Literature Review

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Physical activity pre- and during pregnancy and gestational diabetes onset across multi-ethnic pregnant populations: a systematic review and meta-analysis of epidemiological studies

Abstract

Background: Gestational diabetes mellitus (GDM) is a common complication during pregnancy and is associated with adverse pregnancy outcomes and maternal and neonatal risks. Lifestyle intervention through physical activity is generally similar to dietary management in that it helps reduce weight and improve metabolism. However, it functions more on the preventive side of the spectrum in managing risk rather than actual treatment and management of the condition. This review aims to present an updated systematic review to determine the relationship between physical activity and onset of GDM across multi-ethnic pregnant populations.

Methods: A systematic review and meta-analysis of epidemiological studies was conducted. We identified papers published from 2010 onwards using CINAHL, MEDLINE, EMBASE, Cochrane, ASSIA, PsycInfo, PubMed and Web of Science databases. Studies were limited to English language only, pregnant populations by ethnicity and reported physical activity pre- and during pregnancy.

Results: Our research identified one pre-pregnancy and seven during-pregnancy studies. These studies were six prospective cohort studies, two case-control studies and one cross-sectional study. Physical activity was assessed pre-pregnancy in four studies, giving a pooled odds ratio (OR) of 0.68 (95% CI 0.53, 0.86). Physical activity in early and mid-pregnancy was assessed in five studies, giving a pooled OR of 0.77 (95% CI 0.66, 0.90) and 0.70 (95% CI 0.35, 1.40), respectively.

Conclusion: Findings suggest that high total physical activity pre- and during pregnancy has a significant protective effect against GDM.

Keywords: GDM, physical activity, prevention, epidemiological studies, ethnicity

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Abbreviations: ACOG, american college of obstetricians and gynaecologists; CI, confidence interval; FITT, frequency, intensity, type and time; GDM, gestational diabetes mellitus; GWG, gestational weight gain; IADPSG, international association for diabetes in pregnancy; IPAQ, international physical activity questionnaire; MET, metabolic equivalent task; ORs, odds ratios; PA, physical activity; PPAQ, pregnancy physical activity questionnaire; PRISMA, preferred reporting items for systematic reviews and meta-analyses; RCOG, royal college of obstetricians and gynaecologists; SB, sedentary behaviour; SOGC, society of obstetricians and gynaecologists of canada guidelines; T2DB, type 2 diabetes mellitus; WHO, world health organization

Introduction

Gestational diabetes mellitus (GDM) is glucose intolerance resulting in hyperglycaemia at first onset during pregnancy.[1,2] In 2019, there were 223 million women living with diabetes and this number is estimated to rise to 343 million by the year 2045.[3] Among these, 20.4 million live births had hyperglycaemia in pregnancy, of which 83.6% were due to GDM.[4] The clinical manifestations of GDM emerge between the 24th and 28th weeks of pregnancy and affect 14.4% of pregnant women globally.[5,6,4] GDM has a substantial effect on the health of mother and foetus. Women with GDM are at higher risk of developing complications and adverse pregnancy outcomes[7] such as pre-term birth, pre-eclampsia, caesarean delivery, macrosomia and neonatal hypoglycaemia.[8,9] In addition, both women and their infants are more likely to have cardiovascular diseases, become obese or overweight and develop type 2 diabetes mellitus (T2DM).[10,7]

Lifestyle intervention through physical activity is generally similar to dietary management in that it helps reduce weight and improve metabolism. However, it functions more on the preventive side of the spectrum in managing risk rather than actual treatment and management of the condition.[10] Most pregnant women benefit from practising physical activity at different pregnancy stages.[11] Benefits include improved feelings of wellbeing, decreased stress and fatigue, lower rates of excessive gestational weight gain (GWG), GDM, lower birth weight, premature birth and preeclampsia, and improved cardiorespiratory function.[12] In addition, physical activity has beneficial impacts during the postpartum period including reduced GWG and depression, improved mental health and wellbeing and prevention of T2DM development in the future.[13] The current recommendations for physical activity practice are based on the standards of the American College of Obstetricians and Gynaecologists (ACOG) and the Royal College of Obstetricians and Gynaecologists (RCOG), which state that physical activity should be performed at moderate intensity, five days a week for 30 minutes or at least 150 minutes a week.[13]

Issues around comparability of GDM prevalence and data quality varied between the regions.[14] Southeast Asia reported the highest

prevalence of 27.0% compared to the Middle East and North Africa region at 7.5%.[4] Ethnicity has been known to be a significant risk factor for GDM development, especially among minority ethnic groups such as Middle Eastern and East, Southeast and South Asian ethnicities in Western countries.[15,16] Health-related practices are strongly shaped by social patterns, cultural factors and living conditions.[17] The development of different ethnic communities and linguistic groups, each with its own cultural characteristics and health profiles, presents healthcare practitioners and policymakers with a dynamic challenge in terms of ensuring equitable access.[18] Greater knowledge of these factors and more studies on methods that can help close the gap between how different ethnicities prevent and manage GDM would possibly result in lower incidence rates and better outcomes.

A previous meta-analysis of epidemiological studies reported an association between physical activity and GDM but no ethnicity analysis was conducted.[5] In this systematic review, our research team synthesised available evidence from epidemiological studies of physical activity interventions pre- and during pregnancy for preventing GDM across multi-ethnic populations. This review aims to present an updated systematic review to determine the relationship between physical activity and onset of GDM across multi-ethnic pregnant populations.

Methods

Search strategy

CINAHL, MEDLINE, EMBASE, Cochrane, ASSIA, PsycInfo, PubMed and Web of Science databases were searched from November 2019 to November 2020 by one member of the research team using a broad search strategy to identify all potentially relevant publications. The text words contained in the titles and abstracts of relevant articles and the index terms used to describe the articles were used to develop a full search strategy. The search strategy, including all identified keywords and index terms, was adapted for each database source included. Initial keywords used in this review were "GDM", "physical activity", "ethnicity" and "prevention", together with the Boolean operator "AND" or "OR". Finally, additional studies were searched for in the reference lists of all identified reports and articles.

Inclusion and exclusion criteria

Studies were included if they met the following criteria: 1) subjects were pregnant population by ethnicity and ≥ 18- 40 years old; 2) studies of physical activity interventions that either subjectively or objectively measured meeting the FITT (frequency, intensity, type and time) principles; 3) studies that reported physical activity pre- and during pregnancy; 4) the onset of GDM was reported as the outcome; 5) epidemiological studies: cohort, case-controls and cross-sectional studies. Studies were excluded if they were in a language other than English, published before 2010, case studies and systematic or narrative reviews.

Study selection

A process of screening and supplementary search parameters was used to ensure relevance to the topic and duplicate articles were removed. Following abstract review, studies were excluded if they were not primary research, unrelated to GDM, excluded human participants, non-English language or did not have full text available for the review. The full text of selected citations was assessed in detail against the inclusion criteria by two independent reviewers. Reasons for exclusion of full-text studies that did not meet the inclusion criteria were recorded and reported in the systematic review. Disagreements between the reviewers at each stage of the study selection process were resolved through discussion and by including a third reviewer if required. The results of the search were reported in full in the final report and presented in a Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) flow diagram.[19]

Quality assessment

The selected epidemiological studies were assessed for methodological quality using the Newcastle–Ottawa Scale and checked with the second reviewer. The scale assesses the selection of the study sample (a maximum of four points), the comparability of the group sample (maximum of two points), the assertion of outcome (for cohort studies, a maximum of three points) or assertion of exposure (for case-control studies, a maximum of three points) and the assessment of outcome for cross-sectional studies (maximum of two points). A third reviewer was available for consultation where there was disagreement between the two reviewers to allow for consensus about methodological quality.

Data extraction

Data from the selected studies were extracted using standardised tables to bring all the data together for easy reference. These included author/year/country, ethnicity, sample size, gestational period, physical activity definition and study outcomes.

Data analysis

Data analysis was conducted using Stata version 16 (StataCorp, College Station, TX). Tabulated data of adjusted odds ratios (ORs) were extracted from the included studies at three gestational periods (pre-, early and mid-pregnancy). Meta-analyses were performed separately according to gestational period to estimate weighted measures of effect across studies by using either fixed or random effect models depending on the level of heterogeneity. Outcomes were reported as OR with 95% confidence intervals (CIs) for binary outcomes (i.e., the onset of GDM) for the highest versus the lowest total physical activity. Heterogeneity was measured using the I^2 index. A p-value less than 0.05 was considered to be statistically significant. Subgroup analyses for ethnicity were synthesised narratively.

Results

A total of 4,570 studies were identified from different electronic databases and other sources. All the citations identified were collected and imported into EndNote and 1,056 duplicates removed. Scanning titles and abstracts and removing irrelevant studies resulted in 143 full texts for review, of which eight were found to be suitable for this review and 135 were excluded. The detailed selection process of PRISMA flowchart is illustrated in Figure 1.[19]

Characteristics of included studies

Participants

A total of 18,795 pregnant women were enrolled across the included studies. A summary of the participants' characteristics is shown in Table 1. All included studies were conducted in different healthcare facilities across seven countries. Studies published between 2010 and 2018 had a sample size varying from 100 to 11,403. There were six prospective cohort studies, two case-control studies and one cross-sectional study. Multi-ethnic pregnant populations were the focus of attention in this review. The main bulk of the studies focused on East, Southeast and South Asia (n= 4). Specifically, China, Vietnam, Malaysia and India. The remaining population studies were Caucasians, Hispanics, Middle Eastern, Africans and Native American.

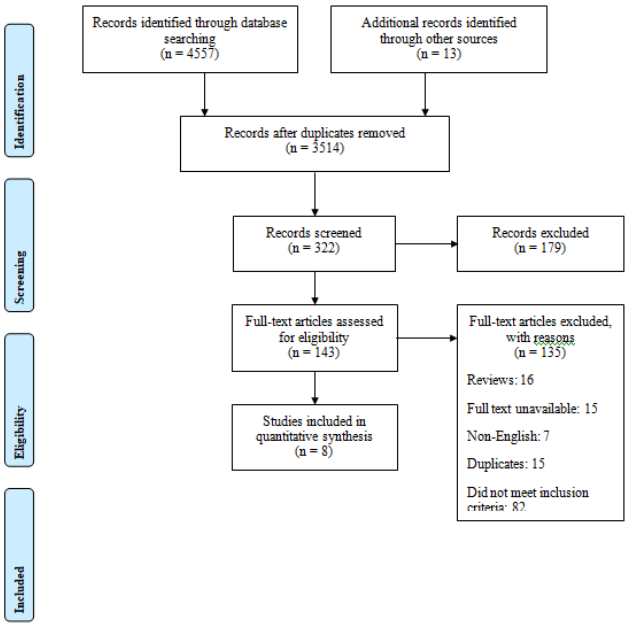

Figure 1 PRISMA Flowchart of the Study Selection Process.

Intervention

FITT

Assessment of physical activity was part of a standardised self-reported questionnaire. Each activity was measured in relation to weekly energy expenditure on physical activity and expressed in metabolic equivalent task (MET)-hours per week.[20] MET scores were based on different physical activity questionnaires and scores ranged from 1.5-6 (light- to vigorous-intensity activity). Physical activity sessions of at least 30 minutes were reported in three studies.[6,21,22] The number of sessions ranged from one to five days a week. Intensity of physical activity was reported in the included studies and varied between light and vigorous intensity. The included studies assessed the association between different types of physical activity and GDM. For example, domestic chores, gardening, household and caregiving activities, recreational and occupational physical activity. Only one study by[22] objectively measured physical activity with an accelerometer.

Synthesis of results

Outcome

Among the eight studies included for this review, four different criteria were employed for GDM diagnosis. Two were based on WHO criteria,[20,23] two on Carpenter and Coustan criteria,[24,25] one on International Association for Diabetes in Pregnancy (IADPSG),[22] one on the Society of Obstetricians and Gynaecologists of Canada guidelines (SOGC)[26] and two were not reported.[21,6]

Physical activity pre-pregnancy

Two cohort studies and one cross-sectional study were included in the analysis of total pre-pregnancy physical activity and GDM Figure 2.[6,21,26] The three studies showed a protective effect against GDM, however, only [22] was significant. In this meta-analysis, there was no heterogeneity (I^2= 0.00%, p= 0.98) and when the three studies were pooled together, the pooled OR was 0.68 (95% CI 0.53, 0.86) p= 0.002. The fixed-effects model used for this meta-analysis suggests a significant 32% lower risk of GDM associated with highest total physical activity versus lowest total physical activity.

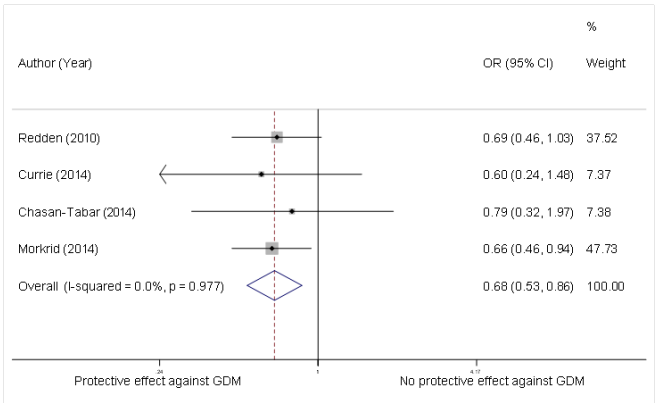

Figure 2 Results of meta-analysis: total pre-pregnancy physical activity.

Physical activity during early pregnancy

All four studies showed a protective effect against GDM, but only two were significant Figure 3.[22,20] In this meta-analysis, there was no heterogeneity (I^2= 0.00%, p= 0.85) and when the studies were pooled together, the pooled OR was 0.77 (95% CI 0.66, 0.90) p= 0.001. The fixed-effects model used for this meta-analysis suggests a significant 23% lower risk of GDM associated with highest total physical activity versus lowest total physical activity.

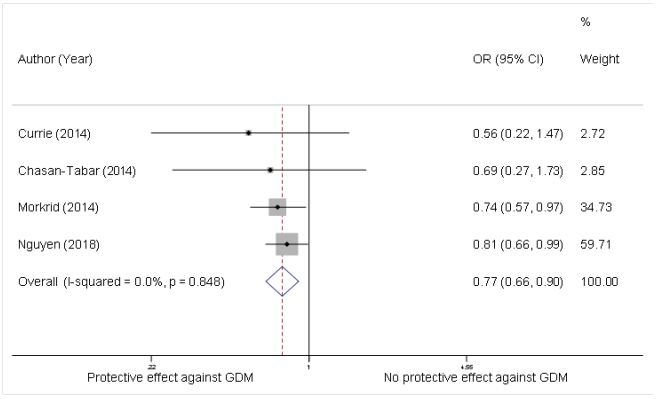

Figure 3 Results of meta-analysis: total physical activity during early pregnancy.

Physical activity during mid-pregnancy

Two cohort studies and two case-control studies were included in the analysis of total physical activity during mid-pregnancy and GDM Figure 4. The pooled OR was 0.51 (95% CI 0.2, 1.30) p= 0.000), which suggests a 49% lower risk of GDM associated with highest total physical activity versus lowest total physical activity. The random effects analysis shows a protective OR for the pooled effect. However, this association was not significant as the 95% CI crosses one (p= 0.16). The heterogeneity in study results was significantly high (I^2= 82.1%, p= 0.001) indicating study differences.

Physical inactivity

Two studies addressed the association of total sitting time and the risk of GDM. In the studies by Padmapriya et al. [23] and,[20] participants who stated they were sedentary had a non-significantly higher risk of GDM (OR 1.42 [95% CI 0.90, 2.22] p= 0.172) and (OR 0.98 [95% CI 0.75, 1.29] p= 0.973), respectively.

Ethnicity analysis

The included studies were designed to determine the relationship

between physical activity pre- and during pregnancy and onset of GDM among multi-ethnic populations Table 2. The studies by[20] and [23] revealed that highest total physical activity among Asian pregnant women was statistically significant with lower GDM risk (0.74 [95% CI 0.57, 0.97] p= 0.017) and (0.56 [95% CI 0.32, 0.98] p= 0.040), respectively.[25] sought to determine the effect of physical activity among South Asian pregnant women residing in Karnataka, India. The results revealed high odds of GDM among women who participated in low to moderate levels of physical activity (5.9 [95% CI 3.6, 9.8] p <0.001). The results were consistent with the findings of [24] which revealed a significantly high risk of developing GDM among Middle Eastern pregnant women (1.09 [95% CI 0.30, 3.96] p= 0.001).

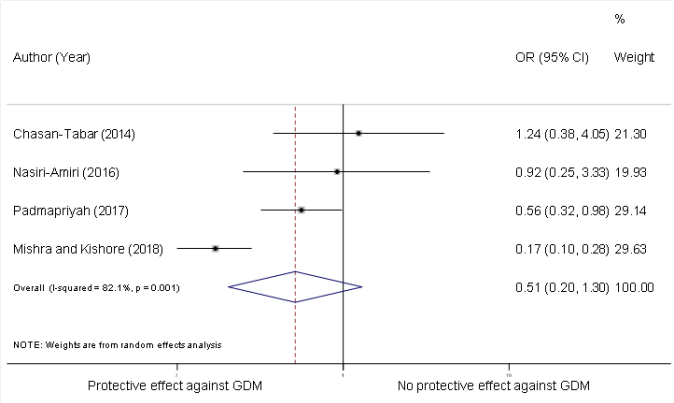

Figure 4 Results of meta-analysis: total physical activity during mid-pregnancy.

Two studies assessed the association among multi-ethnic pregnant populations residing in Western countries.[6,22] [6] concluded there was an inverse relationship between pre-pregnancy physical activity and GDM development. The odds of GDM were low, however, the result was not statistically significant after adjustment for ethnicity (0.69 [95% CI 0.46, 1.03] p= 0.10). On the other hand, the significant inverse relationship between objectively recorded physical activity and odds of GDM continued after adjustment for ethnicity (0.79 [95% CI 0.65, 0.97] p= 0.032).[22]

[21]assessed the relationship between pre- (0.79 [95% CI 0.32, 1.97] p=0.64), early (0.69 [95% CI 0.27, 1.73] p=0.72) and mid- (1.24 [95% CI 0.38, 4.05] p=0.999) pregnancy total physical activity and GDM risk among Hispanics. The relationship was not statistically significant. The results were consistent with the findings of [26]who found no significant association of physical activity in the year pre-pregnancy (p=0.24) and in the first half of pregnancy (p=0.28) with GDM development.

Discussion

This meta-analysis of eight studies determined the relationship between total physical activity and the onset of GDM among 18,795 multi-ethnic pregnant populations. The meta-analysis showed a protective effect of physical activity on the development of GDM. When stratified by gestational period, the association between high total physical activity and GDM was significant in pre- and early pregnancy but not in mid-pregnancy.

Multi-ethnic pregnant populations were the focus of this review. Our analysis indicates differences in study outcomes, which are mostly due to differences in physical activity measurements as well as ethnic differences between study groups. Only one study demonstrated that, after adjusting for ethnicity, objectively recorded physical activity was inversely associated with lower odds of GDM.[22] However,[6] demonstrated that, after adjusting for ethnicity, the relationship was not significant.

In the present review, the relationship between total physical activity pre- and during pregnancy and onset of GDM provided support for the hypothesis that physical activity reduces the risk of GDM and was consistent with the published literature. Both [28] (2004) studies and[29] found that physical activity pre- and during pregnancy was associated with a reduction in GDM risk. However, none of the estimates reached statistical significance. The meta-analysis conducted by[5] is consistent with our results. However, our review focused on studies published from 2010 until now to concentrate on up-to-date current research practices.

To the best of our knowledge, this review is the first meta-analysis focusing on the relationship between physical activity and onset of GDM in multi-ethnic pregnant populations. This meta-analysis included all eight studies focused on the topic. Conducting a comprehensive search to identify eligible studies across various relevant databases with time limitations indicates that most up-to-date studies were examined. In addition, the adoption of a well-known appraisal tool ensured, to some extent, that the bias of studies was limited. Nevertheless, adjustment for confounders was consistent across the studies.

One of the strengths of the present review was the use of a validated instrument for the assessment of physical activity. However, our analysis has some limitations. With regard to eligibility criteria, the search results identified eight papers for inclusion in this review with varied sample sizes, an unexpectedly small number given the recent rise in editorials and reports that recommend physical activity for the obstetric community. Retrieving studies published in English only may mean some eligible studies that could influence the conclusion of the review were excluded. In addition, there were difficulties in obtaining the full text of some studies even after attempts to contact the author. Among studies of physical activity during mid-pregnancy, high heterogeneity was found (I^2= 82.1%). However, there were not enough studies to carry out subgroup and meta-regression or other sensitivity analyses.

The methodological quality of the included studies was good. However, the main issue identified was the use of self-reported questionnaires to measure the exposure of interest, which are prone to recall bias physical activity that done in the year before pregnancy. Nevertheless, the nature of the majority of the studies included means it is unlikely to significantly affect the results since the authors collected the exposure information before GDM diagnosis, except for one study by[25]which may be prone to recall bias. Furthermore, this meta-analysis revealed no randomized controlled trials (RCTs) assessing the effect of physical activity on GDM risk preventions. Nevertheless, it would seem reasonable to believe that physical activity reduces the risk of GDM in a similar manner.

Conclusion

This meta-analysis has found a relationship between high total physical activity pre- and during pregnancy and prevention of GDM development in pregnant women. There remains a need to conduct further research on how women in other ethnic groups have been managing this condition or otherwise minimizing the risks of developing it. More importantly, policymakers must resist the urge to adopt a one-size-fits-all approach to the problem and instead work on devising policies and interventions that are best suited to the population they are being designed for. Comprehensive information should be not only be provided on GDM and its resulting complications but also

on the specific steps an expectant mother can take to minimize her risk of developing GDM.

Acknowledgments

None.

Conflicts of interest

The author declares there is no conflict of interest.

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