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Ethnic differences in physical activity participation when managing gestational diabetes mellitus: a mixed-methods study comparing ethnic Chinese migrants and Australian women

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ABSTRACT

Background: Physical activity is a key component in gestational diabetes mellitus management to optimise glycaemic control and reduce adverse pregnancy outcomes. However, inadequate physical activity during pregnancy is common. Underpinned by a woman-centred pregnancy care model, appropriate strategies targeting patients' cultural needs may facilitate physical activity participation. Ethnic Chinese migrants have a four-fold higher risk of gestational diabetes mellitus than the Australian Caucasian host population. To identify potentially effective disease management strategies to improve physical activity participation, understanding and comparing ethnic Chinese migrants' and Caucasian women's views will provide insights into developing an end-user-informed intervention.

Aims: This study aimed to compare perceptions and practices around physical activity participation during pregnancy between 44 ethnic Chinese migrants and 39 Australian-born Caucasian women with gestational diabetes mellitus.

Methods: This mixed-methods study used in-depth, semi-structured audio-recorded interviews, validated pregnancy physical activity questionnaires and pedometers. Qualitative data were thematically analysed and compared between ethnicities. SPSS (SPSS Inc) was used in quantitative data analysis. Data triangulation was made to identify patterns in participant characteristics, physical activity beliefs and participation.

Results: Despite both ethnic groups doing less physical activity than recommended, Chinese participants were less physically active than Caucasian participants. Chinese participants expressed

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greater safety concerns about physical activity and opted for a more sedentary lifestyle. Data triangulation indicated that non-Australian-born Chinese participants whose husbands were Asian were overcautious about miscarriage risk related to physical activity, which promoted a sedentary lifestyle. Chinese participants suggested individualised, specific physical activity advice on safe physical activity during pregnancy would mitigate their concerns. Caucasian participants reported that digital step measurement technologies motivated their participation in physical activity.
Conclusion: Different strategies are suggested by Chinese and Caucasian participants to improve physical activity participation to manage gestational diabetes mellitus among ethnic Chinese and Caucasian populations, which will be evaluated in future interventions.

1. Introduction

Gestational diabetes mellitus (GDM) has become increasingly prevalent worldwide due to an increase in risk factors for GDM (Kiani et al. 2017) and the concomitant implementation of more inclusive GDM diagnostic criteria (Behboudi-Gandevani et al. 2019). This escalating prevalence poses an increasing public health burden, as GDM affects the health of at least two generations in a perpetuating transgenerational cycle (Madhu 2018). Although women with GDM are at increased risk of adverse short-term and long-term maternal and neonatal outcomes, these complications can be reduced with optimal glycaemic control (Horvath et al. 2010). Physical activity (PA) is an inherent component of lifestyle modification aimed at optimising glycemic control and reducing adverse pregnancy outcomes (Colberg, Castorino, and Jovanovič 2013).

Although PA during pregnancy is well-known to have several maternal and neonatal benefits throughout the perinatal period (DiPietro et al. 2019), and relevant guidelines have been published in the past two decades (American College of Obstetricians and Gynecologists 2020; Kader and Naim-Shuchana 2014), PA participation amongst pregnant women is lower than the general population and less than recommended levels of PA (Currie et al. 2013). Insufficient PA among women with GDM is also common (Bgeginski et al. 2017), even though the desire for a healthy baby is a significant motivating factor for self-managing GDM (Jakubowski et al. 2022). Nevertheless, pregnancy remains an ideal time to initiate healthier lifestyle changes in young women for long-term health benefits, as they are more responsive to health messages directed at motivating change (Lindqvist et al. 2017). Therefore, identifying effective strategies to promote PA participation during pregnancy is essential.

Extensive literature has investigated the effectiveness of different PA intervention strategies although the evidence is still uncertain due to the diversity of population characteristics (Currie et al. 2013; James et al. 2020; Such et al. 2016). PA participation is influenced by conceptualisation in defining PA, PA knowledge, perceptions of health status, individual demographics and psychosocial factors (O'Driscoll et al. 2014). For instance, migrant and majority host populations are likely to respond to PA interventions differently as they may have different health perceptions, sociocultural

norms and health needs (Haith-Cooper et al. 2018; Harrison et al. 2018; Romeike et al. 2016). Underpinned by the concept of woman-centred pregnancy care embodied in the national guideline (Department of Health 2020), culturally appropriate intervention strategies are attuned to increasing the likelihood of women following PA advice, optimising glycaemic control, and improving health outcomes (Ball et al. 2016). Understanding ethnic differences between migrants and the host population in their perceptions and experiences of PA participation in managing GDM could assist in identifying evidence-based strategies to provide effective and culturally appropriate PA advice to migrants and members of the host population (Romeike et al. 2016). However, little is known about the similarities and differences in the perceptions and experiences of PA participation across culturally diverse groups in Australia (Langøien et al. 2017).

Ethnic Chinese are one of the largest groups of migrants arriving in Western countries (Hooper and Batalova 2015) and have a four-fold higher risk of GDM than the Caucasian host populations (Wan, Abell, et al. 2019). No study to our knowledge has explored and compared PA practices and the perceptions and experiences of PA participation among ethnic Chinese migrants and the Caucasian host population in GDM management. Understanding ethnic differences in PA practices and the perceptions of PA's role in self-managing GDM may inform the development of culturally appropriate strategies to improve PA participation. Therefore, we used a mixed-methods study design to explore and compare perceptions and experiences of PA participation during pregnancy and PA practices among ethnic Chinese migrants with GDM (herein referred to as Chinese participants) and Australian-born Caucasian women with GDM (herein referred to as Caucasian participants) in Australia.

2. Materials and methods

This research was part of a larger, predominantly qualitative mixed-methods study with embedded quantitative components collected concurrently, which aimed to compare the perceptions, experiences and lifestyle practices of GDM management among ethnic Chinese migrants living with GDM with those of Australian-born Caucasian counterparts and their health care providers. This paper reports only on the results of the perceptions and experiences of PA drawn from the qualitative data sets of interviews with women living with GDM and the PA assessments drawn from the quantitative data sets. The Good Reporting of A Mixed Methods Study (GRAMMS) was followed in reporting (O'cathain, Murphy, and Nicholl 2008).

2.1. Theoretical framework

A symbolic interactionist framework underpinned the mixed-methods study design. It assumes that individuals interpret and assign meanings to their experiences and actions and that their subsequent actions are based on those perceptions and interpretations (Carter and Montes Alvarado 2019). The qualitative component enables insights into individuals' interpretations and/or assignment of meanings to their experiences and interactions. The quantitative component describes PA behaviours. Qualitative and quantitative data triangulation further examines how cultural values and philosophies may influence PA participation and behaviour decision-making.

Table 1. Examples of questions asked in the interview.

Question topics	Sample questions
PA during pregnancy	What do you think about doing PA during pregnancy? What PA means to you?
GDM experiences	What is its impact on the rest of your daily activities, lifestyle, PA, work, home and family life?
PA in GDM management	How do you feel about roles of PA in GDM management?
Motivators and barriers	What motivates or prevents you from doing PA? What kind of things have or have not helped you during your pregnancy?
GDM management	How confident are you in blood glucose management? How healthcare could be better improved to assist you with managing GDM?

GDM: gestational diabetes mellitus; PA: physical activity.

2.2. Participant recruitment

We recruited self-identified Chinese and Caucasian women who had singleton pregnancies and were diagnosed with GDM at two of the largest public maternity services in Australia using purposive sampling strategies. Both health services provided similar GDM intervention programmes, involving group education after diagnosis and ongoing follow-up appointments with multi-disciplinary healthcare teams. Potential participants were approached in the waiting area of the GDM clinics and invited to participate using their preferred language. To facilitate communication between ethnic Chinese participants and researchers, a bicultural, bilingual female researcher without pregnancy experience (CW) but fluent in Mandarin, Cantonese and English was responsible for recruitment and data collection. Participants were recruited for a year before the pandemic to ensure coverage of the seasonality of GDM and associated maternal lifestyle and psychosocial factors (Verburg et al. 2016). Theoretical sampling was used to determine the final number of participants recruited (Minichiello, Aroni, and Hays 2008). This involved iterative sampling, data collection, and analysis until no new conceptual insights were generated, i.e. theoretical saturation was achieved (Minichiello, Aroni, and Hays 2008). Data collection occurred during the third trimester.

2.3. Qualitative data collection and analysis

In-depth, semi-structured, audio-recorded, face-to-face or telephone interviews (dependent on participants' preference) were conducted in their preferred languages. The duration of the interviews varied between 45 and 90 min. In the first instance, the interviews were guided by a brief list of researcher-developed themes and initiating questions (see Table 1). Probing questions were used to develop interview discussions further and explore key issues based on participants' indication of relevance. Data collection and analysis were conducted concurrently, so the coding of interview transcripts guided subsequent theoretical sampling decisions and refinement of the interview guide. Reflexive thematic analysis was used in the qualitative analysis (Braun and Clarke 2021). Field notes and memos provided contextual information as part of the constant comparison and theme development process. NVivo 11 Pro (QSR International Pty Ltd.) was used to assist qualitative data management.

Inter-coder reliability was examined to ensure rigour of the qualitative analysis process (Creswell and Clark 2011). Coding of verbatim Chinese and English transcripts (dependent on the language spoken in interviews) was undertaken by the Chinese

bicultural researcher and dietitian (CW). To minimise the loss of meanings during language translation, the Chinese bilingual researcher (CW) independently analysed the Chinese and English transcripts. The coding, categorisation, and themes were described in English in the data analysis process. A subset (ten each from Chinese and Caucasian participants' transcripts) of transcripts was randomly selected by a second Caucasian senior qualitative researcher (RA) to be independently analysed for checking inter-coder reliability (O'Connor and Joffe 2020). The subset of verbatim Chinese transcripts chosen by RA were translated into English by a professional translation company. The two researchers discussed the codes until a consensus was reached regarding coding, categorisation and themes. Critical comparison of themes between research team members who were insiders and outsiders of Chinese culture and language enabled more reflexive and rigorous data analysis (Joseph, Earland, and Ahmed 2021).

2.4. Quantitative data collection and analysis

Demographic data on age, pre-pregnancy BMI, week gestation, country of birth, marital status (and husband ethnicities if appropriate), highest level of education and occupation was collected before collecting PA quantitative data using demographic questionnaires.

Two PA assessment tools were used in this study: the self-reported Pregnancy PA Questionnaire (PPAQ) (Chasan-Taber et al. 2004) and pedometers as an objective measure of PA (Leicht 2008). The PPAQ was designed as a proxy measure to assess PA behaviours during pregnancy (Chasan-Taber et al. 2004) and has been validated for use with different ethnic groups, including Chinese and Caucasians (Hawkins et al. 2014; Zhang et al. 2014). A bilingual researcher translated the English version of PPAQ into traditional and simplified Chinese. Back-translation was performed by an accredited translator to confirm accuracy. The PPAQ, either in English or Chinese, was used to ask participants to report time spent on different activities in their third trimesters.

For each question in PPAQ, participants were asked to select one of six options for the amount of time spent on a particular PA. The level of a particular PA was calculated by multiplying the weekly time spent on that specific PA by the metabolic equivalent of task (MET) for the PA and was presented as energy expenditure (MET-hours per week). PA reported in PPAQ were categorised using two methods (intensity and type) (Chasan-Taber et al. 2004). Exercise intensity was classified as sedentary (<1.5METs; e.g. sitting at work or watching television), light (1.5–<3.0METs; e.g. preparing meals and walking slowly), moderate (3.0–6.0METs; e.g. walking for exercise and prenatal exercise class) and vigorous (>6.0METs; e.g. jogging or walking quickly uphill). PA was categorised into household/caregiving, occupational and sports/exercise.

The Yamax Digiwalker SW-700 Pedometer (Yamax Corporation, Tokyo, Japan) was used to measure energy expenditure. Considering the daily variations of PA of an individual, 7 consecutive days (including two weekend days of pedometer recording) were used to calculate the weekly number of free-living steps taken during waking hours (excluding water activities). Participants were asked to attach the pedometer to belts or waistbands in an upright position on either side of the body during waking hours. Instructions on how to wear the pedometer correctly were provided and demonstrated

by the researcher. The pedometer was sealed to blind participants to limit motivation to increase PA (Kang et al. 2009).

Statistical analyses were performed using the Statistical Package for Social Sciences 23.0 (SPSS version 23.0, SPSS Inc., Chicago, IL, USA). The values were either presented as mean ± standard deviation for normally distributed data or median and interquartile range for data of non-normal distribution. An independent-samples t-test (for normally distributed data) and a Mann-Whitney U test (for non-normal distributions) were used to compare PA between the participant groups.

2.5. Mixed methods data analysis and interpretation

As each question in the PPAQ provided an explicit description of the PA of interest to measure PA behaviours during pregnancy, the individual difference in the conceptualisation and interpretation of PA is not expected to influence the answers provided by participants. These self-reported quantitative PA data were triangulated with qualitative data from interviews at the individual participant level to identify patterns in participant characteristics and beliefs in PA that influence PA participation measured by PPAQ and pedometers. Side-by-side comparison of each participant's qualitative and quantitative data would also enable the identification of disconfirming evidence (Creswell and Clark 2011), if any.

3. Results

A total of 83 (44 Chinese and 39 Caucasian) participants completed PPAQ, with 42 Chinese and 30 Caucasian participants also being interviewed. Among those, 21 Chinese and 17 Caucasian participants completed the pedometer assessment. Potential participants who declined to participate cited a lack of interest. Participants who completed the PPAQ only noted that time constraints limited their participation in interviews and felt that wearing pedometers for a week would be inconvenient. Five Chinese participants refused to wear pedometers because the requirement to wear pedometers close to the abdomen (and hence their babies) raised their concerns about the potential negative impact of battery-emitted radiation on their babies.

There were no significant differences in demographic characteristics between participants who completed PPAQ only and those who completed both interviews and PPAQ (shown in Table 2). Both Chinese and Caucasian participants had similar age (32.0 ± 3.6 years old in 44 Chinese participants versus 33.3 ± 4.7 years old in 39 Caucasian participants) and gestational weeks (30.8 ± 4.1 weeks in 44 Chinese participants versus 31.1 ± 4.9 weeks in 39 Caucasian participants) during data collection. Chinese participants with a lower BMI were less likely to use insulin and more likely to have completed higher education than Caucasian participants. Most interviewed Chinese participants were born in China (73.8%), Mandarin spoken (52.4%) had husbands who were Chinese (66.7%).

3.1. Qualitative findings

Analysis of the interview data identified three main themes: Attitudes to PA participation during pregnancy, motivators for PA participation and barriers to PA participation.

Table 2. Maternal characteristics of participants, by ethnicity.

	In-depth interview data		PA data	
	Ethnic Chinese ($n = 42$)	Caucasian ($n = 30$)	Ethnic Chinese ($n = 44$)	Caucasian ($n = 39$)
Age, years	31.9 ± 3.7	33.3 ± 4.8	32.0 ± 3.6	33.3 ± 4.7
Pre-pregnancy BMI, kg/m^2	21.5 ± 2.5	29.9 ± 7.1	21.5 ± 2.5	29.7 ± 7.0
Gestational age, weeks	31.1 ± 3.6	30.1 ± 5.1	30.8 ± 4.1	31.1 ± 4.9
Primiparous, *n* (%)	25 (59.5)	12 (40.0)	26 (59.1)	15 (38.5)
Country of birth, *n* (%)				
China	31 (73.8)	0 (0.0)	33 (75.0)	0 (0.0)
Taiwan	1 (2.4)	0 (0.0)	1 (2.3)	0 (0.0)
Singapore	1 (2.4)	0 (0.0)	1 (2.3)	0 (0.0)
Malaysia	5 (11.9)	0 (0.0)	5 (11.4)	0 (0.0)
Vietnam	1 (2.4)	0 (0.0)	1 (2.3)	0 (0.0)
Australia	3 (7.1)	30 (100)	3 (6.8)	39 (100)
Husband ethnicity, *n* (%)				
Chinese	28 (66.7)	0 (0.0)	29 (65.9)	0 (0.0)
Other Asian	7 (16.7)	0 (0.0)	7 (15.9)	0 (0.0)
Non-Asian	7 (16.7)	30 (100)	8 (18.2)	39 (100.0)
Marital status, *n* (%)				
Married	36 (85.7)	21 (70.0)	38 (86.4)	25 (64.1)
De-facto	6 (14.3)	8 (26.7)	6 (13.6)	13 (33.3)
Single	0 (0.0)	1 (3.3)	0 (0)	1 (2.6)
Level of education, *n* (%)				
High School	3 (7.1)	6 (20.0)	3 (6.8)	8 (20.5)
Diploma	6 (14.3)	10 (33.3)	6 (13.6)	13 (33.3)
Bachelor	23 (54.8)	11 (36.7)	25 (56.8)	13 (33.3)
Postgraduate	10 (23.8)	3 (10.0)	10 (22.7)	5 (12.8)
Occupation, *n* (%)				
Housewife	5 (11.9)	3 (10.0)	5 (11.4)	5 (12.8)
On maternity leave	4 (9.5)	4 (13.3)	4 (9.1)	4 (10.3)
Self-employed	5 (11.9)	0 (0.0)	5 (11.4)	1 (2.6)
Desk based work	12 (28.6)	9 (30.0)	13 (29.5)	11 (28.2)
Non sedentary work	12 (28.6)	10 (33.3)	13 (29.5)	13 (33.3)
Health professional	4 (9.5)	4 (13.3)	4 (9.1)	5 (12.8)
Insulin use, *n* (%)	7 (16.7)	12 (40.0)	7 (15.9)	17 (43.6)
Language of interview conducted, *n* (%)				
English	13 (31.0)	30 (100)	15 (34.1)	39 (100)
Mandarin	22 (52.4)	–	22 (50.0)	–
Cantonese	7 (16.7)	–	7 (15.9)	–

BMI: Body mass index.

Similarities and differences in these themes were found between Chinese and Caucasian participants.

3.1.1. Theme 1: attitudes to PA participation during pregnancy

3.1.1.1. Subtheme 1.1: conceptualisation of PA. Both ethnic groups used the terms 'PA' and 'exercise' interchangeably when describing PA participation and believed PA participation helped manage blood glucose. However, Chinese and Caucasian women conceptualised PA differently. Chinese participants used a broader conceptualisation of PA, which encompassed both incidental and intentional activity, whilst Caucasian participants only discussed PA as intentional activity, suggesting this was their primary perception of PA. Chinese women discussed participating in incidental activities but mentioned avoiding intentional activities such as swimming, gym, badminton and kickboxing due to safety concerns associated with these activities.

> I treat doing housework as doing PA, and so I do not do exercises intentionally. (Chinese-born Mandarin-speaking participant)

In contrast, Caucasian participants referred to PA as intentional activities only.

> I have not been doing PA because I am on my feet all day … doing loads of washing, doing the dishes, vacuuming the floor … I am not going out for a run or anything like that. (Caucasian participant)

3.1.1.2. Subtheme 1.2: vulnerability in pregnancy. Both Chinese and Caucasian participants considered pregnancy a vulnerable life stage characterised by symptoms such as fatigue, nausea, vomiting, shortness of breath, and headache.

> I had a bit shortness of breath all through the pregnancy from the very first trimester … I just felt really unfit. (Caucasian participant)

Furthermore, non-Australian-born Chinese participants believed the level of vulnerability changed according to the stage of pregnancy. They viewed the first trimester as the most vulnerable pregnancy period and related PA participation to increased miscarriage risk. They believed that coughing too hard, carrying heavy objects and performing lower limb exercises such as climbing and squatting increased miscarriage risk.

> In my social group, they all talked about maintaining sedentary PA in the first three months of pregnancy because of miscarriage concerns. Starting the fourth month, we can do some PA after a meal, such as walking for 10–20 minutes. (Chinese-born Mandarin-speaking participant)

Chinese participants who classified themselves as having a high miscarriage risk or preterm birth risks according to their body constitution type, previous miscarriage history, placenta positioning and bleeding symptoms reported lying down on their bed or sitting at home all the time.

> In the first three months of pregnancy, I preferred staying at home and lying down if I could … Everyone has a different body constitution type. I feel tired all the time because of my weak body constitution type, so I need to. (Chinese-born Mandarin-speaking participant)

In contrast, Australian-born Chinese and all Caucasian participants reduced PA participation during pregnancy due to physical sickness and not fear of miscarriage.

> I was having morning sickness all day, so that makes exercise quite difficult … To be more mindful of everything because I am pregnant. (Caucasian participant)

> I am not a believer of Chinese childbearing traditions or Traditional Chinese Medicine, and hence I don't think I need to alter my physical activity levels during pregnancy. (Australian-born English-speaking Chinese participant)

3.1.1.3. Subtheme 1.3: determinants of unsafe PA during pregnancy. Both Chinese and Caucasian participants believed that altering behaviour to maximise foetal wellbeing was a motherhood obligation. They believed unsafe PA during pregnancy precipitated concerning symptoms such as aches, pain and bleeding.

Furthermore, non-Australian-born Chinese participants described differences in the determinants of unsafe PA throughout the pregnancy journey. They believed PA that involved large lower limb movements was unsafe in early pregnancy, while any specific PA likely to increase the risk of falls was unsafe in late pregnancy.

> In the first trimester, because of the miscarriage concern, I stopped playing badminton … And in the later stage of pregnancy, because my tummy is getting bigger, we are concerned about fall risks … such as jumping and jogging. (Chinese-born Mandarin-speaking participant)

Non-Australian-born Chinese participants mentioned fatigue and tightening or hardening of abdominal muscles as additional indicators of unsafe PA participation.

> If I am carrying something really heavy … I feel my tummy is very stiff … like a contraction … So with the exercise, obviously pregnant people can't run or do heavy carrying exercise … Walking is the best … At the early stage [of pregnancy], I felt more tired too … preferred to lie down and rest. (Malaysian-born English-speaking participant)

They believed more detailed advice on the type, frequency and duration of safe PA during pregnancy would help alleviate their PA participation concerns. Even though clinicians recommended 30 min of walking after meals to help manage GDM, Chinese participants, regardless of which language spoken, expressed the need for more detailed advice on the pace and frequency of walking.

> The doctor told me to do any PA that I did previously before pregnancy, but boxing involves a lot of lower abdomen core exercises. After thinking it through, I decided to avoid it … If the doctor provides me with more detailed information on safe PA would be helpful. (Chinese-born Egnlish-speaking participant)

> Doctors have suggested yoga, but I did not do it because I am not professional in yoga and not sure what specific yoga is suggested and what type of yoga would cause any problem. (Chinese-born Mandarin-speaking participant)

Australian-born Chinese and all Caucasian participants considered aches and pain as indicators of unsafe PA.

> I stopped Pilates and yoga because of the pelvic pain, and I had to stop and do more walking. (Caucasian participant)

They tended to maintain similar levels of PA before and during pregnancy unless clinicians recommended this should change.

> I was still doing the same [PA] in the first trimester. And I didn't do jogging as I did not do it before pregnancy … I would stop doing exercises if I am in pain … I obviously would consult the doctor first. (Caucasian participant)

Two Chinese-born Chinese participants whose parents were not strong believers in Chinese cultural beliefs shared similar views with Caucasian participants about what constitutes safe PA during pregnancy.

> I believe in evidence-based Western medicine more than Chinese cultural beliefs and practices … I still try to be physically active during pregnancy … eat whatever I want to except what is suggested by the hospital … my parents were not strong believers in Chinese cultural beliefs either. (Chinese-born Cantonese-speaking participant)

3.1.2. Theme 2: motivators of PA participation

3.1.2.1. Subtheme 2.1: acute postprandial glycaemia management strategies. Both Chinese and Caucasian participants described PA as a GDM self-management strategy

to reduce high postprandial sugar. They conceded that PA assisted the management of postprandial glycaemia.

> Exercise definitely helps … If I have had something very high in sugar at dinner … I will go for a walk before actually doing my reading … rather than waiting to get the high reading and then do some exercise. (Caucasian participant)

They believed they could have bigger meals by increasing PA participation without worrying about blood glucose readings.

> Exercise is helping me … I could eat more after exercising. But if I don't do exercise then I have to eat less carbohydrate … worried about not eating enough. (Chinese-born Cantonese-speaking participant)

If their postprandial blood glucose was high after a high carbohydrate meal, they tended to continue PA for longer.

> If I had a big meal … eat a bit more at dinner … sugars a bit higher for dinner … I did a bit of walk after dinner, and they would be in the reasonable range, so I think it did have an impact on it. (Caucasian participant)

Chinese participants expressed more concerns about the potential consequences of high blood glucose levels. If the postprandial blood glucose readings from the previous meal were high, they would skip meals in addition to doing PA.

> If my postprandial reading is high, I will do another walk immediately … skip my snacks … have to bear hunger till dinner … so worried about complications of having continuously high blood sugar. (Chinese-born Mandarin-speaking participant)

In contrast, some Caucasian participants discussed reducing meal portions in the next meal and increasing water intake to dilute blood glucose if the postprandial readings were high.

> I would go for a walk or try to burn it up somehow. And then taking into consideration of what the next meal is and maybe cut something out. (Caucasian participant)

3.1.2.2. Subtheme 2.2: acceptance of digital step measurement technologies. Some Chinese participants avoided using digital step measurement technologies such as pedometers because they believed that battery-emitted radiation could negatively influence their baby's growth and development.

> I prefer keeping myself away from any potential radiation emission sources because the radiation could affect babies' health … like microwave and pedometer. (Chinese-born English-speaking participant)

In contrast, some Caucasian participants considered digital step measurement technologies as motivators for PA participation. They found 'Fitbits' useful in providing a more comprehensive understanding of their PA routines and did not express concerns about using electronic devices during pregnancy.

> I use Fitbit to check my steps every day so that I know how physically active I am. (Caucasian participant)

3.1.3. Theme 3: barriers to PA participation

3.1.3.1. Subtheme 3.1: physical and environmental constraints. Both Chinese and Caucasian participants reported that laziness and feeling unwell were barriers to PA participation.

> There had been days where I was a bit lazy and did not walk as I should have. I know my readings were going to be a bit higher. (Caucasian participant)

Some of them also talked about weather being too hot or cold, acting as an environmental constraint to outdoor PA. Some Chinese and Caucasian participants mentioned walking around inside the house and using exercise equipment (such as exercise bikes and treadmills) at home as an alternative to outdoor PA, respectively.

> I walk back home when the weather is good. These days when the weather is not good … cold and rainy … I don't go. (Malaysian-born English-speaking participant)

3.1.3.2. Subtheme 3.2: sociocultural constraints. Chinese and Caucasian participants reported that even though caring for other children increased incidental PA, it was a constraint to undertaking outdoor PA.

> Going for a walk has been difficult because I have got my son. (Caucasian woman)

Specifically, Chinese participants whose husbands were ethnic Chinese reported that their PA participation was influenced by their husbands' PA preferences. For instance, some Chinese participants avoided playing badminton, cycling, carrying heavy objects or doing heavy housework because their husbands, who were Asian, believed these PAs increased their risk of falls or miscarriage.

> I do some simple housework, like helping children take a bath and washing plates. My husband does more physically intense housework such as sweeping the floor. (Chinese-born Mandarin-speaking participant)

A few also talked about quitting a physically demanding job at their husband's request. Quitting work led to a more sedentary life and boredom at home.

> This is my first pregnancy. My husband, who works every day, asked me to quit the job once I became pregnant because he was worried about miscarriage. So I stayed alone at home every day. I was a bit depressed because of feeling bored. (Chinese-born Mandarin-speaking participant)

In contrast, Chinese participants whose husbands were non-Asian mentioned that their husbands supported and encouraged them to be physically active.

> My husband is very supportive of me in relation to keeping physically active as long as the doctors say it's okay to do it. (Chinese-born Mandarin-speaking participant)

Similarly, most Caucasian participants mentioned maintaining their level of PA at work, regardless of the type of occupation.

> I am doing what I normally do. I am not impacting on my ability to work and drive. (Caucasian woman)

They often received family support to do PA together.

My husband sometimes would walk with me … it's helpful … someone accompanies with … doing alone is a bit boring. (Caucasian participant)

3.2. Quantitative findings

Table 3 shows findings on PA participation using PPAQ and pedometers. Both Chinese and Caucasian participants did less PA than recommended in Australian guidelines (150 min/week exercise) (Australian Institute of Health and Welfare 2019). Chinese participants were less physically active than Caucasian participants based on PPAQ ($p = 0.001$) and pedometer ($p = 0.055$) results. Chinese participants had significantly lower light intensity ($p = 0.009$) and moderate intensity ($p = 0.001$) PA than Caucasian participants. Despite similar occupation characteristics in the ethnic groups, Chinese participants were less physically active in the workplace than Caucasian participants ($p = 0.017$).

3.3. Mixed methods interpretation

There was marked congruence between each participant's measured PA and comments made in interviews about engagement with PA, indicating concordance between the qualitative and quantitative data sets. For instance, Chinese participants who were concerned about the perceived miscarriage risk incidental activities might bring had lower light intensity PA than Australian-born Chinese participants who were less concerned. Caucasian participants who consulted health professionals about safe intentional PA or used digital step measurement technologies had more moderate intensity PA than Caucasian participants without using digital step measurement technology. Chinese participants who were fearful of radiation emitted from electronic devices refused to use the pedometers being put at the waist area provided in this study and were less physically active than Caucasian participants with digital step measurement technologies. Participants who were less physically active viewed PA as merely an acute treatment to

Table 3. Ethnic differences in physical activity using two assessment tools.

	Ethnic Chinese ($n = 44$)	Caucasian ($n = 39$)	*P*-value
Working status while completing questionnaire and using pedometer:			
Working, *n* (%)	32 (72.7)	29 (74.4)	0.867
Desk based work, *n* (%)	16 (50.0)	12 (41.4)	0.500
Pregnancy PA questionnaire, MET hours per week:			
Total activity:	202.2 ± 82.8	291.4 ± 109.8	0.001*
Intensity of PA			
Sedentary	65.6 ± 35.1	76.6 ± 40.8	0.189
Light-intensity	77.4 [50.1, 104.7]	101.7 [69.3, 134.1]	0.009*
Moderate-intensity	37.3 [17.1, 57.6]	74.5 [15.2, 133.9]	0.001*
Vigorous-intensity	0 [0, 0]	0 [−0.8, 0.8]	0.155
Type of PA			
Household/caregiving	75.0 [41.7, 108.3]	86.1 [25.7, 146.5]	0.135
Occupational	59.9 [17.3, 102.4]	86.5 [16.2, 156.7]	0.017*
Sport or exercise	9.5 [4.6, 14.4]	9.1 [2.4, 15.9]	0.556
Pedometer, steps per week: (From 21 Ethnic Chinese and 17 Caucasian)			
Number of steps	36599.2 ± 15519.1	47036.1 ± 16868.2	0.055

MET: metabolic equivalent of task.
*Statistically different physical activity between ethnic groups.

reduce high postprandial glycaemia rather than a critical component of glycaemic optimisation.

4. Discussion

This mixed-methods study has compared ethnic Chinese migrants with GDM and their host population counterparts regarding perceptions of PA participation and PA practices in GDM management. The key findings of this study are that notwithstanding Australian GDM guideline recommendations for PA during pregnancy, both ethnic groups did not engage in sufficient PA. Non-Australian-born ethnic Chinese participants (regardless of what language spoken) whose parents withhold Chinese cultural beliefs and whose husbands were Asian expressed greater safety concerns about PA participation during pregnancy and hence were less physically active than Caucasian participants. Regarding preferences for strategies to improve PA participation, ethnic Chinese participants expressed the need for specific and individualised PA advice on safe PA during pregnancy. Conversely, the Caucasian participants preferred using digital step measurement technologies to monitor and motivate their PA participation.

4.1. Chinese cultural values and philosophies consideration

Despite both ethnic Chinese and Caucasian participants in this study having less than recommended PA participation, ethnic Chinese participants who withheld stronger Chinese cultural values and philosophies tended to have more sedentary lifestyles because they were overcautious about miscarriage risk in PA participation. In Chinese obstetrical culture, two key philosophies drive culturally specific obstetric-related behaviours among ethnic Chinese pregnant women, which are 'yin-yang balance' and 'tai-jiao' (Cheng 2016). According to Traditional Chinese Medicine principles, maintaining 'yin-yang balance' is critical in optimising maternal and neonatal health from pre-conception to confinement (one whole month of convalescence after childbirth) (Sacco, Ramsey-Marcelle, and Yoong 2012). Changes in 'yin-yang equilibrium' are observed throughout the pregnancy journey, which starts from a cold and vulnerable stage in the first trimester, followed by neutral conditions in the second trimester, and progressively hot and tonic status in the third trimester (Gao et al. 2013). Making relevant lifestyle changes to achieve equilibrium can prevent miscarriage and optimise health status (Gao et al. 2013). It resonates with ethnic Chinese participants' views on the vulnerability status in the first trimester and changes in vulnerability throughout pregnancy. PA participation increased among Hong Kong Chinese women from the first to second trimester (Put, Chuang, and Chan 2015). However, most Chinese women did not increase their PA level to meet the recommendation in the third trimester due to the fear of miscarriage (Zhang et al. 2014), which is driven by another Chinese philosophical value, 'tai-jiao'.

'Tai-jiao' describes how maternal behaviours influence foetal growth and development (Cheng 2016). It originated from Neo-Confucianism, a moral and metaphysical Chinese philosophy influenced by Confucianism (Richardson 2012). The underpinning Confucian principle is that pregnant women's behaviour serves as both a reflection of and a method for nurturing neonatal health (Richardson 2012). Protecting neonatal well-

being involves avoiding a stressful workload, maintaining a sedentary lifestyle and avoiding unfavourable environmental factors such as pollutants to prevent adverse pregnancy outcomes such as miscarriage (Cheng 2016; Ge et al. 2016). Therefore, in this study, ethnic Chinese participants who hold stronger Chinese cultural values expressed more miscarriage concerns in PA participation.

In addition, this study found that ethnic Chinese women's parents' and husbands' adherence to Chinese cultural values and philosophies directly influences ethnic Chinese women's PA participation. Despite the growing emphasis on individualism globally in decades, Chinese families continue to prioritise social-oriented and collective interest over individual interest (Xu and Xia 2014). The Chinese social structure and cohesion as a family unity remain dominant in exhibiting perceived healthy behaviours in optimising pregnancy health to protect the next generations in the family (Luo et al. 2024). In the context of optimising pregnancy and neonatal health in family collectivism, GDM management decisions are escalated from an individual level to the interest of extended families (Luo et al. 2024). In a collectivistic culture, Chinese women are likely to preserve relational harmony by following health behaviours suggested by family members and eluding potentially conflicting perspectives (An and Chou 2016). Family-based GDM education among ethnic Chinese women may be more culturally appropriate and beneficial when encouraging PA participation during pregnancy.

4.2. Recommendations and future implications

Our findings illustrate that all participants engaged in PA less than recommended because they considered PA as an acute treatment to reduce initially high postprandial blood glucose levels. Reframing their perspective on PA participation by highlighting the physiological benefits of PA may improve PA participation in GDM management (Bgeginski et al. 2017; Ruchat and Mottola 2013; Wah et al. 2019). Patient education on how daily PA improves insulin sensitivity and blood glucose levels and might delay or avoid the need for insulin therapy (Bgeginski et al. 2017; Ruchat and Mottola 2013; Wah et al. 2019) may raise their awareness of the significance of following daily PA recommendations in GDM management and motivate PA participation.

Furthermore, when delivering PA education, it is also imperative to acknowledge the ethnic differences in the conceptualisation of PA found in this study. PA beliefs in the ethnic Chinese population are similar in other ethnic minorities, such as South Asian, Arabic-speaking, Filipino and Sudanese immigrants, whereby they are more attuned to a broader definition of PA (Caperchione et al. 2011; Di Biase et al. 2019; Gupta, Aroni, and Teede 2017). Ethnic minority women in the United States viewed PA as both incidental and intentional activity, whereas white women viewed PA as intentional activities (Im et al. 2013). The variation in the conceptualisation of PA across ethnic groups suggests the need to clarify definitions of PA when presenting GDM guideline recommendations in patient education.

To mitigate their safety concerns regarding PA participation among ethnic Chinese pregnant women, co-designing education resources (Wan et al. 2023) to provide clearer recommendations on frequency, duration, intensity and type of safe PA during pregnancy (Di Biase et al. 2019) and using a family-based prescriptive approach (Wan, Teede, et al. 2019) are suggested. Clarifying signs of unsafe PA participation and

differentiating them from normal pregnancy abdominal tightening experiences such as Braxton Hicks contractions may also help alleviate their PA participation concern.

Related to the Chinese obstetric-related cultural beliefs about avoiding unfavourable environmental determinants (Cheng 2016; Ge et al. 2016), ethnic Chinese participants in our study were worried about the negative impact of low-dose radiation emitted from electronic devices, including digital step measurements. They expressed concerns about putting pedometers close to their abdomen because they considered pregnancy a highly radiosensitive life stage (Tang and Loganovsky 2018). Radiation exposure to a developing fetus increases the risk of adverse health outcomes (Ji et al. 2019; Tang and Loganovsky 2018). In contrast, Caucasian participants in our study considered digital step measurement technology to be a facilitator of PA participation. Individuals who had positive experiences using pedometers could use pedometers for PA self-monitoring and motivation (Cross-Bardell et al. 2015). The variation in the acceptance of using pedometers in different ethnic groups highlights the significance of considering patients' preferences for electronic devices in formulating therapeutic recommendations and educating and reassuring ethnic Chinese pregnant women when advocating for electronic monitoring devices.

Overall, the findings of this study imply that in addition to education on emphasising the physiological benefits of PA in GDM management, different culturally relevant and appropriate strategies may be required to improve PA participation in GDM management in a multifaceted intervention tailored for ethnic Chinese and Caucasian women's needs. To ethnic Chinese pregnant women who follow Chinese philosophical obstetric practices, a family-oriented approach in providing detailed and prescriptive recommendations on individualised and safe PA may be beneficial. To Caucasian pregnant women, setting PA goals and recommending digital step measurement technology in PA self-monitoring may facilitate PA participation. These strategies will guide the development of end-user-informed interventions that will be evaluated in future trials.

4.3 Strengths and limitations

The key strength of this study was the mixed methods design, which enabled matching perspectives regarding the value and risk of engaging in PA with PA practices during pregnancy. Qualitative components of this study allowed the exploration of potential underlying reasons for the trend observed in PA participation from quantitative findings. An additional strength of this study was having a multi-lingual researcher collect and analyse interview data. This enhanced rapport building with participants, promoted sincerity in expressing their viewpoints and enabled the accurate translation of interview data. However, there are several limitations. Firstly, given the variations in ethnic Chinese migration patterns to Australia and other countries, the findings are of limited generalisability to global Chinese migrant communities. In addition, despite the similarity of results drawn from the analysis of pedometer use and the PA questionnaires, only half the participants agreed to use pedometers. This may raise uncertainty about the validity of interpretations across these data sets and suggests the need for research using alternative technologies. Ankle-worn or wrist-worn accelerators or pedometers with similar accuracy in measuring PA might be a more acceptable alternative to ethnic Chinese migrants.

5. Conclusion

Ethnic Chinese migrants and the Caucasian host population with GDM in Australia participated less in PA than recommended. It relates to women's conceptualisation of PA as an acute treatment for high postprandial sugar readings. Educating women with GDM to raise their awareness of the physiological benefits of PA in GDM management may improve their PA participation. Regarding culturally appropriate strategies to increase PA participation, ethnic Chinese migrants preferred receiving detailed advice on safe PA during pregnancy. Education resources co-developed with ethnic Chinese migrants regarding frequency, duration, intensity and type of safe PA during pregnancy, and physiological signs of unsafe PA, may be beneficial. For the Caucasian host population, digital step measurement technology may aid PA self-motivation and self-monitoring. A future evaluation study is required to assess the effectiveness of these different strategies on different ethnic groups in improving PA participation in GDM management.

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Author contributions

Ching Shan Wan: Conceptualisation, Methodology, Investigation, Formal analysis, Visualisation, Writing – Original Draft. **Helena Teede:** Conceptualisation, Writing – Review & Editing, Supervision. **Alison Nankervis:** Conceptualisation, Writing – Review & Editing, Supervision. **Rosalie Aroni:** Conceptualisation, Methodology, Writing – Review & Editing, Supervision.

Ethical statement

This study was approved by the Monash University Human Research Ethics Committee (Project number: 8458), Monash Health (Reference: LNR/16/MonH/396) and Royal Women's (Reference: LNRSSA/16/monH/406) Human Research Ethics Committee.

Disclosure statement

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