Scand J Work Environ Health 1995;21(6):412-418

<https://doi.org/10.5271/sjweh.56>

Issue date: Dec 1995

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by [Fortier I](#), [Marcoux S](#), [Brisson J](#)

Key terms: [fetal growth](#); [maternal employment](#); [pregnancy outcome](#); [preterm birth](#)

This article in PubMed: www.ncbi.nlm.nih.gov/pubmed/8824746

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Maternal work during pregnancy and the risks of delivering a small-for-gestational-age or preterm infant

by Isabel Fortier, PhD,¹ Sylvie Marcoux, PhD,¹ Jacques Brisson, DSc¹

Fortier I, Marcoux S, Brisson J. Maternal work during pregnancy and the risks of delivering a small-for-gestational-age or preterm infant. *Scand J Work Environ Health* 1995;21:412–8.

Objective The objective of this study was to assess the relation of some maternal job characteristics to the risks of delivering a small-for-gestational-age or preterm infant.

Methods Altogether 4390 women who lived in Quebec City, Canada, and the surrounding area, and who gave birth between January and October 1989 to a singleton liveborn neonate were included. Information on gestational age at delivery, job characteristics, nonoccupational physical activities, and several potential confounders was obtained in a telephone interview a few weeks after the delivery. Birthweight was recorded from the birth certificate.

Results The risk of having a small-for-gestational-age infant (birthweight lower than the 10th percentile for gestational age and gender) was increased among the women who worked at least 6 h a day in a standing position. The adjusted odds ratios (OR) were 1.00, 1.13 [95% confidence interval (95% CI) 0.83–1.55], and 1.42 (95% CI 1.02–1.95) for the women working in a standing position < 3, 3–5, and ≥ 6 h a day, respectively. The risk for a small-for-gestational-age infant also slightly increased as the gestational age at work cessation increased. A modest increment in the risk of delivering preterm (OR 1.45, 95% CI 0.84–2.49) was observed for the women working regularly in the evening or at night. Physical effort, lifting heavy objects, and long workhours were not related to either a small-for-gestational-age or a preterm infant.

Conclusions The results indicate that prolonged standing and working late into pregnancy may increase the risk of delivering a small-for-gestational-age infant, whereas regular evening or night work may be a risk factor for preterm birth.

Key terms fetal growth, maternal employment, pregnancy outcome, preterm birth.

Despite years of investigation, the effect of maternal work during pregnancy on fetal growth and preterm birth remains unclear. Several epidemiologic studies (1–25) have assessed the relation of prolonged standing, the lifting of heavy objects, long hours of work, shiftwork, or high physical demand to these birth outcomes. However, the results have been inconsistent. For instance, of seven studies of prolonged standing position at work in relation to fetal growth (1, 2, 10, 18, 20, 21, 23), three showed no association (2, 18, 21), whereas four reported either a statistically significant (1, 20) or nonsignificant (10, 23) reduction in fetal growth with prolonged standing. An association between physical effort and preterm birth (4, 10, 15, 22) or fetal growth (10) has been observed by some authors but in other studies physical effort was not related to preterm birth (7–9, 12, 18, 21, 23, 24) or fetal growth (21, 23, 24). Although informa-

tion on job characteristics was collected prospectively in some studies (15, 17, 18, 20, 21, 23) and retrospectively in others (1–6, 8, 9, 11–13, 19, 24), associations have been found regardless of that aspect of study design. However, other study characteristics could explain discrepancies in the study results. Studies have been carried out in different settings. As work conditions vary over time and from place to place, apparently identical job characteristics may in fact entail different risks. Moreover, the determination of the job characteristics was sometimes based only on the job title (1, 6, 15, 23, 24) and could potentially lead to an underestimation of effect. The definitions and categories of exposures differed much between the studies, as did the reference groups. Unemployed women (19, 21) have sometimes been included in the reference category. In many studies, the exposures were only dichotomized (6, 7, 9, 11, 12, 20,

¹ Groupe de Recherche en Épidémiologie de l'Université Laval (Laval University Epidemiology Research Group), Quebec, Canada.

Reprint requests to: Dr Sylvie Marcoux, Groupe de Recherche en Épidémiologie de l'Université Laval, Centre de Recherche, Hôpital du Saint-Sacrement, 1050 Chemin Sainte-Foy, Québec, Qc, Canada G1S 4L8.

23), and hence no dose-relation could be assessed. Few authors took into account the influence of gestational age at work cessation when assessing the effect of job characteristics on pregnancy outcome (1, 17). Some authors focused on a single or a few specific job characteristics (1, 6, 17, 19, 23) and thus failed to take into account the possible confounding or modifying effect of other occupational factors. Finally, only a few studies have considered nonoccupational physically demanding activities (1, 3, 6, 18, 20, 21).

The objective of our analysis was to assess further the relation between selected job characteristics and risks of delivering a small-for-gestational-age or preterm infant. As a secondary objective, we wanted to explore the influence of gestational age at work cessation on the associations.

Subjects and methods

The women in this study were those who participated in our study on caffeine and birth outcomes (26). Eligible women were those residing in the territory of six community health departments of Quebec City and the surrounding area and who gave birth between 1 January and 15 October 1989 to a liveborn singleton weighing at least 500 g. Soon after delivery, the community health departments sent us a copy of the birth certificates of newborns of mothers under their jurisdiction.

The mothers were called by a trained interviewer, and a telephone interview was carried out with those who agreed to participate. The median interval from delivery to interview was six weeks. The mothers who were employed during pregnancy were asked to specify the job title, when they had started and stopped working during pregnancy, the number of hours per week they had worked, and their work schedule. They also had to rate, on an ordinal scale, the daily number of hours in a standing position (< 3, 3–5, ≥ 6 h), whether they had to lift objects at work (0, 1–9, ≥ 10 kg, weight unknown) and their perception of the physical effort required by their job (none, weak, moderate, important). Questions on nonoccupational activities included a list of 19 leisure-time physical activities and two open-ended questions on other sports and on demanding housework activities. Finally, information was collected on several potential confounders.

Birthweight was recorded from the birth certificate. The duration of pregnancy was estimated from a comparison of the actual date of delivery with the expected date of confinement. The latter was reported by the mother and had been determined by the physician taking into account both the date of the last menses and the clinical and ultrasonographic evaluations. Gestational age was

also available on the birth certificate for 88% of the participants. For 97% of these women, the gestational age based on the interview data closely agreed (within one week) with the gestational age recorded on the birth certificate. Neonates were said to be small for their gestational age if their birthweight was below the 10th percentile of the birthweight distribution specific for their gender and gestational age, according to Canadian standards (27). Preterm newborns were those whose birth occurred before 37 completed weeks of pregnancy.

Of the 9226 women who delivered during the study period and who were eligible for our study on caffeine and birth outcomes (26), 1800 were not referred to the study because the community health departments failed to do so, 262 could not be reached, 78 refused to participate, and 61 were not interviewed for miscellaneous reasons. Thus interviews were completed on 7025 women. There were little or no differences between the interviewed and noninterviewed women with respect to age, parity, education, birthweight, and duration of pregnancy. Among the interviewed women, 2635 were excluded: 2360 were unemployed at the onset of pregnancy, 207 had two jobs and the total exposure resulting from both jobs could not be estimated, and 68 had missing information on some occupational or confounding variables. This left 4390 women in the analysis. Adjusted odds ratios (OR) were obtained by logistic regression. Variables considered as a priori potential confounders were age, parity, history of low birthweight or preterm delivery, education, family income, prepregnancy weight, height, alcohol and caffeine intake, active and passive smoking, and energy expenditure in nonoccupational activities. These variables were entered as covariates in the models. Then variables were deleted if such deletion had virtually no effect on the adjusted odds ratio relating the exposure to the end point. Trends were tested by entering, in the regression model, a single categorical variable that took a different value according to the category of exposure (eg, 1, 2 or 3 for women working in a standing position < 3, 3–5, or ≥ 6 h a day).

Results

The associations between the job characteristics and the risk of giving birth to a small-for-gestational age infant are shown in table 1. The odds ratio increased with the number of hours in a standing position (test for trend: $X^2=4.42$, $P=0.04$). Compared with women who worked upright < 3 h a day, those standing 3–5 h or ≥ 6 h a day had an adjusted odds ratio of 1.13 and 1.42, respectively. The latter was statistically significant (95% CI 1.02–1.95). The lifting of objects, nightwork or shiftwork, long hours of work and physical effort at work were not

related to the risk of having a small-for-gestational-age infant. The only other variable which was moderately associated with the risk of delivering a small-for-gestational-age infant was gestational age at work cessation. The odds of having a small-for-gestational-age infant for women who worked for 16–23, 24–31, and 32 weeks or more were, respectively, 1.09, 1.24, and 1.30 times the corresponding odds for women who left work before 16 weeks (test for trend: $X^2 = 2.21$, $P = 0.13$). When prolonged standing was considered jointly with gestational age at work cessation, the odds ratio increased consistently across the levels of each variable, and it was statistically significant (OR 1.91, 95% CI 1.12–3.25)

for the women who worked until at least 24 weeks of gestation in a job involving standing for ≥ 6 h a day (table 1).

We explored the joint effect of standing and prepregnancy weight on the risk of having a small-for-gestational-age infant (data not shown). Women weighing at least 50 kg before pregnancy and working upright less than 3 h a day constituted the reference category. The odds ratios were adjusted for height and confounders. (See footnote a of table 1.) The adjusted odds ratios of having a small-for-gestational-age infant were 1.00, 1.06 (95% CI 0.73–1.52), and 1.21 (95% CI 0.85–1.73) for women who worked in an upright posture < 3, 3–5, and

Table 1. Crude and adjusted odds ratios of having a small-for-gestational-age (SGA) infant by job characteristics, Quebec City, 1989.

Job characteristics	N	% SGA	Crude odds ratio	Adjusted odds ratio	95% confidence interval
Standing (hours/day) ^a					
< 3 ^b	2160	8.56	1.00	1.00	.
3–5	888	9.23	1.09	1.13	0.83–1.55
≥ 6	1342	12.30	1.50	1.42	1.02–1.95
Lifting objects ^a					
None ^b	2500	9.04	1.00	1.00	.
1–9 kg	876	10.50	1.18	1.03	0.77–1.38
≥ 10 kg	578	10.90	1.23	1.03	0.71–1.51
Unknown	436	11.70	1.33	1.11	0.75–1.65
Work schedule ^a					
Day only ^b	3144	9.32	1.00	1.00	.
Evening or night only	272	11.03	1.21	0.98	0.63–1.53
Shiftwork	974	11.19	1.23	0.98	0.75–1.27
Hours worked/week ^a					
< 30 ^b	880	8.41	1.00	1.00	.
30–39	2557	10.05	1.22	1.11	0.82–1.49
≥ 40	953	10.60	1.29	0.99	0.70–1.39
Physical effort ^a					
None ^b	801	8.99	1.00	1.00	.
Weak	1110	8.29	0.92	0.89	0.63–1.24
Moderate	1451	10.48	1.19	1.00	0.70–1.43
Important	1028	11.28	1.29	0.87	0.56–1.35
Gestational age at work cessation (weeks) ^a					
< 16 ^b	444	10.14	1.00	1.00	.
16–23	561	11.23	1.12	1.09	0.72–1.67
24–31	1030	11.17	1.11	1.24	0.85–1.82
≥ 32	2355	8.87	0.86	1.30	0.89–1.89
Standing (h · d ⁻¹) by gestational age at work cessation (weeks) ^c					
< 3					
Gestational age < 24 weeks ^b	271	8.12	1.00	1.00	.
Gestational age ≥ 24 weeks	1889	8.63	1.07	1.43	0.88–2.34
3–5					
Gestational age < 24 weeks	194	9.28	1.16	1.38	0.70–2.73
Gestational age ≥ 24 weeks	694	9.22	1.15	1.56	0.91–2.66
≥ 6					
Gestational age < 24 weeks	540	12.59	1.63	1.69	0.96–2.97
Gestational age ≥ 24 weeks	802	12.09	1.56	1.91	1.12–3.25

^a The regression model included the first six job characteristics of the table and education (< 12, 12, 13–16, ≥ 17 years), smoking (0, 1–10, ≥ 11 cigarettes per day), energy expenditure from nonoccupational activities (quartiles), pregravid weight (< 50, 50–59, 60–69, ≥ 70 kg), height (< 160, 160–169, ≥ 170 cm), parity and previous low birthweight newborn (primiparae, multiparae with no previous low birthweight newborn, multiparae with previous low birthweight newborn).

^b Reference category.

^c The regression model included five dummy variables for joint exposure to standing and gestational age at work cessation, other job characteristics [lifting objects, work schedule, hours worked per week, physical effort (same categories as in the table)] and the other covariates mentioned in footnote a.

≥ 6 h a day and weighed 50 kg or more before pregnancy. The corresponding odds ratios for the women whose pregravid weight was lower than 50 kg were 1.51 (95% CI 1.07–2.14), 1.87 (95% CI 1.16–3.03), and 2.69 (95% CI 1.79–4.05), respectively. The latter odds ratios (1.87 and 2.69) were higher than those expected according an additive model, which would be 1.57 (1.51 + 1.06 – 1) and 1.72 (1.51 + 1.21 – 1), respectively.

Table 2 shows the relations of the job characteristics to preterm delivery. Prolonged standing, lifting objects, physical effort, or shiftwork did not increase the risk of preterm delivery. However, a modest association was observed between regular evening or night work and preterm birth. The adjusted odds of preterm birth was 1.45 times higher (95% CI 0.84–2.49) for the women

working during evenings or nights without changing shift than for the women always working in the daytime. When gestational age at work cessation was also considered, working regularly during evenings or nights increased significantly the risk of preterm birth for the women who continued working after 23 weeks of pregnancy. In the latter group, the adjusted risk of preterm birth was 1.96 times higher than for the women who had a daytime job and who stopped working before 24 weeks of pregnancy. There was no consistent trend between the odds ratio of preterm birth and the number of hours worked per week. The risk of preterm birth was higher for the women who worked 30–39 h a week than for the women working less than 30 h a week, but then the risk decreased with longer workhours.

Table 2. Crude and adjusted odds ratios of preterm birth (PTB) by job characteristics, Quebec City, 1989.

Job characteristics	N	Preterm birth (%)	Crude odds ratio	Adjusted odds ratio	95% confidence interval
Standing (hours/day) ^a					
< 3 ^b	2160	5.56	1.00	1.00	
3–5	888	4.39	0.78	0.78	0.52–1.19
≥ 6	1342	5.66	1.02	0.88	0.59–1.33
Lifting objects ^a					
None ^b	2500	5.24	1.00	1.00	
1–9 kg	876	5.59	1.07	0.96	0.66–1.41
≥ 10 kg	578	5.19	0.99	0.87	0.52–1.45
Unknown	436	5.73	1.10	0.95	0.56–1.62
Work schedule ^a					
Day only ^b	3144	5.25	1.00	1.00	
Evening or night only	272	6.99	1.36	1.45	0.84–2.49
Shiftwork	974	5.24	1.00	1.03	0.72–1.48
Hours worked per week ^a					
< 30 ^b	880	4.32	1.00	1.00	
30–39	2557	5.87	1.38	1.37	0.92–2.03
≥ 40	953	4.93	1.15	1.14	0.71–1.82
Physical effort ^a					
None ^b	801	5.24	1.00	1.00	
Weak	1110	5.59	1.07	1.20	0.79–1.82
Moderate	1451	5.17	0.99	0.95	0.60–1.50
Important	1028	5.45	1.04	0.87	0.49–1.54
Gestational age at work cessation (weeks) ^a					
< 16 ^b	444	5.18	1.00	1.00	
16–23	561	5.35	1.03	0.99	0.56–1.75
24–31	1030	9.51	1.93	1.93	1.20–3.12
≥ 32	2355	3.57	0.68	0.63	0.38–1.04
Work schedule by gestational age at work cessation (weeks) ^c					
Day only or shiftwork					
Gestational age < 24 weeks ^b	905	5.19	1.00	1.00	
Gestational age ≥ 24 weeks	3213	5.26	1.01	1.13	0.79–1.62
Evening or night only					
Gestational age < 24 weeks	100	6.00	1.17	1.13	0.46–2.79
Gestational age ≥ 24 weeks	172	7.56	1.49	1.96	1.00–3.83

^a The regression model included the first six job characteristics of the table and education (< 12, 12, 13–16, ≥ 17 years), smoking (0, 1–10, ≥ 11 cigarettes per day), energy expenditure from nonoccupational activities (quartiles), pregravid weight (< 50, 50–59, 60–69, ≥ 70 kg), height (< 160, 160–169, ≥ 170 cm), parity and previous low birthweight newborn (primiparae, multiparae with no previous low birthweight newborn, multiparae with previous low birthweight newborn).

^b Reference category.

^c The regression model included three dummy variables for joint exposure to work schedule and gestational age at work cessation, other job characteristics [standing, lifting objects, hours worked per week, physical effort (same categories as in the table)] and the other covariates mentioned in footnote a.

Discussion

Our results suggest that working for at least 6 h a day in a standing posture during pregnancy may increase the risk of delivering a small-for-gestational-age neonate. Of seven previous studies (1, 2, 10, 18, 20, 21, 23) on standing and fetal growth, four (1, 10, 20, 23) suggested small increments in the risk of fetal growth retardation with standing jobs although the associations were not always statistically significant (10, 23). Naeye & Peters (1) reported that the mean birthweight of newborns at term was lower when mothers worked in a standing position. In their study, the reduction in birthweight was more important when women continued working into late gestation. In the study by Launer et al (20), the odds ratios for delivering a small-for-gestational-age infant at term were 1.21 (95% CI 1.02–1.44) and 1.28 (95% CI 1.07–1.53), respectively, for Guatemalan mothers who had jobs involving standing or walking rather than sitting. Nurminen et al (10) reported that the relative risk of delivering a small-for-gestational-age infant was 1.4 (95% CI 0.9–2.3) for women engaged in a standing job in the third trimester, but no excess risk was found for jobs mostly involving walking. Finally, in the study by Teitelman et al (23), when women with standing jobs were compared with those engaged in active jobs, the relative risk for delivering a low birthweight newborn (adjusted for gestational age) was 1.58 (95% CI 0.51–4.94). Standing, by reducing venous return, could cause uteroplacental underperfusion and thus alter the supply of oxygen and nutrients to the fetus (28). Supporting this hypothesis is the observation by Naeye & Peters (1), according to which mothers who work in a standing position and who continue working late into gestation have a higher incidence of large placental infarct at term, a condition which has uteroplacental underperfusion as a predisposing factor (29). Altogether, these observations suggest that prolonged standing during pregnancy may affect fetal growth.

Low prepregnancy weight for height is a well known independent risk factor for fetal growth retardation (30). Rauramo & Forss (31) reported that maternal weight was positively correlated with placental blood flow in normal pregnant women. On the basis of these observations, we had hypothesized that the detrimental effect of prolonged standing on fetal growth, if any, could be more pronounced for underweight women. As hypothesized, we observed an interaction between prolonged standing and prepregnancy weight. Tafari et al (32) reported that, among Ethiopian women who had a limited weight gain during pregnancy, the reduction in infant birthweight associated with hard maternal work was more pronounced for women weighing less than 49 kg in early pregnancy than for those weighing 49 kg or over. The interaction between prepregnancy weight and specific

job characteristics such as prolonged standing needs to be further assessed in future studies.

We observed a 45% increment in the risk of preterm birth for women always working during evenings or nights without changing shift compared with women always working during the daytime. After stratification for gestational age at work cessation, this increase in risk appeared to be confined to women who had continued working after 23 weeks of pregnancy. In our study, shiftwork was not related to preterm birth. Previous studies did not allow an examination of the specific effect of regular evening or night work, as we did. Shiftwork (ie, occasional evening or night work) was examined in some studies (9, 12, 13, 19), whereas in others (4, 8, 14) nightwork and shiftwork were lumped together. In the Montreal study (9), shiftwork significantly increased the risk of preterm birth but only for women engaged in the services sector. Mamelie et al (4) reported that shiftwork or nightwork increased the crude risk of preterm birth by 60%, but whether the association persisted after adjustment was unclear. Other studies found no relation between work schedule and preterm birth (8, 12, 19), birth before 40 weeks of gestation (13), or gestational age at delivery (14). If, as suggested by our findings, regular evening or night work is related to preterm birth, whereas shift work is not, the inconsistency of previous results on work schedule and birth outcomes could be explained.

In our study, gestational age at work cessation was related to the risk of delivering a small-for-gestational-age infant. The latter risk slightly increased as women worked later during pregnancy. For preterm birth, we observed a statistically significant increment in risk for women who stopped working between 24–31 weeks of pregnancy and a trend towards a lower risk of preterm birth for women still working at 32 weeks. Results of previous studies are inconsistent, suggesting a higher risk of preterm birth sometimes with early (33, 34), and sometimes with late (35), work leave during pregnancy. Our findings with regard to time at work cessation and preterm birth are likely to be due to selection bias. Indeed, we observed (results not shown), as several others did (6–8), that women with obstetrical risk factors are not only at higher risk of poor pregnancy outcome, but are also more likely to leave their jobs earlier during pregnancy. In addition, premature contractions or rupture of membranes often precede preterm birth, alerting women of their increased risk of preterm delivery and forcing them to leave their job prematurely. This occurrence would explain why the risk of preterm birth is increased among women who leave their work between 24–31 weeks. Healthy pregnant women are probably overrepresented in the group of women who continue working after 31 weeks. Such a “healthy worker effect” would explain the low risk of preterm birth observed for women still working at 32 weeks. Growth retardation on

the other hand, especially if defined as birthweight lower than the tenth percentile, may well remain unsuspected until after delivery. Future observational studies aimed at clarifying the relation between gestational age at work leave and birth outcomes should include information on the indication for work leave. Unfortunately, we did not have such information.

In our view, the associations found in our study are not likely to be due to a differential recall of exposure among women with or without a poor birth outcome. The mothers and the interviewers were not aware of the specific study hypotheses. Moreover, the associations were observed with only a few of the job characteristics and were generally confined to only one of the two birth outcomes. We do not think that our results are explained by a confounding bias. Our results were adjusted for several factors, including parity, which is sometimes viewed as a proxy measure for work load at home, and energy expenditure in nonoccupational physical activities.

In conclusion, our results support the view that prolonged standing and working late into gestation may increase the risk of having a small-for-gestational-age infant. Future studies should distinguish static standing posture from walking because the two may have a different physiological effect on uteroplacental perfusion. Our observation that low prepregnancy weight may modify that association is interesting and warrants further investigation. Our findings also suggest that regular night-work may be related to preterm birth.

Acknowledgments

Drs Marcoux and Brisson were supported by National Health Research Scholar awards from Health and Welfare Canada. The study was funded by the National Health Research and Development Program (NHRDP grant no 6605—3066—53) of Health and Welfare Canada.

References

1. Naeye RL, Peters EC. Working during pregnancy: effects on the fetus. *Pediatrics* 1982;69:724—7.
2. Saurel-Cubizolles MJ, Kaminski M, Rumeau-Rouquette C. Activité professionnelle des femmes enceintes, surveillance prénatale et issue de la grossesse. *J Gynecol Obstet Biol Reprod (Paris)* 1982;11:959—67.
3. Berkowitz GS, Kelsey JL, Holford TR, Berkowitz RL. Physical activity and the risk of spontaneous preterm delivery. *J Reprod Med* 1983;28:581—8.
4. Mamelie N, Laumon B, Lazar P. Prematurity and occupational activity during pregnancy. *Am J Epidemiol* 1984;119:309—22.
5. Saurel-Cubizolles MJ, Kaminski M, Llado-Arkhipoff J, Du Mazaubrun C, Estryn-Behar M, Berthier C, et al. Pregnancy and its outcome among hospital personnel according to occupation and working conditions. *J Epidemiol Community Health* 1985;39:129—34.
6. Zuckerman BS, Frank DA, Hingson R, Morelock S, Kayne HL. Impact of maternal work outside the home during pregnancy on neonatal outcome. *Pediatrics* 1986;77:459—64.
7. Mamelie N, Munoz F. Occupational working conditions and preterm birth: a reliable scoring system. *Am J Epidemiol* 1987;126:150—2.
8. Saurel-Cubizolles MJ, Kaminski M. Pregnant women's working conditions and their changes during pregnancy: a national study in France. *Br J Ind Med* 1987;44:236—43.
9. McDonald AD, McDonald JC, Armstrong B, Cherry NM, Nolin AD, Robert D. Prematurity and work in pregnancy. *Br J Ind Med* 1988;45:56—62.
10. Nurminen T, Lusa S, Ilmarinen J, Kurpa K. Physical work load, fetal development and course of pregnancy. *Scand J Work Environ Health* 1989;15:404—14.
11. Armstrong BG, Nolin AD, McDonald AD. Work in pregnancy and birth weight for gestational age. *Br J Ind Med* 1989;46:196—9.
12. Hartikainen-Sorri AL, Sorri M. Occupational and socio-medical factors in preterm birth. *Obstet Gynecol* 1989;74:13—6.
13. Nurminen T. Shift work, fetal development and course of pregnancy. *Scand J Work Environ Health* 1989;15:395—403.
14. Axelsson G, Rylander R, Molin I. Outcome of pregnancy in relation to irregular and inconvenient work schedules. *Br J Ind Med* 1989;46:393—8.
15. Homer CJ, Beresford SAA, James SA, Siegel E, Wilcox S. Work-related physical exertion and risk of preterm, low birth-weight delivery. *Paediatr Perinatal Epidemiol* 1990;4:161—74.
16. Homer CJ, Sherman AJ, Siegel E. Work-related psychological stress and risk of preterm, low birthweight delivery. *Am J Public Health* 1990;80:173—7.
17. Ahlborg G, Bodin L, Hogstedt C. Heavy lifting during pregnancy — a hazard to the fetus?: a prospective study. *Int J Epidemiol* 1990;19:90—7.
18. Klebanoff MA, Shiono PH, Carey JC. The effect of physical activity during pregnancy on preterm delivery and birth weight. *Am J Obstet Gynecol* 1990;163:1450—6.
19. Klebanoff MA, Shiono PH, Rhoads GG. Outcomes of pregnancy in a national sample of resident physicians. *N Engl J Med* 1990;323:1040—5.
20. Launer LJ, Villar J, Kestler E, De Onis M. The effect of maternal work on fetal growth and duration of pregnancy: a prospective study. *Br J Obstet Gynaecol* 1990;97:62—76.
21. Rabkin CS, Anderson HR, Bland JM, Brooke OG, Chamberlain G, Peacock JL. Maternal activity and birth weight: a prospective, population-based study. *Am J Epidemiol* 1990;131:522—31.
22. Ramirez G, Grimes RM, Annegers JF, Davis BR, Slater CH. Occupational and physical activity and other risk factors for preterm birth among US army primigravidae. *Am J Public Health* 1990;80:728—9.
23. Teitelman AM, Welch LS, Hellenbrand KG, Bracken MB. Effect of maternal work activity on preterm birth and low birth weight. *Am J Epidemiol* 1990;131:104—13.
24. Peoples-Sheps MD, Siegel E, Suchindran CM, Origasa H, Ware A, Barakat A. Characteristics of maternal employment

- during pregnancy: effects on low birthweight. *Am J Public Health* 1991;81:1007—12.
25. Saurel-Cubizolles MJ, Subtil D, Kaminski M. Is preterm delivery still related to physical working conditions in pregnancy? *J Epidemiol Community Health* 1991;45:29—34.
26. Fortier I, Marcoux S, Beaulac-Baillargeon L. Relation of caffeine intake during pregnancy to intrauterine growth retardation and preterm birth. *Am J Epidemiol* 1993;137:931—40.
27. Arbuckle TE, Sherman GJ. An analysis of birth weight by gestational age in Canada. *Can Med Assoc J* 1989;140:157—65.
28. Suonio S, Simpanen AL, Olkkonen H, Haring P. Effect of the left lateral recumbent position compared with the supine and upright positions on placental blood flow in normal late pregnancy. *Ann Clin Res* 1976;8:22—6.
29. Naeye RL. Placental infarction leading to fetal or neonatal death. *Obstet Gynecol* 1977;50:583—6.
30. Kramer MS. Determinants of low birth weight: methodological assessment and meta-analysis. *Bull WHO* 1987;65:663—737.
31. Rauramo I, Forss M. Effect of exercise on maternal hemodynamics and placental blood flow in healthy women. *Acta Obstet Gynecol Scand* 1988;67:21—5.
32. Tafari N, Naeye RL, Gozebie A. Effects of maternal undernutrition and heavy physical work during pregnancy on birth weight. *Br J Obstet Gynaecol* 1980;87:222—6.
33. Marbury MC, Linn S, Monson RR, Wegman DH, Schoenbaum, Stubblefield PG, et al. Work and pregnancy. *J Occup Med* 1984;26:415—21.
34. Mamelie N, Munoz F, Collin D, Charvet F, Lazar P. Fatigue professionnelle et prématurité. *Arch Mal Prof* 1981;42:211—6.
35. Stengel B, Saurel-Cubizolles MJ, Kaminski M. Healthy worker effect and pregnancy: role of adverse obstetric history and social characteristics. *J Epidemiol Community Health* 1987;41:312—20.

Received for publication: 31 May 1994