



## Association between regular physical activity during pregnancy and perinatal outcomes: A population-based cohort study

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### ABSTRACT

**Introduction:** Regular physical activity during pregnancy is associated with several maternal and neonatal health benefits. However, most studies focus on specific forms of exercise in low-risk populations, limiting generalizability.

**Objective:** To investigate associations between regular physical activity during singleton pregnancy and perinatal outcomes using a national perinatal registry.

**Methods:** A population-based cohort study was conducted using data from the Slovenian National Perinatal Information System (2013–2022), which included 190,331 singleton pregnancies. Regular physical activity was defined as any form of physical activity at least twice weekly throughout pregnancy. The outcomes analyzed included preterm birth (<37 and <32 weeks), preeclampsia, gestational hypertension, gestational diabetes mellitus (GDM), pelvic girdle pain, small-for-gestational-age (SGA) and large-for-gestational-age (LGA) neonates, cesarean delivery, urinary incontinence postpartum, and Apgar scores < 7 at 5 minutes. Multivariate logistic regression adjusted for parity, maternal age, BMI, prepregnancy hypertension and diabetes, and gestational weight gain.

**Results:** Regular physical activity during pregnancy was reported by 69 % of the women. It was significantly associated with reduced odds of preterm birth (<37 weeks, aOR 0.658; <32 weeks, aOR 0.393), preeclampsia (aOR 0.719), gestational hypertension (aOR 0.708), pelvic girdle pain (aOR 0.808), SGA (aOR 0.903), LGA (aOR 0.902) and low Apgar scores (aOR 0.638). Physically active women with GDM were less likely to require insulin (aOR 0.768). No significant associations were found with cesarean delivery or urinary incontinence.

**Conclusion:** Regular physical activity during pregnancy, regardless of specific type, was associated with improved perinatal outcomes without safety concerns. These findings highlight the potential benefits of encouraging physical activity during pregnancy in diverse populations.

### Introduction

In the absence of obstetric complications or medical contraindications, several forms of physical exercise are recommended during pregnancy because of their maternal and fetal health benefits [1–7]. Walking, swimming, indoor cycling, yoga or pilates, and several other forms of exercise have all been proven to reduce the incidence of perinatal complications, such as gestational diabetes, hypertensive disorders of pregnancy, urinary incontinence, pregnancy-related pelvic girdle pain and intrauterine growth restriction (IUGR) [8–16]. Exercise also

has a positive effect on pregnant women's overall sense of well-being and reduces the risk of mental disorders such as anxiety, depression, and panic attacks [17,18]. Exercising during pregnancy can also serve as good preparation for labor and delivery and contributes to faster postpartum recovery [19–21].

Physical exercise is a planned, structured, and repetitive form of physical activity [22]. It is specifically focused on improving or maintaining one or more components of physical fitness [22]. Considering the anatomical and physiological changes that occur during pregnancy, not all forms of exercise are recommended for pregnant women [1–3].

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On the other hand, even pregnancy-adapted exercise may not be beneficial for all pregnant women, as it could be contraindicated in some high-risk pregnancies [1,2]. Most studies on the effects of physical activity during pregnancy have examined the impact of specific pregnancy-adapted forms of exercise on maternal and fetal/neonatal outcomes in healthy, low-risk pregnant women [8–21]. These studies were limited to particular forms of physical exercise and to subsets of pregnant women who may not be fully representative of the unselected real-world population. Therefore, conclusions on the safety and benefits of regular physical activity during pregnancy should not be based solely on well-controlled but narrowly focused trials on specific forms of exercise but should be complemented by large population-based studies on associations between physical activity during pregnancy in general and perinatal outcomes.

The objective of this study was to analyze the associations between regular physical activity during pregnancy and perinatal outcomes via a national perinatal registry.

## Methods

This was a population-based cohort study evaluating data from the Slovenian National Perinatal Information System (NPIS) for the period 2013–2022. The study population included all singleton pregnancies in Slovenia during the study period. The National Medical Ethics Committee approved the study (Project number 0120–32/2023/3). STROBE guidelines for cohort studies (available at <https://www.equator-network.org/reporting-guidelines/strobe/>) have been followed when conceptualizing the study as well as when writing the report.

The Slovenian National Perinatal Information System registers all deliveries in Slovenia at  $\geq 22$  weeks of pregnancy or when the birth weight has been  $\geq 500$  g since 1987. Registration is mandatory by law in all the country's 14 maternity units, and more than 140 variables are entered into a computerized database at the time of delivery by the attending midwife and doctor. Patient demographics: family, medical, gynecologic, and obstetric history, and data on current pregnancy, including data on physical activity during pregnancy, labor and delivery, the postpartum period, and the neonatal period, were collected. To ensure the quality of the data collected, automatic controls are built into the computerized system, the data are audited periodically, and comparisons are made with international databases, such as the Vermont Oxford network, in which Slovenia participates.

In the present study, the primary parameter analyzed was regular physical activity during pregnancy, as reported by the pregnant woman herself at the time of admission to the maternity hospital. Regular physical activity was defined as any form of physical activity at least twice weekly throughout pregnancy. We investigated the associations between physical activity and several perinatal outcomes: preterm birth (<37 0/7 weeks'), very preterm birth (<32 0/7 weeks'), preeclampsia (defined as hypertension  $\geq 140/90$  mmHg and proteinuria or multisystemic signs or symptoms of organ damage consistent with the disease after 20 weeks of gestation), gestational hypertension (defined as hypertension  $\geq 140/90$  mmHg without proteinuria or multisystemic signs or symptoms after 20 weeks of gestation), gestational diabetes mellitus (GDM, diagnosed using the International Association of Diabetes and Pregnancy Study Groups criteria), GDM requiring treatment with insulin, pelvic girdle pain during pregnancy, urinary incontinence during pregnancy, small for gestational age neonates (SGA, defined as neonatal weight < 10th percentile for gestation according to Slovenian population-specific growth curves), large for gestational age neonates (LGA, defined as neonatal weight > 90th percentile for gestation according to Slovenian population-specific growth curves), cesarean delivery, and an Apgar score < 7 at 5 minutes of life.

For comparisons of the basic characteristics of the two study groups (regular physical activity vs no regular physical activity), Student's t test was used for continuous variables, and the chi-square test was used for categorical variables. The chi-square test was used for univariate

comparisons of perinatal outcomes between the two groups. Multivariable logistic regression was used to examine the associations between regular physical activity and perinatal outcomes, controlling for the effects of the following potential confounding variables: parity (nullipara vs. multipara), maternal age, prepregnancy maternal body mass index (BMI), prepregnancy diabetes mellitus, prepregnancy hypertension, and gestational weight gain. Prepregnancy BMI was classified as underweight (<18.5 kg/m<sup>2</sup>), normal (18.5–24.9 kg/m<sup>2</sup>), overweight (25.0–29.9 kg/m<sup>2</sup>) or obese ( $\geq 30.0$  kg/m<sup>2</sup>). Gestational weight gain was defined via the Institute of Medicine criteria as optimal, too high or too low [23]. Statistical analysis was performed via IBM SPSS Statistics version 27.0 (IBM Corporation, Armonk, NY, USA). All the statistical tests were two-sided, and the level of significance was set at 0.05.

## Results

A total of 190331 pregnancies were included. Among these women, 132226 (69 %) reported being physically active at least twice weekly during pregnancy.

Table 1 presents a comparison of the basic characteristics of pregnant women who did and did not report being physically active at least twice weekly during pregnancy.

A comparison of perinatal outcomes between pregnancies in which women reported being physically active regularly and those in which they did not is presented in Table 2.

Regular physical activity during pregnancy was significantly associated with a lower incidence of preterm birth (both at <37 and <32 weeks of gestation), preeclampsia, gestational hypertension, pelvic girdle pain, SGA and LGA, as well as low Apgar scores at 5 min of life. Women with GDM reported being physically active during pregnancy more often. The incidence of GDM requiring insulin treatment was lower in physically active pregnant women. There was no statistically significant association between regular physical activity during pregnancy and mode of delivery (vaginal vs. cesarean delivery) or urinary incontinence during pregnancy.

## Discussion

At the population level, there was a significant association between any form of regular physical activity during pregnancy and a decreased incidence of several pregnancy complications, such as preterm birth,

**Table 1**  
Comparison of the characteristics of pregnant women who did and did not report being physically active at least twice weekly during pregnancy.

	Regular physical activity during pregnancy (n = 132226)	No regular physical activity during pregnancy (n = 58105)	p
Maternal age (years)	30.27 $\pm$ 4.85	30.44 $\pm$ 5.04	< .001
Prepregnancy BMI <sup>a</sup> (kg/m <sup>2</sup> )	23.81 $\pm$ 4.47	24.33 $\pm$ 4.95	< .001
Prepregnancy BMI <sup>a</sup> $\geq 30$ kg/m <sup>2</sup>	12891 (9.70 %)	7510 (12.90 %)	< .001
Nulliparity	62759 (47.50 %)	27635 (47.60 %)	0.696
Prepregnancy diabetes	367 (0.30 %)	299 (0.50 %)	< .001
Prepregnancy hypertension	741 (0.60 %)	629 (1.10 %)	< .001
Previous cesarean delivery	10248 (7.80 %)	4319 (7.40 %)	0.016
Excessive gestational weight gain (according to IOM <sup>b</sup> )	43292 (32.70 %)	20244 (34.80 %)	< .001
Insufficient gestational weight gain (according to IOM)	29081 (22.00 %)	12476 (21.50 %)	0.011

<sup>a</sup> BMI body mass index

<sup>b</sup> IOM Institute of Medicine

**Table 2**

Perinatal outcomes in pregnancies in which women reported being physically active regularly at least twice weekly during pregnancy and pregnancies in which women reported no regular physical activity. Odds ratios were adjusted for parity (nullipara vs. multipara), maternal age, prepregnancy maternal body mass index, prepregnancy diabetes, prepregnancy hypertension, and gestational weight gain. Physically active group was the referent group.

	Regular physical activity during pregnancy (n = 132226)	No regular physical activity during pregnancy (n = 58105)	Unadjusted OR (95 % CI)	Adjusted OR (95 % CI)
Preterm birth < 37 weeks*	6619 (5.00 %)	4372 (7.50 %)	0.648 (0.623–0.674)	0.658 (0.633–0.685)
Preterm birth < 32 weeks*	1017 (0.80 %)	1153 (2.00 %)	0.383 (0.352–0.417)	0.393 (0.36–0.428)
Preeclampsia*	1729 (1.30 %)	1199 (2.10 %)	0.629 (0.584–0.677)	0.719 (0.666–0.776)
Gestational hypertension*	4280 (3.20 %)	2984 (5.10 %)	0.618 (0.589–0.648)	0.708 (0.673–0.745)
GDM*	19949 (15.10 %)	7985 (13.70 %)	1.115 (1.084–1.147)	1.207 (1.172–1.242)
GDM on insulin*	2236 (1.70 %)	1447 (2.50 %)	0.674 (0.63–0.72)	0.768 (0.717–0.822)
Pelvic girdle pain during pregnancy*	1658 (1.30 %)	900 (1.50 %)	0.807 (0.744–0.876)	0.808 (0.745–0.877)
Urinary incontinence during pregnancy	27 (0.00 %)	18 (0.00 %)	0.659 (0.363–1.197)	0.701 (0.386–1.275)
SGA*	7169 (5.40 %)	3409 (5.90 %)	0.92 (0.882–0.959)	0.903 (0.866–0.942)
LGA*	9456 (7.20 %)	4772 (8.20 %)	0.861 (0.83–0.893)	0.902 (0.869–0.936)
Cesarean delivery	26416 (20.00 %)	12102 (20.80 %)	0.949 (0.926–0.972)	0.995 (0.971–1.02)
Apgar score < 7 at 5 min*	764 (0.60 %)	550 (0.90 %)	0.608 (0.545–0.679)	0.638 (0.571–0.713)

GDM, gestational diabetes mellitus; SGA, small-for-gestational age; LGA, large-for-gestational age; OR, odds ratio; CI, confidence interval; \* denotes a statistically significant association

preeclampsia, gestational hypertension, and pelvic pain, as well as lower rates of both SGA and LGA neonates. Women diagnosed with GDM who were regularly physically active were less likely to require insulin treatment. We did not find any significant associations between physical activity during pregnancy and cesarean delivery rates or urinary incontinence during pregnancy.

Our results are in accordance with those of numerous studies indicating that physical activity during pregnancy is key to improving the health of both mothers and children [1–21,24]. Most perinatal societies are currently encouraging regular pregnancy-adapted physical exercise for most pregnant women. However, specific recommendations on the exact volume and schedule of physical activity differ slightly. The SOGC (Society of Obstetricians and Gynecologists of Canada) and the SEGO (Spanish Society of Gynecology and Obstetrics) recommend at least 150 minutes of physical exercise per week spread over at least 3 days [2, 25,26]. The American College of Obstetricians and Gynecologists (ACO) recommends physical exercise in sessions of 30–60 minutes spread over at least 3–4 days but encourages daily physical activity [1]. Similarly, the Royal Australian and New Zealand College of Obstetricians and Gynecologists (RANZCOG) endorses between 150 and 300 minutes per week of exercise for pregnant women across all seven days [27]. The ZPMS (Slovenian Society for Perinatal Medicine) also supports daily physical activity during pregnancy for at least 30 minutes per session [2]. We found an association between physical activity during pregnancy and improved perinatal outcomes even at the lower frequency of activity currently recommended. Regular physical activity was defined as two sessions of any activity weekly in the present study.

The absence of an association between physical activity during pregnancy and the cesarean delivery rate contrasts with several studies published to date. Ribeiro et al. reported a higher percentage of vaginal births among physically active pregnant women [28]. Similarly, a systematic review by Szumilewicz et al. revealed that physical activity during pregnancy was significantly associated with a reduced rate of cesarean births [21]. We have only analyzed the overall cesarean rate in the present study and have not focused specifically on emergency vs planned cesarean delivery, onset of labor, duration of labor, etc. Our data also did not permit the study of associations between specific forms of physical activity and mode of delivery. Therefore, further studies are needed to elucidate the exact impact of physical activity during pregnancy on labor itself.

Ribeiro et al. also reported that physical exercise, especially if it includes pelvic floor muscle strengthening, was associated with a lower incidence of urinary incontinence during pregnancy and postpartum [28]. We did not find any significant association between regular

physical activity and urinary incontinence during pregnancy in the present study. However, our registry does not include data on the incidence of postpartum urinary incontinence. Notably, the rate of reported urinary incontinence during pregnancy was very low in both groups.

An important weakness of the study is its observational nature, which does not allow accounting for all potential confounding factors affecting the effects of physical activity during pregnancy on perinatal outcomes. As a result, no definitive conclusions on the causality of associations between regular physical activity and outcomes can be drawn. Another limitation of the study is the lack of information on the exact volume and frequency of sessions of physical activity. Moreover, NPIS data on physical activity do not allow the assessment of specific forms of physical activity. Therefore, our study focused on the potential effects of physical activity during pregnancy in general and not on specific forms of structured and planned physical exercise. Nevertheless, our findings support previously reported results on specific forms of physical exercise. In addition, our study highlights the safety and benefits of regular physical activity during pregnancy, even outside structured exercise programs.

**Key findings**

This study highlights the benefits of regular physical activity during pregnancy, including reduced risks of preterm birth, preeclampsia, and gestational hypertension. Our population-based analysis demonstrates that even moderate, non-structured activity confers significant health benefits.

**Conclusion**

Regular physical activity during pregnancy was significantly associated with lower rates of preterm birth, preeclampsia, gestational hypertension, GDM requiring insulin treatment and pelvic girdle pain. These findings support previously reported beneficial effects of different physical exercise programs on pregnancy outcomes. The study included all forms of physical activity, regardless of whether they were planned, structured or specifically designed for pregnant women. Despite this, we found no safety concerns related to physical activity during pregnancy. There was no association between regular physical activity during pregnancy and increased risks of any adverse perinatal outcome.

**Ethics approval and consent to participate**

The National Medical Ethics Committee of the Republic of Slovenia

approved this study. The case reference number: 0120–32/2023/3.

### Authors' contributions

Author 1 drafted the manuscript, incorporated feedback from all authors, and managed the submission process, Author 2 conceptualized and designed the study, oversaw data collection, and contributed to the interpretation of findings, Author 3 conducted the statistical analysis, ensured the accuracy of data processing, and provided critical insights into the methodology., Author 4 provided subject matter expertise, critically reviewed the manuscript, and contributed to the interpretation of findings. All authors read and approved the final manuscript.

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### CRediT authorship contribution statement

**Lučovnik Miha:** Writing – original draft, Supervision, Formal analysis, Conceptualization. **Verdenik Ivan:** Methodology, Data curation. **Šćepanović Assistant Professor Dr. Darija:** Writing – review & editing, Resources, Project administration. **Helježović Šejla:** Writing – review & editing, Data curation, Conceptualization.

### Declaration of Competing Interest

The authors declare no competing interests.

### Data availability statement

The data used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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