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Sedentary Behavior Determinants in Pregnant Women During the Second and Third Trimesters: Prospective Findings from the Large-Scale Japan Environment and Children's Study

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Abstract

Extended periods of sedentary behavior during pregnancy have been associated with negative health outcomes and unfavorable pregnancy results. This research aimed to pinpoint specific factors that could be targeted in efforts to reduce sedentary behavior among expectant mothers. Out of 103,057 pregnancies documented in the Japan Environment and Children's Study, 83,733 participants were analyzed after removing repeated enrollments, missing responses, and incomplete outcome data. Sedentary behavior and activity levels were assessed using the International Physical Activity Questionnaire. Logistic regression was applied to estimate both unadjusted and adjusted odds ratios. To address missing data, multiple imputation techniques were used, and statistical computations were carried out with SAS software. The average daily sedentary time increased from 5.4 hours before pregnancy to 5.9 hours during pregnancy. The proportion of women classified within the high sedentary behavior category rose from 25.6% pre-pregnancy to 31.2% during pregnancy. Key factors linked to increased sedentary behavior included greater time spent watching television and playing video games prior to pregnancy, higher household income levels, and being employed during pregnancy. Conversely, engaging in at least 150 minutes of moderate to vigorous physical activity weekly before pregnancy was identified as a potential protective factor against elevated sedentary behavior. This large-scale cohort provides important insights into sedentary habits among pregnant women in Japan. Reducing sedentary time during pregnancy may be achieved by monitoring and limiting time spent on television and video games, along with fostering regular exercise habits before pregnancy.

Keywords: Self-administered questionnaire, Screen time, Sedentary time, Cohort study, Physical activity

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Introduction

Physical activity during pregnancy, including sedentary behavior (SB), is believed to influence fetal development by altering the intrauterine environment through changes in energy metabolism and placental nutrient transfer. Excessive sedentary time in pregnancy has been linked to elevated markers such as C-reactive protein [1, 2] and low-density lipoprotein cholesterol [2], as well as the development of gestational diabetes mellitus [3, 4]. Moreover, SB is related to fetal health issues, including restricted growth [5] and fetal macrosomia [6], indicating that SB may impact both maternal and offspring well-being.

Sedentary behavior comprises activities like sitting, lying down, watching television (TV), and playing video games, which require minimal increase in resting energy expenditure, roughly 1.0–1.5 metabolic equivalent units (METs), near the basal metabolic rate [7]. Despite the World Health Organization advising pregnant women to reduce sedentary time and increase physical activity [8], studies show that SB tends to rise during pregnancy compared to before pregnancy [9, 10]. Given the challenges of decreasing SB during this period, understanding factors that facilitate reducing sedentary time is crucial.

Various approaches have measured SB, including self-administered questionnaires and wearable devices, but findings vary widely [10]. While some reports suggest that self-reported SB may underestimate actual sedentary time compared to device-based assessments [11], tools like the International Physical Activity Questionnaire (IPAQ) [12] offer practicality for large population studies and allow for international comparisons [13]. The present research aims to assess changes in SB duration before and during pregnancy using IPAQ and to identify characteristics and factors linked with prolonged sedentary time to support reduction strategies.

Materials and Methods

Study design

The Japan Environment and Children's Study (JECS) is a government-supported, nationwide birth cohort project examining environmental influences on child health and development. Detailed information on the JECS design and participant baseline data have been published elsewhere [14, 15]. Pregnant women were recruited from January 2011 to March 2014 at healthcare facilities across 15 regional centers covering rural and urban Japan. Data collection involved self-administered questionnaires and medical record reviews conducted by healthcare professionals or research staff.

Ethical approval for JECS was granted by the Ministry of Environment's Institutional Review Board on Epidemiological Studies (100910001) and ethics committees of all participating institutions. Written informed consent was obtained from all participants. This specific analysis received additional approval from the Ethics Committee of the University of Toyama (no. R2023172). The study complied fully with national and institutional human research ethics guidelines and the World Medical Association's Declaration of Helsinki.

Study population

This study utilized the jecs-qa-20210401 dataset released in April 2021 and updated in February 2022, encompassing 103,057 pregnancies. After excluding 5,647 repeated enrollments of the same mothers, 8,051 cases with missing pre-pregnancy SB data, and 5,626 with missing SB data during pregnancy, 83,733 participants were included in the final dataset **(Figure 1)**.

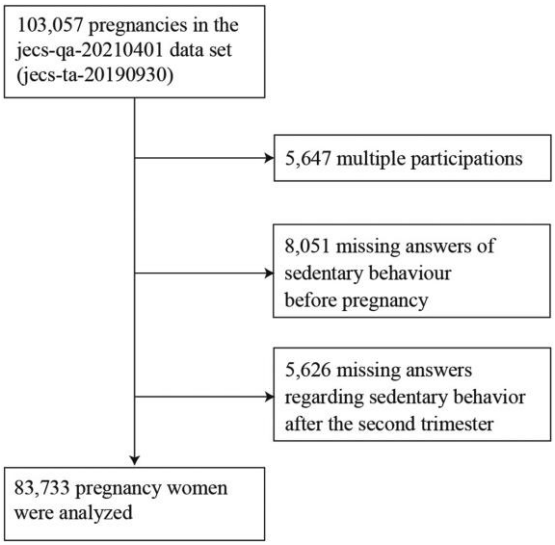

Figure 1. Participant flow diagram

Measures

Sedentary behavior

The duration of sedentary behavior (SB) on weekdays was assessed using the Japanese edition of the short form of the International Physical Activity Questionnaire (IPAQ) [16]. The question posed was: "On a typical weekday, how much time do you usually spend sitting or lying down, including time spent sitting at a desk, chatting with friends, reading, or sitting/lying down while watching television? Please exclude sleeping time." Participants provided their answers in a handwritten format specifying "[ ] hours and [ ] minutes."

At the time of enrollment—generally during the first trimester—the questionnaire (M-T1) asked participants to recall "the amount of time spent during an ordinary day before pregnancy." Additionally, respondents reported the time spent watching TV or playing video games during their overall SB period. Pre-pregnancy durations of TV watching and video game playing were treated as independent lifestyle variables in the analysis. Later, after

the second trimester, the questionnaire (M-T2) inquired about SB time at the time of survey completion. This study examined SB duration during pregnancy as the outcome variable.

Total hours of SB were calculated using the full dataset prior to exclusions. Responses deemed illogical, such as those exceeding 24 hours or 60 minutes in the minute field, were discarded. Subsequently, the 1st and 99th percentiles for SB during pregnancy were identified as 0 hours/day and 17 hours/day, respectively. Values of 0 hours/day or more than 17 hours/day for both pre-pregnancy and pregnancy SB were marked as "missing" and excluded from analysis.

Based on previous research [17–19], participants were classified into a "high-SB group" if they reported SB ≥ 8 hours/day, and a "low-SB group" if SB was less than 8 hours/day. Since no established cutoff exists for pregnant women, this 8-hour threshold was adopted from data on the general adult population in Japan.

Variables considered for association

To explore factors related to SB during pregnancy, the following variables were selected: hours spent watching TV before pregnancy, hours spent playing video games before pregnancy, sleep duration during the first trimester, maternal age categories (< 25, 25–29, 30–34, or ≥ 35 years), annual household income brackets (< 4 million, 4 to < 6 million, or ≥ 6 million Japanese yen (JPY)), highest educational attainment (≤ 12, > 12 to < 16, or ≥ 16 years), employment status in the first trimester (unemployed or employed), parity (primipara or multipara), conception through reproductive medicine (no or yes), multiple pregnancy status (no or yes), pre-pregnancy body mass index (BMI) categories (< 18.5, 18.5 to < 25, or ≥ 25), type of residence (stand-alone house, living on the 5th floor or lower of a residential complex, living on the 6th floor or higher of a residential complex, or other), smoking status (never smoked, quit before pregnancy, quit after pregnancy, or current smoker), alcohol consumption (never drank, quit, or current drinker), nausea and vomiting during pregnancy (NVP) before 12 weeks gestation (no symptoms, nausea only, NVP but able to eat, or NVP and unable to eat), stressful events after pregnancy (no or yes), psychological distress in the first trimester categorized by total Kessler 6 (K6) scores (< 5, 5–12, and ≥ 13) [20], weekly moderate-to-vigorous physical activity (MVPA) derived from IPAQ (< 150 minutes or ≥ 150 minutes) [8], dog ownership (no or yes), and physical and mental health as measured by SF-8 scores. All data were obtained via self-administered questionnaires (M-T1 and M-T2) during pregnancy, except parity and BMI, which were extracted from medical records.

Statistical analysis

Descriptive data are shown as percentages or as means with standard deviations (SD). Logistic regression was applied to estimate both crude and adjusted odds ratios (cOR and aOR) for being classified as high sedentary behavior (≥ 8 hours/day) during the second or third trimester, along with corresponding 95 percent confidence intervals (CI). The analysis stratified participants into low-SB and high-SB groups based on their pre-pregnancy sedentary time.

To handle missing data, multiple imputation was employed. Most variables had missing rates of ≤ 1.0%, except for several: hours spent watching TV (7.6 percent), annual household income (6.3 percent), hours spent playing video games (3.9 percent), working status in the first trimester (3.1 percent), weekly MVPA (2.9%), sleep duration in the first trimester (2.5 percent), SF-8 physical and mental health scores (1.4 percent), and multiple pregnancy status (1.1 percent). Ten imputed datasets were generated using chained equations [21], and results were pooled according to Rubin's rules [22].

All statistical procedures were conducted using SAS version 9.4 (SAS Institute Inc., Cary, NC).

Results and Discussion

The analysis included data from 83,733 pregnant women. The average weekday sedentary time was 5.4 hours (SD = 3.4) before pregnancy and increased to 5.9 hours (SD = 3.5) during pregnancy. The Pearson correlation coefficient between sedentary time before and during pregnancy was 0.478 ($p < 0.0001$). The proportion of women categorized as high-SB rose from 25.6% pre-pregnancy to 31.2 percent during pregnancy. Notably, 15.1% of participants shifted from low-SB before pregnancy to high-SB during pregnancy, whereas 9.5 percent moved from high-SB before pregnancy to low-SB during pregnancy **(Figure 2)**.

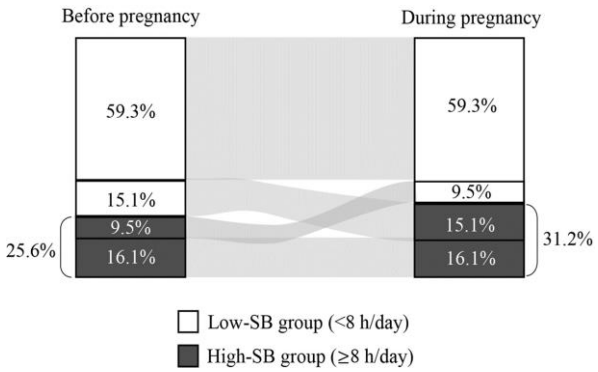

Figure 2. Percentages of women classified in the low- and high-SB groups before and during pregnancy

Table 1 presents typical values for the analyzed items categorized by SB group before pregnancy. Sleep duration during the first trimester of pregnancy was nearly identical between the two groups. While there was no significant difference in age distribution, the high-SB group included

larger proportions of individuals from the highest income bracket, highest education level, primiparas, and those engaging in less than the recommended amount of MVPA.

Table 1. Participant characteristics according to amount of time spent engaged in sedentary behavior before pregnancy (N = 83,733)

	Sedentary behavior before pregnancy	
	< 8 h/day n = 62,349 (74.5%)	≥ 8 h/day n = 21,384 (25.5%)
Length of time spent sedentary prior to pregnancy		
Hours, mean (SD)	3.8 (1.7)	10.3 (2.2)
Pre-pregnancy television viewing duration		
Hours, mean (SD)	2.2 (1.3)	3.3 (2.2)
Playtime duration for video games		
Hours, mean (SD)	0.4 (0.7)	0.6 (1.2)
Sleep duration in the first trimester		
Hours, mean (SD)	7.5 (1.2)	7.4 (1.2)
Age at baseline, n (%)		
< 25	6.801 (10.9)	2,411 (11.3)
25–29	18,436 (29.6)	6,256 (29.3)
30–34	21,909 (35.1)	7,404 (34.6)
≥ 35	15,188 (24.4)	5,309 (24.8)
Proportion of annual household income (JPY) (%)		
< 4 million	23,989 (41.1)	7,270 (36.2)
4–<6 million	19,611 (33.6)	6,470 (32.2)
≥ 6 million	14,752 (25.3)	6,335 (31.6)
Highest level of education attained (in years), n (%)		
< 13	22,024 (35.5)	7,636 (35.8)
13–<16	27,507 (44.3)	7,695 (36.1)
≥ 16	12,590 (20.3)	5,988 (28.1)
Working status (%)		
Unemployed	23,378 (38.8)	6,616 (31.8)
Employed	36,924 (61.2)	14,196 (68.2)
Parity (%)		
Primipara	24,604 (39.8)	12,153 (57.3)
Multipara	37,292 (60.2)	9,054 (42.7)
Pregnancy attained via assisted reproductive technology, n (%)		
No	58,137 (93.7)	19,353 (90.9)
Yes	3,939 (6.3)	1,931 (9.1)
Multiple pregnancy (%)		
No	61,062 (99.0)	20,919 (99.0)
Yes	588 (1.0)	213 (1.0)
BMI before pregnancy (%)		
< 18.5	9,885 (15.9)	3,583 (16.8)
18.5–<25	45,898 (73.6)	15,586 (72.9)
≥ 25	6,545 (10.5)	2,207 (10.3)
Type of residence, n (%)		
Stand-alone house	29,823 (48.2)	9,290 (43.8)
Residential complex ≤ 5th floor	25,085 (40.5)	9,293 (43.8)
Residential complex ≥ 6th floor	6,190 (10.0)	2,393 (11.3)
Other types of residence	782 (1.3)	239 (1.1)
Smoking status (%)		
Never smoked	35,839 (57.9)	13,104 (61.6)
Quit before pregnancy	14,690 (23.7)	4,642 (21.8)

Quit after pregnancy	8,455 (13.7)	2,625 (12.3)
Current smoker	2,933 (4.7)	899 (4.2)
Alcohol consumption in the first trimester, n (%)		
Never	21,557 (34.7)	7,036 (33.0)
Quit	34,357 (55.3)	11,983 (56.2)
Current	6,190 (10.0)	2,299 (10.8)
NVP before 12 gestational weeks, n (%)		
No experience	10,311 (16.6)	4,035 (18.9)
Nausea only	26,591 (42.8)	9,225 (43.3)
Experienced NVP but able to eat	18,156 (29.2)	5,947 (27.9)
Experienced NVP and unable to eat	7,109 (11.4)	2,118 (9.9)
Stressful occurrences during pregnancy, n (%)		
No	34,816 (56.2)	12,044 (56.7)
Yes	27,106 (43.8)	9,211 (43.3)
Psychological distress in the first trimester (overall K6 score), n (%)		
< 5	42,186 (67.8)	14,575 (68.2)
5–12	17,887 (28.7)	6,091 (28.5)
≥ 13	2,188 (3.5)	693 (3.2)
MVPA per week, n (%)		
< 150 min	40,491 (67.1)	17,234 (82.2)
≥ 150 min	19,835 (32.9)	3,727 (17.8)
Ownership of a dog, n (%)		
No	53,970 (86.6)	18,654 (87.2)
Yes	8,379 (13.4)	2,730 (12.8)
Physical and mental well-being (SF-8 score)		
Physical component summary scores, mean (SD)	45.1 (7.3)	45.0 (7.4)
Mental component summary scores, mean (SD)	46.0 (7.2)	46.4 (7.2)

BMI body mass index, JPY Japanese yen, K6 Kessler 6, MVPA moderate to vigorous physical activity, NVP nausea and vomiting in pregnancy, SD standard deviation, TV television

The crude and adjusted odds ratios (cOR and aOR) for the low- and high-SB groups during pregnancy were computed for each factor, and these were applied to categorize the low and high-SB groups before pregnancy. Results shown in **Table 2** focus on those initially assigned to the low-SB group. Findings indicated that increased hours spent playing video games and watching TV prior to pregnancy, carrying multiples, living in apartment complexes, consuming alcohol in the first trimester, and experiencing stressful events during pregnancy were linked with elevated sedentary behavior during pregnancy. On the other hand, longer sleep duration in the first trimester, having had previous births (multipara), higher annual household income, education between 13 and under 16 years, being employed during the first trimester, suffering from NVP severe enough to prevent eating, participating in at least 150 minutes of MVPA weekly, and better SF-8 scores were connected to a lower likelihood of high sedentary behavior during pregnancy

Table 2. Odds ratios (95% CIs) for ≥ 8 h/day of sedentary behavior after the second trimester among women who engaged in < 8 h/ day of sedentary behavior before pregnancy (N = 62,349)

	Case ≥ 8 h/day	Subtotal	Prevalence	cOR(95% CI)	aOR[a] (95% CI)
Duration of TV viewing before pregnancy					
By hour		-	-	1.26 (1.25, 1.28)	1.20 (1.18, 1.22)
Duration of playing video games before pregnancy	-				
By hour		-	-	1.23 (1.21, 1.26)	1.09 (1.07, 1.12)
Length of sleep during the first trimester	-				
By hour		-	-	0.90 (0.88, 0.91)	0.97 (0.96, 0.99)
Age at baseline	-				

< 25	1,728	6,803	25.4%	Reference	Reference
25–29	3,948	18,442	21.4%	0.80 (0.75, 0.85)	1.00 (0.94, 1.06)
30–34	4,165	21,914	19.0%	0.69 (0.65, 0.73)	1.01 (0.94, 1.08)
≥ 35	2,828	15,190	18.6%	0.67 (0.63, 0.72)	1.04 (0.97, 1.12)
Yearly household income (JPY)					
< 4 million	5,609	25,941	21.6%	Reference	Reference
4– < 6 million	3,976	20,872	19.0%	0.80 (0.77, 0.84)	0.90 (0.86, 0.95)
≥ 6 million	3,083	15,536	19.8%	0.97 (0.92, 1.02)	0.93 (0.88, 0.98)
Maximum educational attainment (years)					
< 13	4,863	22,118	22.0%	Reference	Reference
13– < 16	5,099	27,596	18.5%	0.85 (0.81, 0.89)	0.82 (0.79, 0.86)
≥ 16	2,706	12,635	21.4%	0.90 (0.85, 0.94)	1.03 (0.97, 1.09)
Employment status during the first trimester					
Unemployed	4,703	24,368	19.3%	Reference	Reference
Employed	7,966	37,981	21.0%	1.11 (1.06, 1.16)	0.91 (0.88, 0.96)
Parity					
Primipara	7,334	24,932	29.4%	Reference	Reference
Multipara	5,334	37,417	14.3%	0.40 (0.38, 0.42)	0.43 (0.41, 0.45)
Pregnancy achieved via reproductive medicine					
No	11,685	58,391	20.0%	Reference	Reference
Yes	983	3,958	24.8%	1.32 (1.23, 1.42)	1.06 (0.98, 1.14)
Multiples pregnancy					
No	12,466	61,749	20.2%	Reference	Reference
Yes	202	600	33.7%	12.39 (6.70, 22.91)	1.87 (1.61, 2.18)
Pre-pregnancy BMI					
< 18.5	2,047	9,889	20.7%	1.03 (0.98, 1.09)	1.00 (0.94, 1.05)
18.5– < 25	9,283	45,914	20.2%	Reference	Reference
≥ 25	1,338	6,547	20.4%	1.01 (0.95, 1.08)	1.01 (0.94, 1.07)
Residence, n (%)					
Stand-alone house	5,389	30,041	17.9%	Reference	Reference
Residential complexes ≤ 5th floor	5,832	25,312	23.0%	1.37 (1.31, 1.43)	1.10 (1.05, 1.15)
Residential complexes ≥ 6th floor	1,285	6,208	20.7%	1.19 (1.12, 1.28)	1.11 (1.03, 1.18)
Other types of residence	162	788	20.6%	1.19 (0.995, 1.41)	0.98 (0.83, 1.17)
Smoking status during the first trimester					
Never smoked	7,291	36,052	20.2%	Reference	Reference
Quit before pregnancy	2,792	14,799	18.9%	0.92 (0.87, 0.96)	0.96 (0.92, 1.01)
Quit after pregnancy	1,972	8,534	23.1%	1.19 (1.12, 1.25)	1.02 (0.96, 1.08)
Current smoker	612	2,964	20.6%	1.03 (0.94, 1.13)	1.04 (0.95, 1.15)
Alcohol consumption during the first trimester					
No history of alcohol consumption	4,137	21,646	19.1%	Reference	Reference
Quit before pregnancy	7,287	34,490	21.1%	1.13 (1.09, 1.18)	1.07 (1.03, 1.12)
Current drinker	1,245	6,213	20.0%	1.06 (0.99, 1.14)	1.17 (1.09, 1.25)
NVP before 12 gestational weeks					
No experience	2,225	10,342	21.5%	Reference	Reference
Nausea only	5,270	26,670	19.8%	0.90 (0.85, 0.95)	0.96 (0.91, 1.02)

Experienced NVP but able to eat	3,664	18,209	20.1%	0.92 (0.87, 0.97)	0.97 (0.91, 1.03)
Experienced NVP and unable to eat	1,510	7,129	21.2%	0.98 (0.91, 1.05)	0.89 (0.82, 0.96)
Stressful events experienced during pregnancy					
No	7,010	35,046	20.0%	Reference	Reference
Yes	5,658	27,303	20.7%	1.05 (1.01, 1.09)	1.05 (1.01, 1.09)
Psychological distress in the first trimester (total K6 score)					
< 5		42,237	19.4%	Reference	Reference
5–12	8,196	17,922	21.9%	1.16 (1.11, 1.21)	0.99 (0.94, 1.04)
≥ 13	3,919	2,190	25.3%	1.40 (1.28, 1.54)	1.03 (0.93, 1.14)
MVPA per week	553				
< 150 min	8,603	41,265	20.8%	Reference	Reference
≥ 150 min	4,065	21,084	19.3%	0.91 (0.87, 0.95)	0.94 (0.90, 0.98)
Dog ownership status					
No				Reference	Reference
Yes				0.99 (0.93, 1.04)	0.96 (0.91, 1.02)
Physical and mental well-being (SF-8 score)					
Physical component summary scores (by 1 point)	-	-	-	0.98 (0.979, 0.984)	0.98 (0.979, 0.985)
Mental component summary scores (by 1 point)	-	-	-	0.99 (0.985, 0.990)	0.99 (0.990, 0.996)

aOR adjusted odds ratio, BMI body mass index, CI confidence interval, cOR crude odds ratio, JPY Japanese yen, K6 Kessler 6, MVPA moderate to vigorous physical activity, NVP nausea and vomiting in pregnancy, TV television
a Adjusted for each other; "—" denotes reference

According to **Table 3**, individuals identified as part of the high-SB group before pregnancy showed similar associations to those in the low-SB group, where spending more time watching TV and playing video games prior to pregnancy was linked to greater sedentary behavior during pregnancy. However, several risk factors specifically associated with increased SB in the high-SB group—unlike those in the low-SB group—included being older, having a higher annual household income, being employed during the first trimester, and having a pre-pregnancy BMI under 18.5. On the other hand, factors that appeared to reduce the likelihood of belonging to the high-SB group during pregnancy, and differed from the protective elements in the low-SB group, included a history of smoking, a K6 score above 13, and owning a dog.

Table 3. Odds ratios (95% CIs) for ≥ 8 h/day of sedentary behavior after the second trimester among women who engaged i ≥ 8 h/ day of sedentary behavior before pregnancy (N = 21,384)

	Case ≥ 8 h/day	Subtotal	Prevalence	cOR(95% CI)	aOR[a] (95% CI)
Time allocated to watching TV prior to pregnancy					
By hour		-	-	1.01 (1.0003, 1.03)	1.06 (1.05, 1.08)
Duration of video game play before pregnancy					
By hour		-	-	0.99 (0.97, 1.02)	1.05 (1.02, 1.08)
Amount of sleep during the first trimester					
By hour	-	-	-	0.90 (0.88, 0.92)	0.96 (0.94, 0.99)
Age at baseline					
< 25	1,393	2,411	57.8%	Reference	Reference
25–29	3,862	6,258	61.7%	1.18 (1.07, 1.29)	1.09 (0.99, 1.21)
30–34	4,753	7,405	64.2%	1.31 (1.19, 1.44)	1.25 (1.12, 1.38)
≥ 35	3,464	5,310	65.2%	1.37 (1.24, 1.51)	1.29 (1.15, 1.44)
Total yearly household income (JPY)					

< 4 million	4,611	7,876	58.5%	Reference	Reference
4– < 6 million	4,286	6,860	62.5%	1.18 (1.10, 1.26)	1.10 (1.02, 1.18)
≥ 6 million	4,575	6,648	68.8%	1.56 (1.46, 1.68)	1.35 (1.24, 1.47)
Highest educational attainment (year)					
< 13	4,703	7,662	61.4%	Reference	Reference
13– < 16	4,711	7,721	61.0%	0.98 (0.92, 1.05)	0.84 (0.79, 0.90)
≥ 16	4,058	6,001	67.6%	1.31 (1.22, 1.41)	1.00 (0.92, 1.08)
Employment status					
Unemployed	3,971	6,905	57.5%	Reference	Reference
Employed	9,501	14,479	65.6%	1.41 (1.33, 1.50)	1.38 (1.28, 1.48)
Parity					
Primipara	8,325	12,296	67.7%	Reference	Reference
Multipara	5,147	9,088	56.6%	0.62 (0.59, 0.66)	0.65 (0.61, 0.70)
Pregnancy achieved via reproductive medicine					
No		19,441	62.4%	Reference	Reference
Yes	1,343	1,943	69.1%	1.35 (1.21, 1.50)	1.05 (0.94, 1.18)
Multiples pregnancy					
No	13,323	21,165	62.9%	Reference	Reference
Yes	149	219	68.0%	1.25 (0.93, 1.69)	1.15 (0.85, 1.55)
BMI prior to pregnancy					
< 18.5	2,310	3,584	64.5%	1.07 (0.99, 1.15)	1.09 (1.005, 1.17)
18.5– < 25	9,805	15,591	62.9%	Reference	Reference
≥ 25	1,357	2,209	61.4%	0.94 (0.86, 1.03)	1.02 (0.93, 1.12)
Residence, n (%)					
Stand-alone house	5,798	9,371	61.9%	Reference	Reference
Residential complexes lower than ≤ 5th floor	5,968	9,367	63.7%	1.08 (1.02, 1.15)	1.00 (0.93, 1.06)
Residential complexes higher than ≥ 6th floor	1,570	2,403	65.3%	1.16 (1.06, 1.28)	1.01 (0.92, 1.11)
Other types of residence	136	243	56.0%	0.79 (0.61, 1.02)	0.81 (0.63, 1.06)
Smoking status during the first trimester					
Never smoked	8,541	13,161	64.9%	Reference	Reference
Quit before pregnancy	2,838	4,670	60.8%	0.84 (0.78, 0.90)	0.90 (0.84, 0.97)
Quit after pregnancy	1,590	2,645	60.1%	0.82 (0.75, 0.89)	0.89 (0.81, 0.98)
Current smoker	503	908	55.4%	0.67 (0.59, 0.77)	0.81 (0.70, 0.94)
Alcohol consumption during the first trimester					
No history of alcohol consumption	4,363	7,060	61.8%	Reference	Reference
Quit before pregnancy	7,594	12,019	63.2%	1.06 (0.999, 1.13)	1.05 (0.99, 1.12)
Current drinker	1,515	2,305	65.7%	1.19 (1.07, 1.31)	1.16 (1.04, 1.28)
NVP before 12 gestational weeks					
No experience	2,627	4,049	64.9%	Reference	Reference
Nausea only	5,867	9,249	63.4%	0.94 (0.87, 1.01)	0.98 (0.90, 1.06)
Experienced NVP but was able to eat meals	3,676	5,962	61.7%	0.87 (0.80, 0.95)	0.95 (0.87, 1.04)
Experienced NVP and was unable to eat meals	1,302	2,123	61.3%	0.86 (0.77, 0.96)	0.93 (0.82, 1.04)
Stressful occurrences during pregnancy					
No	7,679	12,113	63.4%	Reference	Reference
Yes	5,793	9,271	62.5%	0.96 (0.91, 1.02)	1.02 (0.96, 1.08)
Psychological distress in the first trimester (total K6 score)					
< 5	9,287	14,588	63.7%	Reference	Reference

5–12	3,811	6,103	62.4%	0.95 (0.89, 1.01)	0.96 (0.90, 1.03)
≥ 13	374	693	54.0%	0.67 (0.58, 0.78)	0.74 (0.63, 0.87)
MVPA per week					
< 150 min	11,296	17,434	64.8%	Reference	Reference
≥ 150 min	2,176	3,950	55.1%	0.67 (0.62, 0.71)	0.71 (0.66, 0.76)
Owning a dog					
No	11,842	18,654	63.5%	Reference	Reference
Yes	1,630	2,730	59.7%	0.85 (0.79, 0.92)	0.89 (0.82, 0.97)
Physical and mental well-being (SF-8 score)					
Physical component summary scores (by point)	-	-	-	0.99 (0.988, 0.996)	0.99 (0.988, 0.996)
Mental component summary scores (by point)	-	-	-	1.01 (1.003, 1.010)	1.00 (0.996, 1.006)

aOR adjusted odds ratio, BMI body mass index, CI confidence interval, cOR crude odds ratio, JPY Japanese yen, K6 Kessler 6, MVPA moderate to vigorous physical activity, NVP nausea and vomiting in pregnancy, SD standard deviation, TV television a Adjusted for each other; "—" denotes reference

This study revealed that, on average, pregnant Japanese women engaged in sedentary behavior (SB) for 5.9 hours (SD = 3.5) on weekdays during their second and third trimesters, with nearly one-third (31.2%) categorized within the high-SB group (≥ 8 hours/day). With a large sample size of 83,733 participants, this investigation stands as the most extensive cohort study examining SB patterns before and throughout pregnancy. Prior to pregnancy, the average SB was 5.4 hours (SD = 3.4), closely resembling the 5.3 hours/day (SD = 3.7) reported in an earlier study of 5,346 Japanese adults, which included men [19]. Furthermore, 25.6% of women were assigned to the high-SB group before pregnancy, mirroring the 25.3% found previously [19]. These similarities suggest that the pre-pregnancy SB behavior in this cohort reflects broader trends among Japanese adults. Consequently, we were able to clearly confirm an increase in SB time as pregnancy progresses, alongside a growing proportion of women classified as high-SB during pregnancy.

Previous research utilizing questionnaire surveys that compared SB durations between pregnant and non-pregnant women [23] demonstrated notably longer sedentary periods in pregnant women. Objective assessments of SB have similarly documented increased sedentary time during pregnancy compared to non-pregnant periods [24]. Our findings align with these prior studies, reinforcing the observation that SB rises during pregnancy relative to pre-pregnancy levels. Notably, the World Health Organization's 2020 Guidelines on Physical Activity and Sedentary Behavior highlighted a gap in evidence concerning actual SB duration in pregnant women [8], emphasizing the significance of the data presented here.

In this research, the amount of time spent engaged in SB was considerably shorter than the 8.6 h reported in a previous study [23], which also used a questionnaire survey excluding sleep time. One possible explanation for this difference is that the earlier study [23] gathered data through interviews, whereas the present study utilized a self-administered questionnaire. However, recent research has shown strong agreement between responses collected by these two survey methods [25, 26]. Furthermore, it has been reported that higher minimum daytime temperatures correspond to longer durations of SB [27]. Since the prior study took place in Singapore, a tropical region, the warmer climate might have contributed to the longer SB times compared to our study area. Other investigations employing objective assessments found SB durations ranging from 7 to 18 h/day [1, 28–31], although comparing these results directly with ours is challenging because those studies did not explicitly exclude or clarify sleep time. Previous studies have also documented a low correlation between SB measurements obtained through objective methods and SB evaluated using the IPAQ [32, 33], emphasizing the importance of validating our findings through future objective SB measurements.

This study revealed multiple factors associated with the duration of sedentary behavior (SB) during the second and third trimesters of pregnancy. To explore these, participants were divided based on their pre-pregnancy SB levels into low-SB (< 8 h/day) and high-SB (≥ 8 h/day) groups. Both groups showed greater amounts of time spent watching TV and playing video games before pregnancy **(Table 1)**. Despite these baseline differences, in both categories, increased pre-pregnancy time spent on these activities was linked to engaging in SB for ≥ 8 hours during pregnancy **(Tables 2 and 3)**. Similarly, differences were observed in the proportions of women achieving ≥ 150 minutes per week of moderate-to-vigorous physical activity (MVPA) and being multiparous in each SB group before pregnancy **(Table 1)**. Yet, in both groups, meeting the ≥ 150-minute MVPA threshold and multiparity prior to pregnancy were negatively correlated with spending ≥ 8 hours in SB during pregnancy **(Tables 2 and 3)**. Prior research has already associated TV viewing during pregnancy with longer SB durations [34]. A notable discovery in this study is that, within the low pre-

pregnancy SB group, pre-pregnancy TV watching and video game playing predicted elevated SB during pregnancy. Additionally, in the high pre-pregnancy SB group, exceeding 150 minutes of MVPA per week before pregnancy was connected to lower SB levels during pregnancy. These findings imply that minimizing TV and video game time and boosting MVPA before pregnancy might help curb excessive SB during pregnancy.

Parity and certain socioeconomic variables were also linked to higher SB during pregnancy **(Tables 2 and 3)**. Multiparous women generally exhibit less sedentary time compared to primiparas, likely due to childcare demands, consistent with earlier studies [35–37]. Our findings indicate that parity along with socioeconomic factors such as education, household income, employment status, and type of residence predicted SB during pregnancy. However, these characteristics are not easily altered once pregnancy has begun, emphasizing the importance of tailored interventions for groups defined by these factors. Among more modifiable influences after conception, dog ownership was inversely related to high SB during pregnancy, though only within the pre-pregnancy high-SB group **(Table 3)**. Evidence supports that owning a dog increases physical activity levels [38] and correlates with reduced SB in Japan [39], even though it does not associate with MVPA. Our previous work also found that dog ownership during pregnancy relates to improved postpartum mental health [40]. While dog ownership may not be feasible for everyone, it may be beneficial for those considering it due to its positive impact.

Furthermore, higher SF-8 physical and mental health scores before pregnancy were negatively associated with high SB during pregnancy **(Table 2)**. Elevated psychological distress and nausea and vomiting of pregnancy (NVP) within the first 12 weeks were also linked with lower SB during pregnancy **(Table 3)**. Although we initially expected that severe psychological distress or NVP combined with poor nutrition might increase SB, the findings were contrary. The underlying reasons remain uncertain but are intriguing. At the very least, these results offer reassurance to women experiencing NVP or psychological distress early in pregnancy that these conditions do not correspond to increased SB during mid-pregnancy.

This study's strengths include its nationwide scope and large sample size. Although data on time spent sitting or lying down, sleeping, and watching TV were collected clearly, these assessments were based on self-report and therefore subjective. Several limitations should also be considered. Important factors potentially relevant to the study, such as health literacy, were not measured. Additionally, approximately 13,600 participants had missing data for the outcome variable, which may have introduced selection bias due to the exclusion of these individuals. Since participants provided responses retrospectively, recall bias is possible, meaning the estimated times may not be fully accurate. To better determine the true duration of sedentary behavior (SB) during pregnancy, further research using both objective and subjective measures is necessary.

Conclusion

Utilizing data from a nationwide self-administered questionnaire survey in Japan, this study examined actual SB durations among women in the second and third trimesters of pregnancy, along with related factors. The average time spent engaged in SB, excluding sleep, was 5.9 hours. Factors linked to SB included time spent watching TV, playing video games, performing more than 150 minutes of moderate-to-vigorous physical activity (MVPA) weekly before pregnancy, and certain socioeconomic characteristics. To decrease SB time, pregnant women should consciously manage their TV and video game usage and develop regular exercise habits prior to pregnancy.

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Ethics statement: The JECS protocol received approval from the Institutional Review Board on Epidemiological Studies of the Ministry of the Environment (100910001) and the ethics committees of all participating institutions. All study participants provided written informed consent. The research protocol for the current analysis was approved by the Institutional Review Board of the University of Toyama (R2023172).

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