



# Effects of Sedentary Behavior on the Complications Experienced by Pregnant Women: A Systematic Review

Osumi, Ayami ; Kanejima, Yuji ; Ishihara, Kodai ; Ikezawa, Natsumi ; Yoshihara, Ryo ; Kitamura, Masahiro ; Izawa, P. Kazuhiro

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1 *Review*

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3 **Effects of Sedentary Behavior on the Complications Experienced**  
4 **by Pregnant Women: A Systematic Review**

5

6 Ayami Osumi<sup>1</sup>, Yuji Kanejima<sup>2,3,4</sup>, Kodai Ishihara<sup>2,3,5</sup>, Natsumi Ikezawa<sup>1</sup>, Ryo Yoshihara<sup>2,3,4</sup>,  
7 Masahiro Kitamura<sup>2,3,6</sup>, Kazuhiro P. Izawa<sup>2,3,\*</sup>

8

9 <sup>1</sup> Department of Health Science, Faculty of Medicine, Kobe University, Kobe, Japan

10 <sup>2</sup> Department of Public Health, Graduate School of Health Sciences, Kobe University,  
11 Kobe, Japan

12 <sup>3</sup> Cardiovascular stroke Renal Project (CRP), Kobe, Japan

13 <sup>4</sup> Department of Rehabilitation, Kobe City Medical Center General Hospital, Kobe, Japan

14 <sup>5</sup> Department of Rehabilitation, Sakakibara Heart Institute of Okayama, Okayama, Japan

15 <sup>6</sup> School of Physical Therapy, Faculty of Rehabilitation, Reiwa Health Sciences University,  
16 Fukuoka, Japan

17

18 **\*Corresponding author:** Kazuhiro P. Izawa

19 e-mail; izawapk@harbor.kobe-u.ac.jp

20 Tel.: +81-78-796-4566

21

22 **ORCID Numbers of Authors**

23 Kazuhiro P. Izawa: 0000-0001-7262-8903

24 Masahiro Kitamura: 0000-0002-1271-6183

25 Yuji Kanejima: 0000-0002-0162-6318

26

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30

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36 Availability of data and material (data transparency): The data underlying this study cannot  
37 be shared publicly due to privacy concerns of individuals who participated in the studies. The  
38 data will be shared on reasonable request to the corresponding author.

39 Code availability (software application or custom code): Not applicable.

1 **Abstract**

2 Pregnant women are encouraged to reduce sitting time and replace it with physical activity.  
3 Complications arising during pregnancy include gestational hypertension, preeclampsia,  
4 gestational diabetes mellitus (GDM), and prenatal and postpartum depression. In this  
5 systematic review, we examined effects of sedentary behavior on the health of pregnant  
6 women. We conducted a systematic review with PubMed from year 2000 to identify the  
7 relationship between a sedentary lifestyle and psychological effects, occurrence of GDM,  
8 gestational hypertension, and preeclampsia. Data extracted included sedentary time of  
9 pregnant women, psychological effects, occurrence of GDM, gestational hypertension, and  
10 preeclampsia as outcomes. Among the 200 studies retrieved, 11 were finally included after  
11 screening. The mean age of eligible pregnant women ranged from 28.5 to 32.9 years. Five  
12 studies were extracted with outcomes of psychological effects on the mother, five with GDM,  
13 and one with gestational hypertension/preeclampsia. Longer sedentary time was associated  
14 with increased risks of prepartum/postpartum depression in three of five studies and GDM in  
15 three of five studies. No association was found between sedentary behavior and the risk for  
16 gestational hypertension/preeclampsia. Higher sedentary behavior in the second trimester of  
17 pregnancy was likely to be associated with postpartum depression. Longer sitting time may  
18 increase the risk of prenatal or postnatal depression and GDM, but no relationship was  
19 proven for gestational hypertension and preeclampsia in one study. High sedentary behavior  
20 in the second trimester may have psychological impacts. The number of studies was small  
21 and further research is needed to statistically evaluate impacts of sedentary behavior during  
22 pregnancy.

23

24 **Keywords** Gestational diabetes mellitus; Gestational hypertension; Pregnant women;  
25 Prenatal depression; Sedentary behavior; Systematic review

26

1 **Background**

2

3 Pregnant women may develop health problems during pregnancy that can involve the health  
4 of the mother, fetus, or both [1]. Complications arising during pregnancy include  
5 hypertension, preeclampsia, gestational diabetes mellitus (GDM), mental health conditions,  
6 anemia, and urinary tract infections [1]. The International Diabetes Federation reported in  
7 2021 that 16.7% of pregnant women in 47 countries had some form of hypertension, 80.3%  
8 of which was due to gestational hypertension [2], which was reported to affect 18.08 million  
9 people worldwide in 2019 [3]. Preeclampsia, which has the greatest morbidity and mortality,  
10 affects 5% to 7% of all pregnant women and is responsible for more than 70,000 maternal  
11 deaths and 500,000 fetal deaths annually worldwide [4]. Pregnancy affects the mother not  
12 only physically but also mentally. Postpartum depression is most common within the first 6  
13 weeks postpartum and is reported to occur in approximately 6.5% to 20% of postpartum  
14 women worldwide [5].

15 Sedentary behavior (SB) is defined as waking behavior characterized by energy  
16 expenditure of 1.5 METs or less in a sitting or lying position [6]. According to a previous  
17 systematic review, pregnant women spent 7.1 to 18.3 hours/day in SB [7]. The World Health  
18 Organization (WHO) stated that pregnant women can gain health benefits by spending less  
19 time sitting and replacing sedentary time with physical activity of any intensity [8]. Excessive  
20 sitting also increases the incidence and mortality of overall disease, cardiovascular disease,  
21 and cancer in pregnant and postpartum women [8]. The guidelines make recommendations  
22 about the association between SB and cancer risk in pregnant women [8], but the evidence is  
23 insufficient because the recommendations apply findings from evidence on SB in the general  
24 adult population to pregnant and postpartum women, rather than from studies of pregnant and

1 postpartum women themselves. Moreover, the association of SB with the incidence of GDM,  
2 gestational hypertension, and prenatal and postpartum depression remains poorly studied.

3 To our knowledge, no systematic review of prenatal and postpartum depression has yet  
4 been conducted showing an association with SB, and thus, the association remains unclear.  
5 As well, no study has evaluated the association between SB and GDM, gestational  
6 hypertension, preeclampsia, and postpartum depression by pregnancy trimester. We  
7 hypothesized that SB would affect the increased risk of gestational hypertension and GDM,  
8 and thus, this review aimed to investigate both the trimester of pregnancy in which SB has  
9 the most unfavorable impact and the effect of SB on the mother's mental health.

10

11

## 12 **Materials and Methods**

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### 14 **Eligibility Criteria**

15 This systematic review was conducted based on the Preferred Reporting Items for Systematic  
16 Reviews and Meta-Analyses (PRISMA) statement [9]. Inclusion criteria were (a) pregnant  
17 women aged under 45 years; (b) pregnant women in all trimesters; (c) having SBs at any  
18 point during pregnancy; (d) both objective and subjective assessment methods of SB were  
19 included; (e) only published studies; (f) only written in English; and (g) published from 2000  
20 to 2022. Exclusion criteria were (a) not including GDM, gestational hypertension,  
21 preeclampsia, or prenatal depression as outcome measures and (b) systematic review, meta-  
22 analysis, interventional study, editorial, or study protocol. In the United States and other  
23 countries, the first trimester is defined as 1 to 12 weeks gestation, the second trimester as 13  
24 to 28 weeks gestation, and the third trimester as 29 to 40 weeks gestation [10]. We used this  
25 definition to classify the pregnancies by trimester.

1

## 2 **Search Strategy**

3 Studies were searched in the PubMed database only. The search was conducted on 10  
4 October 2022. Keywords related to “pregnant women”, “sedentary behaviour”, and  
5 “observational study” were used (Figure 1). A publication date filter from January 2000 to  
6 October 2022 was used for the search on PubMed.

7

## 8 **Selection Process**

9 This selection process consisted of the first and second screenings. In the first screening, two  
10 reviewers independently read each study’s title and abstract to check whether the study met  
11 the inclusion criteria. In the second screening, two reviewers independently read the full text  
12 of the included manuscripts, and the studies meeting the exclusion criteria were excluded.  
13 Any disagreements about screening results that remained unresolved by consensus were  
14 discussed with a third reviewer. When the full-text manuscripts were unavailable in our  
15 institution, we contacted the author or other institutions by e-mail. E-mails were sent to one  
16 author in another institution. Finally, 31 full-text studies were obtained.

17

## 18 **Data Collection**

19 The following information was extracted from the included studies and summarized in a  
20 table: author, country, number of participants, study design, pregnancy trimesters, assessment  
21 method of SB, outcomes, outcome method, and results. When compiling the table, we  
22 separated the papers into two groups, those with and without group comparisons.

23

## 24 **Risk of Bias Assessment**

1 Two researchers independently assessed the risk of bias in the studies following The Risk of  
2 Bias tool for Non-randomized Studies (RoBANS) [11] and integrated the results. Each of the  
3 six domains (selection of participants, confounding variables, measurement of exposure,  
4 blinding of outcome assessments, incomplete outcome data, and selective outcome reporting)  
5 was evaluated as “low risk”, “unclear risk”, or “high risk”. Disagreements not resolved by  
6 consensus were discussed with a third reviewer.

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## 9 **Results**

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### 11 **Results of First and Second Screenings**

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13 The search on PubMed retrieved 200 relevant studies. Through the first screening, 169 were  
14 excluded based on a review of titles and abstracts. Through the second screening, 20  
15 additional studies were excluded based on criteria. Of these studies, six did not involve SB,  
16 three were not observational studies, five had different target populations, and six had  
17 different outcomes. Finally, we included 11 full-text studies [12-22] in this review (Figure 2).

18

### 19 **Characteristics of Included Studies**

20

21 Characteristics of the 11 included studies are summarized in Table 1, which summarizes the  
22 included studies with comparative analysis, and Table 2, which summarizes the included  
23 studies without comparative analysis.

24 Four were cohort studies [12, 16, 20, 22], five were cross-sectional studies [14, 15, 17,  
25 18, 21], and two were case-control studies [13, 19]. The studies were conducted in Europe

1 (n=4) [12-14, 16], Asia (n=5) [15, 17, 19-21], South America (n=1) [18], and North America  
2 (n=1) [22].

3 The mean age of the eligible pregnant women ranged from 28.5 [21] to 32.9 [14] years.  
4 The lowest number of participants was 161 [12] and the highest was 15,538 [16]. One study  
5 measured maternal sitting behavior in the first trimester [20], four studies in the second  
6 trimester [12, 14, 20, 21], two studies in the third trimester [16, 17], and two studies in each  
7 trimester [15, 18], one study on average for all trimesters [13], and one study where the  
8 individual trimester was unknown [19]. Five were on the outcomes of psychological impacts  
9 on mothers [12-16], five on GDM [17-21], and one on gestational hypertension and  
10 preeclampsia [22]. Eight studies used comparative analysis [12, 13, 17-22], and three studies  
11 used multiple regression analysis with no group comparison [14-16].

12

13 **Sedentary Behavior**

14

15 Two studies used objective methods such as accelerometers to assess SB [12, 14], and nine  
16 used non-objective measures such as questionnaires. Of these nine studies, five used the  
17 Pregnancy Physical Activity Questionnaire (PPAQ) [15-18, 22], one the International  
18 Physical Activity Questionnaire (IPAQ) [19], and three another kind of survey or  
19 questionnaire (the Saltin-Grimby Physical Activity Level [13] and other types of self-  
20 reporting methods [20, 21]). In the studies using accelerometers, the mean sitting time of the  
21 pregnant subjects was 3588.6 min/week [14]. Mean sitting time was 980.84 minutes/day in  
22 those with prenatal depression and 752.76 minutes/day in those with postpartum depression  
23 [12].

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25 **Psychological Impacts**

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Studies were included that showed three cases of postpartum depression [12, 13, 16], two cases of maternal anxiety [12, 14], and one case each of maternal mental distress [15], positive and negative affect [14], prenatal depression [14], emotional attention/emotional clarity/emotional regulation [14], and resilience [14] as outcomes.

Of the five included studies, two indicated a higher risk for postpartum depression with longer SB [12, 16], and one showed a significant positive correlation between length of SB and prenatal depression [15]. One study also found a significant difference in the Edinburgh Postnatal Depression Scale (EPDS) total score [23] by physical activity level, but the differences were not significant when comparing depressive symptoms between the sedentary and physically active groups with the cutoff value for the EPDS of  $\geq 12$  used in Sweden [13]. In the remaining study [14], sedentary time correlated significantly negatively with positive affect measured by the Trait Positive and Negative Affect Schedule (PANAS T) [24].

In one study, EPDS scores after delivery were higher with longer sitting time in the second trimester of pregnancy ( $p=0.008$ ) [12]. Another study that averaged over the entire pregnancy also showed significant differences in EPDS total score by physical activity level ( $p=0.04$ ). The median EPDS total score (interquartile range) was 7 (6–11) in the sedentary group, 7 (5–10) in the low-intensity physical activity (LPA) group, 7 (5–9) in the moderate physical activity (MPA) group, and 6 (5–8) in the vigorous physical activity (VPA) group. However, the differences were not significant when comparing depressive symptoms between the sedentary and physically active groups with  $EPDS \geq 12$ , the cutoff value in Sweden [13]. One study found no significant association between SB and any mental distress symptoms in the first trimester, but in the second trimester, SB was associated with higher mental distress symptoms (The Global Severity Index [GSI]:  $p<0.001$ , depression:  $p=0.006$ , anxiety:  $p=0.001$ ). In the third trimester, pregnant women reached a plateau as their mental

1 distress increased with the amount of time spent sedentary. Later, however, as the amount of  
2 sedentary time increased, they experienced certain mental health benefits [15]. In the third  
3 trimester of pregnancy, leisure time SB and postpartum depression were significantly  
4 associated in univariate (odds ratio [OR]=1.16, 95% confidence interval [CI] 1.07–1.22) and  
5 multivariate (OR=1.16, 95% CI 1.06–1.23) analyses [16]. Contrastingly, in the second  
6 trimester of pregnancy, sedentary time correlated positively but not significantly with  
7 negative affect, anxiety, emotional attention, emotional regulation, or resilience, and  
8 correlated negatively with emotional clarity and positive affect, of which only that with  
9 positive affect was significant ( $p = 0.022$ ) [14].

10

### 11 **Gestational Diabetes**

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13 Longer sitting time caused increasing risks for GDM in three of five studies. In the third  
14 trimester, no significant difference between women without or with GDM was found [17]. In  
15 the second trimester of pregnancy, no association was found between SB and GDM [20],  
16 whereas another study showed that increased sitting time also significantly increased the risk  
17 of GDM [21]. In two studies examining all trimesters, SB was associated with a higher odds  
18 ratio of GDM [18, 19].

19

### 20 **Gestational Hypertension/Preeclampsia**

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22 One study suggested no association between SB in early pregnancy and the risk of gestational  
23 hypertension and preeclampsia ( $p=0.67$ ), nor was an association present in models adjusted  
24 for age, body mass index (BMI), and parity. Because of the low incidence of gestational

1 hypertension, the outcomes of risk of gestational hypertension and preeclampsia were not  
2 assessed separately [22].

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#### 4 **Risk of Bias**

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6 A summary of the risk of bias for each study and domain is shown in Figure 3. All studies  
7 showed a low risk of bias in terms of participant selection and selective outcome reporting.  
8 Most studies showed a high risk of bias in terms of measurement of exposure.

9

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#### 11 **Discussion**

12

13 A systematic review was performed to assess the relationship between SB during  
14 pregnancy and the risk of mental health issues, GDM, and gestational hypertension in  
15 pregnant women. Of the 11 studies included, five were on GDM [17-21], one on gestational  
16 hypertension [22], and five were on the psychological impact on mothers [12-16]. Three of  
17 these studies showed an increased risk of GDM with longer sitting time [17, 18, 20]. In the  
18 study on gestational hypertension, no relationship was found between SB and the risk for  
19 gestational hypertension/preeclampsia [22]. Three of the five included studies showed a  
20 higher risk of prenatal or postpartum depression with longer sitting time [12, 15, 16], one  
21 found a significant difference in EPDS total score by physical activity level [13], and one  
22 showed a significant negative correlation between sitting time and positive affect [14]. Two  
23 studies on psychological impact used accelerometers and found that mean sitting time was  
24 980.84 minutes/day for those with prenatal depression and 752.76 minutes/day for those with  
25 postpartum depression [12]. The key finding of the present systemic review was that SB

1 significantly impacts prenatal and postpartum depression, especially SB in the second  
2 trimester of pregnancy. This study focused on SB during pregnancy and not on SB prior to  
3 pregnancy. However, pre-pregnancy lifestyle habits may be related to life during pregnancy,  
4 and we believe it would be worthwhile to conduct future studies focusing on this aspect.

5

## 6 **Gestational Diabetes**

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8 A previous meta-analysis found that increased total physical activity performed before or  
9 during early pregnancy was significantly associated with a decreased risk of GDM [25].  
10 Another meta-analysis also suggested a protective association of physical activity (21–46%)  
11 against GDM during pre-pregnancy or early pregnancy [26]. A United Kingdom study found  
12 that obese ( $BMI \geq 30 \text{ kg/m}^2$ ) pregnant women who developed GDM had longer sedentary  
13 time and lower LPA and moderate-to-vigorous physical activity in early pregnancy (16–18  
14 weeks of gestation), but the differences were not significant [27]. No statistically significant  
15 associations between total physical activity or achievement of exercise guidelines and the risk  
16 of GDM have been found [28]. However, physical activity performed both before and in  
17 early pregnancy was associated with a reduced OR for GDM compared to no physical  
18 activity [29]. According to Li et al., the relationship between SB during pregnancy and the  
19 risk of GDM is uncertain; however, they also found that SB was associated with metabolic  
20 outcomes such as fasting or postprandial blood glucose, blood lipids, and cytokine levels  
21 among women with GDM or women at risk of GDM [30].

22 We found that SB was associated with an increased risk of GDM in three of five  
23 studies [17, 18, 20] but not in the other two studies [19, 21]. Thus, the present study suggests  
24 that SB may influence GDM, proving the uncertainty of the previous studies on GDM. This  
25 is a novel point of our study. However, there are still some aspects of SB and GDM risks that

1 are not yet clear. For example, it is not clear whether a particular trimester of pregnancy is  
2 more strongly associated with SB and GDM. Overall, physical activity likely has a beneficial  
3 effect on pregnant women, and reducing the time spent in sedentary activities may reduce the  
4 risk of GDM. We must also consider the possibility that pregnant women at high risk for  
5 GDM, such as those with obesity, older age at pregnancy, or pregnancies with fetuses that are  
6 too large, may have SB. We believe that future research should focus on this point as well.

7

## 8 **Gestational Hypertension**

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10 A systematic review by Fazzi et al. [7] found no association between SB and gestational  
11 hypertension in two of three studies [22, 31] but found in one study that women who were  
12 sedentary and not allowed to move from the workplace during work hours were significantly  
13 more likely to develop gestational hypertension than women in a control group who were also  
14 sedentary but were allowed to travel during work hours [32]. One study focusing exclusively  
15 on Hispanic women investigated the association between sedentary time and gestational  
16 hypertension, but the results were uncertain; however, longer sedentary time may be  
17 associated with a higher risk of gestational hypertension [22]. It has been suggested that  
18 Hispanic women may have higher rates of risk factors for preeclampsia, obesity, insulin  
19 resistance, type 2 diabetes, and gestational diabetes, as well as a higher risk of gestational  
20 hypertension, compared to non-Hispanic white women [33]. Our review did not find an  
21 association between SB and gestational hypertension. This difference from the results  
22 presented in the Fazzi et al. study may be related to the fact that there is only one study [22]  
23 in common between the studies we have incorporated versus those they incorporated. More  
24 studies are necessary to examine this potential association, and race and other factors need to

1 be taken into consideration. Moreover, as we were not able to search for articles on SB and  
2 preeclampsia, further research is needed.

3

#### 4 **Prenatal and Postpartum Depression**

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6 The key finding of the present systemic review was that SB significantly impacts prenatal and  
7 postpartum depression, especially SB in the second trimester of pregnancy. As to why SB is  
8 so deeply involved in the second trimester of pregnancy, Xiang et al. suggested that in the  
9 second trimester, as the fetus becomes heavier, pregnant women face many challenges of  
10 pregnancy and are often forced to remain sedentary due to discomfort, frustration, and fatigue  
11 [15]. Such SB usually results from and tends to exacerbate negative emotions, and the longer  
12 a pregnant woman practices SB, the more emotional distress she may experience [15]. Even  
13 mild-intensity exercise can reduce the onset of depression and is superior to being sedentary  
14 [12, 13].

15 Another likely factor in prenatal and postpartum depression is morning sickness,  
16 which limits exercise. Consequently, morning sickness is associated with SB. A study by  
17 Gadsby et al. found that morning sickness began 39 days and ended at 84 days [34] and a  
18 later study Gadsby et al. reported that it began at 34 days [35]. These studies concluded that  
19 morning sickness was associated with specific developmental stages at the fetal-maternal  
20 interface. As morning sickness affects over 90% of pregnant women [35], it is unlikely that  
21 exercise would abolish this condition, but it could alleviate its severity. The affect, if any, of  
22 SB on morning sickness will require further study.

23 The second trimester is considered the time when more women can shift from a  
24 sedentary lifestyle to exercise, and exercise should be incorporated into their life. However,  
25 while women engaging only in LPA had significantly lower odds of psychological distress

1 during pregnancy than women not engaging in physical activity, it is notable that women who  
2 engaged in a combination of LPA, MPA, and VPA had significantly higher odds of  
3 psychological distress [36]. The reason for this seemingly contradictory finding is unknown.  
4 Thus, while there is a positive association between exercise practices during pregnancy and  
5 reduced prenatal anxiety scores, supervised physical activity during pregnancy may be  
6 needed to prevent or reduce prenatal anxiety and anxiety symptoms [37]. Further examination  
7 of this problem is necessary.

8

### 9 **Strength and Limitations**

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11 To the best of our knowledge, this is the first systematic review to examine both the  
12 relationship between SB during pregnancy and GDM and gestational hypertension and that  
13 by pregnancy trimester. The review found that high SB in the second trimester of pregnancy  
14 may be particularly associated with postpartum depression.

15 The present review also has some limitations. We used only the PubMed database, and  
16 the number of studies and samples in the review was limited. Of the papers captured in this  
17 study, only one paper [22] was identical to the one captured by Fazzi et al. Moreover,  
18 outcome measures and their units differed, so meta-analyses could not be performed.

19 Only one paper on gestational hypertension was included, and its association with SB  
20 remains unclear. Only two papers measured SB using accelerometers, both with  
21 psychological impacts as the outcome, and it was not clear how much of an adverse effect SB  
22 would have had on the mothers. To exclude age-related risks [38, 39], the present study  
23 included women up to age 45, which is younger than the generally accepted upper end of  
24 reproductive age. Thus, the risks posed by SB in older pregnant women may differ from the  
25 data in this study.

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## **New Contribution to the Literature**

Longer sitting time may increase the risk of prenatal or postnatal depression and GDM. For gestational hypertension and preeclampsia, no relationship was proven in one included study. In addition, high SB in the second trimester of pregnancy may be strongly related to psychological impacts. However, the number of studies investigating these issues is small, and more research is needed to statistically assess their impact.

## **Statements and Declarations**

**Informed Consent** Formal consent is not required for this type of study.

**Ethical approval** Ethical approval is not required for this type of study.

**Author Contributions** Conceptualization, AO, YK, KI, NI, RY, MK, and KPI; methodology, AO, YK, KI, NI, RY, MK, and KPI; validation, YK, KI, RY, MK, and KPI; formal analysis, AO and NI; investigation, YK, KI, RY, MK, and KPI; resources, YK, KI, RY, MK, and KPI; writing—original draft preparation, AO, and NI; writing—review and editing, YK, KI, RY, MK, and KPI; visualization, AO; supervision, KPI; funding acquisition, KPI.

**Competing Interests** The authors declare no conflicts of interest.

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1

2 **Data Availability Statement** The data underlying this study cannot be shared publicly due  
3 to privacy concerns of individuals who participated in the studies. The data will be shared on  
4 reasonable request to the corresponding author.

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- 24

1 **Figure Legends**

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3 **Fig. 1** Search terms used in this study

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5 **Fig. 2** Flow diagram of this study

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7 **Fig. 3** The risk of bias in each study and domain

**Table 1** Summary of included studies with comparative analysis

Author	Country	Number of participants	Study design	Pregnancy terms	Assessment method	Outcome	Outcome method	Results	Findings
Baran <i>et al.</i> 2022 [12]	Poland	236	Cohort study	Second trimester of pregnancy (20–24 weeks)	7 days wearing of accelerometer	Postnatal depression/ occurrence of anxiety states	EPDS/GAD-7	Those with severe postnatal anxiety symptoms had the highest sedentary time scores before the delivery ( $p = 0.020$ ). For depressive symptoms, the longer the sitting time before delivery, the higher the EPDS scale score after delivery ( $p=0.008$ ).	Even light physical activity protects against the occurrence of depression and is better than SB. Although no definite conclusions can be drawn regarding anxiety symptoms, SB may promote anxiety symptoms in the immediate postpartum period.
Ekelöf <i>et al.</i> 2021 [13]	Sweden	532	Case-control study	Average	SGPAL	Postpartum depression	EPDS	Median EPDS total scores (25th–75th percentile) varied from 7 (6–11) for sedentary group, 7 (5–10) for LPA group, 7 (5–9) for MPA group, and 6 (5–8) for VPA group. However, when comparing depressive symptoms between the sedentary and physically active groups with EPDS $\geq 12$ (the cutoff value used in Sweden), the differences were not statistically significant.	An association was found between higher levels of physical activity and less depressive symptoms. The physical activity level in 2nd trimester remains a predictor for depressive symptoms. Although, limited sociodemographic differences were found, several psychological variables were shown to be important such as the perception of inadequate social support and the perception of having a difficult child.
Aburezq <i>et al.</i> 2020 [17]	Kuwait	653	Cross-sectional study	Third trimester of pregnancy	PPAQ	GDM	Diagnosis	A significant difference was not found between the group of women without GDM and that with GDM ( $p=0.794$ ).	This study found no independent association between PA/SB and GDM during pregnancy. Furthermore, there was a positive and significant association between sedentary activity and labor induction, which was significantly higher in the GDM population.
do Nascimento <i>et al.</i> 2019 [18]	Brazil	544	Cross-sectional study	First, second, and third trimesters of pregnancy	PPAQ	GDM	Diagnosis	262 women were sedentary, of which 58 were diagnosed as having GDM and 205 were not ( $p = 0.008$ ). SB was associated with higher odds of GDM (OR=1.8, 95% CI=1.1–2.9).	In low-income women with a pattern of physical inactivity in early pregnancy, the risk of GDM increases. Overweight/obesity was also a risk factor for GDM.
Mishra <i>et al.</i> 2018 [19]	India	373	Case-control study	All terms	IPAQ	GDM	Diagnosis: 3-h 100-g OGTT	The odds of GDM in those spending $\geq 3000$ min/week of their time in sitting were 11 times higher than those spending $< 2900$ min/week sitting ( $p < 0.001$ )	Exposure to low-to-moderate levels of physical activity was high during pregnancy. The risk of GDM was higher in the group with less than moderate levels of physical activity during pregnancy. Prolonged sitting was also a significant risk factor.
Padmapriya <i>et al.</i> 2017 [20]	Singapore	1236	Cohort study	Second trimester of pregnancy (26–28 weeks)	Self-report	GDM	Diagnosis: 2-h 75-g OGTT	No significant association of SB between glucose levels or GDM.	There was no evidence of an association between SB and GDM. Nonetheless, a consistent increase in the odds of developing GDM was observed in women who sat for more than 7 hours per day, but this did not reach statistical significance.

Leng <i>et al.</i> 2016 [21]	China	11,450	Cross-sectional study	Second trimester of pregnancy (22–24 weeks)	Self-administered questionnaire	GDM	Diagnosis: 2-h 75-g OGTT	Sitting time at home for 2–4 hours/day and $\leq 4$ hours/day significantly increased GDM risks compared with sitting time of $>2$ hours/day in an ordinal manner.	SB during pregnancy was associated with the increased risk of GDM among overweight/obese women as well as women with normal weight.
Chasan-Taber <i>et al.</i> 2015 [22]	United States (Hispanic women)	1240	Cohort study	First trimester of pregnancy ( $>20$ weeks)	PPAQ	Hypertensive disorders of Pregnancy	Diagnosis	Not significantly associated with risk of total hypertensive disorders or pre-eclampsia, although there was the suggestion of an increased risk for high levels of sedentary behavior as compared to low levels.	The associations observed in the present study were consistent with the findings of previous studies conducted in a predominantly non-Hispanic white population.

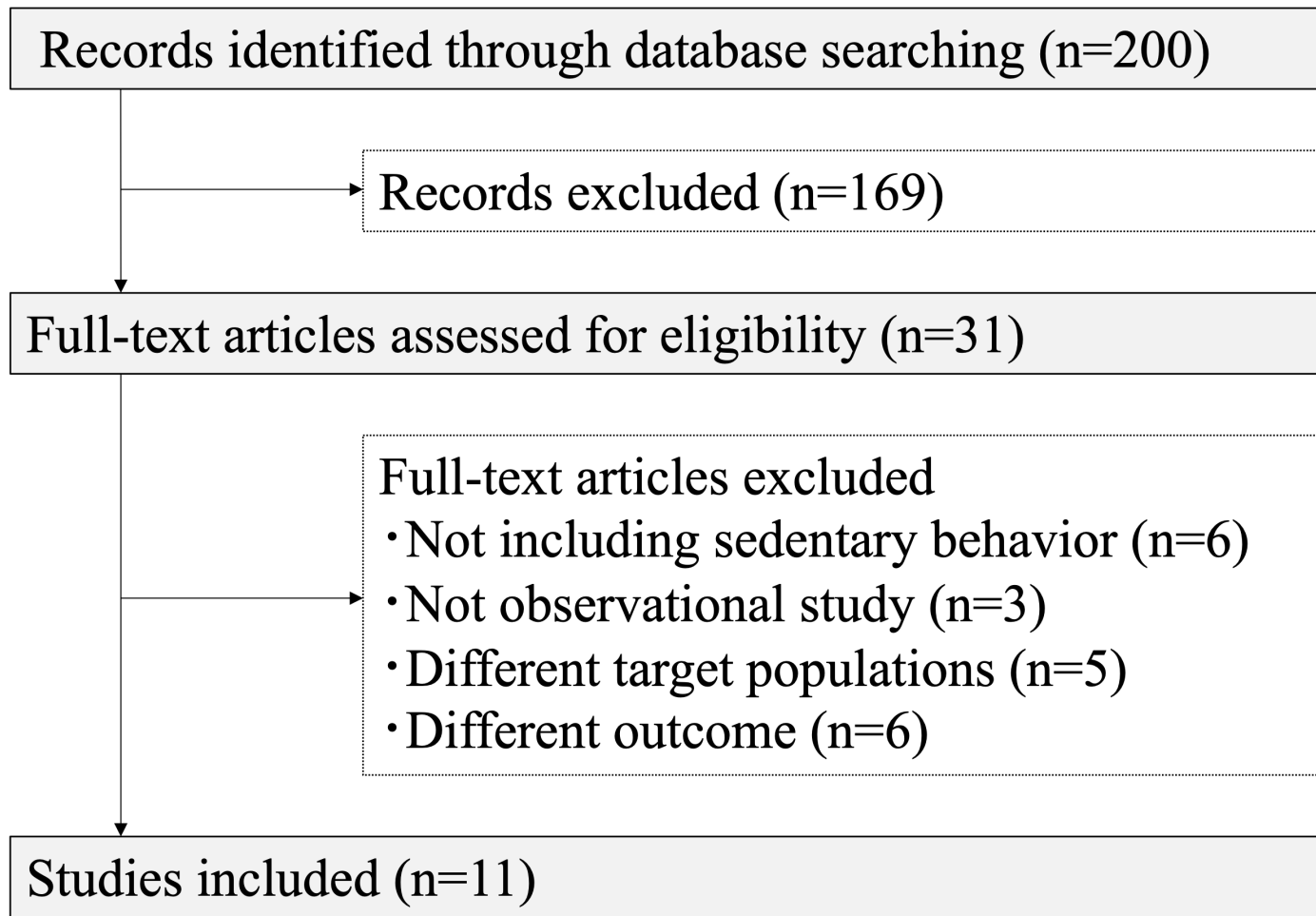
EPDS = The Edinburgh Postnatal Depression Scale; GAD-7 = General Anxiety Disorder-7; SGPAL = Saltin-Grimby Physical Activity Level; PPAQ = Pregnancy Physical Activity Questionnaire; SB = sedentary behavior; GDM = gestational diabetes mellitus; OR = odds ratio; CI = confidence interval; IPAQ = International Physical Activity Questionnaire; LPA = light physical activity; MPA = moderate physical activity; VPA = vigorous physical activity; OGTT = oral glucose tolerance testing

**Table 2** Summary of included studies without comparative analysis

Author	Country	Number of participants	Study design	Pregnancy terms	Assessment method	Outcome	Outcome method	Results	Findings
Rodriguez-Ayllon <i>et al.</i> 2021 [14]	Spain	161	Cross-sectional study	Early second trimesters of pregnancy (16th ± 2nd gestational weeks)	9 days of wearing accelerometer	Pregnant antenatal depression/positive and negative affect/anxiety/emotional attention, emotional clarity, emotional regulation/resilience	CES-D/the Trait Positive and Negative Affect Schedule/ STAI-T/ TMMS32/10-item Connor-Davidson Resilience Scale	No significant associations were found with sedentary time and negative affect, anxiety, emotional attention, emotional clarity, emotional regulation, and resilience. Sedentary time was inversely associated with positive affect (p=0.022) when the model was adjusted for age, educational level, and accelerometer wearing time. Even if the number of miscarriages and low back pain were added to the model, the association remained statistically significant (p=0.017).	Higher moderate-to-vigorous physical activity and lower sedentary time were shown to be modestly associated with lower depressive symptoms and higher positive affect, respectively, in the early second trimester of pregnancy.
Xiang <i>et al.</i> 2020 [15]	China	1272	Cross-sectional study	First (<13 weeks), second (13–28 weeks), and third (>28 weeks) trimesters of pregnancy	PPAQ	Pregnant women's mental distress	SCL-90-R	First trimester: no significant association between SB and any mental distress symptoms. Second trimester: SB was associated with higher mental distress symptoms (GSI: p <0.001, depression: p=0.006, anxiety: p=0.001). Third trimester: There was an inverted U-shaped curvilinear relationship between SB and psychological distress, including depression and anxiety symptoms.	An independent association between SB and maternal mental distress was confirmed, indicating that the relationship between SB and maternal mental distress, including depression and anxiety symptoms, differed across the three trimesters.
van der Waerden <i>et al.</i> 2019 [16]	France	15,538	Retrospective cohort study (The ELFE cohort)	Third trimesters of pregnancy	PPAQ	Postpartum depression	EPDS	After examining the impact of specific activity domains, leisure time SB was significantly associated with postpartum depression in univariate (OR=1.16 95%, CI 1.07-1.22) and multivariate (adjusted for age at birth, nationality, maternal education level, etc.) models (OR=1.16 95%, CI 1.06-1.23).	Women who engage in more leisure-time SB at the end of their pregnancy have an increased likelihood of postpartum depression.

CES-D = The Center for Epidemiologic Studies Depression Scale; STAI-T = State-Trait Anxiety Inventory; TMMS32 = Trait Meta-Mood Scale-32; PPAQ = Pregnancy physical activity questionnaire; SCL-90-R = The Symptom Checklist-90 Revised Scale; SB = sedentary behavior; GSI = The Global Severity Index; ELFE = French Longitudinal Study since Childhood; EPDS = The Edinburgh Postnatal Depression Scale; OR = odds ratios; CI = confidence interval

- #1 “pregnant woman” [Title/Abstract]
- #2 “pregnant women” [Title/Abstract]
- #3 “pregnancy” [Title/Abstract]
- #4 “pregnancies” [Title/Abstract]
- #5 “gestation” [Title/Abstract]
- #6 “child bearing” [Title/Abstract]
- #7 “childbearing” [Title/Abstract]
- #8 “gravidity” [Title/Abstract]
- #9 “Pregnant Women” [MeSH Terms]
- #10 #1 or #2 or #3 or #4 or #5 or #6 or #7 or #8 or #9
- #11 “sedentary behavior” [Title/Abstract]
- #12 “sedentary behaviour” [Title/Abstract]
- #13 “sedentary lifestyle” [Title/Abstract]
- #14 “sedentary lifestyles” [Title/Abstract]
- #15 “sedentary activities” [Title/Abstract]
- #16 “physical inactivity” [Title/Abstract]
- #17 “lack of physical activity” [Title/Abstract]
- #18 “Sedentary Behavior” [MeSH Terms]
- #19 #11 or #12 or #13 or #14 or #15 or #16 or #17 or #18
- #20 “Cross-sectional study” [MeSH Terms]
- #21 “cohort study” [MeSH Terms]
- #22 “Case-control study” [MeSH Terms]
- #23 “observational study” [Publication Type]
- #24 “cross-sectional study” [Title/Abstract]
- #25 “cohort study” [Title/Abstract]
- #26 “case-control study” [Title/Abstract]
- #27 “observational study” [Title/Abstract]
- #28 #20 or #21 or #22 or #23 or #24 or #25 or #26 or #27
- #29 #10 and #19 and #28



	Selection of participants	Confounding variables	Measurement of exposure	Blinding of outcome assessments	Incomplete outcome data	Selective outcome reporting
Baran et al. 2022	+	-	-	+	?	+
Ekelöf et al. 2021	+	-	-	?	+	+
Rodriguez-Ayllon et al. 2021	+	-	-	+	+	+
Xiang et al. 2020	+	+	-	+	?	+
van der Waerden et al. 2019	+	+	-	?	?	+
Aburezq et al. 2020	+	-	-	?	?	+
Ramos do Nascimento et al. 2019	+	-	+	?	+	+
Mishra et al. 2018	+	+	+	?	+	+
Padmapriya et al. 2017	+	+	-	?	+	+
Leng et al. 2016	+	+	-	?	?	+
Chasan-Taber et al. 2015	+	+	-	+	+	+

(+) low risk of bias      (?) unclear risk of bias      (-) high risk of bias

