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Key terms: employment; exertion; gestational hypertension; job strain; job stress; occupational health; occupational physical activity; occupational risk factor; population-based study; posture; preeclampsia; pregnancy outcome; pregnancy-induced hypertension

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Population-based study on occupational risk factors for preeclampsia and gestational hypertension

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Objectives Preeclampsia is a leading cause of maternal and perinatal morbidity. Work-related factors may influence the occurrence of this disorder. This case–control study estimated the associations between work-related physical and psychosocial factors and the risk of preeclampsia and gestational hypertension.

Methods The eligible women consisted of a random sample of the women who delivered a singleton live birth in 1997–1999 in six regions of Quebec and worked during pregnancy. Cases of preeclampsia (N=102) and gestational hypertension (N=99) were compared with normotensive controls (N=4381). Information on occupational exposures at the onset of pregnancy was collected during phone interviews a few weeks after delivery. Detailed information was obtained on work schedule, postures, physical exertion, work organization, noise, vibration, and extreme temperature. Adjusted odds ratios (aOR) were estimated through polytomous logistic regression.

Results Women standing daily at least 1 hour consecutively without walking experienced a higher risk of preeclampsia [aOR 2.5, 95% confidence interval (95% CI) 1.4–4.6], as well as women climbing stairs frequently (aOR 2.3, 95% CI 1.2–4.1) and women working more than 5 consecutive days without a day-off (aOR 3.0, 95% CI 1.0–9.5). Squatting or kneeling, pushing or pulling objects, whole-body vibration, forced pace, job strain, and no control on breaks were positively, but nonsignificantly, associated with preeclampsia. The associations were weaker for gestational hypertension.

Conclusions These findings suggest that being exposed to physically demanding and stressful occupational conditions at the onset of pregnancy increases the risk of preeclampsia.

Key terms employment; exertion; job strain; job stress; occupational health; occupational physical activity; posture; population-based study; pregnancy outcome; pregnancy-induced hypertension.

Preeclampsia, defined as the development of hypertension with proteinuria after 20 weeks of pregnancy, is one of the most common causes of maternal adverse outcome and death and a major contributor to perinatal morbidity and mortality (1–4). By contrast, the mild form of pregnancy-induced hypertension, gestational hypertension, does not significantly affect the mother or the neonate (4, 5).

Working during pregnancy was found to be associated with an increased frequency of preeclampsia (6–9) and gestational hypertension (8) in some studies. In other studies, however, such an association was not found (10–14).

Supported by solid literature relating job stress to cardiovascular diseases (15–17), three studies investigated the relation of job stress to pregnancy-induced hypertension (7, 8, 18). They showed fairly consistent evidence of an association between high job stress and an increased risk of gestational hypertension and preeclampsia.

A high level of physical activity at work was found to be associated with an elevated risk of preeclampsia (11) or hypertension in pregnancy (19, 20) in a few studies (table 1). In particular, women who carry heavy loads at work experienced an approximately 70% increase in the occurrence of preeclampsia (10) and hypertension

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Table 1. Methodological characteristics and main results of the studies that examined associations of occupational physical activity with gestational hypertension and preeclampsia in pregnant working women. (BMI = body mass index)

Study	Design	Data collection	Sample size and outcome	Exposure definition	Period of exposure	Adjustment for potential confounders	Result			
							Carrying heavy loads	Standing or walking	Summary measure of physical exertion	Other
Saurel-Cubizolles et al, 1985 (19); Saurel-Cubizolles et al, 1991 (20)	Retrospective cohort	Interview when resuming work	621 women; outcome was self-reported systolic blood pressure >130 mmHg or diastolic blood pressure >80 mmHg any time during pregnancy (N=90)	Yes, no	Not provided	Age, parity, father socioprofessional level, ethnic origin	Carrying heavy loads associated with high blood pressure	Standing up for long periods of time associated with high blood pressure	Accumulation of heavy cleaning tasks, carrying heavy loads, and standing up for long periods of time associated with high blood pressure (OR 3.3, 95% CI 2.0–5.5)	Climbing stairs often not associated with high blood pressure
Estryn et al, 1978 (21)	Retrospective cohort	Interview when resuming work	204 women, among whom 26 with self-reported hypertension (not defined) any time during pregnancy	Yes, no	Not provided	None	Carrying heavy loads increased risk of hypertension (17% versus 6%)	Standing up for long periods of time not associated with hypertension; standing up without moving increased risk (18% versus 8%)	–	–
Saurel-Cubizolles et al, 1991 (22)	Retrospective cohort	Interview after delivery	2587 women; outcome was self-reported systolic blood pressure ≥140 mmHg or diastolic blood pressure ≥90 mmHg any time during pregnancy (N=285)	Yes, no; physical exertion not defined	First trimester	Other work conditions, parity, age, level of education, smoking, BMI	Carrying heavy loads associated with third trimester high blood pressure (OR 1.7, 95% CI 1.2–2.4) but not with first and second trimester high blood pressure	Standing most of the time not associated with high blood pressure	Strong physical exertion not associated with high blood pressure	–
Nurminen et al, 1989 (24)	Retrospective cohort	Interview 2–4 months after delivery and medical record abstraction	1475 women, among whom 59 with pregnancy-induced hypertension	Physical load assessed from a description of tasks during an ordinary workday and translated in energy expenditure	Second and third trimesters	Age, parity, outcome of previous pregnancies, prepregnancy weight, alcohol intake, and smoking	–	Standing work and walking work not associated with pregnancy-induced hypertension	High mean physical load not associated with pregnancy-induced hypertension	High short-term physical load associated with pregnancy-induced hypertension (RR 2.1, 95% CI 1.1–3.8)
Marcoux et al, 1989 (26)	Case–control	Interview at the hospital a few days after delivery and medical record abstraction	254 cases of gestational hypertension, 172 cases of preeclampsia and 505 controls	Walking (frequent versus not frequent) and standing position (hours/day) during a regular workday	First 20 weeks	Restricted to primiparous; age, BMI, education; smoking, and leisure-time physical activit taken into account	–	Standing position not associated with preeclampsia or gestational hypertension; frequent walking associated with a reduced risk of preeclampsia (OR 0.6, 95% CI 0.4–0.9) but not gestational hypertension	–	–
Landsbergis & Hatch, 1996 (8)	Prospective cohort	Interview by phone around 13 weeks of gestation and medical record abstraction	575 women among which 11 with preeclampsia and 16 with gestational hypertension	Physical work demands measured as the sum of five items: (1) climbing or balancing, (2) lifting, carrying, pulling or pushing objects, (3) moving around a lot, (4) exerting a lot of physical effort, (5) sitting or standing in uncomfortable positions for long periods of time	First trimester	None (main objective was to study impact of work stress)	–	–	High physical work demand not associated with preeclampsia or gestational hypertension	–

(continued)

Table 1. Continued.

Study	Design	Data collection	Sample size and outcome	Exposure definition	Period of exposure	Adjustment for potential confounders	Result			
							Carrying heavy loads	Standing or walking	Summary measure of physical exertion	Other
Irwin et al, 1994 (25)	Retrospective cohort	Job types assessed from a routine database and hospital discharge record abstraction	5605 women, outcome was pregnancy-induced hypertension (ICD-9 diagnosis codes) (N=494)	Job titles classified as high, medium, or low for a variety of occupational exposures	Not provided	No adjustment; analyses stratified for parity (primiparous versus multiparous)	Jobs with high level of lifting not associated with pregnancy-induced hypertension	Jobs with high level of standing associated with pregnancy-induced hypertension (RR 1.5, 95% CI 1.0–2.5) only in multiparous women	Jobs with high level of physical exertion not associated with pregnancy-induced hypertension	–
Wergeland & Strand, 1997 (10)	Retrospective cohort	Questionnaire completed by mothers after delivery, while in the maternity institution	3321 women among whom 180 with self-reported hypertension and proteinuria	Questions with 3–5 response categories; lifting heavy loads defined as lifting 10–20 kg more than 20 times weekly; daily frequency for other exposure	When became aware of pregnancy	Smoking, other occupational exposures, age, instruction level, and parity taken into account	Lifting heavy loads associated with preeclampsia (OR 1.7, 95% CI 1.2–2.5)	Standing or walking associated with a slightly reduced risk of preeclampsia (OR 0.7, 95% CI 0.5–1.0)	–	Work with hands above shoulder level associated with preeclampsia (OR 1.4, 95% CI 1.0–2.2), twisting or bending not associated with preeclampsia
Ceron-Mireles et al, 2001 (23)	Retrospective cohort	Interview in the hospital after delivery and medical record abstraction	2436 women among whom 131 with preeclampsia or eclampsia	Job requiring physical effort (yes, no); standing (hours/day)	Not provided	Parity, age, prepregnancy weight, smoking, and education taken into account	–	Standing not associated with preeclampsia	Work physical effort not associated with preeclampsia	–
Spinillo et al, 1995 (11)	Case–control	Questionnaire administered at birth and medical record abstraction	122 cases of severe preeclampsia and 217 controls	Four-level score of physical activity including items on type of work, physical intensity (sedentary, moderate or intense), posture, and workhours	First trimester	Adjustment made for age, social status, BMI, time of stopping work, and history of previous abortion	–	–	Moderate or high level of physical activity associated with preeclampsia (OR 2.1, 95% CI 1.1–3.9)	–
Higgins et al, 2002 (29)	Prospective cohort	Interview during pregnancy, medical record abstraction, 24-hour ambulatory blood pressure monitoring	245 women, outcome was gestational hypertension and preeclampsia, and mean blood pressure	Job titles classified into three categories: (1) standing, (2) active, (3) sedentary	Not provided	Age, smoking, BMI, and marital status	–	Standing jobs not associated with gestational hypertension or preclampsia	Active jobs not associated with preeclampsia or gestational hypertension; higher mean 24-hour diastolic blood pressure for women with active job compared with women with sedentary jobs (65.6 versus 63.4 mmHg)	–
Saftlas et al, 2004 (27)	Case–control with prospective data collection	Face-to-face interviews before 16 weeks of gestation and review of medical charts	44 cases of preeclampsia, 172 cases of gestational hypertension, and 2422 controls	Time at work spent sitting, standing and walking; women with sedentary work (more time sitting than standing) versus nonsedentary work (more time walking or standing than sitting); proportion of time spent sitting (three levels)	Early pregnancy (<16 weeks of gestation)	Adjustment for age, parity, history of abortion, BMI, years of education, cigarette smoking, and leisure-time physical activity taken into account	–	Non-significantly reduced risk of preeclampsia in non-sedentary jobs and in the low or moderate sitting categories; gestational hypertension not associated	–	–

during pregnancy (19–22) in four studies. However, these few studies have been challenged by others showing that a high physical workload does not confer an increased risk of preeclampsia (23) or pregnancy-induced hypertension (8, 24, 25). They are also in contrast to those suggesting that leisure-time physical activity may reduce the risk of preeclampsia (26–28).

A few studies have assessed the association of pregnancy-induced hypertension with other occupational exposures such as standing-up, keeping back bent forward, keeping arms above shoulders, or twisting and bending for long periods of time (10, 19–27, 29), noise (10, 22, 23, 30), or long weekly workhours (10, 19, 20, 22, 23, 31). These studies provide conflicting results.

In summary, diverse occupational conditions may be associated with a higher risk of pregnancy-induced hypertension. However, the literature on this issue is scanty, and findings from previous studies are highly inconsistent and conflicting. These studies often lacked statistical power and relied on poor exposure or outcome definitions (table 1). Either no exposure definition was provided or no mention of period or the amount of exposure was made. Outcome was defined as hypertension at any time during pregnancy in several studies, and, for those that used pregnancy-induced hypertension as the outcome, preeclampsia was often not distinguished from gestational hypertension. The data analysis usually presented several shortcomings. Typically, no attempt was made to examine dose–response effects, and control for potential confounders was inadequate. In particular, only two studies proceeded to adjustments for other occupational exposures (10, 22). Currently, a vast proportion of pregnant women work during pregnancy, therefore the need for studies addressing the limitations of previous studies. We conducted this case–control study in order to estimate the associations of occupational physical exertion and postures, work schedule, job strain, breaks during worktime, workpace, noise, whole-body vibration, and extreme temperature with the risk of preeclampsia and gestational hypertension.

Study population and methods

Study population

We were authorized by the "Commission d'accès à l'information du Québec" to obtain personal data recorded on birth certificates for all singleton live births between January 1997 and March 1999 in six regions of the Province of Quebec (Saguenay-Lac-Saint-Jean, Québec, Mauricie-Centre-du-Québec, Estrie, Chaudière-Appalaches, Laval). A total of 43 898 singleton live births was reported to the investigators by the Regional Public Health Directions (93.7% of the singleton live births declared). The source population for our present case–control study was a random sample of 20% (N=8902) of the women who delivered these singleton live births. This sample was drawn in the context of a previous study (32).

The interviewers were able to make telephone contact with 8411 (94.5%) potential participants. Of those contacted, 8267 (98.3%) agreed to participate. Only the women who had been employed since the first month of pregnancy, during at least 4 consecutive weeks and at least 20 hours weekly were eligible (N=4959). Those who had several employments during pregnancy were excluded (N=196). Altogether 4763 women who completed the interview were left. For our present analysis, we excluded 27 women who declared a history of hypertension or diabetes requiring medication before pregnancy and 7 others with a chronic disease that can predispose to preeclampsia (rheumatoid arthritis, ulcerative colitis, systemic lupus erythematosus).

During the interview, each woman had to report whether she experienced preeclampsia. She was also asked about blood pressure equal to or over 140/90 mmHg and proteinuria or albuminuria during pregnancy, including timing and number of episodes. In order to reduce the risk of outcome misclassification, we also excluded 147 women who experienced hypertension before 20 weeks of gestation or who reported only one episode of hypertension or who declared having had preeclampsia in the index pregnancy but did not report two episodes of hypertension or proteinuria from the 20th week of gestation on.

The cases with preeclampsia were comprised of women who had two self-reported episodes of elevated blood pressure (≥140/90 mmHg) with self-reported albuminuria both first occurring in the 20th week of gestation on (N=102). The cases with gestational hypertension were comprised of women who reported an elevation of blood pressure on at least two occasions occurring from the 20th week of gestation on without albuminuria (N=99). Thus, of the 4582 women with no chronic disease predisposing to preeclampsia, delivery of a singleton live birth, work during pregnancy, and interview completion, 2.2% was classified as cases of preeclampsia and 2.2% as cases of gestational hypertension. The controls (N=4381) were all of the remaining eligible women (ie, women who remained normotensive during pregnancy).

Data collection

Exposures and covariates were ascertained through a standardized computerized telephone interview (median time of interview: 31 days postpartum for preeclampsia, 28 days for gestational hypertension, and 30 days for the controls). Detailed information was collected on work schedule, postures, physical exertion, breaks, workpace, job strain (Karaseks' model) (33, 34), social support, and environmental exposures (noise, vibration, temperature) at the onset of pregnancy (see the appendix). The women reported time spent sitting, standing, and walking during a typical workday. The daily frequency of pushing or pulling objects, carrying or lifting loads, and stair climbing during a typical workday was asked for. The average weight carried or lifted was reported. The women were also asked whether they benefited from a preventive withdrawal or from job reassignment. Notification of the withdrawal or reassignment timing was required. In Quebec, pregnant women whose work conditions are considered to entail a risk for themselves or their fetuses can legally benefit from job reassignment or, if not possible, can be withdrawn from work on salary. Last, data were obtained on medical and obstetrical history, type of delivery, leisure-time physical activity, smoking, pregravid weight, height, and level of education. In addition to the women's identification data, age, birth weight, gestational duration, and parity were obtained from the birth certificate.

Analysis

Occupational exposures were defined from information on work conditions at the onset of pregnancy. [See the appendix.] The number of hours worked per day and during evenings or nights was computed from the work schedule. The variables were examined separately and then combined (eg, time spent standing crossed with possibility to sit, average weight of load carried crossed with frequency of load carrying, opportunity to have a break with control on the time of the break). The job psychological demand score (sum of nine items) and the job control score (sum of nine items) were both dichotomized at the median for the controls. Job strain was defined by combining job demand and job control into the following four levels: low demand–high control, low demand–low control, high demand–high control, and high demand–low control.

The following set of covariates was used in all of the adjusted analyses: age (<25 years, 25–29 years, 30–34 years, >34 years), parity (primiparous versus multiparous), history of abortion (spontaneous or induced) (yes, no), body mass index (<25.0 kg/m^2, 25.0–29.9 kg/m^2, ≥30.0 kg/m^2), smoking during the last 3 months of pregnancy (no smoking versus smoking at least 1 cigarette per day), education (in three levels), and leisure-time physical activity during the first trimester of pregnancy (less than once a month, once a month–twice a week, 3 times per week or more).

We first computed crude odds ratios (OR) for the associations between occupational exposures at the onset of pregnancy and the outcomes. We combined the categories with small numbers and similar odds ratios. We then estimated adjusted odds ratios (aOR) using polytomous logistic regression (SAS, CATMOD procedure) (35). Occupational exposures were first examined one-by-one, with adjustment for the aforementioned set of covariates. At the next step, we analyzed each subset of occupational variables belonging to the same group (schedule, postures, physical exertion, work organization and job strain, environmental exposures). Using multiple logistic regressions, we examined the effect of each occupational exposure with adjustment not only for the aforementioned set of covariates, but also for the potentially confounding effect of other occupational exposures of the same group. To avoid collinearity, when two variables were highly correlated, we only kept the one most strongly related to the outcomes for further analyses. The 11 occupational variables that remained associated with the outcomes at this step were then considered simultaneously in a model. At each step of our analysis, the models were simplified by keeping occupational exposures associated with the outcomes (aOR ≥1.20 or ≤0.80) for further analyses. Other occupational variables were deleted if deletion did not change the adjusted odds ratios for the other exposures. Ultimately, nine occupational variables remained in the final model.

We tested interactions between weekly workhours, job strain, and the number of consecutive days of work without a day-off on one hand and the other occupational variables in the final model on the other hand. To assess preventive withdrawal, we then compared the women exposed for less than 20 weeks (those who utilized preventive withdrawal before 20 weeks of gestation) with the unexposed women.

Ultimately, we verified the robustness of our findings by comparing the adjusted odds ratios from our final model with the adjusted odds ratios obtained when self-reported preeclampsia was used as the outcome.

To assess dose–response relationships for variables with more than two ordered categories, we used the linear component of the polynomial contrast corresponding to the variable. All along the analyses, we examined standard errors of the regression coefficients and variance inflation factors to check for collinearity. The analyses were performed with SAS (SAS Inc, Gary, NC, USA) and SPSS (SPSS Inc, Chicago, IL, USA) software.

Results

The outcome of pregnancy differed for the three groups (table 2). The mean birthweight was 256 grams lower for the babies of the women who had had preeclampsia

Table 2. Comparison of pregnancy outcomes among the cases and controls.

Group	Elective cesarean section (%)		Labor induction (%)		Gestational age at birth <37 weeks (%)		Birthweight <2500 g (%)		Gestational age at birth (week)		Birthweight (grams)	
	N	%	N	%	N	%	N	%	Mean	SD	Mean	SD
Controls (N=4381)	245	5.6	990	22.6	216	4.9	143	3.3	39.1	1.6	3411	501
Preeclampsia (N=102)	8	7.9	66	65.3	15	14.7	15	14.7	38.2	2.0	3155	693
Gestational hypertension (N=99)	7	7.1	44	44.4	2	2.0	4	4.0	39.0	1.4	3390	488

Table 3. Distribution of maternal sociodemographic, reproductive, and lifestyle baseline characteristics among the cases and controls. (OR = odds ratio, 95% CI = 95% confidence interval)

Maternal characteristics	Controls (N=4381)		Preeclampsia (N=102)		Gestational hypertension (N=99)		Preeclampsia		Gestational hypertension	
	N	%	N	%	N	%	Crude OR	95% CI	Crude OR	95% CI
Age										
≤24 years	795	18.2	23	22.6	24	24.2	1.6	0.9–2.7	2.0	1.2–3.5
30–3425–29 years	1732	39.5	32	31.4	26	26.3	1.0	..	1.0	..
30–34 years	1386	31.6	34	33.3	30	30.3	1.3	0.8–2.2	1.4	0.9–2.5
≥35 years	468	10.7	13	12.7	19	19.2	1.5	0.8–2.9	2.7	1.5–4.9
Parity and history of spontaneous or induced abortion										
Multiparous without history of abortion	1682	38.4	25	24.5	24	24.2	1.0	..	1.0	..
Primiparous without history of abortion	1784	40.7	47	46.1	50	50.5	1.8	1.1–2.9	2.0	1.2–3.2
Multiparous with a history of abortion	539	12.3	10	9.8	11	11.1	1.3	0.6–2.6	1.4	0.7–2.9
Primiparous with a history of abortion	376	8.6	20	19.6	14	14.1	3.6	2.0–6.5	2.6	1.3–5.1
Level of education										
<12 years	315	7.2	8	7.8	10	10.1	1.3	0.6–2.8	1.7	0.8–3.6
12–16 years	2760	63.1	68	66.7	65	65.7	1.2	0.8–1.9	1.3	0.8–2.0
≥17 years	1298	29.7	26	25.5	24	24.2	1.0	..	1.0	..
Smoking during the last trimester of pregnancy	831	19.0	11	10.8	13	13.1	0.5	0.3–1.0	0.6	0.4–1.2
Body mass index										
<25.0 kg/m^2	3409	78.1	52	51.0	52	52.5	1.0	..	1.0	..
25.0–29.9 kg/m^2	678	15.5	32	31.4	30	30.3	3.1	2.0–4.8	2.9	1.8–4.6
≥30 kg/m^2	279	6.4	18	17.6	17	17.2	4.2	2.4–7.3	4.0	2.3–7.0
Vigorous leisure-time physical activity during the first trimester of pregnancy										
Less than once/month	3499	80.0	79	77.4	72	72.7	1.0	0.6–1.9	0.7	0.4–1.3
Once/month–twice/week	540	12.4	12	11.8	15	15.2	1.0	..	1.0	..
More than twice/week	333	7.6	11	10.8	12	12.1	1.5	0.6–3.4	1.3	0.6–2.8

than for the babies of the control women. In contrast, the babies of the women with gestational hypertension averaged only 21grams lighter than the babies of the control women. The risk of low birthweight and preterm birth was strongly increased in the group with preeclampsia but not in the group with gestational hypertension. As compared with the controls, the women with preeclampsia and those with gestational hypertension had labor induction three times and twice more frequently, respectively. The frequency of elective prelabor cesarean section was slightly and nonsignificantly increased in the two case groups.

Table 3 shows the distribution of the maternal characteristics among the cases and the controls. The women who had had preeclampsia or gestational hypertension were more likely to have been primiparous, were more frequently either in the younger (≤24 years) or older (≥30 years) age category, and were less likely to be smokers. They showed an increase in the frequency of overweight and an even stronger increase in the frequency of obesity.

We then estimated the adjusted odds ratios for the associations of occupational exposures with preeclampsia and gestational hypertension. Table 4 shows a first series of odds ratios adjusted for the common set of classical covariates (age, parity, history of abortion, body mass index, smoking, education, and leisure-time physical activity). The second series of odds ratios in the last two columns of table 4 have been adjusted for the common set of covariates, as well as for the other occupational exposures with an adjusted odds ratio in the corresponding column. Only occupational exposures with an

Table 4. Associations between occupational risk factors at the onset of pregnancy and the risks of preeclampsia and gestational hypertension. (95% CI = 95% confidence intervals)

Occupational exposure	Controls (N=4381) (N)	Preeclampsia (N=102) (N)	Gestational hypertension (N=99) (N)	Preeclampsia		Gestational hypertension		Preeclampsia		Gestational hypertension	
				OR [a]	95% CI [a]	OR [a]	95% CI [a]	OR [b]	95% CI [b]	OR [b]	95% CI [b]
Work schedule											
Average number of weekly workhours											
20–34	1303	27	26	1.0	..	1.0	..	·	·	·	·
35–40	2658	64	63	1.2	0.7–1.8	1.2	0.7–1.9	·	·	·	·
>40	420	11	10	1.2	0.6–2.5	1.1	0.5–2.4	·	·	·	·
Workhours varying from week to week											
No	3467	76	76	1.0	..	1.0	..	·	·	·	·
Yes	914	26	23	1.2	0.8–1.9	1.1	0.7–1.8	·	·	·	·
Typical consecutive number of days without a day off											
1–3	463	6	7	1.0	..	1.0	..	1.0	..	1.0	..
4–5	3659	86	85	1.7	0.7–4.0	1.4	0.7–3.1	1.6	0.7–3.8	1.5	0.7–3.3
6–12	194	7	5	2.6	0.8–7.9	1.6	0.5–5.1	3.0	1.0–9.5	1.8	0.5–5.8
Average number of weekly evening workhours (0600 to 2300)											
None	2776	62	66	1.0	..	1.0	..	·	·	·	·
1–6	838	19	19	1.0	0.6–1.7	0.9	0.6–1.6	·	·	·	·
7–32	747	19	12	1.1	0.7–1.9	0.7	0.4–1.3	·	·	·	·
Average number of weekly night workhours (2300 to 0600)											
None	3888	89	86	1.0	..	1.0	..	·	·	·	·
≥1	473	11	11	1.0	0.5–2.0	1.0	0.5–2.0	·	·	·	·
Work postures											
Number of hours spent walking [c]											
<2	1882	43	47	1.0	0.5–1.8	1.5	0.8–2.9	·	·	·	·
2 to <3	676	15	11	1.0	..	1.0	..	·	·	·	·
≥3	1806	44	41	1.0	0.6–1.9	1.3	0.7–2.6	·	·	·	·
Number of consecutive hours spent standing at the same place, without walking [c]											
0	2694	48	65	1.0	..	1.0	..	1.0	..	1.0	..
>0 to <1	1237	32	25	1.4	0.9–2.2	0.8	0.5–1.3	1.3	0.8–2.1	0.7	0.4–1.2
≥1	404	21	8	2.9	1.7–5.0	0.7	0.4–1.6	2.5	1.4–4.6	0.7	0.3–1.6
Number of hours spent squatting or kneeling [c]											
0	3031	63	71	1.0	..	1.0	..	1.0	..	1.0	..
>0 to <1	875	22	13	1.2	0.7–2.0	0.6	0.3–1.2	1.2	0.7–2.0	0.5	0.3–1.0
≥1	429	17	15	1.8	1.0–3.1	1.4	0.8–2.6	1.5	0.8–2.7	1.1	0.6–2.2
Number of hours spent with arms above shoulder level [c]											
0	2902	68	63	1.0	..	1.0	..	·	·	·	·
>0 to <1	481	8	9	0.7	0.3–1.5	0.9	0.4–1.8	·	·	·	·
≥1	941	26	26	1.1	0.7–1.8	1.2	0.7–1.9	·	·	·	·
Number of hours spent with back bent forward [d]											
0	2509	50	60	1.0	..	1.0	..	·	·	·	·
>0 to <1	837	27	12	1.7	1.0–2.7	0.6	0.3–1.2	·	·	·	·
≥1	972	25	27	1.2	0.7–2.0	1.1	0.7–1.7	·	·	·	·
Occupational physical exertion											
Carrying or lifting loads [d]										·	·
Never	2283	48	47	1.0	..	1.0	..	·	·	·	·
Weight 1–6 kg or frequency 1–9 times/day	1644	39	38	1.1	0.7–1.7	1.1	0.7–1.7	·	·	·	·
Weight ≥7 kg and frequency ≥10 times per day	429	14	14	1.4	0.7–2.5	1.3	0.7–2.5	·	·	·	·
Pushing or pulling objects or persons [c]											
Never	2915	58	59	1.0	..	1.0	..	1.0	..	1.0	..
<5 times per day	533	12	9	1.1	0.6–2.1	0.8	0.4–1.6	0.9	0.5–1.8	0.9	0.5–2.0
≥5 times per day	929	31	31	1.6	1.0–2.5	1.6	1.0–2.5	1.2	0.7–2.1	1.9	1.1–3.1
Climbing stairs [d] (daily frequency)											
Never	2275	40	57	1.0	..	1.0	..	1.0	..	1.0	..
1–4	956	24	20	1.5	0.9–2.6	0.9	0.5–1.5	1.7	1.0–2.9	0.8	0.5–1.4
5–9	554	21	8	2.5	1.4–4.3	0.7	0.3–1.4	2.3	1.2–4.1	0.6	0.3–1.3
≥10	589	17	14	1.9	1.0–3.3	1.1	0.6–2.0	1.9	1.0–3.5	0.9	0.5–1.8

(continued)

Table 4. Continued.

Occupational exposure	Controls (N=4381) (N)	Preeclampsia (N=102) (N)	Gestational hypertension (N=99) (N)	Preeclampsia		Gestational hypertension		Preeclampsia		Gestational hypertension	
				OR [a]	95% CI [a]	OR [a]	95% CI [a]	OR [b]	95% CI [b]	OR [b]	95% CI [b]
Work environment exposures											
Noisy environment [d]											
No	3725	87	85	1.0	..	1.0	..	.	.	.	.
Yes	655	15	14	0.9	0.5–1.6	0.9	0.5–1.6	.	.	.	.
Extreme temperatures [e]											
Never or rarely	3792	80	80	1.0	..	1.0	..	.	.	.	.
Frequently or always	589	22	19	1.6	1.0–2.6	1.3	0.8–2.2	.	.	.	.
Whole-body vibration (any exposure)											
No	4070	92	91	1.0	..	1.0	..	1.0	..	1.0	..
Yes	305	10	8	1.4	0.7–2.8	1.1	0.5–2.2	1.2	0.6–2.5	0.9	0.4–2.2
Work organization and job strain											
Break during half-day work [c]											
Always or most often and opportunity to choose the time	1276	20	27	1.0	..	1.0	..	1.0	..	1.0	..
Always or most often but no opportunity to choose the time	1194	33	27	1.8	1.0–3.2	1.1	0.6–1.9	1.3	0.7–2.5	1.0	0.6–1.9
Never or rarely	1894	46	43	1.7	1.0–2.9	1.2	0.7–2.0	1.5	0.9–2.7	1.2	0.7–2.1
Forced pace, piece work or assembly-line work											
No	4081	91	90	1.0	..	1.0	..	1.0	..	1.0	..
Yes	292	11	9	1.6	0.8–3.1	1.1	0.5–2.4	1.5	0.7–3.4	0.9	0.4–2.1
Job strain according to Karasek's model											
Low demand–high latitude	973	14	25	1.0	..	1.0	..	1.0	..	1.0	..
Low demand–low latitude	1129	24	23	1.4	0.7–2.7	0.7	0.4–1.3	1.3	0.6–2.7	0.7	0.4–1.4
High demand–high latitude	1175	29	19	1.8	0.9–3.4	0.6	0.4–1.2	1.7	0.8–3.2	0.6	0.3–1.1
High demand–low latitude	1067	33	32	2.1	1.1–3.9	1.1	0.6–1.9	1.7	0.8–3.3	1.0	0.6–1.9

[a] Adjusted for age, parity, history of abortion, level of education, body mass index, smoking, leisure-time physical activity.
[b] Adjusted for age, parity, history of abortion, level of education, body mass index, smoking, leisure-time physical activity, and the other occupational exposures with an odds ratio in this column of the table.
[c] Average number during a typical workday.
[d] Usually, to be heard by someone at 2 meters: could speak normally (not exposed), had to speak loudly or shout (exposed).
[e] High temperature producing sweating in most people or low temperature obliging people to wear a coat.

adjusted odds ratio equal to or above 1.20 or equal to below 0.80 were kept in this latter analysis.

Most of the occupational variables examined showed odds ratios between 1.00 and 1.20 (nonsignificant) for the association with preeclampsia, whether in the crude or adjusted analyses. The associations with gestational hypertension were usually even weaker. Most of the adjusted associations were slightly weaker than the corresponding crude ones.

Work schedule

The average number of weekly workhours and other characteristics of the work schedule, such as working during evening or night, were similarly distributed among the cases and controls. The number of consecutive workdays without a day off was strongly associated with preeclampsia. The adjusted odds ratio for preeclampsia was 3.0 for 6–12 days when compared with the value for less than 4 days, and a dose–response relation was observed (test for trend, P=0.064). Such increased risk was also found for gestational hypertension, but the corresponding odds ratios were lower.

Work postures

Spending time walking did not influence the risk of preeclampsia or gestational hypertension. In contrast, spending time standing without walking was related to a higher risk of preeclampsia, and this association showed a dose–response relation (test for trend, P=0.003). The women who spent consecutively at least 1 hour daily in such a posture experienced a particularly increased risk of preeclampsia (aOR 2.5). There was no such association with gestational hypertension. The influence of squatting or kneeling on the risk of preeclampsia was moderate and nonsignificant. Spending time with arms above the shoulders was not associated with the outcomes.

Occupational physical exertion

Carrying or lifting loads of at least 7 kilograms at least 10 times a day was related to an increased risk for preeclampsia before other occupational exposures were taken into account (aOR 1.4). However, after other occupational exposures were introduced into the regression model, carrying or lifting loads was not associated with a higher risk for either outcome (aOR <1.2). In contrast, pushing or pulling objects or persons at least five times a day was slightly associated with preeclampsia (aOR 1.2) and more strongly in relation to gestational hypertension (aOR 1.9). The women who climbed stairs had approximately twice the odds of experiencing preeclampsia as compared with the women who never did. No regular increase in the adjusted odds ratio with level of exposure was observed. Climbing stairs was not related to gestational hypertension.

Work environment exposures

Whole-body vibration slightly increased the risk of preeclampsia (aOR 1.2), but this association was not significant. Noise and extreme temperatures were not associated with the outcomes.

Job strain and workbreaks

The women who never or rarely had a workbreak, those who had no control of the time of their breaks, and those working with a forced pace or in piecework or on an assembly line tended to experience an increased risk of preeclampsia. The adjusted odds ratio for preeclampsia was 1.7 (nonsignificant) for the women with high job strain (high demand–low latitude) when they were compared with those with low job strain (low demand–high latitude). Social support by colleagues and by superiors did not modify the association (not shown). In contrast, job strain did not increase the risk of gestational hypertension.

There was no interaction between weekly workhours, job strain, and the number of consecutive days of work without a day off on one hand and the other occupational variables on the other.

Preventive withdrawals were frequently used. Nearly half of the preventive withdrawals occurred before 20 weeks of gestation. Of the control women, 17.7% benefited from a preventive withdrawal before 20 gestational weeks (21.6% of preeclamptic women and 24.2% of the women with gestational hypertension). Another 8.7% of the control women used preventive reassignments or personal arrangements with employers instead of preventive withdrawal before 20 weeks (9.8% of the women with preeclampsia and 8.1% of the women with gestational hypertension). The adjusted odds ratios for preeclampsia were similar whether the exposed women benefited from a preventive withdrawal before 20 weeks of pregnancy or remained exposed for a longer period.

Except for workbreaks, the associations had a similar magnitude when self-reported preeclampsia was used as the outcome instead of self-reported hypertension plus proteinuria in our final model. No association was found between control of the time of workbreak and self-reported preeclampsia.

Discussion

This study suggests that physically demanding occupational conditions (such as pushing or pulling objects or persons, climbing stairs) and strenuous postures (such as standing for long periods without walking, squatting or kneeling) at the onset of pregnancy increase the risk of preeclampsia. Job strain, forced pace, no breaktime or no control of breaktime, and a high number of consecutive workdays were also related to a higher risk of preeclampsia, although statistical significance was not achieved for some of these exposures.

On the whole, the literature on the impact of occupational physical activity on pregnancy-induced hypertension is sparse, the methods used are poorly described, and findings are inconsistent (table 1). Most of the previous studies had insufficient power to detect associations with preeclampsia, did not distinguish between preeclampsia and gestational hypertension, used very imprecise definitions of physical activity, did not control for the confounding effect of other occupational exposures, and did not take account of the level of exposure. We were able to assess dose–response effects, as we quantified the amount of exposure. This was not the case in several previous studies in which very crude yes or no questions were used to assess physical activity at work (table 1). In addition, our study took several occupational exposures into account in the analyses simultaneously, and only two previous studies have followed the same procedure (10, 22). Most previous studies did not distinguish between preeclampsia and gestational hypertension, or even between hypertension and pregnancy-induced hypertension (table 1). In contrast, we analyzed preeclampsia and gestational hypertension separately. This approach was critical because it is still unknown whether the two entities have a common etiology and because misclassification with essential hypertension may be more frequent for gestational hypertension than for preeclampsia. The weaker patterns of associations found for gestational hypertension in this study are consistent with gestational hypertension being a mix of mild forms of preeclampsia and of misclassified latent essential hypertension. Although power was not outstanding in our study, it was better than for most earlier studies. Several of them had a very small number of preeclampsia cases. Only one included more women than our study did (25), and only 4 of 12 included more cases of preeclampsia (10, 11, 23, 26). Of these four studies, none fully adjusted for other occupational exposures as we did.

Among the limited number of studies that assessed the impact of physical activity on the risk of pregnancy-induced hypertension, the ways to measure physical activity varied a great deal. Some used yes or no questions about physical activities at work, while others used composite measures of physical exertion, such scores based on job titles (25, 29) or based on summing yes or no items (8). Ways to combine exposures in order to define physical exertion were not standardized. The use of disparate definitions of physical activity at work certainly accounts for inconsistencies among the findings.

Four studies used a composite measure of occupational physical activity during pregnancy in relation to preeclampsia (8, 11, 23), gestational hypertension (8), or pregnancy-induced hypertension (24). Nurminen et al (24) built a score for physical workload reflecting energy expenditure from the description of worktasks. Spinillo et al (11) combined physical intensity (not defined), posture, and number of workhours. Landsbergis & Hatch (8) estimated physical work demands as the sum of a person's responses to five items (climbing or balancing, lifting or carrying, pulling or pushing objects, moving around a lot, exerting physical effort, sitting or standing in uncomfortable positions for long periods). In a last report, no definition of physical activity at work was provided (23). Of these four studies, only one reported a positive association (11).

Few studies have considered specific aspects of physical activity at work separately, as in our study. A limited number of exposures was usually examined, and the exposure levels were often not reported. Only two studies (10, 26) are comparable with ours in the way to define exposures. They assessed the effect of several aspects of physical activity on preeclampsia separately and quantified the level of exposure. Only one of them examined a large number of exposures related to physical activity at work as we did. This study also suggested that physical exertion and strenuous postures during pregnancy increase the risk of preeclampsia (10).

Carrying heavy loads was found to be associated with hypertension (19–22) or preeclampsia (10) in four studies. In our study, carrying heavy loads was no longer associated with preeclampsia (OR <1.2) once other occupational exertion, such as pushing or pulling objects, was taken into account. This contrast with previous studies may reflect a low level of exposure to carrying heavy loads in this population.

In two French studies, prolonged standing was related to a higher risk of hypertension during pregnancy (19–21). This finding contrasts with those of other studies in which prolonged standing was associated with a decreased (10) or unchanged (22, 23) risk of preeclampsia (10, 23) and high blood pressure during pregnancy (22). None of these studies distinguished between standing with and without walking, and this lack of distinction may account for the inconsistencies. A few studies used more-specific definitions for exposure. A case–control study in Quebec found frequent walking during occupational activities to be associated with a reduced risk of preeclampsia (aOR 0.61) (26). In line with this finding, a recent study from the United States reported that women with jobs involving more time standing or walking than sitting had a nonsignificantly reduced risk for preeclampsia but not for gestational hypertension (27). Interestingly, Estryn et al (21) found that long periods of standing without moving were associated with an elevated risk of preeclampsia, whereas prolonged standing alone was not; this finding is similar to our own observations. This body of literature is compatible with studies suggesting that leisure-time physical activity, which includes walking, jogging, and swimming, may be protective against preeclampsia and gestational hypertension (26–28). Unfortunately, we did not have enough details on leisure-time physical activity in this study to assess its impact on pregnancy-induced hypertension accurately.

Overall, the findings of our study and also from previous ones suggest that physical effort, such as carrying or pushing and pulling heavy loads may be deleterious. In addition, they suggest that standing per se may not be deleterious, while standing without moving may be.

In our study, as in previous ones, night work (19, 20, 22), shift work (10, 23), high temperature (22, 23), and noise (10, 23) were not related to the risk of preeclampsia (10, 23) or high blood pressure during pregnancy (19, 20, 22). Whole-body vibration and piecework or assembly-line work were slightly associated with preeclampsia in our study; this finding differs somewhat from that of two previous studies, in which no impact was found on high blood pressure during pregnancy (22) or preeclampsia (23).

Two studies from Norway reported that women who have control on their workpace and workbreaks experience a reduced risk of preeclampsia (10, 36). Our results were very similar, although not statistically significant. As regards job strain, our findings are consistent with previous observations in several aspects as well. The women with high job strain experienced a 66% increase in their risk for preeclampsia; this finding resembles the association found in previous publications reporting adjusted odds ratios ranging from 1.6 (8) to 2.1 (7, 18). As in our study, Marcoux et al (18) found that the association with job strain was stronger for preeclampsia (aOR 2.1) than for gestational hypertension (aOR 1.3). Therefore, overall, our findings, that the lack of control on workpace (including the absence of breaks or the lack of control on the time of breaks and external pacing) and job strain increase the risk of preeclampsia are consistent with the results of previous studies.

In this study, occupational exposures were measured at the onset of pregnancy. As many as 18% of the control women benefited from a preventive withdrawal before 20 weeks of gestation. Moreover, the women without preventive withdrawal may have reduced their level of exposure through other preventive measures, such as preventive reassignments or personal arrangements with employers. This action occurred for 9% of the controls. Such preventive measures were even more frequent among those heavily exposed. Nevertheless, we could verify that at least half of the women exposed to our main occupational exposures did not have any preventive measure before 20 gestational weeks.

We found that women exposed at the onset of pregnancy are at higher risk of preeclampsia even when they benefit from preventive withdrawal before 20 weeks of gestation. In Quebec, preventive withdrawal is implemented on the basis of occupational conditions and should be independent of health status. However, it is likely that, for some women, health status influences the decision to implement a preventive withdrawal. In addition, women who are more heavily exposed may be more likely to have access to preventive withdrawal. We excluded women with chronic diseases predisposing to preeclampsia, such as chronic renal diseases. In addition, we adjusted odds ratios for risk factors of preeclampsia, such as obesity. However, residual biases leading to an underestimation of the protective effect of preventive withdrawal on the frequency of preeclampsia cannot be discarded, and this result must be interpreted cautiously.

Being exposed during early pregnancy may be sufficient for a higher risk of preeclampsia. This finding is consistent with the pathological process of preeclampsia. Although its clinical signs occur in the second half of pregnancy, the pathological process leading to preeclampsia starts early in pregnancy during the period of placentation (37). We may thus hypothesize that occupational exposures could be a trigger for preeclampsia during the period of early placentation. However, these observations were based on a limited number of persons and should be interpreted cautiously.

Our study had limitations. First, although its sample size was larger than most previous studies on the topic, it had limited power. As in most studies on the topic, occupational exposures and outcomes were self-reported retrospectively. Nevertheless, expected associations with recognized risk factors for preeclampsia and gestational hypertension were found (table 3). In addition, the pregnancy outcomes of the two case groups differed as expected (table 2). In our low-risk study population, we found that 2.2% of the women had preeclampsia and 2.2% had gestational hypertension. In other published population-based studies, gestational hypertension occurred in 5–8% of all pregnant women, and preeclampsia occurred in 2–8% of all pregnant women (2, 38–42). The frequency found in our study is thus in the lower range of published population-based figures; this situation suggests that our study included few false positive cases. Finally, the main results could be reproduced with an alternate more-specific definition of outcome. This result provides reassurance of the validity of our outcome data. Some degree of nondifferential misclassification is likely and may have led to an underestimation of the true magnitude of the associations. Differential misclassification whereby women would report more preeclampsia and gestational hypertension and also worse work conditions cannot be excluded. It is unlikely, however, as the primary focus of the study was not on preeclampsia or gestational hypertension (32).

A "healthy worker effect" cannot be disregarded. The women who were the most heavily exposed to physical effort may be those who were better fit and at lower risk for adverse pregnancy outcome. If present, such bias would also produce an underestimation of the association between occupational physical activity and preeclampsia.

Several observations support the biological plausibility of a link between job strain or strenuous physical activity and pregnancy-induced hypertension. Preeclampsia is characterized by oxidative stress (43). Prolonged or strenuous physical exercise has been suggested to be detrimental to health through the induction of oxidative stress (44, 45). Strenuous exercise enhances the accumulation of secondary products of lipid peroxidation (37) and the formation of free radicals and other reactive oxygen species (45–47). A recent study compared surgery room nurses, whose work involves prolonged standing without moving, with outpatient department nurses, who can walk during their worktime (48). Interestingly, the surgery room nurses had significantly higher mean levels of reactive-oxygen-species after work. Therefore, if causal, the harmful effect of long periods of standing without walking on preeclampsia may be mediated by an elevated oxidative stress.

Preeclampsia is also characterized by decreased uteroplacental blood flow (37) and increased peripheral vascular resistance, which is in part mediated by overactivity sympathetic system (49). Doppler studies indicate an increase in uteroplacental vascular resistance with physical exertion (4). Both stress and strenuous physical exertion activate the sympathetic nervous system and therefore lead to the release of catecholamines and vasoconstriction, which, in turn, may have a detrimental effect on uteroplacental blood flow (50–52). Our findings that both physically demanding and stressful work conditions increase the risk of preeclampsia are in line with Hogue's hypothesis that hard physical work represents a set of acute physical stressors stimulating biophysical responses, which are similar to emotional stress (53).

In conclusion, this study suggests that occupational physical exertion, long lasting static postures, lack of control on workpace, and job strain at the onset of pregnancy increase the risk of preeclampsia.

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Appendix

Information collected on work conditions

Group of occupational exposure	Questions
Work schedule	
Weekly workhours	Unchanging or varying from week to week—average, minimum and maximum number
Workdays per week	Unchanging or varying from week to week—average, minimum and maximum number
	Typical consecutive number of days without a day off
Daily workhours	Number of hours in a typical workday
	Time at onset and end of a typical workday
	If several schedules: time at onset and end of a workday in the other schedules
	Time at onset and end of breaks
Type of schedule	Unchanging work, shift work or irregular work
Work postures	
Sitting	Time spent sitting during typical workday
	Average time spent sitting consecutively during typical workday
	Possibility to stand-up when sitting for long periods of time (never or nearly never, sometimes, quite often, whenever needed)
Standing	Time spent standing (whether on the same place or walking) during typical workday
	Average time spent consecutively standing without sitting or having a break, during typical workday
	Possibility to sit when standing (whether on the same place or walking) for long periods of time (never or nearly never, sometimes, quite often, whenever needed)
	Time spent standing at the same place during a typical workday
	Time spent consecutively standing at the same place, without walking or sitting during a typical workday
Walking	Time spent walking during a typical workday
Other postures	Time spent with arms above shoulder level during a typical workday
	Time spent with back bent forward during a typical workday
	Time spent squatting or kneeling during a typical workday
	Time spent in any other uncomfortable posture—describe
Physical exertion at work	
	Daily frequency of pushing or pulling objects or persons during a typical workday
	Daily frequency of carrying or lifting loads during a typical workday
	Average weight of the load carried or lifted
	Daily frequency of climbing stairs
Work organization, job strain and social support at work	
	Break during half-day work (never, rarely, most often, always)
	Choice of the time of the break (yes, no)
	Forced pace, piece work or assembly-line work (yes, no)
	Items required to measure job strain through the Karasek "Job Content Questionnaire"[a]
	French validated version of the Karasek social support scale questionnaire[b]
Work environment exposures	
	Usually, to be heard by someone at 2 meters: could speak normally, had to speak loudly or shout
	Whole-body vibration (eg, from driving a vehicle or using machines with vibration), weekly hours of exposure
	High temperature producing sweating in most people (never, rarely, often, always)
	Low temperature obliging people to wear a coat (never, rarely, often, always)

[a] Reference: Karasek RA. Job content questionnaire and user's guide. Los Angeles (CA): Department of Industrial and System Engeneering, University of Southern California; 1985.

[b] Reference: Brisson C, Blanchette C, Guimont C, Dion G, Moisan J, Vezina M. Reliability and validity of the French version of the 18-item Karasek Job Content Questionnaire. Work Stress. 1998;12:322–36.