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Research Article

Effect of Lifestyle and Diet on Gestational Diabetes (GDM) in South Asian Women: A Systematic Review

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Abstract

Background: Evidence suggests that all forms of diabetes are on the increase, especially Gestational Diabetes Mellitus (GDM), which increases the risk of maternal and neonatal morbidities. However, the global effect of diet (HA) and lifestyle (PA) of GDM in the South Asian (SA) population remain uncertain. The study aimed to examine the global burden of gestational diabetes mellitus in the SA population living in UK.

Methods: A systematic review of the studies reporting the effect of diet and lifestyle on pregnant women who were a high risk of GDM was conducted. Cochrane (Central), PubMed, Scopus, JBI, Medline, EMBASE and reference lists of retrieved studies were searched from inception to December 2019. Publications on the effect of diet and lifestyle on GDM in the SA population were included in the study. Studies were limited to the English language and women aged between 18 and above inclusive.

Results: Though there are some studies on the management of GDM outside the UK covering from ethnic groups in the sample, in the context of UK there are not enough studies published to date. Twelve studies met the inclusion criteria for this review. The included studies collectively reported GDM rates of 13,450 pregnant women immigrants from 9 countries. The diagnostic criteria used in the studies were the World Health Organisation (WHO) 1985 and 1999, International Association of Diabetes, Pregnancy Study Group (IADPSG), National Diabetes Data Group (NDDG), Carpenter-Coustan (C&C) and O'Sullivan's criteria. Of 12 studies presented, 2 indicated diet restrictions specifically for SA GDM patients. 8 of the 12 studies showed physical activity in early pregnancy and post-operative monitoring and recommended food choices as well for the prevention of Type II Diabetes Mellitus (T2DM).Of the 12 studies reviewed, 2 indicated that dietary restrictions and physical activity through a smart phone APP is beneficial for reducing birth complications and T2DM in the near future.

Conclusion: This review suggests that dietary restrictions (healthy eating) and mild to moderate physical activity pre-pregnancy and continued throughout could help prevent GDM. Evidence also suggested that SA women, especially immigrants, with a low level of knowledge, low awareness and education, a language barrier, and cultural practices are more at risk of GDM than immigrants and non-GDM women as well.

Keywords: Diet; Gestational Diabetes; GDM; Immigrants; Lifestyle; South Asian; Women

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Introduction

Gestational Diabetes Mellitus (GDM) is defined as a high level of insulin in the blood with onset or first recognition during pregnancy. Unlike recognized diabetes antedating the onset of pregnancy, GDM is usually not recognized until the late second trimester and not linked with increased malformation rate. However, the raised maternal glucose and level of Amino acids can result in foetal complications such as macrosomia, hyperinsulinemia, shoulder dystocia, birth injuries, neonatal hypoglycaemia, respiratory distress syndrome, polycythaemia and hypocalcaemia. Whereas, the long term complications include weight gain and risk of developing T2DM in the near future as well [1,2]. Gestational Diabetes Mellitus (GDM) is the commonest medical disorder of pregnancy [1] where the level of insulin is high due to insufficient function of the pancreas to overcome the diabetogenic milieu of pregnancy. GDM is a state of glucose intolerance that was not existing or known before pregnancy [3]. The rate of GDM is constantly higher with associated risks of antenatal and postnatal complications and the chance of future Diabetes and Obesity in both mother and baby worldwide [4]. GDM is a state of hyper-glycaemia where the body is not able to make sufficient insulin to achieve the extra needs in pregnancy [5]. Globally, over 451 million people were assessed to have diabetes and about 21.3 million were estimated to be women and mostly affected by some forms of the high level of sugar in the blood during pregnancy. Out of this, nearly 18.4 million were due to GDM which shows that 14% of pregnancies per year are affected by GDM worldwide [6]. Back in 1882, a study by Matthews Duncan reported that 10 out of 19 maternal deaths which occurred at the time of labour or within a few weeks were due to diabetic coma caused by 'diabetes antedating pregnancy' This seminal study also stated that of the 27 pregnancies which were studied, 6 cases of abortion, whereas 8 others had stillbirth or death of babies soon after birth [7-9]. The current guidance on GDM diagnosis is a 75 g oral glucose tolerance test, which is recommended by the World Health Organisation (WHO, 1980). However, in some countries such as the US, the criteria for diagnosis are 100g oral glucose test. To Perform

a test 75-g oral glucose tolerance test (OGTT), with plasma glucose measurement fasting and at 1 and 2 h, at 24-28 of weeks' gestation in women not previously diagnosed with overt diabetes. NICE (National Institute for Health and Care Excellence) and SIGN (Scottish Intercollegiate Guidelines Network) have suggested the following triggers (risk factor) for oral glucose tolerance test in week 24-28 [10] BMI >30 kg /m^2, Previous neonate weighing ≥ 4.5 kg, Previous gestational diabetes, Family history (first degree relative) of gestational diabetes and Minority ethnic family origin with a high prevalence of diabetes [11,12].

One of the most dominant influences on the incidence of GDM is ethnicity. The prevalence of Gestational Diabetes Mellitus (GDM) has increased over the years predominantly in SA populations [13,14]. According to study conducted in 2013 depicts that annually almost 21 million people are diagnosed with the disease [15]. The prevalence of GDM is higher in the developing countries like Pakistan, India, Sri Lanka and Bangladesh and is mostly attributed to the low level of knowledge, awareness about risk and outcomes, low physical activity and dietary patterns [16]. GDM is found to be more prevalent in South Asian women as compared to white British women. It is reported that almost 20% of South Asian women above the age of 40 living in the UK have GDM. It was reported that the prevalence in South Asian women from India, Pakistan, Bangladesh, Nepal, Sri-Lanka and Bhutan is 15.2% as compared to the prevalence rate of 3.8% in the White British population. In Low-Middle Income Countries (LMIC) such as Pakistan and India GDM goes mostly unobserved with no noteworthy data available to date about the prevalence of this disease and development of preventive strategies [17]. GDM occurrence in Asian and South Asian women two to three times higher than national averages [18-20]. The occurrence of GDM is higher for Pakistani, Indian and Bangladeshi born women in the UK compared to the UK born Pakistani, Indian and Bangladeshi women and white British women [21]. This is explained by the differences in diet, cultural aspects, and lifestyles [21]. A study conducted in 2003 by Cianni highlights that women with a positive family history of T2DM shows chances of getting GDM during pregnancy and also increases the risk of getting T2DM in near future is compared with patients with a negative family history of T2DM [7]. Appropriate education about the diagnosis and prognosis of GDM, follow-up, advanced screening tools, diet restrictions, awareness, and a healthy lifestyle are key measures for the prevention of GDM and T2DM in these women. Likewise [3,22] evidence suggests that future risk of GDM and subsequent pregnancies is seven times higher in women with GDM compared to women without GDM. In a study in Iran also reported that GDM complication with a high BMI of above 30 [23], age above 30 years and a history of family diabetes. The key differences were inadequate knowledge of the disease, inadequate or unavailability of knowledge in their own language and poor self-management of diet restrictions, and poor physical activity lead to health problems for both mother and baby. The authors also suggested that further research with large sample size could investigate all of these differences. Immigrant women in the UK from SA countries have a higher rate of GDM compared to the UK born SA women. Among immigrant women in the UK, SA has the highest incidence rates, with more than 3 times the cases of GDM than UK born pregnant women. In addition to this, about half of the SA women with GDM develop T2DM within 14 years compared to 21.3% for the general population [24]. The treatment for GDM is similar to T2DM with mainly focussing on a healthy diet, increased physical activity and appropriate medication to maintain normal glucose levels in the blood. However, there are several socio-cultural barriers for the SA population in managing T2DM. For instance, some believe that diabetes is not a serious disease and there is no need for changes in the diet and lifestyle [1,10,25,26]. Additionally, some feel that educational resources for diabetes management do not account for culturally appropriate foods and do not consider their need for gender-specific exercise spaces. Moreover, Diabetes-related stigma makes it difficult for some SA to follow and management regimens [2,13,15,20,27].

Aims

This systematic review aims to investigate the effectiveness of Diet (healthy eating) and lifestyle (physical active) on GDM in South Asian (SA) women in the United Kingdom (UK).

Objectives

1. Effectiveness of healthy eating pre-pregnancy, pregnancy, and post-partum monitoring in women with GDM specifically SA immigrants living in the UK.
2. Effectiveness of mild to moderate physical activity in SA women with GDM during pregnancy and post-partum monitoring as well.

Methods

Search strategy

An intensive computerized literature search was undertaken to collect the research already available in the public spectrum concerning to GDM, diet, and lifestyle. Even though research has been carried out in this area since 1987, only literature published between the years of 2000 and 2019 were included, to select the most current research available. EMBASE, MEDLINE, Cochrane CENTRAL, Scopus, PubMed, Joanna Briggs Institute (JBI), TRIP and Cumulative Index to Nursing and Allied Health Literature (CINAHL) databases were searched from inception to week 11th December 2019 using a broad search strategy to identify all potentially relevant publications for this review. Broad keywords including Medical Subject Heading (MeSH) search terms "Diet" Lifestyle" South Asian women" "immigrants" and "UK" were combined with terms that covered "GDM", "Gestational diabetes mellitus", "Pregnancy-Induced Diabetes" and "Gestational Diabetes".

Inclusion criteria

Original publications reporting on the effectiveness of diet and lifestyle on GDM in the South Asian women were included in the study. Studies were limited to the English language, all studies, and women aged 18 years and above, previous history of GDM, current GDM more than 20 weeks of gestations inclusive.

Exclusion criteria

Studies that reported less than 20 weeks of gestations, high risk of T2DM and on medications for GDM, GDM with co-morbidities, articles published before 2000, studies written in a language other than English, studies on animals, inaccessible full-text papers were not included.

Selection of studies

Titles and abstracts of studies retrieved from the database were initially screened. Full details of those that fulfilled the inclusion criteria were assessed and included in the study whereas duplicates and irrelevant studies were excluded. Each Study was analyzed using the adapted CASP checklist. The Author aimed to retrieve further studies by

searching the references of studies. The study focused solely on diet, lifestyle, SA women living in the UK in the management of GDM. Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines were used for the study selection.

Data Extraction and Quality Assessment

Two review authors assessed the titles and abstracts of all articles identified from the database searches. Full texts of selected articles were retrieved and assessed independently for study eligibility. Disagreements were resolved through discussion or through consulting a third reviewer. The author showed in Figure 1 the PRISMA flow diagram used to narrow down the articles found on the search databases. A total of 12 studies were assessed in this review. The studies that met the inclusion criteria were printed onto A4 paper, separated by the design type and ordered according to the Hierarchy of Evidence [27]. Reviews were assessed using the Quality Criteria Checklist (CASP) for review articles. The author adapted the checklists by solely including questions that focused on the quality of the study. (APPENDIX). Each question was answered with a 'Yes' – receiving one point or 'No' or 'C/T' (Can't tell) receiving zero points. The quality of 12 selected studies was assessed based on the Cochrane risk-of-bias tool criteria using three domains: randomization method, allocation concealments, and blinding.

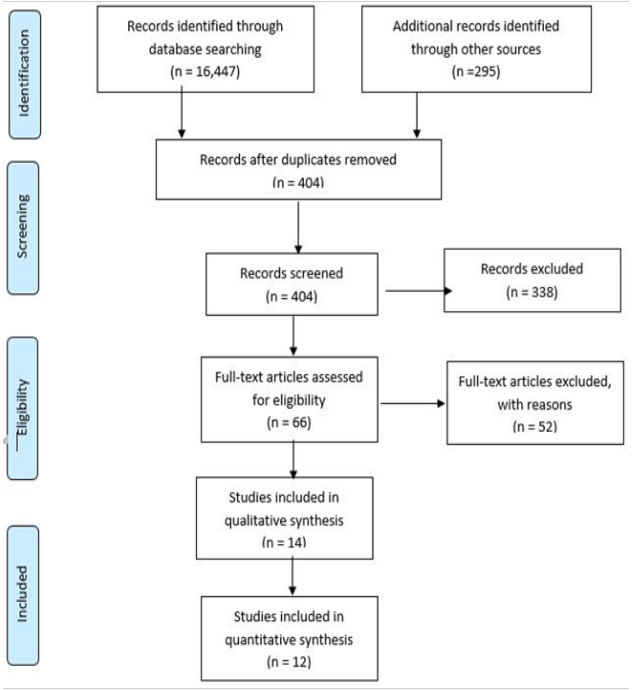

Figure 1: Shows PRISMA 2009 Flow Diagram.

Blinding and Randomisation

2 of 12 studies showed blinding between researcher and participants (studies 1 and 11). 9 of 12 studies showed a method of randomization; (studies 1, 2, 3, 4, 5, 6, and 12). Participants were randomised at their first visit to either selective screening when one or more risk factors were present or to universal screening (studies 1, 2, 6 and 4). Concealed randomisation was performed by independent researchers using a Web-based computerized procedure (studies 3, 5 and 6). Randomisation was generated using a computer program (SPSS16.0, Random Number Generator Version 1.0 Segobit software, Issaquah, WA, NUTTAB 2010 databaseN8 software, SAS V9R 292 database) (1,3 and 6)

Allocation Concealments

Only 4 out of 12 studies had information on a method of allocation concealment (studies 7,9,11 and 12). No clear information on allocation concealment was reported by the remaining 9 studies.

Results

A total of 16, 447 articles were identified from different databases and sources. Irrelevant studies were removed by assessing titles and abstracts. Removing duplicates and applying the inclusion criteria, 66 studies were retrieved for a more detailed assessment of full text; from which 12 were found to be suitable for this review and 54 being excluded with reasons. The characteristics of included studies are shown in Table 1. Which include all details about Author and year of study with full detailed participant's information with possible outcomes and type of intervention with results and follow-up as well. The ROB column showed the quality of study with possible bias participant's bias, sampling errors, outcomes and inappropriate errors in follow-up. The studies were published from 2000 – 2019. Details of 12 included studies and the risk of bias assessment through CASP checklist is shown in Table 2 and details of CASP checklist is in the appendix section.

Discussion

Globally rising rates of GDM and associated complications have prompted calls to identify potentially modifiable risk factors that are associated with GDM [11]. The present systematic review identifies 12 studies reporting on the effect of Diet in terms of healthy eating and physical activity and the consequent risk of GDM.

Theme 1: Diet and GDM risk

According to included studies only 1 study (3) mainly focussing on the type of specific diet, meal size and traditional foods during pregnancy with GDM.

Study Number	Author/ Year	Study information	Participants Information	Outcomes	Interventions	Results	Risk of Bias (ROB)
1	Reinhardt et al., 2012 [28]	South-wales2007-2010 Pilot study	N=38 N=18 n=20 Age=18 and above T2DM with previous GDM Number of children's Length of breast feeding in months, Family history of T2DM &GDM.	Diet BMI Lifestyle, Physical activity.	Intervention group;06-month phone-based motivational interview program and also access to usual care as well. Control group; The only access to usual care	At follow-up, the intervention group compared to the control group significantly reduced total fat intake by -19 g/d (95%CI: -37 to -1), total carbohydrate intake by -42 g/d (95%CI: -82 to -1), and glycemic load by -26 units (95%CI: -48 to -4).These women also increased leisure physical activity compared to the control group by 11 min/d (95%CI: 1 to 22); no significant change in total physical activity levels occurred.	7/10 Medium to high

						At follow-up, body mass index in the intervention group improved by -1.5 kg/m2 (95%CI: -2.8 to -0.1) compared to the contro group	
2	Bandyopadhyay et al., 2011 [29]	Melbourne, Australia April to December 2009. Qualitative study	n=17 age=18+ Median age is 28 years. Married Homemaker, unemployed and full-term employed. duration of stay =5 years in Australia immigrant countries: Pakistan, Bangladesh, India, Sri Lanka	Postpartum screening, Diet, lifestyle practices	Two-phased study First phase=face to face in-depth interviews from recent immigrants' women from South-Asia. Second phase= 23 GDM diagnosed women were an interview with their choice of place and time.	The majority of women with previous GDM ultimately presented for post-partum screening irrespective of high -risk T2DM, lifestyle restrictions, traditional dietary, and exercise practices. SA women require culturally appropriate advice regarding strategies to reduce the risk of GDM as early as possible in pregnancy, ideally at the time of pregnancy is confirmed.	8/10 Medium to high
3	Croxford et al., 2018 [30]	Australia Immigrants countries: Pakistan, Bangladesh, India, and Sri-Lanka Mixed-method study	n=26 21 from lived study and 5 additional from convenience sampling, N=13(final) 11=Indian, 1= Bangladesh, 1 Sri Lanka. Vegetarian n=7 & non-vegetarians n=6, Age 18 and above < 20-week gestation, BMI of ≥30kg/m	Micro and macronutrients on a daily basis, designed appropriate food consumed during pregnancy, sample menu	In-depth lifestyle and diet survey Pre-pregnancy, pregnancy, and post GDM. Traditional food consumed during pregnancy. Face to face interviews via home/telephones with audio recorded. One-day menus were derived from data collected during the interviews, taking account of some specific cultural beliefs. The one-day menus were then distributed to three of the participants to review and provide feedback before development of three-day menus. Recipes for the menu were developed or modified to improve their nutrient profile from recipes from participants and key recipe texts; Healthy Indian cooking for diabetes: Delicious Khana (meal) for Life, Health Indian in minutes, and 50 great curries of India.	Energy, protein, and fat intake were lower and CHO only marginally lower in vegetarians: however, the differences were not statistically significant in the non-vegetarian group. Dietary intake was not consistent with guidelines for the management of GDM. Confusion about a specific food, inadequate practitioner advice, and conflict with cultural expectations during pregnancy was evident.	8/10 Medium to high
4	Koivusalo B.et al.,2016	Finland RADIEL study, Multi-centered randomized trial, 2008-2014	n=293 Age 18 and above, previous history of GDM, and current GDM, gestation more than 20 weeks, pre-pregnancy BMI of 30kg/m2	Primary; GDM (diet &physical active). Secondary; Pre-eclampsia, gestational HTN& mod (Mode of delivery)	intervention group; n=155 Counseling on the diet, weight control, physical activity, group meeting with a dietician. Control group; n= 138 standard antenatal care	The incidence of GDM was 13.9% in the intervention group and 21.6% in the control group ([95% CI 0.40– 0.98%]; P = 0.044, after adjustment for age, pre-pregnancy BMI, previous GDM status, and the number of weeks of gestation). Gestational weight gain was lower in the intervention group (20.58 kg [95% CI 21.12 to 20.04 kg]; adjusted P = 0.037). Women in the intervention group increased their leisure time physical activity more and improved their dietary quality compared with women in the control group.	5/10 Low to medium
5	Tierney et al., 2015 [31]	Galway university hospital in Ireland. 2006-2010 [32]	n=13 with GDM diagnosed in the previous 3.6-6.6 years. Median age:41.2 years Semi-structured interview with thematic analysis.	Diet, lifestyle change, external support from family and finances.	Semi-structured interviews with themes and sub-themes 1.Motivators, Health of unborn baby, Future risk of T2DM, Insulin.2. Barriers: Unable to exercise, Dietary practices, Weather, Finances Family commitments. 3. Facilitators, having children, education, lifestyle intervention programs, regular communication through emails, letters etc. 2.ability to live a healthy lifestyle: 3. satisfaction with care: 4. risk awareness and acknowledgement:	Women implemented with positive lifestyle changes as they were motivated by protecting the health of unborn babies. However, the continued support to maintain these changes was insignificant due to the lack of external support and self-management skills by women. The routine inclusion of interventions to develop prioritization and health self-management skills among these women	8/10
6	Lipscombe et al., 2014 [33]	Canada Ongoing prospective multi-center observational cohort study, [34] July 2009-june 2013	N= 1353 N= 960 completed a baseline survey before delivery, Pregnant women with GDM above 24 weeks of gestation	Readiness for behavior change, socio-demographic, psychosocial, clinical predictors of a healthy diet and physically active.	The quantitative survey, qualitative interviews, Predictors of behavior change, diabetes risk perception, self- efficacy for physical activity and self-efficacy for diet, social support, motivators.	The fundamental first step in effectively addressing diabetes prevention in women with GDM. The readiness for behavioral change will be lowest in the first year postpartum, during which certain barriers to a healthy lifestyle will be greatest. However, while readiness for change may increase in the second year postpartum, new barriers to a healthy lifestyle may become more salient	7/11 Medium To high

7	Lim et al., 2019 [35]	Singapore Open-label RCT.	n=200 Age= 21 years and above Diagnosed with GDM, knows how to use a smart phone, Able to speak and read English	Diet, BMI, education and physical activity.	n= 200 intervention n=100 APP smart phone app 3-5 minutes educational videos on diet, weight and physical activity. Control group n= 100 Standard usual care.	This will be the first randomized controlled trial investigating the use of a smartphone application for postpartum weight loss in women with gestational diabetes. The major ethnic groups in our study population represent the majority of ethnic groups in Asia, amongst which the prevalence of diabetes is high. If shown to be effective, this APP may be used in wider clinical settings to improve postpartum weight loss and reduce the risk of developing T2DM in these women	6/10
8	Sequeira et al., 2019 [36]	Toronto, Canada. Qualitative study	N=13 Semi-structured interviews in 08 months, Median age=33 years, stay in Canada in the last 15 years, Diagnosed with GDM more than 20 weeks of gestation, participants belong from India, Pakistan, Bangladesh, Nepal, Sri-lanka, Bhutan	Readiness for physical activity, readiness for diet change, predictors of behavioral change, social support, overall support and guidance.	n=13 semi-structured interviews in their own choice of place and time with consent and properly recorded and with following themes; 1. Low awareness of culturally tailored resources of GDM. 2. The overabundance of GDM information. 3. Gendered role reversal.	1. There is a barrier in healthcare providers communicating these resources to South Asian patients. 2. while technology has increased the availability and accessibility of GDM management information, the overabundance of informational sources makes it difficult for women to decide which Advice to follow. 3.we found that husbands, parents, and even children pick up the mental load to help the mom-to be during her GDM pregnancy. Patients reported the entire family coming together and providing them With care and support.	7/10
9	Gupta et al., 2019	India, Sri Lanka, Bangladesh, PROBE study. Oct 2017- Dec 2019.	N=23 N=8(Australian), n= 15 (Bangladesh=4, Pakistani=1, India=3, Sri Lanka=1, China=1, Indonesia=1, Thailand=1, south Africa=1, Philippine=1, Peru=1) overseas born, Age=20-45, BMI 20-32, years of stay 5-35 years,	Weight BMI>23, Metabolic & inflammatory markers and quality of life.	Intervention group; 4 Face to face in depth sessions; about simple healthy eating, behavioral skills & enhancing internal motivation about self-efficacy and self-management of GDM. Four group sessions, 84 voice messages and review call over the first year. 2 individual additional sessions over the latter half of the first year. Control group; The usual standard care.	diet: RR: 0.85, 95% CI: 0.56, 1.22; physical activity: RR: 0.88, 95% CI: 0.63, 1.22; non-smoker: RR: 0.55, 95% CI: 0.30, 0.99; low stress RR: 0.75, 95% CI: 0.55, 1.04 (P values for interaction: diet=0.76, physical activity=0.59, smoking=0.50, stress=0.92	7/10
10	Zulfiqar et al., 2017 [17]	Australia Qualitative interview-based study, March-July 2014.	Age=18 and above, Able to speak and understand English, more than 20 weeks of gestation, n=140	Diet, BMI, Physical activity includes healthy and unhealthy, smoking and stress.	In-person structured interviews by trained professionals at an average of 15 weeks which include socio-demographic characteristics, reproductive, medical history, and lifestyle behavior before and during pregnancy and also after delivery. Lifestyle score components (0-4) into healthy/unhealthy with questionnaires. Diet self-administered semi-quantitative food frequency questionnaires with score (AHEI-2010). Smoking Stress	Overall, 7% of participants practiced all four healthy lifestyle behaviors and 1% practiced non-considered healthy lifestyle behaviours.20% of participants had a healthy diet, 66% were physically active, 95% did not smoke during pregnancy, and 55% had low stress levels. After adjustment for maternal age, race, parity, and all lifestyle components, only non-smoking was significantly associated with reduced risk of GDM (diet: RR: 0.85, 95% CI: 0.56, 1.22; physical activity: RR: 0.88, 95% CI: 0.63, 1.22; non-smoker: RR: 0.55, 95% CI: 0.30, 0.99; low- stress RR: 0.75, 95% CI: 0.55, 1.04). Associations did not differ significantly between normal weight and overweight/obese women (P values for interaction: diet=0.76, physical activity=0.59, smoking=0.50, stress=0.92. Each one-point increase in lifestyle score was associated with 21% lower risk of GDM (95% confidence interval: 0.65, 0.96) after adjusting for age, race, and nulliparity.	
11	Badon et al., 2017 [37]	USA Omega study (Washington),prospective pregnancy cohort study, 1996-2008,	Age=18 and above, Able to speak and understand English, more than 20 weeks of gestation, n=140	Primary Outcome; glycemic control. Secondary outcomes; BMI, BP, Physical Activity and Diet.	Two-faced process Interview based study about diet, lifestyle, cultural practices by using the following themes and sub-themes Barriers Facilitators Lack of support Mental stress	Women in both groups faced many barriers to improving the post-gestational-diabetes lifestyle. Women from both groups recalled healthy lifestyle recommendations for during pregnancy they received at the service, but had difficulty recalling the long-term lifestyle recommendations. Both groups had excellent Compliance with the first annual postnatal oral-glucose-tolerance-test. This was attributed to the personal motivation and health professional reminder. Women only reverted to the healthy lifestyles post-natal for weight loss.	7/10

12	Chason-Taber et al., 2009	USA Massachusetts, B.A.B.Y study, Randomized controlled trial.	N=364 N=182 N=182 through proper randomization, Age 18 to 40 years, Pregnant with the risk of GDM	Primary outcomes; tailored physical activity among women with GDM, high risk of GDM, serum biomarkers, insulin resistance. Secondary outcomes; intervention to assess gestational weight gain and selected birth outcomes	Trans-theoretical model and Social cognitive theory. 1.precontemplation 2.contemplation 3.preparation 4.Action 5.maintainence a. Health &Wellness group b. Exercise group telephone interviews at 2 weeks In-person education at 12 weeks Telephone interviews at 22-24 weeks Routine GDM screening at 24-28 weeks Telephone interviews at 32-34 weeks Abstract medical records after birth at 40 weeks	The relative validity of 24-hour physical activity recalls has been described in detail, with correlations for women ranging from 0.54 for household activity, 0.74 for occupational activity, and 0.68 for leisure time physical activity when compared with a physical activity diary.58 Intra-class correlation coefficients used to measure the reproducibility of the PPAQ were 0.78 for total activity, and 0.82 for moderate activity, and 0.81 for vigorous activity and ranged from 0.83 for sports=exercise to 0.93 for occupational activity. Spearman correlations between the PPAQ and three published cut off points used to classify accelerometer data ranged from 0.08 to 0.43 for total activity, 0.25 to 0.34 for vigorous activity, and 0.20to 0.49for moderate activity. A series of three 24-hour physical activity recalls has been found to provide a reasonable measure of short-term physical activity energy expenditure. Adoption of such a lifestyle-based intervention by pregnant women is facilitated by custom fitting the physical activity into a daily routine appropriate to individual lifestyles.	7/10

Table 1: Shows characteristics of included studies and Risk of Bias (ROB).

First author	1	2	3	4	5	6	7	8	9	10			Total score
Reinhardt et al., 2012 [37]	Y	y	ct	n	ct	y	y	Y	n	Y			6/10
Bandyopadhyay et al., 2011 [5]	Y	y	y	n	n	y	y	Y	Y	Y			8/10
Croxford et al., 2018 [16]	Y	y	n	y	y	n	y	Y	Y	Y			8/10
Koivusalo B.et al.,2016	Y	y	n	y	y	y	y	ct	n	n			6/10
Tierney et al., 2015 [6]	Y	y	y	n	y	y	y	ct	Y	Y			8/10
Taber et al., 2009	Y	y	ct	y	y	y	ct	ct	Y	Y			7/10
Lipscombe et al., 2014 [10]	Y	y	ct	y	y	y	y	ct	n	Y	n		7/11
Lim et al., 2019 [18]	Y	y	n	y	y	y	ct	y	n	n			6/10
Sequeira et al., 2019 [23]	Y	y	n	y	n	y	y	n	Y	Y			7/10
Gupta et al., 2019	Y	y	ct	n	y	y	n	y	Y	Y			7/10
Badon et al., 2017 [32]	Y	y	n	y	y	y	ct	y	Y	n			7/10
Zulfiqar et al., 2017 [38]	Y	y	ct	y	n	y	y	ct	Y	Y			7/10

Table 2: Methodological quality and risk of bias assessment results.

Groups into vegetarians and non-vegetarians for micro and macro nutrients. The authors suggested that there was no statistical significance found between both groups for micro/macronutrients in comparison with NRVs for pregnancy. All participants did some changes on type of food consumed during pregnancy such as choosing low-fat milk, eating smaller portions, eating less rice, eating more fruits in general etc. This is a small study with participants recruited only from one health centre; interviews were in depth and did yield rich data on dietary beliefs which added significant value to the study. Lastly, the interviews were conducted some years after the birth of children so there was some error in recalling memory as well [20]. Appropriate advice should be given to SA women taking into account their behavioural practices and dietary habits during pregnancy. This can be done by providing relevant information to health care professionals on the diversity of SA women diet, positive attitudes, healthy behavioural practices [13]. The Authors suggests that proper information on GDM is not available currently in any of the SA languages: which depicts that there is urgent need to correct this situation thereby making inroads in reducing SA women's load of ill health because of GDM. This is desirable from the cultural and socioeconomic point of view, but may have an impact on the response to nutritional management of GDM and should be addressed in future research [20].

Theme 2: Physical activity and GDM

The LIVING study is a large study which reports on lifestyle intervention for the prevention of GDM in SA women with recent GDM. However, this study mainly focused on low intensity lifestyle intervention programmes and aims at high feasibility, acceptability and cost effectiveness in SA context with recent GDM [15,30,38,39]. RADIEL study conducted on moderate individualized lifestyle intervention reduced the incidence of GDM in high risk pregnant women by 39%. To our knowledge this is the first RCTs which shows overall reduced incidence of GDM with mild to moderate lifestyle intervention programme and diet restrictions in early pregnancy and continued throughout the pregnancy and post pregnancy as well. Evidence suggest that with little diet restrictions such as portion size of meal,

and healthy meal plan, and improved physical activity like adding daily walk around 30 minutes, and healthy workout will provide a real effort to change their overall lifestyle in a healthier direction [4,40].The included study number 6 that readiness for behavioural changes hypothesis will be helpful in developing a role model for the prevention of GDM in first and second year postpartum with mild to moderate lifestyle interventions will also reduce the future risk of developing T2DM in near future which supports the evidence as well [39,41,42].This study also has some limitations of participation bias, sample size and recruitment errors [33]. A study [43] showed that the most common barrier to GDM is due to insufficient exercise, although women exercised more during the postnatal period than before or during pregnancy [44,45]. The study conducted in 2015 by Tierney reports that women with GDM need positive lifestyle change as they were motivated by protecting the health of their unborn child however; he suggests that lack of motivation to continue a healthier lifestyle in the postpartum period was minimal. Additionally, group of evidence recommend that routine inclusion of lifestyle interventions to develop prioritizations and self-management skills among women with GDM to manage their GDM risk [16,33,46,47] Healthy lifestyle behaviour includes eating a healthy diet, being physically active, avoid smoking and minimal or no stress at all. The study 10 highlights that healthy lifestyle behaviour during pre-pregnancy, pregnancy and post pregnancy shows 23% improvement in reducing the risk of T2DM in near future. A group of evidence suggests that a healthy lifestyle with little diet restriction will be significant in reducing the risk of T2DM in near future [44,48,49]. The B.A.B.Y study is a novel study in developing a personalized exercise intervention programme for the prevention of GDM risk in multi-ethnic populations. In addition, counselling about diet, nutrition and weight gain should be added routinely worldwide in order to reduce the risk of GDM and T2DM in future as well [22,50]. Another pilot RCTs study on lifestyle interventions through proper phone based motivational interviews with GDM women shows positive attitudes in lifestyle change during follow-ups which is a good sign in reducing the risk of getting GDM and T2DM in future as well. Although this study has many limitations like small sample size, randomization error, long-term follow-ups assessment and concealment error but still shows significant improvement in BMI, increase leisure time physical activity and reduced fat intake in comparison with control group [16,40].Similarly, another study(7) conducted on post-partum weight loss monitoring in women with GDM through smart phone APP. Up-to- date knowledge shows this was the first RCTs which exploring the use of smartphone APP for postpartum weight loss in women with GDM in Singapore. The participants recruited in this study from only one maternity centre. Nevertheless, the major ethnic group in this study are from China, Malays and India [35]. Another qualitative study (8) highlights that the awareness of culturally tailored resources was low among participants and there is a significant gap in knowledge of Health Care professional's awareness level as well. This qualitative study was conducted in only one clinic with small sample size and language barriers which may not generalize to immigrant's women who experience a language barrier within health care [25,42,50]. Up-to- date evidence showed that women with GDM have poor compliance with healthy lifestyle recommendations after childbirth especially in overseas-born-women. The common reasons for non-compliance in overseas-born-women are lack of assistance in childcare, mental stress, emotional and physical support from partner and family as well [17]. However, his research highlights poor and fragmented healthcare systems as a vital barrier for women, especially overseas-born-women. Whereas, in the long run the risk of diabetes could be reduced by specialized clinics and improved primary health care systems [17].

Conclusion

This review suggests that dietary restrictions (healthy eating) and mild to moderate physical activity pre-pregnancy and continued throughout could help prevent GDM. Evidence also suggested that SA women, especially immigrants, with a low level of knowledge, low awareness and education, a language barrier and cultural practices are more at risk of GDM than non- immigrants, and non-GDM, and White British women with GDM as well. Above review highlighted that these factors are associated with higher risk of developing GDM and that further work is needed to explore in depth.

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