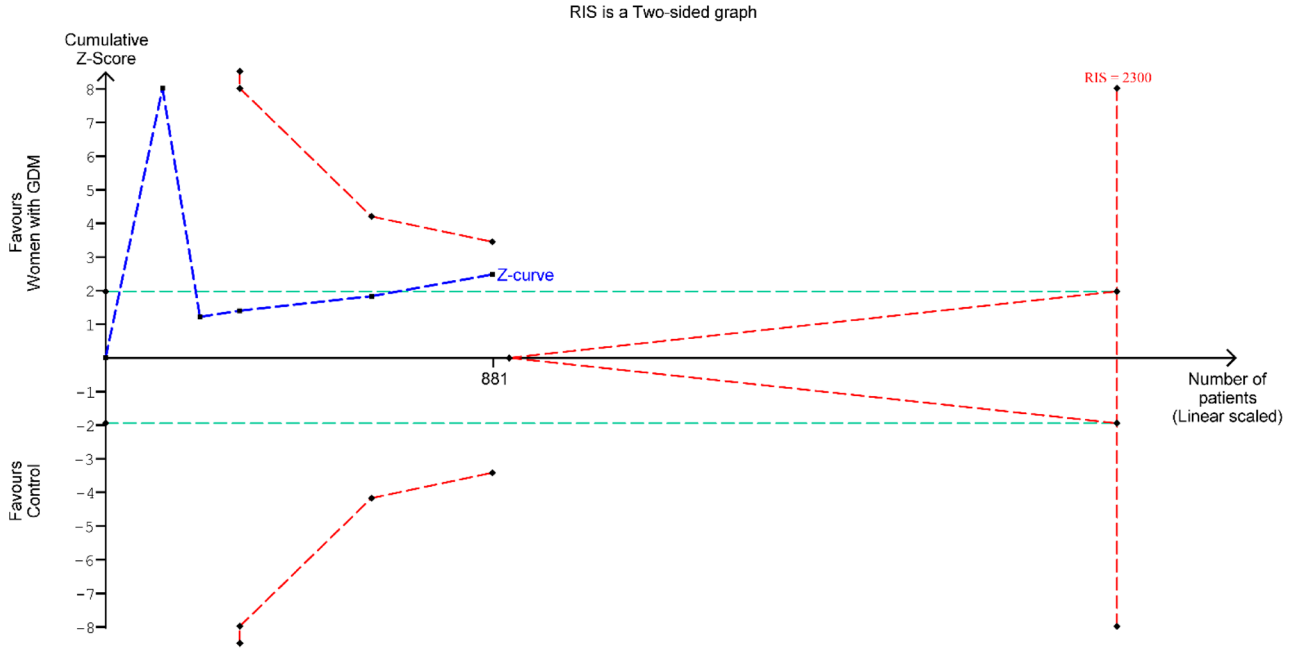

Fig. 3 Trial sequential analysis for the total score of sexual function in women with gestational diabetes mellitus (GDM) compared with non-GDM women (5 studies, alpha: 5%, beta: 80%, mean difference (MD): -7.23, variance: 0.711, $I^2 = 99.9$ (Model variance based), required information size (RIS): 2300)

imprecision, leading to a decrease in the overall confidence in the findings (Table 2).

Sensitivity analysis

The leave-one-out sensitivity analysis revealed that excluding certain studies resulted in significant changes in our findings. Specifically, the exclusion of the Zare et al. (2021) study rendered the associations between GDM and sexual desire, arousal, and lubrication non-significant. Similarly, the removal of the Nunes et al. (2019) study led to the associations for the total score of sexual function and arousal also becoming non-significant (Supplementary File, Table 4).

Discussion

The results of the present investigation indicate that women with GDM experience lower overall sexual function than pregnant women without GDM. More specifically, the GDM group had significantly lower scores in the areas of sexual desire, arousal, lubrication, and satisfaction. In contrast, the study did not find statistically significant differences between the GDM group and the non-GDM group with respect to sexual pain, or orgasmic function. These findings align with previous research, which has consistently reported a high prevalence of sexual dysfunction in nonpregnant women with diabetes [7, 54]. For example, a cross-sectional study revealed that all domains of the FSFI were decreased in nonpregnant women with type 2 diabetes, with the largest reduction observed in sexual desire [55]. Interestingly, the current study revealed that the most significant decrease in the GDM group was also related to sexual desire. This is noteworthy, as sexual desire naturally varies throughout pregnancy, reaching a peak in the second trimester before declining in the third trimester due to physical and emotional changes [15].

Interestingly, the two included studies [23, 26] that reported no difference in total sexual function between the GDM and control groups had relatively smaller sample sizes of GDM participants (33 and 44, respectively) than the other included studies did.

The causes behind the sexual difficulties experienced by women with diabetes, including those with GDM, are complex and multifaceted [56–58]. One critical pathway involves the accumulation of advanced glycation end products (AGEs) in reproductive organs. Sustained hyperglycemia in diabetes leads to the nonenzymatic formation of these AGEs, which can directly impair the structure and function of the gonads, erectile tissues, and other reproductive tissues [56]. AGEs have been shown to interfere with normal signaling pathways regulating sexual arousal and response, as well as stiffening the vasculature to supply the genital tissues, compromising blood flow and impairing lubrication and engorgement [59]. Furthermore, the presence of AGEs induces oxidative stress and inflammation, which can negatively affect the neural, vascular, and hormonal aspects of sexual function [60]. In pregnant women with GDM, additional hormonal and metabolic changes worsen these pathways. This results in more urinary problems and a decrease in

Table 2 Summary of findings for the main comparison. Sexual function in women diagnosed with gestational diabetes. Patient or population: GDM women. Setting: Brazil; Iran; and Turkey. Exposure: GDM. Comparison: Non-GDM women

Outcomes	Anticipated absolute effects [95% CI]		Relative effect [95% CI]	No of Participants [studies]	Quality of the evidence
	Risk with non-GDM	Risk with GDM			
Total score of sexual function	The mean of the total score of sexual function in the control groups was 46.16	The mean of the total score of sexual function in the GDM group was 1.80 [-3.44, -0.15]	SMD − 1.80 [-3.44, -0.15]	881 [4 Cross-Sectional and 1 Case–Control]	Low [a] ⨁⨁◯◯
Sexual desire	The mean of sexual desire in the control groups was 34.96	The mean of sexual desire in the GDM group was − 5.31 [-8.31, -2.30]	SMD − 5.31 [-8.31, -2.30]	751 [3 Cross-Sectional and 1 Case–Control]	Low [a, b] ⨁⨁◯◯
Arousal	The mean of arousal in the control groups was 29.39	The mean of arousal in the GDM group was − 0.56 [-0.92, -0.21]	SMD − 0.56 [-0.92, -0.21]	751 [3 Cross-Sectional and 1 Case–Control]	Low [c, b] ⨁⨁◯◯
Lubrication	The mean of lubrication in the control groups was 26.23	The mean of lubrication in the GDM group Was − 2.51 [-7.36, 2.33]	MD -2.51 [-7.36, 2.33]	475 [3 Cross-Sectional]	Low [a, b] ⨁⨁◯◯
Orgasm	The mean of orgasm in the control groups was 27.86	The mean of orgasm in the GDM group Was − 1.21 [-2.80, 0.38]	SMD − 1.21 [-2.80, 0.38]	751 [3 Cross-Sectional and 1 Case–Control]	Low [a, b] ⨁⨁◯◯
Satisfaction	The mean of satisfaction in the control groups was 29.27	The mean of satisfaction in the GDM group Was − 4.29 [-6.59, -2.00]	SMD − 4.29 [-6.59, -2.00]	881 [4 Cross-Sectional and 1 Case–Control]	Low [a, b] ⨁⨁◯◯
Pain	The mean of pain in the control groups was 38.40	The mean of pain in the GDM group Was 0.83 [-1.25, 2.91]	SMD 0.83 [-1.25, 2.91]	751 [3 Cross-Sectional and 1 Case–Control]	Low [a, b] ⨁⨁◯◯

Low quality: the actual effect may vary significantly from the estimated value

a The statistical tests indicate high heterogeneity ($I^2 = 99\%$, $p < 0.001$) despite relatively good overlap of confidence intervals, leading to a 2-level downgrade in the assessment

b The evidence was rated down by 1 level due to imprecision caused by a wide confidence interval

c The statistical tests revealed high heterogeneity ($I^2 = 80\%$, $p < 0.001$) despite the relatively good overlap in the confidence intervals. This led to a 1-level downgrade in the assessment

overall well-being, as reported in previous studies [61, 62].

Previous studies have indicated that sexual dysfunction affects approximately 70% of pregnant women [63]. This alarmingly high rate underscores the importance of better understanding and addressing this significant issue, which can have considerable implications for expectant mothers' overall health and well-being. Some studies have explored potential demographic factors associated with sexual dysfunction during pregnancy. For instance, research indicates that the prevalence of sexual dysfunction increases with age, affecting both women and their partners [15]. This finding aligns with our meta-regression results, which reveal a negative relationship between age and sexual function in our control groups. In contrast to our analysis, which found no association between education level and sexual function, previous studies have identified a positive correlation between education level and sexual dysfunction. This finding is less intuitive [64, 65]; however, This may be due to more educated women having greater awareness and expectations regarding sexual health, leading to more frequent reporting of dysfunction.

The observed difference was potentially influenced by the limited number of studies included in the meta-analysis. Expanding this research area by examining larger and more diverse populations could help shed light on how different demographic factors might influence sexual dysfunction during pregnancy.

Strengths and limitations

This systematic review and meta-analysis makes a significant contribution by providing the first comparative assessment of sexual function in women with GDM versus non-GDM women. Additionally, the use of meta-regression analysis offers more profound insights into the impact of confounding factors on the relationship between GDM and sexual function. Third, the study utilized TSA to investigate the RIS and the conclusiveness of the available evidence, enhancing the reliability of the findings. Finally, the researchers conducted a comprehensive literature search and evaluated the strength and reliability of the evidence via the GRADE methodology. This approach enables a comprehensive and transparent assessment of the available information.

One limitation of this study is that it considered only research articles published in English and Persian. This

may have excluded relevant studies in other languages, potentially restricting the broad applicability of the findings across diverse global populations. Second, the included studies were geographically limited to Brazil, Turkey, and Iran, limiting the ability to extrapolate the results to women with GDM in other regions where healthcare systems and cultural norms may differ. The limited number of studies and high heterogeneity, along with challenges in assessing publication bias, restricted the reliability of the findings.

Practical applications

The results of our study have several significant implications for healthcare professionals who work with pregnant women, especially those diagnosed with GDM.

Research suggests that women with GDM may experience reduced sexual function, thereby suggesting increased awareness and routine screening for these issues. Healthcare providers should consider implementing targeted interventions to address deficits in sexual desire, arousal, and satisfaction, such as counseling, educational resources, or referrals to specialists. A multidisciplinary approach involving various healthcare professionals, including obstetricians, endocrinologists, mental health experts, and sexual health specialists, is recommended to provide comprehensive care given the complex physical and psychological factors involved. Additionally, proactive patient education and support to normalize the experience and encourage help-seeking can be beneficial, as providers can discuss the potential impact of GDM on sexual function, provide resources, and create an environment where women feel comfortable seeking assistance.

Implications for future research

Our study provides valuable insights that can guide future research on the sexual health of pregnant women with GDM. Due to the limited number of studies and their considerable heterogeneity, which affects how we interpret our findings, it is crucial to conduct larger-scale investigations involving diverse populations. This approach will provide more robust insights and help shape better practices and policies. Key directions for future research include longitudinal studies that follow women with GDM throughout pregnancy and into the postpartum period, which could offer critical insights into the trajectory of sexual function over time. Additionally, further research is needed to closely examine the relationship between glycemic control and various aspects of sexual function in this population. The incorporation of qualitative methods could provide a deeper understanding of the personal experiences and challenges faced by these women. Developing and evaluating targeted interventions aimed at improving sexual function and overall well-being in women with GDM will contribute to a comprehensive understanding of this important issue.

Conclusion

This review highlights the importance of addressing the sexual well-being needs of women with GDM. These aspects should be considered an essential part of holistic care throughout pregnancy. By recognizing and addressing these needs, healthcare providers can contribute to the overall well-being and quality of life of this vulnerable population. However, the evidence indicated low certainty, and TSA suggests that the current data are insufficient and lack the necessary statistical power, with considerable heterogeneity observed among the included studies. This highlights the need for further research involving larger and more diverse populations to validate these findings and evaluate potential publication bias.

Abbreviations

AGEs	Advanced glycation end products
BMI	Body mass index
CI	Confidence interval
FSFI	Female sexual function index
GDM	Gestational diabetes mellitus
GRISS	Golombok-Rust Inventory of Sexual Satisfaction Female Questionnaire
GTT	Glucose tolerance test
MD	Mean difference
NR	Not reported
PSRI	Pregnancy Sexual Response Inventory
RIS	Required information size
SE	Standard error
SMD	Standardized mean difference
TSA	Trial Sequential Analysis

Supplementary Information

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Supplementary Material 1

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Author contributions

MMi and MMa played equal roles in various aspects of the study, including literature screening, assessment of the quality of included studies, and writing the manuscript. They were also involved in conducting statistical procedures and interpreting the findings. All authors contributed to editing the manuscript and approving the final submission.

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Data availability

All data relevant to the study are included in the article or uploaded as an additional file.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Clinical trial number
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Competing interests
The authors declare no competing interests.

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