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Physical Activity and Sedentary Behavior Patterns Before and During Pregnancy in a Multi-ethnic Sample of Asian Women in Singapore

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Abstract

Objectives To describe physical activity (PA) and sedentary behavior (SB) patterns before and during pregnancy among Chinese, Malay and Indian women. In addition, to investigate determinants of change in PA and SB during pregnancy.

Methods The Growing Up in Singapore Towards healthy Outcomes cohort recruited first trimester pregnant women. PA and SB (sitting time and television time) before and during pregnancy were assessed as a part of an interview questionnaire at weeks 26–28 gestational clinic visit. Total energy expenditure (TEE) on PA and time in SB were calculated. Determinants of change in PA and SB were investigated using multiple logistic regression analysis.

Results PA and SB questions were answered by 94 % (n = 1171) of total recruited subjects. A significant reduction in TEE was observed from before to during pregnancy [median 1746.0–1039.5 metabolic equivalent task (MET) min/week, $p < 0.001$]. The proportion of women insufficientlyactive(<600MET-min/week)increasedfrom19.0 to 34.1 % ($p < 0.001$). Similarly, sitting time (median 56.0–63.0 h/week, $p < 0.001$) and television time (mean 16.1–16.7 h/week, $p = 0.01$) increased. Women with higher household income, lower level of perceived health, nausea/vomitingduringpregnancyandhigherlevelofpre-pregnancyPA were more likely to reduce PA. Women with children were less likelytoreducePA.Womenreportingnausea/vomitingandlower level of pre-pregnancy sitting time were more likely to increase sittingtime.

Conclusions for Practice Participants substantially reduced PA and increased SB by 26–28 weeks of pregnancy. Further research is needed to better understand determinants of change in PA and SB and develop effective health promotion strategies.

On behalf of the GUSTO Study Group.

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Significance

What is already known on this topic? Maintaining an active lifestyle during pregnancy is beneficial to the health of mothers and their offspring and is recommended in international obstetric guidelines.

What this study adds? This study from a population of Chinese, Malay and Indian women highlights substantial reductions in physical activity, as well as increases in television viewing and overall sitting time during pregnancy as compared with pre-pregnancy. The study identifies factors associated with reductions in physical activity and increases in sedentary behavior. This knowledge will help to develop effective health promotion strategies to prevent adverse health outcomes in pregnant women and their children in Asia.

Introduction

Regular physical activity (PA) during pregnancy could play an important role in the prevention of excessive gestational weight gain (GWG) [1, 2], and associated risk of adverse pregnancy outcome such as caesarean section [3, 4], preeclampsia [3, 5], and gestational diabetes mellitus (GDM) [6, 7]. PA across the pregnancy period appears to improve women's perception of health [8], maintain long term fitness, and decrease cardiovascular risk profile in perimenopausal period [9]. Moreover, children's body mass index (BMI) and risk of overweight at 7 years old was found to be inversely related to maternal recreational exercise during pregnancy in the Danish National Birth Cohort study [10]. However, previous studies indicate that PA generally declines during pregnancy as compared to pre-pregnancy [11, 12]. PA among Asian pregnant women was sparsely studied, a cross sectional study among urban Chinese women reported that 74.4 % of total subjects reduced PA during pregnancy [13].

The World Health Organization's (WHO) recommendation on PA for healthy adults is 150 min of moderate-intensity or 75 min of vigorous-intensity PA or an equivalent combination of moderate and vigorous intensity PA achieving at least 600 metabolic equivalent task (MET)-min/week for health. For accumulation, each session should last minimum of 10 min [14, 15]. Correspondingly, for healthy pregnant women, at least 150 min of moderate-intensity aerobic activity per week is recommended in 2008 PA guidelines for Americans [16].

Sedentary behavior (SB), independent of PA, may have an impact on health and wellbeing [17]. SB is any waking behavior in sitting or reclining posture with less than or equal to 1.5 METs of energy expenditure [18]. A survey suggested an association between mid-pregnancy SB, including watching television, and risk of abnormal glucose tolerance during pregnancy [19]. Previous studies often reported only PA during pregnancy [11, 20, 21], while only few studies addressed SB during pregnancy [19, 22]. Moreover, magnitude and determinants of changes in PA and SB during pregnancy compared with pre-pregnancy among Asian women is not described in the literature.

We aim to examine the PA and SB patterns before and during pregnancy in selected multi-ethnic groups in Asia (Chinese, Malay and Indian), as part of the Growing Up in Singapore Towards healthy Outcomes (GUSTO) birth cohort study, Singapore. In addition, we aim to investigate the determinants of changes in PA and SB pattern during pregnancy.

Methodology

Study Design and Population

The GUSTO birth cohort study recruited pregnant women from June 2009 to September 2010 at two major public maternity units in Singapore, namely KK Women's and Children's Hospital (KKH) and National University Hospital (NUH). Pregnant women aged 18 years and above attending first trimester antenatal dating ultrasound scan clinics were screened for eligibility. Singapore citizen or permanent residents who had the intention of delivering in KKH or NUH and staying in Singapore for at least next 5 years, major ethnic groups (Chinese, Malay and Indian), and who had agreed to donate birth tissues were included in the study. Women receiving chemotherapy, psychotropic drugs or who had type I diabetic mellitus were excluded. Informed written consent was obtained from each participant. Participants were asked to attend study visits at 12–14, 19–21, 26–28 and 32–34 weeks' of gestation for ultrasound scans to assess gestational age and fetal growth. Detailed interviews were conducted at recruitment visit and at 26–28 weeks' gestational visit, including PA and SB questions at 26–28 weeks' gestational visit. Maternal anthropometric measurement performed at 26–28 weeks' gestational visit, and routine antenatal clinical data were extracted from hospital medical records. The GUSTO study was reviewed and approved by ethics committees of the hospitals involved; SingHealth Centralized Institutional Review Board and National Healthcare Group Domain Specific Review Board in Singapore [23].

Data Collection Procedures

Participant Characteristics

Socio-demographic, obstetrics, and maternal health related data were collected at various time points. In the recruitment visit interview, participants were asked about their ethnicity, age, educational level, marital status, household income, pre-pregnancy weight, infertility treatment, perceived health condition, and chronic illness. At the 26–28 weeks' gestational visit, as part of an interviewer administered questionnaire, participants were asked about their occupation during pregnancy, pregnancy planning, and experience of nausea/vomiting during pregnancy. Height in centimeters was taken using a stadiometer (SECA model 213, Hamburg, Germany) by the research staff. On delivery, parity and medical data such as antepartum hemorrhage in the first trimester were collected from the hospital medical records. Pre-pregnancy BMI (kg/m^2) was calculated based on self-reported pre-pregnancy weight in kilograms, and their height in centimeters measured at the 26–28 weeks' gestational visit. According to the WHO BMI cut-off [24], BMI was categorized as underweight, normal weight, over-weight and obese ($<$18.5, 18.5–24.9, 25–29.9 and $\geq$30, respectively). Monthly household income was categorized as low, lower-medium, medium and high based on hierarchy in the administered questionnaire (Singapore dollars $<$2000, 2000–3999, 4000–5999 and $\geq$6000, respectively).

Assessment of Physical Activity

PA questions were part of a structured questionnaire administered by trained interviewers at 26–28 weeks' of gestation; it included questions on physical activities during the year before pregnancy and during the first 6 months of pregnancy. Physical activities were categorized as light-moderate, moderate and vigorous intensity. Light-moderate activity was defined as PA which normally leaves the person tired but not exhausted (e.g. walking, housework, gardening and golf). Moderate activity was defined as PA which normally leaves the person exhausted but not breathless (e.g. brisk walking, easy swimming, dancing and cycling). Vigorous activity was defined as PA which normally makes the heart beat rapidly and leaves the person breathless (e.g. jogging, vigorous swimming, cycling and aerobics).

The women were asked about the frequency and duration of light-moderate, moderate and vigorous intensity PA. Frequency was categorized in the questionnaire as never, once every 2–3 months, once a month, once a fortnight, 1–2 times per week, 3–6 times per week, once a day, and more than once a day. Based on these categories an average frequency per week was converted into 0, 0.1, 0.25, 0.5, 1.5, 4.5, 7, and 10.5 times per week, respectively. Women were asked an average duration of each period of activity, and the answers were standardized to the nearest 0.5 h. Frequency of light-moderate activity per week was multiplied with duration to obtain total hours spent on light-moderate level of physical activities per week, and then it was converted into min/week. The same method was used to calculate minutes spent on moderate and vigorous level of physical activities per week.

Energy expended on PA was calculated in MET-min/week. MET values for each level of intensity and formula for computation of MET-min/week were adopted from protocol for International Physical Activity Questionnaire (IPAQ) short form. In that 1.0 MET corresponding to resting energy expenditure [25]. According to the definition of each level of intensity and examples in the questionnaire, the MET values of 3.3, 4.0 and 8.0 were assigned to represent the average MET values of light-moderate, moderate and vigorous intensity, respectively. Energy expended on each level of PA intensity in MET min/week was calculated by multiplying total minutes spent on specific intensity per week with its corresponding MET value, for example energy expended on light-moderate physical activities was calculated by multiplying total minutes spent on light-moderate physical activities per week with MET value of 3.3. Total energy expended (TEE) on PA per week was calculated by summing up the energy expended in all three levels of PA intensity per week (light-moderate + moderate + vigorous).

Proportion (%) of contribution of different intensity PA in TEE was calculated by dividing energy expended on specific intensity (light-moderate, moderate and vigorous) with TEE in specific period (pre-pregnancy and pregnancy) and then multiplied by 100.

WHO recommends a minimum of 600 MET-min/week PA for health benefits [14, 15], hence, we further categorized TEE on PA in pre-pregnancy and during pregnancy into insufficiently active ($<$600 MET-min/week), and sufficiently active ($\geq$600 MET min/week).

WHO recommends that the minimum length of PA bouts should be 10 min of moderate-intensity PA [14]. Studies have further shown that 15 min of moderate PA result in health benefits and substantial reductions in mortality [26–28]. Based on these considerations we defined a minimum relevant reduction of PA during pregnancy to be consistent with at least 15 min moderate intensity PA. Assuming previously defined MET values for moderate intensity, this is equivalent to 60 MET-min/week. More substantial reductions of PA were also calculated, using PA reductions equivalent to 120, 180, 240, 300 and 360 MET-min/week or more.

Assessment of Sedentary Behavior

Along with PA assessment, SB pattern during the year before pregnancy and during the first 6 months of pregnancy was also assessed as a part of 26–28 weeks' gestational visit interview. This assessment included how many hours spent on sitting down in total per day (e.g. sitting at work, reading, and watching television), and the answers were standardized to the nearest 0.5 h. A separate question determined how many hours were spent on watching television per day; answers categorized as none, less than an hour, 1–2, 2–3, 3–4, 4–5 h, and more than 5 h. Based on these categories, an average watching television hours per day was converted into 0, 0.5, 1.5, 2.5, 3.5, 4.5 and 5.5 h per day, respectively. Daily sitting time and television time were converted into weekly data.

In this study, a relevant increase in SB was defined as an increase in sitting time per day by 2 h or more during pregnancy compared with pre-pregnancy. Given the lack of established cut-offs for relevant changes in SB, this threshold was calculated based on upper quartile of difference in sitting time during pregnancy compared with pre-pregnancy. However, increase in sitting time, including watching television about 2 h or more per day, has been found to be associated with detrimental health outcomes in previous studies [29, 30].

A study reported that more than 20 h per week on watching television during pre-pregnancy could associate with risk of adverse pregnancy outcome, GDM [31]. Therefore, television watching time ≥21 h per week before and during pregnancy was calculated.

Statistical Analysis

The percentages, medians, inter-quartile ranges (IQR), means and standard deviations (SD) for total time spent on light-moderate, moderate and vigorous physical activities, TEE on PA, proportion of different intensity in TEE on PA, sitting down, and watching television per week were calculated. Physical activity and sitting time were skewed, and television time was normally distributed. Wilcoxon signed rank test was used to calculate statistical difference between pre-pregnancy and pregnancy in physical activities and sitting time, and paired *t* test was used to calculate statistical difference of watching television. McNemar's test was conducted to examine the differences in the proportion of women who reported different categories of TEE on PA per week (insufficiently and sufficiently active) in pre-pregnancy and

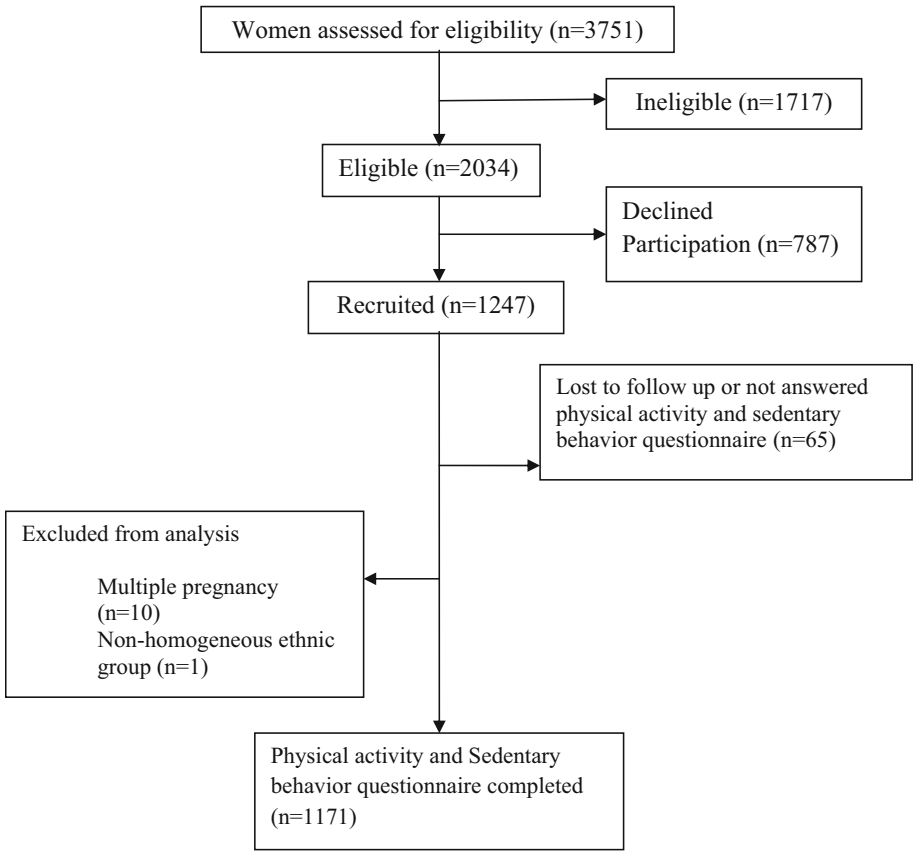

Fig. 1 Study flow diagram

Table 1 Characteristics of study participants in terms of socio-demographic and health factors (n = 1171)

Characteristics	N (%)
Ethnic group	
Chinese	664 (56.7)
Malay	298 (25.5)
Indian	209 (17.8)
Maternal age in years	
≤25	186 (15.9)
26–30	386 (33.0)
31–35	383 (32.7)
≥36	216 (18.4)
Education	
No formal education/primary/secondary	337 (29.2)
GCE 'A' levels/Polytechnic/Diploma/Technical education	404 (34.9)
University	377 (32.6)
Other formal education	38 (3.3)
Marital status	
Married/single living with spouse/partner	1118 (97.5)
Not living with spouse/partner	29 (2.5)
Working during pregnancy	
No	369 (31.5)
Yes	802 (68.5)
Household monthly income	
Low	163 (14.9)
Lower medium	335 (30.7)
Medium	274 (25.1)
High	320 (29.3)
Pre-pregnancy BMI	
Underweight	132 (12.2)
Normal weight	678 (62.7)
Overweight/obese	272 (25.1)
Infertility treatment	
No	1089 (93.0)
Yes	82 (7.0)
Parity at recruitment	
0	527 (45.7)
≥1	625 (54.3)
Planned pregnancy	
No	603 (51.8)
Yes	561 (48.2)
Perceived health condition in pregnancy	
Very good	136 (11.8)
Good	745 (64.9)
Fair/bad/very bad	267 (23.3)
Chronic illness	
No	1057 (92.5)
Yes	86 (7.5)
Nausea/vomiting due to pregnancy	
Never	298 (25.5)
Mild	342 (29.3)
Moderate/severe	528 (45.2)

Table 1 continued

Characteristics	N (%)
Antepartum hemorrhage in first trimester	
No	1019 (88.5)
Yes	132 (11.5)

Other formal education formal education but not sure within defined categories, *GCE 'A' levels* General Certificate of Education-Advance levels, *BMI* body mass index, *Chronic illness* any long term illness or disability troubled over a period of time at recruitment

Table 2 Means (standard deviations, SD) and medians (inter-quartile ranges, IQR) of time spent on physical activities, total energy expenditure on physical activity, television time, and sitting time before and during pregnancy (n = 1171)

Activities	Before pregnancy		During pregnancy	
	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)
Light-moderate PA				
Min/week	627.8 (760.1)	420.0 (180.0–840.0)	495.7 (651.8)	270.0 (90.0–630.0)***
Proportion in TEE on PA (%)	78.5 (28.1)	92.3 (62.4–100.0)	90.4 (21.5)	100 (96.4–100)***
Moderate PA				
Min/week	68.3 (190.2)	6.0 (0.0–90.0)	40.6 (180.3)	0.0 (0.0–3.0)***
Proportion in TEE on PA (%)	12.3 (20.8)	1.6 (0.0–16.4)	8.7 (20.1)	0.0 (0.0–2.7)***
Vigorous PA				
Min/week	31.8 ((97.8)	0.0 (0.0–12.0)	12.1 (183.5)	0.0 (0.0–0.0)***
Proportion in TEE on PA (%)	9.3 (19.8)	0.0 (0.0–7.2)	0.9 (7.2)	0.0 (0.0–0.0)***
TEE on PA (MET-min/week)	2593.4 (2787.3)	1746.0 (769.5–3372.0)	1895.3 (2896.6)	1039.5 (328.5–2685.0)***
Television time (h/week)	16.1 (9.5)	17.5 (10.5–24.5)	16.7 (10.3)*	17.5 (10.5–24.5)
Total sitting time (h/week)	57.3 (23.3)	56.0 (42.0–70.0)	60.5 (22.9)	63.0 (42.0–77.0)***

PA physical activity, *TEE* total energy expenditure, sum of energy expended on different physical activity intensity (light-moderate + moderate + vigorous), *MET* metabolic equivalent task

* Significantly different from before pregnancy at alpha level $p = 0.01$ in paired t test

*** Significantly different from before pregnancy at alpha level $p < 0.001$ in Wilcoxon signed rank test

pregnancy. Multiple logistic regression was used to calculate odds ratios (OR) and 95 % confidence intervals (CI) to address the association of socio-demographic and health factors with reduction of PA, and increase in SB during pregnancy as compared to pre-pregnancy. Two sided tests were used, a value of $p < 0.05$ was considered statistically significant. All data were analyzed using IBM SPSS Statistics (Version 19, IBM SPSS, Chicago, IL, USA).

Results

Patterns of Physical Activity

PA and SB questions were answered by 94 % (n = 1171) of total recruited subjects (n = 1247), only these subjects were included in the analysis (Fig. 1). Participants' characteristics were shown in Table 1.

Table 2 shows a significant reduction during pregnancy in time spent in all PA intensity categories, light-moderate, moderate and vigorous intensity (all $p < 0.001$). Light-moderate PA contributed the largest proportion towards TEE in pre-pregnancy and it increased significantly during pregnancy (median 92.3–100 %, $p < 0.001$). TEE per week on PA in MET-min/week was significantly reduced during pregnancy when compared with pre-pregnancy (median 1746.0–1039.5, $p < 0.001$). Compared with pre-pregnancy, during pregnancy the proportion of women reported insufficiently (19.0–34.1 %) and sufficiently active (81.0–66.0 %) were significantly different ($p < 0.001$). The proportion of women insufficiently active increased during pregnancy.

Table 3 Association of participants' socio-demographic and health factors with reduction in physical activity (≥60 MET-min/week) during pregnancy compared with pre-pregnancy

Characteristics	Reduction in physical activity (≥60 MET-min/week) during pregnancy				
	n (%)	Unadjusted OR (95 % CI)	*p* value	Adjusted OR (95 % CI)*	*p* value
Ethnic group			0.58		0.30
Chinese	405 (62.3)	1.0		1.0	
Malay	181 (61.6)	1.0 (0.7, 1.3)	0.83	1.0 (0.7, 1.5)	0.95
Indian	120 (58.3)	0.8 (0.6, 1.2)	0.30	0.8 (0.5, 1.1)	0.15
Maternal age in years			0.19		0.18
≤25	103 (56.6)	1.0		1.0	
26–30	243 (64.5)	1.4 (1.0, 2.0)	0.07	1.4 (0.9, 2.2)	0.14
31–35	236 (62.8)	1.3 (0.9, 1.9)	0.16	1.3 (0.8, 2.0)	0.34
≥36	124 (57.7)	1.1 (0.7, 1.6)	0.83	0.9 (0.6, 1.6)	0.80
Education			0.09		0.60
No formal education/primary/secondary	187 (56.8)	1.0		1.0	
GCE 'A' levels/ Polytechnic/Diploma/Technical education	242 (61.4)	1.2 (0.9, 1.6)	0.21	1.0 (0.7, 1.4)	0.94
University	247 (66.0)	1.5 (1.1, 2.0)	0.01**	0.8 (0.5, 1.2)	0.25
Other formal education	23 (60.5)	1.2 (0.6, 2.3)	0.66	0.8 (0.4, 1.8)	0.59
Marital status			0.73		0.65
Married/single living with spouse/partner	679 (61.8)	1.0		1.0	
Not living with spouse/partner	17 (58.6)	0.9 (0.4, 1.9)		1.2 (0.5, 3.1)	
Working during pregnancy			0.14		0.31
No	209 (58.2)	1.0		1.0	
Yes	497 (62.8)	1.2 (0.9, 1.6)		1.2 (0.9, 1.7)	
Household monthly income			<0.001**		<0.001**
Low	83 (51.9)	1.0		1.0	
Lower medium	179 (54.7)	1.1 (0.8, 1.6)	0.55	1.2 (0.8, 1.9)	0.42
Medium	171 (64.0)	1.7 (1.1, 2.5)	0.01**	2.1 (1.3, 3.5)	0.004**
High	223 (70.1)	2.2 (1.5, 3.2)	<0.001**	3.1 (1.8, 5.4)	<0.001**
Pre-pregnancy BMI			0.48		0.11
Underweight	80 (62.5)	1.0		1.0	
Normal weight	403 (60.4)	0.9 (0.6, 1.4)	0.66	1.0 (0.6, 1.6)	0.95
Overweight/obese	172 (64.7)	1.1 (0.7, 1.7)	0.68	1.4 (0.9, 2.4)	0.19
Infertility treatment			0.31		0.95
No	652 (61.0)	1.0		1.0	
Yes	54 (66.7)	1.3 (0.8, 2.1)		1.0 (0.5, 1.9)	
Parity at recruitment			0.002**		0.02**
0	345 (66.3)	1.0		1.0	
≥1	349 (57.1)	0.7 (0.5, 0.9)		0.7 (0.5, 0.9)	
Planned pregnancy			0.04**		0.28
No	347 (58.7)	1.0		1.0	
Yes	358 (64.7)	1.3 (1.0, 1.6)		1.2 (0.9, 1.6)	
Perceived health condition in pregnancy			0.92		0.41
Very good	79 (60.3)	1.0		1.0	
Good	452 (61.7)	1.1 (0.7, 1.6)	0.76	1.2 (0.8, 1.9)	0.40
Fair/bad/very bad	165 (62.5)	1.1 (0.7, 1.7)	0.67	1.4 (0.9, 2.3)	0.19
Chronic illness			0.48		0.45
No	642 (62.0)	1.0		1.0	
Yes	50 (58.1)	0.9 (0.6, 1.3)		0.8 (0.5, 1.4)	

Table 3 continued

Characteristics	Reduction in physical activity (≥60 MET-min/week) during pregnancy				
	n (%)	Unadjusted OR (95 % CI)	*p* value	Adjusted OR (95 % CI)*	*p* value
Nausea/vomiting due to pregnancy			0.01**		0.01**
No	158 (54.7)	1.0		1.0	
Mild	204 (60.5)	1.3 (0.9, 1.8)	0.14	1.3 (0.9, 1.8)	0.23
Moderate/severe	342 (65.5)	1.6 (1.2, 2.1)	0.002**	1.7 (1.2, 2.4)	0.004**
Antepartum hemorrhage in first trimester			0.29		0.75
No	609 (60.8)	1.0		1.0	
Yes	84 (65.6)	1.2 (0.8, 1.8)		1.1 (0.7, 1.7)	
Pre-pregnancy physical activity (MET-min/week)			<0.001**		<0.001**
Insufficient (<600)	90 (41.3)	1.0		1.0	
Sufficient (600 to <3000)	382 (62.8)	2.4 (1.8, 3.3)	<0.001**	2.8 (2.0, 4.1)	<0.001**
High (≥3000)	234 (72.2)	3.7 (2.6, 5.3)	<0.001**	5.5 (3.5, 8.6)	<0.001**

In total 21 subjects excluded, because total energy expended on physical activity was missing either before or during pregnancy (n = 1150). Proportion of women decreased physical activity 60 MET min/week or more during pregnancy were 61.4 %, n = 706

OR odds ratio, *CI* confidence intervals, *MET* metabolic equivalent task, *Other formal education* formal education but not sure within defined categories, *GCE 'A' levels* General Certificate of Education-Advance levels, *BMI* body mass index, *Chronic illness* any long term illness or disability troubled over a period of time at recruitment

* Odds ratios are adjusted for the rest of variables in the table

** Significantly associated at alpha level $p = 0.05$

Patterns of Sedentary Behavior

Total hours spent on sitting per week increased from pre-pregnancy to during pregnancy (median 56.0–63.0, $p < 0.001$). Total hours spent on watching television per week increased significantly from pre-pregnancy to during pregnancy (mean 16.1–16.7, $p = 0.01$), the proportion of women that watched television for more than 21 h per week increased in pregnancy (27.9–31.9 %).

Determinants of Change in Physical Activity and Sedentary Behavior

Table 3 shows that planned pregnancy and university education were significantly associated with reduction of PA (≥60 MET-min/week) during pregnancy but these associations ceased to exist when adjusting for other variables. Household income, parity, nausea/vomiting during pregnancy, pre-pregnancy activity levels were significantly associated with reduction of PA (≥60 MET-min/week) both in unadjusted and adjusted models. Ethnicity, age, marital status, occupation during pregnancy, infertility treatment, chronic illness and antepartum hemorrhage were not associated with reduction of 60 MET-min/week or more PA. These findings were consistent when considering more substantial reductions in PA behavior (120, 180, 240, 300 and 360 MET-min/week or more, results not shown). Perceived health condition was associated with reductions of 120 MET-min/week or more in PA. Women who perceived their health as fair/bad/very bad were more likely to substantially reduce PA compared to those who perceived their health as very good (adjusted OR 1.8, 95 % CI 1.1–3.0, $p = 0.02$), this association was stronger in more substantial reductions (180, 240, 300 and 360 MET-min/week). Women with pre-pregnancy overweight/obese was associated with 120 (adjusted OR 1.8, 95 % CI 1.1–3.0, $p = 0.02$) and 180 MET-min/week reduction in physical activity, however, this association did not exist in more substantial reductions of 240, 300, 360 MET-min/week.

Table 4 shows that, ethnicity, General Certificate of Education-Advance levels (GCE 'A' levels)/Polytechnic/Diploma/Technical education, working during pregnancy and higher household income were significantly associated with increases in sitting time during pregnancy, these associations ceased to exist when adjusting for other variables. In adjusted analysis, nausea/vomiting during pregnancy and level of pre-pregnancy sitting time were significantly associated with increases in sitting time during pregnancy. Other variables were not associated with increase in SB in both adjusted and unadjusted analysis.

Discussion

To the authors' knowledge, GUSTO is the first birth cohort in Asia that reports PA and SB patterns before and during pregnancy among a sample of Chinese, Malay and Indian

Table 4 Association of participants' socio-demographic and health factors with increase in sitting time (2 h per day) during pregnancy compared with pre-pregnancy

Characteristics	Increase in sitting time (2 h per day) during pregnancy				
	n (%)	Unadjusted OR (95 % CI)	*p* value	Adjusted OR (95 % CI)*	*p* value
Ethnic group			0.02**		0.41
Chinese	153 (23.1)	1.0		1.0	
Malay	79 (26.6)	1.2 (0.9, 1.7)	0.24	1.0 (0.7, 1.5)	0.91
Indian	69 (33.0)	1.6 (1.2, 2.3)	0.004**	1.3 (0.9, 2.0)	0.23
Maternal age in years			0.50		0.57
≤25	53 (28.5)	1.0		1.0	
26–30	105 (27.3)	0.9 (0.6, 1.4)	0.77	1.3 (0.8, 2.2)	0.27
31–35	93 (24.3)	0.8 (0.5, 1.2)	0.28	1.2 (0.7, 2.1)	0.43
≥36	50 (23.3)	0.8 (0.5, 1.2)	0.23	1.0 (0.6, 1.9)	0.90
Education			0.14		0.28
No formal education/primary/secondary	102 (30.4)	1.0		1.0	
GCE 'A' levels/ Polytechnic/Diploma/Technical education	92 (22.9)	0.7 (0.5, 1.0)	0.02**	0.7 (0.5, 1.1)	0.10
University	97 (25.7)	0.8 (0.6, 1.1)	0.17	0.9 (0.6, 1.5)	0.74
Other formal education	9 (23.7)	0.7 (0.3, 1.6)	0.40	0.6 (0.2, 1.5)	0.26
Marital status			0.54		0.80
Married/single living with spouse/partner	289 (25.9)	1.0		1.0	
Not living with spouse/partner	9 (31.0)	1.3 (0.6, 2.9)		1.2 (0.4, 3.3)	
Working during pregnancy			0.001**		0.30
No	119 (32.3)	1.0		1.0	
Yes	182 (22.8)	0.6 (0.5, 0.8)		0.8 (0.6, 1.2)	
Household monthly income			0.18		0.27
Low	53 (32.7)	1.0		1.0	
Lower medium	83 (24.8)	0.7 (0.5, 1.0)	0.06	0.8 (0.5, 1.3)	0.43
Medium	69 (25.4)	0.7 (0.5, 1.1)	0.10	1.3 (0.8, 2.2)	0.38
High	76 (23.8)	0.6 (0.4, 1.0)	0.04**	1.2 (0.7, 2.2)	0.54
Pre-pregnancy BMI			0.34		0.68
Underweight	37 (28.0)	1.0		1.0	
Normal weight	165 (24.4)	0.8 (0.6, 1.3)	0.38	1.0 (0.6, 1.7)	0.87
Overweight/obese	78 (28.7)	1.0 (0.7, 1.6)	0.89	1.2 (0.7, 2.1)	0.49
Infertility treatment			0.18		0.95
No	285 (26.2)	1.0		1.0	
Yes	16 (19.5)	0.7 (0.4, 1.2)		1.0 (0.5, 2.0)	
Parity at recruitment			0.75		0.41
0	132 (25.1)	1.0		1.0	
≥1	162 (26.0)	1.0 (0.8, 1.4)		0.9 (0.6, 1.2)	
Planned pregnancy			0.24		0.49
No	164 (27.3)	1.0		1.0	
Yes	136 (24.2)	0.9 (0.7, 1.1)		0.9 (0.6, 1.3)	
Perceived health condition during pregnancy			0.14		0.30
Very good	43 (31.6)	1.0		1.0	
Good	181 (24.4)	0.7 (0.5, 1.0)	0.08	0.7 (0.5, 1.1)	0.14
Fair/bad/very bad	75 (28.2)	0.9 (0.5, 1.3)	0.48	0.8 (0.5, 1.4)	0.46
Chronic illness			0.91		0.74
No	276 (26.2)	1.0		1.0	
Yes	23 (26.7)	1.0 (0.6, 1.7)		1.1 (0.6, 2.0)	

Table 4 continued

Characteristics	Increase in sitting time (2 h per day) during pregnancy				
	n (%)	Unadjusted OR (95 % CI)	*p* value	Adjusted OR (95 % CI)*	*p* value
Nausea/vomiting due to pregnancy			0.07		0.03**
Never	63 (21.2)	1.0		1.0	
Mild	87 (25.4)	1.3 (0.9, 1.8)	0.21	1.6 (1.0, 2.4)	0.05
Moderate/severe	150 (28.5)	1.5 (1.1, 2.1)	0.02**	1.7 (1.2, 2.6)	0.007**
Antepartum hemorrhage in first trimester			0.46		0.50
No	257 (25.3)	1.0		1.0	
Yes	37 (28.2)	1.2 (0.8, 1.8)		1.2 (0.7, 1.9)	
Pre-pregnancy sitting time (hours per day)			<0.001**		<0.001**
>8	74 (14.1)	1.0		1.0	
6–8	64 (25.5)	2.1 (1.4, 3.0)	<0.001**	2.2 (1.5, 3.4)	<0.001**
4–6	82 (42.1)	4.4 (3.0, 6.4)	<0.001**	4.6 (2.9, 7.0)	<0.001**
≤4	81 (40.9)	4.2 (2.9, 6.1)	<0.001**	4.0 (2.6, 6.2)	<0.001**

In total three subjects excluded, because total sitting time per week was missing either before or during pregnancy (n = 1168). Proportion of women increased sitting time 2 h per day or more during pregnancy were 25.8 %, n = 301

OR odds ratio, *CI* confidence intervals, *Other formal education* formal education but not sure within defined categories, *GCE 'A' levels* General Certificate of Education-Advance levels, *BMI* body mass index, *Chronic illness* any long term illness or disability troubled over a period of time at recruitment

* Odds ratios are adjusted for the rest of variables in the table

** Significantly associated at alpha level $p = 0.05$

women. We were able to show that time spent on light-moderate, moderate and vigorous physical activities were substantially reduced during pregnancy compared to pre-pregnancy. The proportion of women insufficiently active increased during pregnancy. Prior international studies also observed that PA decreases from pre-pregnancy to pregnancy [11, 12, 22, 32–35]. A birth cohort study conducted among 1442 women in Boston and Massachusetts reported that prevalence of insufficiently active lifestyle increased from pre-pregnancy to during pregnancy (12.6–21.6 %) [35].

In addition, we found that sitting time increased substantially during pregnancy. Our findings are consistent with one other study among nulliparous women that reported marked increases in proportion women reporting sedentary activity during pregnancy [22]. Similar to overall trends in sitting time, we observed an increase in time spent in watching television during pregnancy. This finding seems to differ from previous study that found no change in television time during pregnancy [35]. Investigating sitting and television time is important because these behaviors have shown to be associated with detrimental health outcomes [17, 36–41]. Similarly, it was reported that television time of more than 20 h per week in the absence of vigorous activity in pre-pregnancy is associated with GDM [31]. Concerningly, more than one quarter of our study participants were watching television for more than 21 h per week both before and during pregnancy which could increase their risk of developing GDM.

Among determinants investigated, household income, nausea/vomiting in first trimester, and level of pre-pregnancy physical activity were negatively, and parity was positively associated with reductions in PA during pregnancy. Perceived health condition was associated with more substantial reduction in PA. These findings are consistent with other studies from western countries that reported that parity [35], level of pre-pregnancy activity [11, 33], and general health [42] were associated with physical activity during pregnancy. In contrast to our study, age, education and infertility treatment also were significantly associated with reductions in PA during pregnancy in studies with western population [11, 22].

Our study seems to be the first that investigates associations of maternal characteristics with increases in sitting time. We found that Indians were more likely to increase sitting time during pregnancy compared with Chinese, and working during pregnancy were less likely to increase sitting time. However, these associations ceased to exist when adjusted for other variables. Women with nausea/vomiting in first trimester and lower level of sitting time in pre-pregnancy were more likely to increase sitting time during pregnancy.

Strength of the study, GUSTO study is designed to recruit a unique multi-ethnic sample of Asian women [23],

and it allowed us to examine the ethnic differences on PA and SB patterns before pregnancy and during pregnancy. PA and SB data was collected as part of a structured interviewer administered questionnaire, it was administered by trained interviewers to improve data quality.

Nevertheless, some limitations need to be considered, Firstly, the data were limited to participants' self-reports with potential for recall bias due to complexity of PA and SB, and the questionnaire was not validated locally against objective methods, such as pedometers or accelerometer [43–45]. Secondly, PA and SB patterns were restricted to pre-gravid and first 6 months of pregnancy; our study did not assess activities during later pregnancy. Previous studies indicated that PA decreases in the third trimester [46], which had implications for maternal and fetal outcome [47, 48].

Thirdly, MET values were assigned based on IPAQ protocol for each level of PA intensity. These MET values are standardized for an average adult but not specifically for pregnant women. Physiological changes during pregnancy might have affected the accuracy of estimated values [49–51]. However, we believe that the magnitude of imprecision will be minimal, as our data was restricted to the first two trimesters. Fourthly, no established cut-offs for relevant changes in SB currently exist and they were therefore calculated based on upper quartile of difference in sitting time during pregnancy compared with pre-pregnancy.

Finally, generalizability of our study population could be limited due to convenience sampling, recruited only pregnant women who met eligibility criteria (54.2 % of total women screened for eligibility) and volunteered to participate. For instance, ethnic background of non-recruited women differed from recruited women ($p = 0.04$) in this study [23].

This large cohort study reported PA and SB patterns and changes in these patterns before and during pregnancy. In addition, determinants of reductions in PA and increases in SB were investigated. To our knowledge, this study reflects the first cohort study of its kind conducted in a sample of Chinese, Malay and Indian women. Despite international recommendations to maintain an active lifestyle even during pregnancy, our findings highlight substantial reductions in PA and increases in SB during pregnancy. These findings are important because they can be associated with detrimental health outcomes for mother and child. However, methodologically rigorous studies are needed, combining subjective and objective assessment of PA and SB, to better understand PA and SB patterns among Asian women in Singapore. Similarly, although this study enlightens the knowledge on factors associated with reductions in PA and increases in SB during pregnancy, a better understanding of barriers in performing PA before and during pregnancy is essential, including individual perception and socio-cultural beliefs and practices with regard to performing PA before and during pregnancy. Hence, this warrants further investigations to better understanding modifiable factors which can influence positive changes in PA and SB pattern before and during pregnancy. This knowledge will help to develop effective health promotion strategies on maternal and child health that have potential to reduce the incidence of chronic diseases, such as GDM and unhealthy weight gain during pregnancy.

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