DIABETES RESEARCH AND CLINICAL PRACTICE 116 (2016) 253–262

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Diabetes Research and Clinical Practice

journal homepage: www.elsevier.com/locate/diabres

International Diabetes Federation

Physical activity patterns and gestational diabetes outcomes – The wings project

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A R T I C L E I N F O

Article history:
Received 6 February 2016
Received in revised form
15 April 2016
Accepted 21 April 2016
Available online 29 April 2016

Keywords:
Physical activity
Exercise
GDM
Asian Indians
Type 2 diabetes
Lifestyle intervention

A B S T R A C T

Objective: To compare physical activity (PA) patterns in pregnant woman with and without gestational diabetes (GDM) and to assess the effects of an exercise intervention on change in PA patterns, blood glucose levels and pregnancy outcomes in GDM women.
Methods: For the first objective, PA patterns were studied in 795 pregnant women with and without GDM. For the second objective, the Women in India with Gestational Diabetes Strategy-Model of Care (WINGS-MOC) intervention were evaluated in 151 women out of 189 with GDM. PA was assessed using a validated questionnaire and a pedometer. Changes in PA patterns, glycemic parameters and neonatal outcomes were evaluated.
Results: Overall, only 10% of pregnant women performed recommended levels of PA. Women with GDM were significantly more sedentary compared to those without GDM (86.2 vs. 61.2%, $p < 0.001$). After the MOC was implemented in women with GDM, there was a significant improvement in PA and a decrease in sedentary behaviour amongst women (before MOC, moderate activity: 15.2%, sedentary: 84.8% vs. after MOC-moderate: 26.5%, sedentary: 73.5%; $p < 0.001$), and an increase in their daily step count from 2206/day to 2476/day ($p < 0.001$). Fasting 1 and 2-h postprandial glucose values significantly decreased ($p < 0.001$ for all). Sedentary behaviour was associated with a fourfold higher risk ($p = 0.02$), and recreational walking with 70% decreased risk, of adverse neonatal outcomes ($p = 0.04$) after adjusting for potential confounders.
Conclusions: PA levels are inadequate amongst this group of pregnant women studied i.e. those with and without GDM. However, a low-cost, culturally appropriate MOC can bring about significant improvements in PA in women with GDM. These changes are associated with improved glycemic control and reduction in adverse neonatal outcomes.

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http://dx.doi.org/10.1016/j.diabres.2016.04.041
0168-8227/© 2016 The Author(s). Published by Elsevier Ireland Ltd.

1. Introduction

Gestational diabetes mellitus (GDM) has emerged as a global public health problem, with nearly one in seven live births worldwide being complicated by hyperglycemia [1]. Untreated hyperglycemia in pregnancy is associated with several adverse maternal and neonatal outcomes, many of which can be prevented with prompt diagnosis and appropriate management [2]. Therapeutic lifestyle change, comprising dietary modifications and encouragement of physical activity (PA), forms the first line of therapy for GDM. Indeed, there is sufficient data now to show that increasing PA prior to conception and in the early stages of pregnancy can prevent development of GDM [3–5]. However, there is little information as to whether PA can improve glycemic control or reduce adverse neonatal outcomes in women already diagnosed with GDM.

Sedentary behaviour (SB), defined as “any waking behaviour characterised by an energy expenditure $\leqslant$1.5 metabolic equivalents (METs) while in a sitting or reclining posture” has been shown to be an important risk factor for adverse health outcomes in the non-pregnant population, irrespective of PA [6,7]. However, there is little data on the prevalence and patterns of sedentary behaviour in pregnancy and whether it is associated with adverse pregnancy outcomes. This assumes significance as earlier studies have shown an increase in sedentary behaviour as pregnancy progresses [8–10].

Guidelines from the American College of Obstetrics and Gynaecology (ACOG) recommend that healthy pregnant and postpartum women perform at least 20–30 min of moderate-intensity exercise on most days of the week [11]. However, PA patterns in pregnant women vary widely depending on ethnicity, geography, socio-economic status, literacy and religious and cultural factors. There is virtually no data on PA patterns in pregnant women in South East Asia and particularly in India in many parts of which PA levels are extremely low even amongst the general population [12].

The present paper has two aims: firstly, we attempted to evaluate the PA patterns of pregnant women, specifically looking at the differences between women with and without GDM. Secondly, in women with GDM, we aimed to assess the effects of the Women in India with Gestational Diabetes Strategy Model of Care (WINGS-MOC), a standardised approach to GDM care on change in PA patterns and blood glucose levels as well as pregnancy outcomes.

2. Materials and methods

2.1. *Women in India with GDM Strategy (WINGS) Model of Care*

The Women in India with GDM Strategy (WINGS) project was developed to address the challenges in effective care for GDM, utilising a multidisciplinary approach designed to be feasible for implementation in low resource settings. The WINGS Model of Care (MOC) was developed based on global aspects of best practice and detailed research into local conditions. The WINGS MOC is a standardised, context-adapted approach to care, consisting of a lifestyle intervention (diet and physical activity) along with pharmacotherapy whenever indicated as per a standardised algorithm, aimed at improvement of maternal and neonatal outcomes in women with GDM [13].

2.2. *Study population*

The study included 1086 consecutive pregnant women with gestational age less than 28 weeks attending six maternity clinics located in Chennai, southern India, between November 2013 and December 2014. Women with pre-existing diabetes and those with multiple pregnancies or assisted pregnancies were excluded.

In all study participants, clinical information including obstetric history, family history of diabetes and previous history of GDM were collected using a structured questionnaire. Height and weight were measured using standardised techniques [14] and the body mass index (BMI) calculated, as weight (kg) divided by height (in metres) squared. The International Association of Diabetes in Pregnancy Study Groups (IADPSG) criteria were used for the diagnosis of GDM [15,16]. A detailed physical activity questionnaire was used to collect data on pregnant women with and without GDM (see below Section 2.4.1).

2.3. *Intervention – the WINGS Model of Care*

Women with GDM were enroled into the MOC during their antenatal visits to the maternity clinics. The “Before MOC” visit was the baseline visit at which questionnaires were administered and anthropometric and biochemical data collected. As part of the MOC, women received in-depth education about GDM and its implications for both themselves and their babies. They were instructed on dietary principles, monitoring and pharmacotherapy for management of GDM. They were also provided a booklet called “Having a Baby” which not only reinforced facts about GDM but also had sample meal plates, details about insulin injections, etc. The WINGS Intervention materials can be accessed at the IDF website.http://www.idf.org/women-and-diabetes/resource-centre [17].

As part of the PA component of the MOC, all women with GDM were offered individualised one-on-one counselling about the importance and benefits of PA in pregnancy. Women were encouraged to meet the PA guidelines at every antenatal visit. The booklet also had illustrations of exercises which are safe to perform in pregnancy. A pedometer was provided to all women with GDM to encourage them to increase their daily step count and to record this in the booklet. The intervention was provided by trained nutritionists and health care professionals for a mean duration of 12 weeks. Women were followed throughout their pregnancy and the intervention was reinforced at every antenatal visit in their respective maternity clinics. At the “After MOC” visit (between 30 and 35 weeks), the questionnaires, anthropometry and biochemical investigations were repeated.

2.4. Outcomes

The outcomes assessed for the MOC were the following.

(1) Changes in PA patterns.
(2) Changes in glycemic parameters.
(3) Neonatal outcomes.

2.4.1. Measurement of physical activity

PA measurement was done using a validated, locally relevant PA questionnaire for India called the Madras Diabetes Research Foundation – Physical Activity Questionnaire (MPAQ) [18]. The MPAQ measures PA in four main domains viz. work, transport, recreational and the general (activities of daily living) domain. Frequency, intensity, type and duration of activities were calculated in the various domains. Physical Activity Level (PAL) scores were then computed to determine whether the woman had a sedentary, moderate or vigorously active lifestyle. The MPAQ-Pregnancy version was adapted from the main MPAQ by deleting questions which were not relevant to pregnant women and adding a question on prenatal exercises. The reproducibility of the MPAQ-Pregnancy version was tested in a random subset of 56 women within a period of 2 weeks. The overall reproducibility of the MPAQ was good (Spearman's correlation coefficient r = 0.60, varying from 0.40 in the recreational domain to 0.60 in the work domain). Criterion validity of the questionnaire was tested against the pedometer in a random subset of 76 women. We found that 15% of the participants were misclassified in the active group while 30% were misclassified in the inactive group suggesting an overall fair agreement of the MPAQ with the pedometer.

In women with GDM, under the MOC-PA was measured twice-once before and once after the MOC to assess changes in PA patterns. The MPAQ was administered by well-trained interviewers and the inter – rater agreement was 95%.

2.4.2. Glycemic parameters

Plasma glucose (PG) was estimated by the glucose oxidase–peroxidase method using auto-analyser AU2700 (Beckman, Fullerton, CA). Glycated haemoglobin (HbA1c) was measured using high performance liquid chromatography (HPLC) using Variant machine (BIORAD, Hercules, CA). The intra and inter-assay coefficients of variation (CV) for the glucose and HbA1c ranged from 0.78–1.68% to 0.59–1.97%, respectively. All samples were processed in a laboratory certified by the College of American Pathologists (CAP) and by the National Accreditation Board for Testing and Calibration Laboratories (NABL), Government of India.

2.4.3. Neonatal outcomes

The neonatal outcomes of interest included macrosomia (birth weight > 3.5 kg) [19], shoulder dystocia, neonatal hypoglycaemia (blood glucose < 30 mg/dl in the first 24 h of life) [20], polycythemia, congenital anomalies, hyperbilirubinemia, fetoscopic tracheal occlusion and admission to neonatal ICU. These were retrieved from the obstetric records at the maternity clinics.

The study was approved by the Institutional Ethics Committee of the Madras Diabetes Research Foundation (MDRF) and informed consent obtained from all study participants. All procedures followed were in accordance with the ethical standards and in keeping with the Declaration of Helsinki 1975, as revised in 2008.

2.5. Statistical analysis

Statistical analyses were performed using SAS (Statistical Analysis System) package (version 9.2; SAS Institute Inc., Cary, NC). Estimates were expressed as median and interquartile range (IQR) for data that were not normally distributed and as frequencies (*n*) and percentages (%) for categorical data. The MPAQ captured data on the frequency (daily/weekly/never), duration (in hours and minutes) and intensity [Physical Activity Ratio (PAR) cost] of reported activities. These were considered for calculation of the total PAR and further divided by 24 h to assess the PAL of the study participants. PAL-based cut offs were used to group the women as sedentary (PAL cut off: 1.40–1.69), moderately active (PAL – 1.70–1.99) and vigorously active (PAL 2.0–2.40). Mann–Whitney *U* and chi-square tests were used to compare continuous variables and categorical variables, respectively, between women with and without GDM. The Wilcoxon signed rank test was used for continuous variables to compare "before" and "after MOC" while McNemar's test was used for categorical variables. Multivariate logistic regression was used to estimate the adjusted odds ratio (OR) and 95% confidence intervals (CI). The dependent variable was a composite of all the neonatal outcomes, while the independent variables were sedentary behaviour and recreational walking. The lowest tertile of time spent (minutes/day) in sedentary behaviour was considered as reference and the risk variable was the upper two tertiles combined. The inverse association of recreational walking to neonatal outcomes was evaluated by taking the lowest tertile of walking (minutes/day) as reference. The analyses were adjusted for age, BMI, previous history of GDM, gestational age and use of insulin. A p value < 0.05 was considered as statistically significant.

3. Results

Out of the 1086 pregnant women with available glucose values at the first visit, 247 met the diagnostic criteria for GDM (Fig. 1). PA data was available in 917 of the pregnant women (response rate 84.4%). There were no significant differences in age, gestational age, BMI, fasting, 1-h and 2-h glucose values and HbA1c between the responders and the non-responders (Data not shown).After removing implausible and missing data and over- and under-reporters data from 795 women was available for PA pattern analysis, of whom 189 had GDM. We were able to complete the second administration of the PAQ after MOC in 151 out of 189 women with GDM.

Table 1 describes the baseline characteristics of women with and without GDM and the time they spent in various domains of activity. Women with GDM were significantly older, had a higher BMI, and were more likely to have a family

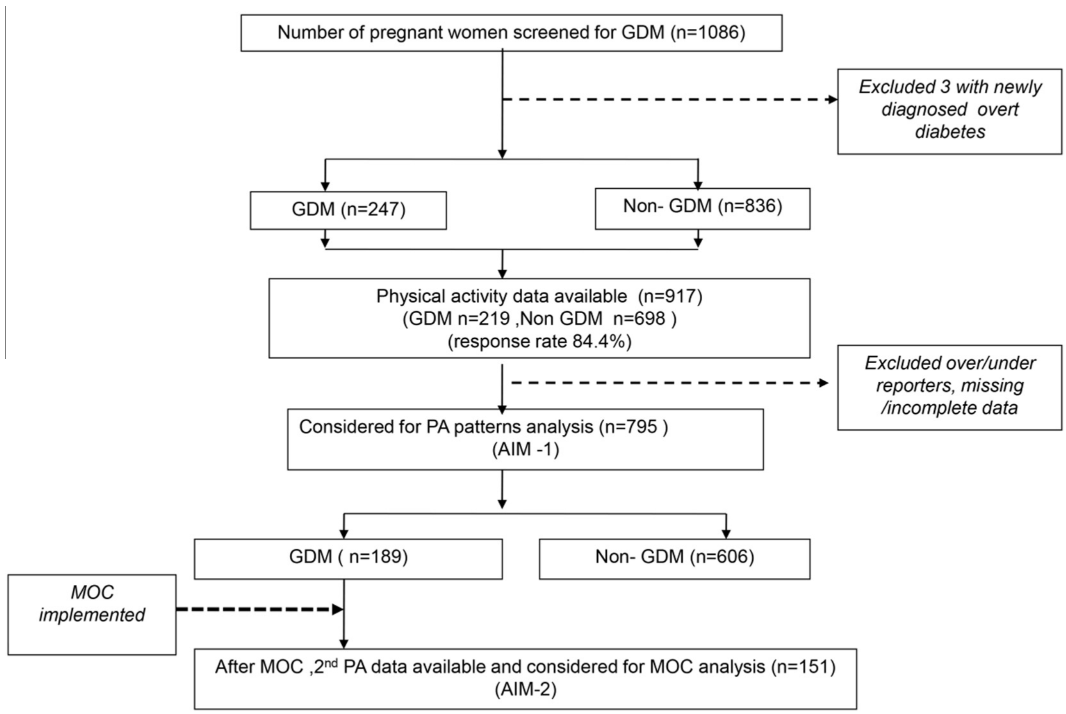

Fig. 1 – Flowchart depicting study design.

history of diabetes and previous history of GDM compared to those without. Amongst the 189 women with GDM, 20 were on insulin (10.6%). Women with GDM were significantly more sedentary compared to those without (86.2% vs. 61.2%) and spent significantly more time sleeping. They were significantly more sedentary in the transport and general domains, but there were no differences in the work and recreational domains. Although moderate activity was notably higher in women without GDM, none of the study participants reported any vigorous activity.

Overall, only 10.7% of pregnant women met the recommended guidelines for PA (8.7% amongst women without GDM and 16.9% amongst women with GDM; $p = 0.001$). The most common types of activities reported by pregnant women included household activities like cooking and non-mechanized domestic chores. This was followed by walking as exercise and going to places of worship. Overall, women spent 23% of their day (median, 375 min) at work, 33% (539 min) in sleep, 21% (340 min) in the general domain (activities of daily living), 2% (34 min) in the transport domain, 11% (182 min) in the recreational domain and 11% (180 min) watching TV. There were no significant differences in time spent in various domains between women with and without GDM (data not shown).

After the MOC, there was a significant improvement in activity and a decrease in sedentary behaviour amongst women with GDM (before MOC, moderate activity: 15.2%, sedentary: 84.8% vs. after MOC – moderate: 26.5%, sedentary: 73.5%; $p < 0.001$). This increase in activity came primarily from the recreational and general domains, with a significant increase in active minutes in these domains (Fig. 2a). Although there was a significant increase in time spent viewing TV, overall sedentary behaviour was significantly lower after the MOC compared to before. There were no significant differences noted in the work domain, although the number of women working came down from 27% to 17%. After the MOC, there was a significant (302%) increase in time spent performing non-mechanized domestic chores (Fig. 2b) and a 20% increase in walking as exercise (recreational walking) (Fig. 2c), with a 26% decrease in overall sedentary behaviour (Fig. 2d). The daily step count measured using the pedometer, increased significantly from 2206/day to 2476/day ($p < 0.001$) in a subset of 91 women who had noted down the pedometer steps in their booklets. Although a greater proportion of women met the recommendations for PA after the MOC as compared to before (23.2% vs. 18.5%), this difference was not statistically significant.

Table 2 shows the maternal and neonatal outcomes after the MOC and odds for adverse neonatal outcomes associated with sedentary behaviour and recreational walking. Fasting, 1-h and 2-h postprandial glucose values significantly decreased after the MOC [Median (IQR) fasting blood glucose before MOC: 89 (17.0) mg/dl vs. after MOC: 85 (13.0) mg/dl; $p < 0.001$, 1-h postprandial blood glucose before MOC: 170 (44) mg/dl vs. after MOC: 124 (34) mg/dl; $p < 0.001$, and 2-h postprandial blood glucose before MOC: 148 (21) mg/dl vs. after MOC: 111 (35.5) mg/dl; $p < 0.001$], but there was no change in HbA1c before and after MOC.

The median gestational age at delivery was 38 ± 2 weeks and the median gestational weight gain was 7 ± 5 kg. The caesarean section rate was 60.9% (42.3% emergency), while 32.5% had a normal delivery and 6.6% had an instrumental delivery. The majority of babies (94%) were born at term. The overall occurrence of all adverse neonatal outcomes was 19.2% (13.2% macrosomia, 3.3% admission to NICU, 1.3% neonatal hypoglycaemia and others, 1.4). When looking at the odds

Table 1 – Baseline characteristics and time spent in various domains by pregnant women with and without GDM ($n = 795$).

Variables	GDM ($n = 189$) Median (IQR)	Non GDM ($n = 606$) Median (IQR)	p Value
Demographic details			
Age (years)[a]	29.0 (6.0)	27.0 (5.0)	<0.001
Height (cm)	156.0 (8.0)	156.0 (9.0)	0.41
Weight (kg)[a]	61.0 (17.8)	58.6 (17.0)	0.05
BMI (kg/m^2)[a]	24.9 (6.4)	24.2 (6.0)	0.01
Family history of diabetes mellitus yes n (%)[b]	87.0 (46.0)	214 (35.3)	0.01
Previous history of GDM yes n (%)[b]	14 (7.4)	9 (1.5)	<0.001
Gestational age (weeks)	14.0 (12.0)	16.0 (10.0)	0.27
Clinical parameters			
HbA1c (%) [a]	5.1 (0.5)	4.8 (0.6)	<0.001
HbA1c (mmol/mol) [a]	32	29	<0.001
Fasting blood glucose (mg/dl) [a]	91.0 (17.0)	78.0 (9.0)	<0.001
OGTT 1 h blood glucose (mg/dl) [a]	169.0 (48.5)	121.0 (27.0)	<0.001
OGTT 2 h blood glucose (mg/dl) [a]	146.0 (33.0)	111.0 (28.0)	<0.001
Nulliparous n (%)	86 (45.5)	320 (52.8)	0.08
Treated with insulin n (%)	20 (10.6)	–	–
Physical activity			
Physical Activity Level (PAL) score based			
Sedentary n (%)[b]	163 (86.2)	371 (61.2)	<0.001
Moderate n (%)[b]	26 (13.8)	235 (38.7)	
Domain wise time spent in min/day			
Work			
Active	83.3 (125.0)	83.3 (108.3)	0.35
Sedentary	291.8 (166.7)	291.8 (114.6)	0.49
General activities			
Active	153.0 (104.8)	239.7 (197.2)	<0.001
Sedentary	119.8 (59.9)	119.8 (69.9)	0.78
Transport			
Active	29.9 (44.9)	29.9 (44.9)	0.33
Sedentary	16.6 (45.5)	8.3 (26.0)	0.02
Recreation			
Active	29.9 (49.9)	29.9 (47.6)	0.88
Sedentary	145.3 (152.3)	149.8 (164.7)	0.88
Sleep	581.6 (124.0)	539.3 (119.8)	<0.001
Watching TV	179.7 (179.7)	179.0 (119.8)	0.31

[a] p value < 0.05 considered as significant. Mann–Whitney U test used for comparison of the study participants.
[b] p value < 0.05 considered as significant. Chi-square test used for comparison of the study participants.

of developing adverse neonatal outcomes, those in the upper tertiles of sedentary behaviour (minutes/day) had 3.8 times higher risk of adverse outcomes (95% CI 1.2–12.2; $p = 0.02$) compared to the lowest tertile after adjusting for age, BMI, previous history of GDM, gestational age at study entry and cereal staple intake. Conversely, recreational walking showed a 70% decreased risk for adverse neonatal outcomes ($p = 0.04$) even after adjusting for the confounding variables.

4. Discussion

Our study shows that the majority of pregnant women-studied at Tamil Nadu in Southern India (both GDM and non-GDM) are sedentary with only a very small percentage of women meeting the recommendations for PA. Most of the activity was derived from household chores, followed by recreational walking. We also show that sedentary behaviour was more common in women with GDM compared to those without. Women with GDM also tended to sleep longer than those without, which probably reflected their more sedentary behaviour. The WINGS MOC helped to significantly improve activity and reduce sedentary behaviour in women with GDM, with more women meeting the PA recommendations. Recreational walking was associated with better neonatal outcomes.

Our findings indicate that only around 10% of women fulfilled the recommendations for PA in pregnancy, perhaps reflecting the overall low levels of PA in the general population [12]. The low prevalence of PA in our study population contrasts directly with the situation in western countries, where studies have shown that a substantial proportion of women are physically active during pregnancy. In the National Maternal and Infant Health Survey, 42% of women reported exercising during pregnancy and half of these exercised for more than 6 months into the pregnancy [21]. Recreational walking, swimming and aerobics were the most

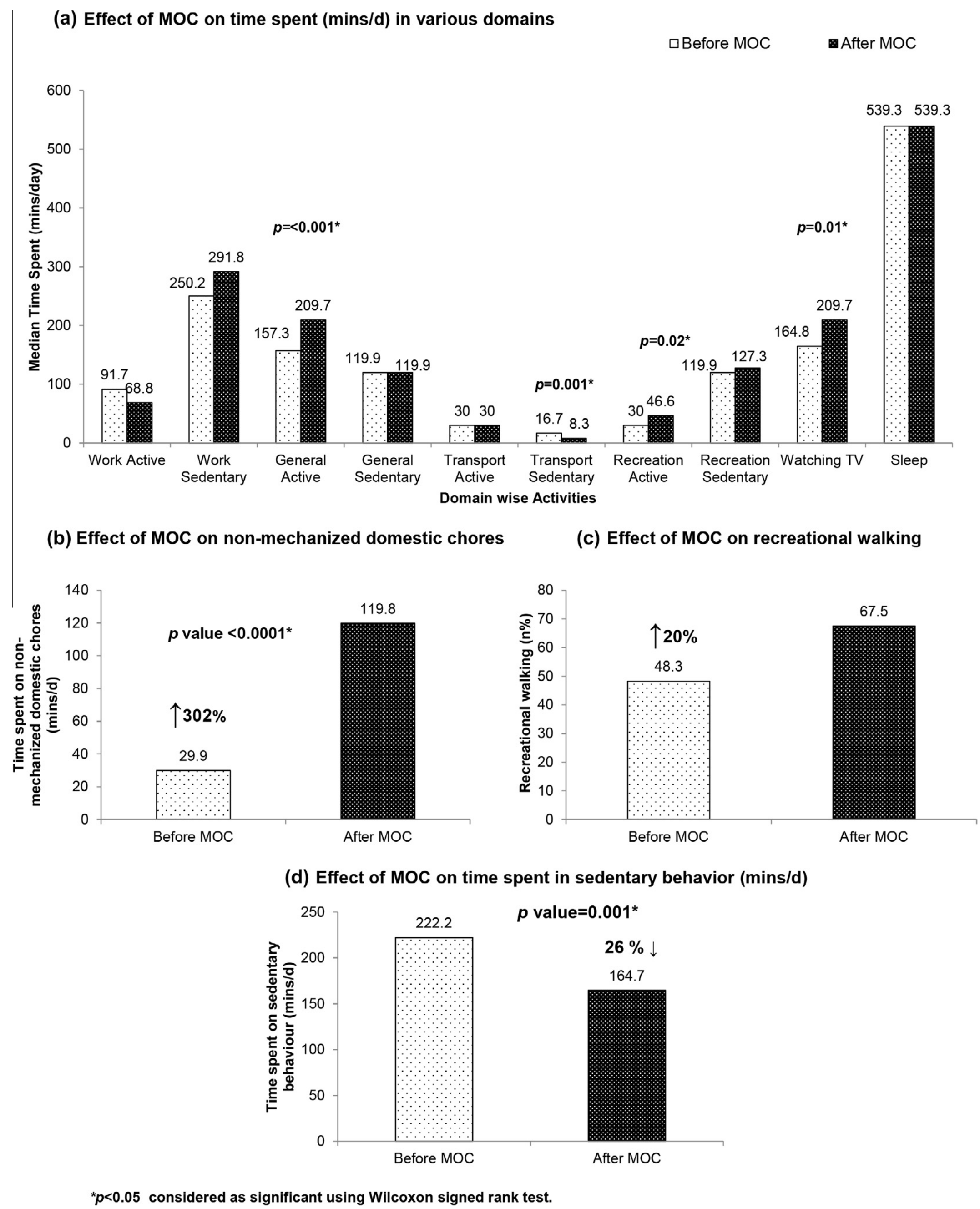

Fig. 2 – Effect of WINGS MOC on physical activity patterns (n = 151). (a) Effect of WINGS MOC on time spent (mins/d) in various domains. (b) Effect of WINGS MOC on non-mechanized domestic chores. (c) Effect of WINGS MOC on recreational walking. (d) Effect of WINGS MOC on the time spent in sedentary behaviour (mins/d). Legend: □ Before MOC, ▩ After MOC.

frequent activities reported. In another study of 386 women, 61% of pregnant women participated in some form of regular PA [22]. In the Avon Longitudinal Study of Parents and Children, 48.8% of pregnant women engaged in strenuous PA in the first trimester, with the most common activities reported being brisk walking, swimming and antenatal exercises [23].

Pregnant women in our study derived most of their daily PA from household work such as cooking and non-mechanized domestic chores, perhaps indicating that these activities are deemed culturally appropriate and safe for women to perform during pregnancy. Household activities were also reported as significant contributors to total PA in the Pregnancy, Infection and Nutrition Study conducted in 1482 pregnant women in the United States [24] and in a racially and economically diverse sample of 233 pregnant women from Australia and the US [9]. Studies from western populations have also reported high prevalence of recreational walking during pregnancy [20,21,25], although participation in sports was relatively low.

Sedentary time has emerged as an independent risk factor for obesity and several other non-communicable diseases (NCDs) [7]. It is important to note that even those who

Table 2 – Maternal and neonatal outcomes after MOC and odds for adverse neonatal outcomes ($n = 151$).

Variables	Median (IQR)
Fasting blood glucose delta	−3.0 (−3.0) [$,*]
One hour postprandial delta	− 43 (−23.9)[$, *]
Two hour postprandial delta	−37.5 (−26.1) [$,*]
Gestational weight gain (kg)	7.0 (5.0)
Gestational age at delivery (weeks)	38.0 (2.0)
Maternal outcomes	N (%)
Normal delivery *n* (%)	49 (32.5)
Instrumental delivery *n* (%)	10 (6.6)
Caesarean section *n* (%)	28 (18.6)
Emergency Caesarean section *n* (%)	64 (42.3)
Neonatal outcomes	N (%)
Term birth *n* (%)	142 (94.0)
Preterm birth *n* (%)	9 (6.0)
Adverse neonatal outcomes *n* (%)	29 (19.2)
Macrosomia *n* (%)	20 (13.2)
Congenital anomalies *n* (%)	1 (0.7)
Hyperbilirubinemia *n* (%)	1 (0.7)
Neonatal hypoglycaemia *n* (%)	2 (1.3)
Neonatal ICU admission *n* (%)	5 (3.3)
Odds for adverse neonatal outcomes	OR (95%CI)
Sedentary behaviour (min/day)	
Lowest tertile (Range: 3.0–275.6) Ref OR	1.0
Upper tertiles (Range: 282.6–754.0) OR (95% CI)	3.8[#] (1.2–12.2) $p = 0.02$
Recreational walking	
Lowest tertile (NO) Ref OR	1.0
Upper tertiles (YES) [Range OR (95% CI)]	0.3[#] (0.07–1.0) $p = 0.04$

$ %change = after minus before MOC.
* p value < 0.001 changes between after and before MOC was tested by Wilcoxon signed rank test.
# Odds adjusted for age (yrs), BMI (kg/m^2), previous history of GDM (yes/no) and gestational age (weeks), main cereal staple.

exercise regularly are prone to long bouts of sedentary behaviour during the remainder of the day. In pregnancy, several studies have shown a tendency towards increasing sedentary behaviour, particularly in the third trimester [8], and even amongst hitherto active women. This has also been shown to be associated with a dip in energy expenditure, and decline in recreational and occupational PA [9]. In a study on Chinese, Malay and Indian women in Singapore, sitting time and television viewing time were found to increase during pregnancy [10]. Sedentary behaviour was significantly prevalent even amongst women who meet the PA recommendations [26]. Increases in sedentary behaviour during pregnancy have been shown to be associated with adverse perinatal outcomes and abnormal glucose tolerance [27]. Our results indicate that women with GDM who accumulate the greatest magnitude of sedentary time have a nearly fourfold higher risk of adverse neonatal outcomes compared to women in the lowest tertile of sedentary time.

It is therefore noteworthy that, in our study population, the application of the WINGS-MOC was able to reverse the trend of declining physical activity associated with progression of pregnancy, with significantly more women reporting active lifestyles during later pregnancy (after MOC) than earlier (before MOC). Our participants also reported a significant decrease in sedentary behaviour towards the last trimester, in addition to improving activity levels. Socio-cultural practices encouraging increased participation in non-mechanised domestic chores as a means to ensure easier labour and delivery, could perhaps have helped to make the recommendations in our MOC more acceptable to pregnant women and their families. Following the MOC, there was also a significant increase in the daily step count as measured by the pedometer. However, this finding should be considered in its proper context. The pedometer readings were available only in a subsample of women who were motivated to record their daily steps, thereby introducing an element of bias in the results. Even so, the daily step count, even after the MOC, remained considerably lower than that reported amongst women of child-bearing age from other countries (2476 steps/day in our study as compared to 5800 steps/day in the United States and 9000 steps/day in Canada) [28], probably reflecting overall lower levels of activity in our population.

The effects of regular aerobic exercise on blood glucose levels in non-pregnant individuals have been well characterised and involve improvement in both hepatic and peripheral (skeletal muscle) insulin sensitivity [29]. In GDM, a total of 7 trials (5 randomized) have been published on the effects of exercise on glycemic parameters, involving a total of 304 women. Intervention was instituted mostly in the third trimester and lasted for a mean of 6 weeks. In most trials, there was a significant decrease in glycemic parameters and in the need for insulin [30]. For instance, ergometer training for 6 weeks was shown to lower fasting and 1-h postprandial glucose and HbA1c levels [31]. Similarly, a low intensity walking programme in women with GDM was found to lower fasting and 1-h postmeal glucose values in the intervention group compared to controls [32]. While a recent Cochrane review evaluating the effect of exercise on glycemic parameters and maternal and perinatal morbidity concluded that there was insufficient evidence to recommend or advise against exercise programmes in pregnant women with diabetes, the authors concluded that there was a need for further studies in women with GDM and type 2 diabetes to evaluate the effects of exercise interventions [33]. In our study, we found that women who were physically active had lower fasting, 1-h and 2-h PG values; however, the HbA1c levels did not change, perhaps reflecting the relatively short duration of the intervention and other fallacies associated with HbA1c estimation in pregnancy, such as anaemia.

There is little data on the effect of exercise on neonatal outcomes in women with GDM. A few studies have shown no increase in adverse neonatal outcomes due to exercise; however, these were performed in women without GDM [34]. Bung et al. showed that there was no difference in maternal and foetal complications in women who exercised, compared to those who did not [35]. Conversely, a retrospective analysis of records of Chinese women with GDM showed that women who exercised had lower rates of preterm birth, low birth weight and macrosomia compared to those who did not exercise [36]. This is similar to our results which indicate that recreational walking helps prevent adverse neonatal outcomes.

Our study is unique in that it is one of the first to have looked at maternal and foetal outcomes of women with GDM after an exercise intervention. In addition, the MOC tested was a low-cost intervention that was easily adapted into routine clinical care and was easy to administer. This is also one of the few studies to have looked at the effects of sedentary time separately. Other strengths of the study include adequate sample size and good response and follow-up rates. The study is first of its kind in Asian Indian women.

The main limitation of the study is the absence of a comparator group, so that we were unable to compare outcomes for women without GDM. Also as this study was done in selected ante – natal centres in urban Chennai its generalisation to the whole of India cannot be done and this a limitation of the study. Assessment of PA was performed using a questionnaire, with the inherent element of recall bias. The pedometer data was available only in a subset of women who were motivated to write down the results introducing an element of bias towards a higher step count. As the lifestyle intervention consisted of both dietary and exercise components, it is difficult to tease out the effects of PA vs. diet on the observed outcomes. It is encouraging to note that, the beneficial effect of PA persisted even after adjusting for the potential confounding effect of staple cereal intake, suggesting that it has possible independent benefits on neonatal outcomes. However, the confounding effects of other lifestyle factors cannot be ruled out.

5. Conclusions

To conclude, our results show that in urban South Indian pregnant women included in this study, the PA levels are inadequate both in those with and without GDM. However, we have also shown that implementation of a low-cost, culturally appropriate MOC can bring about positive behavioural change in the form of improved PA and reduction of sedentary time amongst women with GDM. Our outcome data suggest that these changes may be associated with improved glycemic control and lower incidence of neonatal complications, which may contribute significantly to the morbidity associated with GDM. Larger randomised studies are necessary to elucidate whether our findings are applicable to the multitudes of women with GDM not only in India, but also in other low and middle-income countries across the world. Further research also needs to be done to better understand the mechanisms of the apparent benefits of PA in GDM, and to evaluate the long-term benefits of such interventions.

Author contributions

RMA was responsible for the conception of this paper and analysis of data, wrote the first draft and revised all drafts of the manuscript. VM and RU helped in the interpretation of data and revised several drafts of the manuscript. VS, NL and CA were involved in analysis of data. BB, MMM, KM and AK were involved in the coordination and execution of the study. VS, HR, MD, PR, UR, LN, SDP, BM and AB reviewed and edited the manuscript. All authors approved the final version of the manuscript. RMA is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Conflict of interest

No potential conflicts of interest relevant to this article were reported.

Acknowledgements

The WINGS project was developed through a partnership between the International Diabetes Federation (IDF) in Brussels, Belgium, the Madras Diabetes Research Foundation (MDRF) in Chennai, India, and the Abbott Fund, the philanthropic foundation of the global healthcare company, Abbott. We would like to place on record our sincere thanks to the Health Secretary, Government of Tamil Nadu and the Director of Public Health, Government of Tamil Nadu for granting permission to carry out the project. We also thank our collaborating maternity clinics – Seethapathy Clinic and Hospital, E.V. Kalyani Medical Centre, Anuradha Maternity Centre, Andhra Mahila Sabha Hospital, Punjab Association Clinic and Prashanth Hospital for their cooperation and support. This is the 8th publication from the WINGS project (WINGS-8).

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