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A Systematic Review on Prevention of Type 2 Diabetes Mellitus after Gestational Diabetes Mellitus

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ABSTRACT

Background: Women with prior gestational diabetes mellitus (GDM) have a high risk of developing type 2 diabetes mellitus (T2DM) in later life. Lifestyle interventions aimed at postpartum weight loss to reduce T2DM risk have been reported but poor compliance remains a barrier.

Objectives: To assess what preventative measures reduce type 2 diabetes prevalence among women with previous gestational diabetes.

Method:
Search Strategy: Electronic databases CINAHL Web of Science PubMed and EMBASE were searched via the e-library gateway of the University of Nottingham using key words combined in a formal search strategy.

Selection Criteria: Randomized Controlled Trials and Cluster Randomized Controlled Trials examining what preventative measures reduce type 2 diabetes prevalence among women with previous gestational diabetes were selected.

Results: 14 studies were identified for inclusion in the review after a stringent criterion and their data was extracted using JBI data extraction tool. Three themes were identified across the 14 studies mainly: weight management healthy eating and medication and physical activities. Most interventions had positive outcomes however a few had no significant impact in the prevention of T2DM.

Conclusion: The likelihood of developing diabetes is higher for women with a history of GDM, increases with a high BMI, high fasting glucose, impaired glucose tolerance, and elevated fasting glucose. This risk can be greatly reduced by making lifestyle adjustments or taking medication. The main risk factors that increase the risk of T2DM after GDM identified in this review were obesity, poor quality of diet and a sedentary lifestyle.

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Introduction

Gestational diabetes mellitus (GDM) is a condition in which glucose intolerance is first recognized during pregnancy [1]. Pregnancies complicated with GDM increase the risk of caesarean section pre-eclampsia and macrosomia [2]. According to Zhu and Zhang in the long term GDM also increases the woman's risk of developing type 2 diabetes (T2DM) [3].

Compared with women without this common complication women with a history of GDM face a 7-fold increased risk for developing diabetes later in life [4]. In addition, the cumulative risk of developing T2DM in women with a history of GDM at 10 years after giving birth varies from 20 to 50% [5]. Therefore, diabetes prevention is critical for women with GDM.

Weight gain following pregnancy has been shown to increase T2DM risk in women with a history of GDM [6]. Screening for GDM presents a prime opportunity to identify patients at high risk of developing T2DM and promote lifestyle programs for weight management healthy eating and physical activity to prevent T2DM after delivery [7].

Electronic health records disease registries and secure patient-provider email systems among other population management tools provide a platform for promoting preventive programs among high-risk patients who are most likely to profit from them [8,9].

Yet participation in diabetes prevention programs is persistently low: over half report participation rates of <20% [8]. In fact women with a history of GDM frequently think of themselves as robust and downplay their risk of developing diabetes after giving birth [10]. This paradox maybe explained by the self-affirmation theory which highlights that people are naturally driven to uphold their self-integrity or a sense of themselves as adaptively adequate [11]. For that reason the possibility of disease risk can cause people to avoid health knowledge because it threatens a self-perception of adequacy [12, 13]. This observation is evident as identified in the low incidence of postpartum screening for T2DM [14].

The American Diabetes Association suggests that more work needs to be done in the healthcare system to increase adherence of women with previous GDM diagnosis [15]. In addition it is important for healthcare practitioners to identify which stage of illness the patient lies as health care needs of T2DM patients vary. While new patients are concerned with disease acceptance and the motivation to change unhealthy lifestyle behaviors aged patients (>55 years) are more interested with diabetic complications management adherence to holistic drug regimen and healthy food selection [16]. Moreover Ferrara et al. advocates for starting lifestyle interventions soon after the diagnosis of GDM [5]. First due to the frequent interactions GDM patients have with the healthcare system both during and after pregnancy this period presents an opportunity for health care system to adopt diabetes preventative interventions.

Second pregnant women with GDM may be concerned about their children's increased risk of negative health outcomes and their own increased risk of diabetes which could motivate the adoption of preventive behaviours [17]. A lifestyle intervention that begins soon after the diagnosis of GDM takes advantage of the unique opportunity "teachable moment" of pregnancy.

In this systematic review important interventions to delay or prevent the development of T2DM following GDM have been identified as 1) weight management 2) diet and medication and 3) physical activities. Here the authors seek to investigate the preventative measures to reduce type 2 diabetes prevalence among women with previous gestational diabetes.

Methodology

Search Strategy

The search strategy entailed a full text database and comprehensive search of RCT and Cluster RCTs) in CINAHL Web of science PubMed and EMBASE from October 2022 to April 2023. Search terms were used to formulate a search string using operators (AND OR) that could be entered into the identified databases. In addition, use of wildcards such as question mark (?) was used when there were spelling variations for a word. Furthermore asterisk (*) truncation was used when searching for variable endings of a root word. Preven* = prevent prevention preventative and preventing. Finally, the use of phrases was utilised. It involves using quotation marks to search for exact phrases such as “Gestational Diabetes Mellitus or “T2DM”. Population/Patient Intervention Comparator/ Control Outcome and Settings (PICOS) was used in this review.

Results

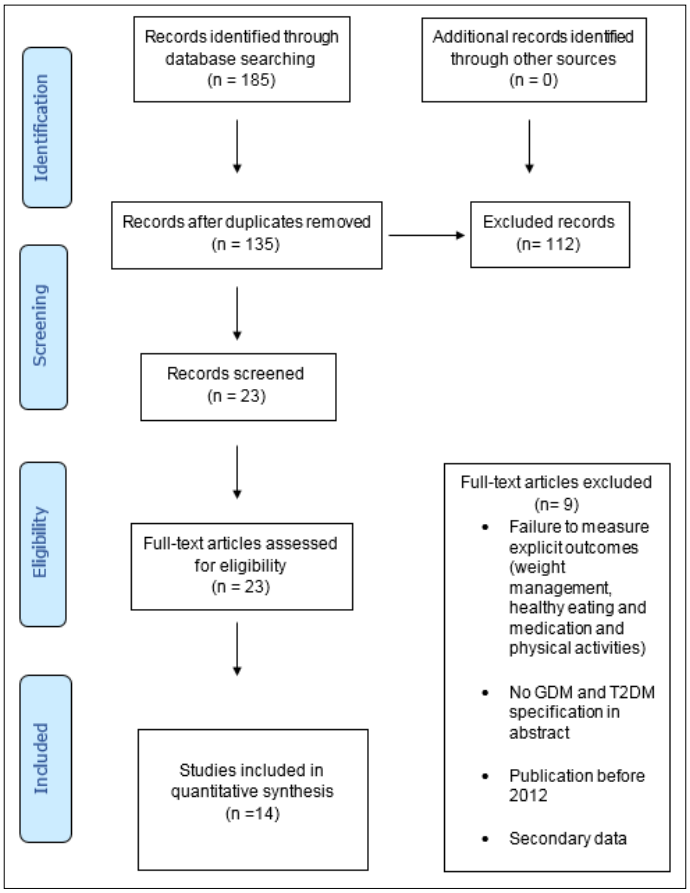

Figure 1: Prisma Flow Diagram

185 articles were identified with fifty (50) studies removed as duplicates. The titles and abstracts of 135 articles were read 112 articles were excluded and 23 primary research studies were further screened. Full text articles of the 23 studies were assessed using the Joanna Briggs Institute (JBI) critical appraisal tool for quality. 14 studies were included for quantitative synthesis. Figure 1 below presents an overview of the search results using Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA). Table 1 also represents the characteristics of studies included in this review.

Table 1: Characteristics of Included Studies

	Author and Publication	Study Design	Participants			Intervention	Clinical Outcomes	Study Results		Limitations
			Setting	Population	Sample Size			Treatment Group	Control Group	
1	Ferrara et al. [5]	RCT	The Kaiser Permanente Medical Care Program California	Women with GDM	Those who attended baseline visit n=197 randomized lifestyle intervention condition (n=96) usual care condition (n=101)	Diet, Exercise and Breastfeeding Intervention (DEBI) for women with GDM	The participants ability to return to their pre-pregnancy weight, if it was normal, or achieve a 5% reduction from pre-pregnancy weight if overweight.	Women who reached the weight goal in the intervention condition than among usual care (37.5 vs. 21.4%, absolute difference 16.1% P = 0.07 (no statistical significance) Intervention more effective on women who did not exceed the recommended gestational weight gain P = 0.04. The intervention condition decreased dietary fat intake more than the usual care P =0.002 and increased breastfeeding, although not significantly P = 0.09	No differences in postpartum physical activity were observed between conditions.	The study had a relatively small sample size and an intervention that needed additional refinement, specifically with input from the target population There was also a small differential loss to follow-up between the intervention and the usual care conditions. This difference may be because of the translational nature of the study, which did not require participants to attend at least two baseline study visits before randomization, as is common practice in efficacy trials.

2	Hu et al. [21]	RCT	Tianjin, Northern China	Women with prior GDM	1180 women Lifestyle intervention (n=586) Control group (n=594)	Six face-to-face meetings with study dietitians in the first year, and two additional sessions and two telephone calls in second year.	Primary outcome is the development of diabetes. Prevention or delaying the onset of type 2 diabetes in women with a history of GDM by intensive and individually designed diet and exercise program.	The mean body weight decreased by 1.40 kg (2.1%) (p=0.001) Among baseline overweight women (BMI≥24kg/m2) (2.91kg[4.2%)] (p=< 0.001) In comparison to the control group, they had decreased BMI, body fat, waist circumference, plasma insulin levels (All p<0.05) and improved behaviours including increased leisure time activity and dietary fibre intake and decreased sedentary time and fat consumptions (All p<0.01)	The mean body weight decreased by 0.21 kg (0.3%) Among baseline overweight women (BMI]≥24kg/ m2) (0.51 kg[0.7%]	It only sampled from women with GDM. Thus, we will not know if the results can apply to all other women.

3	Shyam et al. [34]	RCT	Malaysian endocrine clinic of a tertiary hospital	Non-diabetic women with previous GDM	77women Intervention LGI (n=39) Control CHDR (n=38)	Conventional healthy dietary recommendation (CHDR) and advice on lowering GI (LGI).	Management of glucose tolerance and body weight.	Mean BMI (LGI vs. CHDR: -0.6 vs. 0 kg/m2, P= 0.03) 2HPP (LGI vs CHDR, p=0.025) weight loss ≥5% in LGI compared to CHDR group (33% vs. 8%, P=0.01) lower GI (57±5 vs. 64±6, P<0.001 higher fibre content (17±4 vs.13±4 g, P<0.001)		The dietary intake including glycaemic and glycaemic load were calculated based on reported intakes, though attempts were made to ensure completeness of reporting.
4	Nicklas et al. [30]	RCT	Diabetes in Pregnancy Program at Brigham and Women's Hospital (Boston, Massachusetts)	Women with recent GDM	75 women Web-based lifestyle intervention Balance after Baby Program (n=36) Control group (n=39)	Web-based lifestyle modification program (Balance after Baby)	Change in body weight at 12 months from 1) first postpartum measured weight; and 2) self-reported pre-pregnancy weight.	Balance after Baby program lost a mean of 2.8 kg (95% confidence interval –4.8 to -0.7) from 6 weeks to 12 months postpartum, (P=0.022) Women in the intervention were closer to pre-pregnancy weight at 12 months postpartum (mean change -0.7kg; -3.5 to +2.2) (p=0.035)	Control group gained a mean of 0.5 kg (-1.4 to +2.4) Women in the control arm (+4.0 kg; +1.3 to +6.8)	As a single-centre trial, results may not be generalizable to other populations. Pre-pregnancy weight was based on self- report, which could result in recall bias.

5	Aroda et al. [53]	RCT with an observational follow-up	27 Clinical Centres United States of America	Women with and without a history of GDM	350 women with a history of GDM 1416 with previous live births but no history of GDM	Placebo or Intensive lifestyle or Metformin	Diabetes Mellitus	Women with a history of GDM assigned to placebo had a 48% higher risk of developing diabetes compared with women without a history of GDM. (P <0.05) In women with a history of GDM, ILS and metformin reduced progression to diabetes compared with placebo by 35.2% and 40.4%, respectively.	Among women without a history of GDM, ILS reduced the progression to diabetes by 29.7%, and metformin did not reduce the progression to diabetes. Non-significant risk reduction by metformin of only 3.3% compared to placebo.	The group of women with GDM enrolled in the study had a mean age of 43 years. This suggests, the study may have excluded women in the highest risk category with GDM who may have progressed to diabetes by 43 years. There is possibility that the non-GDM group may have included some women with undiagnosed GDM during pregnancy if they delivered the baby during a time when universal testing for GDM was not standard of care.

6	Peacock et al. [32]	RCT	Tertiary maternity hospital in Brisbane, Australia	Women with a history of GDM and BMI > 25 kg/ m2	31 women Intervention (I) (n= 16) or a control (C) (n = 15) group	A pedometer program combined with nutrition coaching.	Weight Loss	Median loss of −2.5 (2.3) kg p=0.002	+0.2 (1.6) kg	Actual recruitment was low; therefore, the statistical power to detect significant differences between intervention and control arms was limited. The women in this study were predominantly Caucasian and in their mid-thirties, and thus our results may not apply to women of other age or racial/ ethnic groups.
7	Pérez-Ferre et al. [60]	RCT	Gestational Diabetes Unit of Hospital Clinico San Carlos	Women with prior GDM	260 women Intervention group (n=130) Control group (n=130)	A Mediterranean lifestyle (educational program on nutrition and monitored physical activity program)	Glucose disorders (Impaired Fasting Glucose, Impaired Glucose Tolerance, T2DM)	42.8% developed glucose disorders (p=0.05) Low fat intake and low saturated fat pattern (p<0.005) Healthy fat pattern (p<0.04)	56.75% developed glucose disorders	

8	Ferrara et al. [35]	Cluster RCT	Kaiser Permanente Northern California 44 medical facilities	Women with GDM	2,280 randomized to intervention plus usual care (n=1,087) randomized to usual care alone (n=1,193)	Mailed gestational weight gain recommendations plus 13 telephone sessions between 6 weeks and 6 months postpartum.	1) reaching pre-gravid weight if pre-gravid BMI <25.0 kg/m2 or 2) losing 5% of pre- 2 gravid weight if BMI ‡25.0 kg/m; and pre-gravid to postpartum weight change	Over the 12-month postpartum period, women in the intervention had significantly higher odds of meeting weight goals than women in usual care (odds ratio [OR] 1.28 [95% CI 1.10, 1.47]). At 6 months, women in the intervention retained significantly less weight than women in usual care (mean 0.39 kg [SD 5.5] vs. 0.95 kg [5.5]; mean condition difference -0.64 kg [95% CI -1.13, -0.14]) and had greater increases in vigorous intensity physical activity. (Mean condition difference 15.4 min/week [4.9, 25.8])		Missing clinic-measured weight for 26.4% of women at 6 months and 32.7% at 12 months postpartum Intervention effects on postpartum weight retention among women with GDM are greater in trials randomised at individual level than cluster randomized. trials

9	O'Reilly et al. [14]	RCT	Australian state capital cities, Melbourne, and Adelaide	Mothers after gestational diabetes	573 women intervention (n = 284) or usual care (n = 289)	Individual session followed by five group sessions at two-week intervals, and two follow-up telephone calls	Changes in diabetes risk factors (weight, waist circumference, and fasting blood glucose)	Mean changes (ITT analysis) over 12months −0.23 kg body weight in intervention group (95% CI −0.89, 0.43) p=0.04 -2.24cm waist measurement (95% CI −3.01, −1.42) p=0.389 +0.18 mmol/l fasting blood glucose (95% CI 0.11, 0.24) p=0.331	Mean changes (ITT analysis) over 12months +0.72 kg (95% CI 0.09, 1.35) -1.74 cm waist measurement (95% CI −2.52, −0.96) +0.22 mmol/l (95% CI 0.16, 0.29)	Low exposure to the full intervention and glucose metabolism profiles being near normal at baseline. The level of engagement during the first postnatal year was low.

10	Tawfik et al. [37]	Cluster RCT	3 Egyptian Cities: Ismailia, Port-Said, and Suez	Women with GDM	201 Women Intervention subjects (n=103) Control subjects (n=98)	Health education intervention based on the Health Belief Model construct.	Women's knowledge, beliefs, self-reported practices, gestational weight gain (GWG), and postpartum weight retention	High knowledge and beliefs scores had significantly increased from less than 50% to more than 70% (p < 0.001) Practicing exclusive breast feeding (85.4 %) and screening for T2DM (43.7%) at 6 weeks postpartum Women with excessive BMI were meeting recommended GWG 65% (p <0.001) and postpartum weight 37.7% (p <0.01)	Practicing exclusive breast feeding (63.3 %) and screening for T2DM (19.4%) at 6 weeks postpartum (p < 0.001) Women with excessive BMI were meeting recommended GWG 11.6% (p <0.001) and postpartum weight 20.3%	The trial framework did not allow for recruiting women who had a late first ante-natal care visit (>12+6 weeks of pregnancy). Synchronizing the implementation of the intervention with the time of GDM diagnosis did not allow for testing the benefits of early implementation of the intervention. The short follow-up period impedes the ability to evaluate the intervention's effectiveness in maintaining weight control over time.

11	Brown et al. [4]	3-arm RCT Mixed methods study design including 2 phases: (1) a quantitative and qualitative development phase to design an affirmation intervention that does not rely on any writing, followed by (2) a randomized study to test its effectiveness in promoting women's interest in diabetes prevention	Email outreach program at Kaiser Permanente Northern California (KPNC)	Women with elevated BMI and a history of GDM	237 women Ratio of 1:1:1 randomized to values affirmation group (n=79) randomized to parenting affirmation (n=80) randomized to control (no affirmation) (n=78)	Affirmation intervention No affirmation (Control) or 1 of 2 affirmations either a value affirmation prompting reflection on any personal value or a parenting affirmation prompting reflection on care giving -related values	Demonstrating interest in the lifestyle program (seeking information about it or intending to join) and seeking publicly available health information about diabetes prevention	Compared with control, participants randomized to the values affirmation demonstrated interest in the lifestyle program (59.0% vs. 74.4%; adjusted relative risk: 1.31; 95% confidence interval: 1.04–1.66 p=0.02) and sought information about diabetes prevention (59.0% vs. 73.4%; adjusted relative risk: 1.22; 95% confidence interval: 0.97–1.54 p=0.09The parenting affirmation yielded no significant differences in either outcome p=0.69)	Control group demonstrated less interest in the lifestyle program and in seeking information about diabetes prevention compared to the value affirmation participants	Most values affirmation interventions have been tested in student or nonclinical samples rather than truly at-risk populations Values affirmation interventions typically rely on a writing exercise that is less practical in busy health care settings and likely burdensome for wide-scale adoption The outreach messages was lengthy and was situated at in a research context rather than an actual encounter with a physician

12	O'Reilly et al. [2]	RCT	Australian states of Victoria and South Australia	Women with previous gestational diabetes primarily within their first year	573 women Intervention (n=284) Usual care (n=289)	Individual session completed in the woman's home (Personalised risk identification, goal setting and lifestyle modification) and five group sessions conducted at community settings close to the woman's home (healthy eating, physical activity, overall wellbeing)	Diet quality	Mean weight loss 0.23kg (95% CI -0.89, 0.43) P=0.04 Low fat/saturated fat foods (+0.28 95% CI 0.08, 0.48) P=0.05	Mean weight gain of 0.72 kg (95% CI 0.09, 1.35) Low fat/ saturated fat foods + 0.02 in usual care (95%CI -0.14, 0.18)	The small effect size seen with the intervention overall which may be related to the low level of session attendance The relatively low metabolic risk of the participants which was communicated to them during the first individual session as a component of their personalized risk score. It is possible that this information was interpreted as a decreased need to change and may have led to women seeing the group sessions as less important thereby decreasing their engagement with the active intervention.

13	Lim et al. [38]	RCT	The National University Hospital (NUH) Singapore	Women with GDM	200 women intervention(n=101) Standard care (n=99)	APP serving as a platform for weight, diet, and physical activity tracking	Achievement of optimal weight	40% (38/96) of women achieved optimal weight at 4 months post-delivery (p=0.27) Women reported significantly reduced caloric intake at 4 months after delivery (p<0.001) Higher health-directed behaviour scores (P=0.045) Under physical activity the mean step count increased to 4880 (95% CI 4195.4 to 5565.5) at 4 months (P=0.04) Increased emotional distress scores (p=0.01)	32% (28/93) of women achieved optimal weight at 4 months post-delivery.	The trial being unable to detect a clear improvement in achievement of optimal weight. It was underpowered to detect a statistically significant. difference in the primary outcome The outcomes in which significant improvements were detected (caloric-intake and health-directed behaviours) were self-reported rather than objectively measured outcomes Limitations of interpreting decreased caloric intake without concomitant data on energy expenditure, as reduced caloric intake may be related to reduced physical activity during the postnatal period

14	Tandon et al. [64]	RCT	19 urban hospitals in India, Sri Lanka, and Bangladesh	Women with recent GDM without T2DM	1601 Women Intervention group (n=800) Usual care (n=801)	A 12- month lifestyle intervention focussed on diet and physical activity. Four 90-minute face-to-face group sessions over 6 months followed by 2 face-to-face individual sessions for individuals who were persistently overweight or had gained more than 2% of baseline body weight.	Deterioration in glycemia	No reduction in worsening glycaemic status (204 women [25.5%] vs 217 women [27.1%]; hazard ratio, 0.92; [95% CI, 0.76–1.12]; P =0 .42)		The participant-unblinded design However laboratory request forms did not include information on participant allocation and an independent observer verified all outcome data in the case record form against original laboratory results. Biased self-reporting on diet and physical activity may have affected interpretation of these outcomes. The trial was limited to hospitals in urban settings, and the findings may not be broadly generalizable even within South Asia, especially to nonurban areas in these countries. COVID-19 restrictions impacted outcome ascertainment among some participants.

Quality Assessment

The JBI critical appraisal tool was employed to assess the methodological quality of the selected studies. Each question graded as being met (yes) unmet (no) unclear or not applicable [18]. The studies included Randomized Controlled Trials (RCTs) and Cluster Randomized Controlled Trials (Cluster RCTs).

Discussion

We sought to establish what preventative measures reduce type 2 diabetes prevalence among women with previous gestational diabetes.We identified three main themes 1) weight management; 2) diet and medication and 3) physical activities.

Theme 1

Weight Management

Obesity is the most significant modifiable risk factor for type 2 diabetes so new methods to promote postpartum weight reduction in women Weight loss has been suggested as the first objective for overweight and obese people in several lifestyle intervention trials to prevent or postpone the progression to type 2 diabetes among adults with impaired glucose test results [20,21]. A therapeutic strategy for overweight or obese individuals who are at risk of developing type 2 diabetes would involve moderate weight loss (5% body weight) [21].

Most of the studies revealed that weight retained during pregnancy at 6 months postpartum is strongly associated with future obesity and weight held at 1 year postpartum is associated with a body mass index (BMI) of greater than 25 15 years later [22]. Similarly, findings by Nicklas et al. were of clinical significance and they echoed the fact that women with GDM tend to retain or gain weight postpartum [23].

Ferrara et al. observations were comparable to those seen in other cluster randomised studies [5]. Women in the lifestyle intervention condition in the cluster randomised study of the Tianjin Gestational Diabetes Prevention Programweighed approximately 1 kg less at 12 months postpartum than women in the control condition suggesting potential long-term beneficial effects of modest weight loss [21]. O'Reilly et al. had similar 1kg weight difference which is potentially significant for diabetes prevention but the poor participation rate reflected how challenging it was to get mothers in this cohort to participate in the first year following the birth of their child [2]. Given that only a select group of motivated volunteers engage in the randomized controlled trialsit is noteworthy that intervention effects on postpartum weight retention among women with GDM are higher in trials randomised at the individual level than cluster randomised trials [5,21,23]. Nonetheless there is potential for great impact if patient engagement in lifestyle interventions is promoted.

Several studies have highlighted the difficulty to create interventions for this life stage but reducing postpartum weight retention lowers the chance of T2DM and perinatal complications [6,24]. Weight retention can also affect the health of a woman's children [25, 26]. In addition, pregnancy-related maternal obesity is linked to higher risks for birth defects hypertension gestational diabetes mellitus caesarean sections and extended hospital stays [27]. Furthermore, weight gain and weight retention following delivery are linked to a higher chance of recurrent GDM and an abnormal cardiometabolic profile [28,29]. It is widely acknowledged that a variety of obstacles prevent mothers from changing their behaviour while their children are young including fatigue a lack of time competing job and caregiving obligations and cultural expectations [30,31]. The findings were consistent with the results of Nicklas et al. analysing postpartum barriers to lifestyle modification for women with GDM and comparably these included a lack of time and energy conflicting expectations from work and family and a lack of childcare. Peacock et al. also demonstrated the challenges of engaging women with young children in interventions aimed at changing lifestyle behaviours [32,33].

More efforts need to be undertaken in order to ensure the interventions for these women are as effective as possible. Wilkinson et al. findings suggest that when talking to women about their own health behaviours after giving birth perhaps a more rigorous approach is preferred. Frequent face-to-face contact may be an effective strategy for encouraging women to adopt healthy behaviours [22]. However, for a problem that affects a significant percentage of women cost-effectiveness of intervention delivery is a crucial factor. Therefore, given the numerous obstacles to in-person interventions and the widespread use of the Internet it might be more effective to use web-based technology to deliver lifestyle change interventions for women with recent GDM [34]. The web-based lifestyle intervention for women with recent GDM showed potential for low cost and broad dissemination by delivering remotely via a website and lifestyle coach [23].

Most of the studies showed statistical significance in weight management in women with previous GDM however 3 studiesdid not have significant impact [5,21,23,33,35-38]. To begin with this was associated with the issue of low penetration and participation in this target group resulting in low effectiveness. Another possible explanation is the Hawthorne effect which suggests that women in the control group may be more inclined to change their health behaviours because of knowledge that they are being watched leading to social desirability bias [38]. Moreover, Tawfik explained the absence of statistically significant differences at baseline between intervention and control group was attributed to low perception of susceptibility for T2DM among trial participants [37]. The intervention was underpinned on the health belief model (HBM). Consistent with other studies women with a history of GDM did not perceive themselves at greater risk for developing T2DM [39]. According to the HBM construct a woman with GDM will engage in preventive health behaviours against T2DM if she perceives that she is more susceptible to the condition than the average person is (perceived susceptibility) that the condition has serious complications (perceived severity) that certain healthy behaviours and screening would lessen her susceptibility to the condition or its severity (perceived benefits) and that benefits accrue from doing so (perceived benefits gain) (self-efficacy) [37]. According to Jones et al. high levels of knowledge and risk perception in women with previous GDM do not necessarily promote increased self-efficacy to prevent T2DM and cardiovascular diseases [40].

On the contrary having a family history of T2DM and excessive BMI were found to significantly predict postpartum weight loss. Women with GDM conceptualise their risk for T2DM in connection to their weight status whether their families have a history of the disease and whether they are obese. Therefore women who are obese and/or have a family history of T2DM would perceive this risk as being greater which would result in a stricter control of their postpartum weight [41].

Theme 2

Diet and Medication

Most diabetes prevention interventions in women after GDM

include dietary modification. An incremental decrease in the risk of developing diabetes is linked with achieving more quantitative dietary goals such as less than 30% energy from fat less than 10% energy from saturated fat and increased fibre [42]. These macronutrient goals are key; however long term adherence is a challenge. Competing priorities between self-care work and needs of the family for reproductive age women alongside tiredness and a lack of time could explain the women's challenges [43].

Glycaemic index (GI) is a classification of the blood glucose-raising potential of carbohydrate foods relative to glucose or white bread [44]. High GI foods not only spike blood sugar levels quickly but also cause an increase to insulin responses [45]. Conversely low GI foods lower peak postprandial blood glucose and have been shown to have a positive effect on glucose control [46]. The findings were also echoed in Shyam et al. low GI diets may be more successful in managing glycaemia in hyper insulinemic dysglycaemic women with a history of GDM as evidenced by the percentage of dysglycaemic subjects returning to normoglycaemia in the intervention arm of the research [34]. Hu et al. identified several lifestyle modification behaviours in the intervention versus control group. There was improvement in diet as noted in vegetable and fibre intake and decreased fat intake [21]. Shyam et al. results were consistent with the Cochrane reviewwhich found that participants in trials lasting up to 6 months who followed low GI diets lost an average of 1 kg more weight than participants who followed high GI diets [34]. Therefore when compared to conventional healthy diets with comparable energy recommendations low GI diets promote weight reduction in the study population of women with prior GDM over a six-month period. Every 1 kg of weight lost during the first year of the Diabetes Prevention Program (DPP) translated into a 16% lower chance of developing T2DM Comparably and of note both physical activity and healthy eating approaches were more effective when delivered within the first six months of a child's birth and lasted longer than a year [34,47]. The American Diabetes Association (ADA) recently advised diabetics to eat whole grains legumes fruits vegetables and dairy products as sources of carbohydrates [48]. The ADA also suggested that priority be given to meals that are higher in fibre and have a lower glycaemic load than other sources particularly those that have added sugar [48].

There are several studies which showed positive effects. Lim et al. demonstrated that women with a history of GDM had lower self-reported calorie consumption and better health-directed behaviours [49]. In addition Kim et al. strongly suggests that simple dietary and lifestyle modifications such as avoiding excessive consumption of animal foods and fat might delay or prevent the onset of T2DM in women with a history of GDM [50]. Furthermore Ferrara et al. identified the themes which emerged from the study population to aid in diet improvement as the need for low fat recipes and information on the ideal type of carbohydrate for the transition from pregnancy diet to the low-fat diet [5]. Moreover two systematic reviews reinforce the idea for improved lifestyle intervention a combination of diet and exercise may be more effective than diet alone [26,51]. Nevertheless despite being successful in many aspects of diabetes T2DM and Impaired glucose tolerance (IGT) patients may not be able to lose weight using low-GI diets. This result could be explained by the lack of satiety that individuals with reduced insulin sensitivity experience [52].

In women with IGT and a history of GDM an intensive lifestyle and metformin are both very effective in delaying and preventing diabetes [7,53]. Metformin was as much as three times more effective in reducing the incidence of diabetes in those with a history of GDM compared to those without. However the population in the Diabetes Prevention Program (DPP) was older and considerably more distant from their index pregnancies.

Consequently the individuals at highest risk who began developing diabetes in the early postpartum years before entering DPP were not represented. This may have resulted from progression into diabetes sooner [7]. The Troglitazone in Prevention of Diabetes (TRIPOD) study data provided the closest comparison to the DPP results. Thiazolidinedione drugs work by reducing insulin resistance. There was a 55% risk reduction with troglitazone treatment comparable to 50.4% risk reduction in DPP for metformin in delaying or preventing diabetes [54]. Observational follow-up by Aroda et al. in the evaluation of the effects of lifestyle intervention and metformin on preventing or delaying diabetes among women with or without gestational diabetes highlights the ongoing long-term benefits of intensive lifestyle in high-risk women with or without a history of GDM with risk reductions of 35% and 30% seen 10 years after the initial intervention randomization [53]. In summary years after the index pregnancy women with a history of GDM and IGT continue to have an increased risk of getting diabetes and it appears that either lifestyle changes or pharmacologic interventions can help.

The findings by Lim et al. raised some very interesting observations women in the intervention group reported higher emotional distress [38]. These results may be explained by a greater awareness of the possibility of having T2DM and the demands of adhering to dietary and lifestyle changes to lessen this risk all of which may in the short term cause emotional distress in the women receiving the intervention. However this is contrary to the findings by Altazan et al. which showed no change in mood and quality of life on the use of an app in the antenatal period to reduce weight gain [55]. In sharp contrast Morrison et al. identified despite being aware of the link between GDM and T2DM women with GDM do not perceive themselves to be at higher risk [56].

It is recommended to start interventions soon after the diagnosis of GDM to take advantage of the teachable moment of pregnancy. According to Ferrara et al. women with GDM might implement preventive behaviours out of concern for their children's elevated risk of poor health outcomes and their own elevated risk of diabetes [5]. In addition an opportunity for such an intervention to be implemented by the healthcare system is presented by patients' frequent interactions with the system during and after pregnancy. The International Diabetes Federation advocated for postpartum blood glucose screening and adoption of healthy lifestyle behaviour mainly diet exercise and weight reduction with the aim of minimizing or delaying occurrence of T2DM in these high-risk women [57].

Theme 3

Physical Activities

The reduction in weight retention observed in the studies was mainly attributed to the significant increase in vigorous-intensity activity among women in the intervention categories. To motivate women with GDM to undergo postpartum T2DM screening and adopt lifestyle modification advice perception of risk is crucial. Increased morbidity and mortality come from accelerated cardiovascular renal and ophthalmic diseases that are caused by poor glycaemic control. Therefore studies on exercise training in patients at risk or with T2DM have typically placed a strong emphasis on glycaemic control [58]. Exercise training has been

demonstrated to help people with T2DM reduce body fat and increase lean mass [58].

Magliano et al. highlighted significant independent and modifiable risk factors for the development of T2DM include low levels of physical exercise and fitness (both cardiovascular and musculoskeletal) [59]. Therefore changing one's lifestyle including engaging in regular exercise is now a key component of diabetes prevention. Exercise training enhances body composition cardiorespiratory fitness and cardiovascular risk profile all of which are closely linked to improved health outcomes [58].

Physical activities have been shown to be beneficial in the delay or prevention of T2DM. To begin with many lifestyle interventions such as increasing leisure time activity decreasing sitting time greater prevalence of moderate/active occupational activity active commuting and reduced prevalence of passive smoking were employed to prevent the development of T2DM in women with a history of GDM [21]. In addition the positive effects of engaging in moderate-intensity physical exercise for 50 minutes each day for at least two months may most likely last for a long time (legacy effects) [60]. Furthermore some studies revealed an increased reduction in the incidence of T2DM by prescribing 150 min/week of moderate activity exercise and dietary change to induce up to 7% weight loss [61]. Likewise Tuomilehto et al. reported in the Finnish Diabetes Prevention Study a 58% risk reduction in T2DM after engaging in 210min/week of moderate to strenuous intensity exercise (including resistance training) [62]. Moreover women with a history of gestational diabetes who engage in vigorous-intensity exercise have a lower chance of developing diabetes and those who participate in more sports have less postpartum weight gain [28,63].

Other studies have shown that postpartum women did not increase exercise despite targeted interventions [21,23]. This was related to barriers to lifestyle management postpartum. According to Makama et al. barriers identified in this group include limited knowledge on how to safely resume exercise after birth fatigue sleep disturbances stress depression lack of access to childcare time constraints and prioritizing care for the child and household commitments over personal health [49]. The COVID-19 pandemic posed another challenge whilst looking into the effects of lifestyle intervention to prevent deterioration in glycaemic status among south Asian women with recent GDM. Tandon et al. observed low amounts of moderate physical activity and sedentary behaviour [64]. These were attributed to Covid-19 restrictions due to loss of in-person group interaction dynamics. Lockdown restrictions may have decreased opportunities to increase physical activity and adapt diet. Suggestions gathered from study participants aimed at overcoming lifestyle modification barriers were noted. The women reported the desire to improve on physical activities by looking into support from family and others in their social networks ways of connecting with other GDM study participants via website and requested for tips on how to exercise with a new infant. Most women cited barriers to physical activities to personal and child illnesses returning to work and bad weather [5]. Therefore strategies for helping postpartum women to overcome barriers and increase their physical activity are needed.

Implications for Practice and Recommendations

The authors sought to investigate the preventative measures to reduce type 2 diabetes prevalence among women with previous gestational diabetes with a view to guide future treatment plans for reproductive-age women who require chronic illness management. Hordern et al. suggested exercise training programs should be written and delivered by individuals with appropriate qualifications and experience to recognise and accommodate comorbidities and complications [58]. Exercise training should be an essential component of any treatment plan for all patients at risk of or with T2DM. In addition the findings suggest that additional strategies including preventive drug therapies should be considered for further research in this group [64]. Another avenue for exploration which may yield a higher success rate is telephone or web-based interventions that can accommodate the time demands of raising a young family [23,35]. These findings were also echoed by Ferrara et al. [5]. Who suggested that future randomized control trials should focus on developing strategies for helping postpartum women to overcome barriers and increase their physical activity particularly by soliciting social support.

Taking forward what has been addressed within this study the implication for Healthcare Professionals is far reaching. These findings may encourage health systems to adopt a variety of strategies such as print/telephone-based life-style interventions to help women with GDM manage their weight and increase physical activity thereby potentially preventing or delaying the on-set of diabetes [35].

Although stigma was not wholly part of this paper stigma on patients with T2DM has been identified as a growing concern [65]. Addressing patients' concerns and sensitising the general population on diabetes and its management is an important role for the healthcare practitioners. People with diabetes report encountering internal stigma related to the condition (feeling judged for having diabetes) as well as external stigma related to the disease (being monitored and blamed for having diabetes) [65]. According to Schabert et al. people with diabetes reported that stigma affected them significantly and occurred in many areas of their lives including their jobs and relationships [66].

Diabetes-related stigmatisation has a major detrimental influence on many facets of psychological health and may also lead to less-than-ideal clinical outcomes for those who experience it. Consequently this poses a challenge in the appropriate management of T2DM. In addition diabetes patients who take insulin to control their condition reported stigma and adverse effects specific to the medication such as embarrassment when taking insulin in public having to explain their condition and feeling judged because the use of needles and syringes is linked to serious/terminal illness or illicit drug use. Furthermore qualitative research has identified family members as a common source of stigma related to obesity and T2DM [66-68]. Considering the stigma faced by T2DM patients it is important for the healthcare practitioners to educate and promote awareness of T2DM whenever an opportunity arises. This is primarily because diabetes-related stigma can lead to attempts at concealment including refusal to declare diabetes hiding and postponing insulin injections and hesitation/refusal to speak freely with medical professionals and family members about self-management glucose levels and weight [69]. Additional research concerning the stigmatisation of diabetes should be examined further.

Conclusion

This study assessed what preventative measures reduce type 2 diabetes prevalence among women with previous gestational diabetes. Three main themes were indicated to be of importance

- Weight Management
- Healthy Eating and Medication and
- Physical Activities.

Although the data gathered suggested the interventions to delay or reduce T2DM prevalence in women with previous GDM were effective there remain challenges for reproductive women which need to be explored further. Competing jobs care giving responsibilities fatigue a lack of time and cultural expectations were just a few of those challenges [70-72].

Moreover, an improved annual diabetes screening programme for women with a history of GDM in family medicine practices may be a better health care strategy to help identify more women at high risk for developing pre-diabetes.

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