Published in final edited form as:
Occup Environ Med. 2009 October ; 66(10): 685–690. doi:10.1136/oem.2008.043935.

OCCUPATIONAL PHYSICAL ACTIVITIES, WORKING HOURS AND OUTCOME OF PREGNANCY: FINDINGS FROM THE SOUTHAMPTON WOMEN'S SURVEY

Dr. Matteo Bonzini[1], **Professor David Coggon**[2], **Professor Keith Godfrey**[2], **Professor Hazel Inskip**[2], **Dr. Sarah Crozier**[2], and **Professor Keith Palmer**[2]

[1]Department of Occupational Health, University of Milan, Foundation IRCCS Ospedale Maggiore, Milan, Italy

[2]MRC Epidemiology Resource Centre, Southampton General Hospital, Southampton SO16 6YD. UK

Abstract

Objectives—To investigate risks of physical activity at work by pregnancy trimester, including the effects on head and abdominal circumference.

Method—At 34 weeks gestation we interviewed 1327 mothers from the prospective Southampton Women's Survey (SWS); we asked about their activities (working hours, standing/walking, kneeling/squatting, trunk bending, lifting and night shifts) in jobs held at each of 11, 19 and 34 weeks gestation, and subsequently ascertained four birth outcomes – preterm delivery, small for gestational age (SGA) and reduced head or abdominal circumference – blinded to employment history.

Results—Risk of preterm delivery was elevated nearly three-fold in women whose work at 34 weeks entailed trunk bending for >1 hour/day. Small head circumference was more common in babies born to women who worked for >40 hours/week. However, no statistically significant associations were found with SGA or small abdominal circumference, and pre-term delivery showed little association with long working hours, lifting, standing, or shift work.

Conclusions—A need exists for more research on trunk bending late in pregnancy, and on the relation of work to reduced head circumference. Our findings on several other occupational exposures common among pregnant workers are reassuring.

INTRODUCTION

In Europe, as in most parts of the world, women of reproductive age make up a substantial proportion of the workforce, and legislation requires employers to assess and, where possible, to minimise the health risks to pregnant workers[1].

To aid risk assessment we recently undertook a systematic review[2] of the epidemiological evidence relating five common occupational exposures (prolonged working hours, shift

Corresponding Author: Professor Keith Palmer [2]MRC Epidemiology Resource Centre, Southampton General Hospital Southampton SO16 6YD UK.

COMPETING INERESTS None

Europe PMC Funders Author Manuscripts

work, lifting, standing, and heavy physical workload) to several major adverse outcomes of pregnancy, including pre-term delivery and low birth weight. These health endpoints were chosen as determinants of perinatal and infant mortality[3,4], and as predictors of adverse outcomes in later life, such as delayed development, neurological and cognitive deficit, high blood pressure, non-insulin dependent diabetes, coronary heart disease, stroke and obstructive lung disease[5]. For pre-term delivery, we found extensive and generally consistent evidence related to each exposure, and this tended to rule out more than moderate effects (relative risks (RR) >1.4)[2], a finding supported by a second independent systematic review and meta-analysis[6]. However, for small for gestational age (SGA), although risk estimates were not dissimilar, the evidence base was smaller. More generally, we found few studies in which risk estimates were presented separately for occupational exposures in different trimesters of pregnancy, although the same activity might carry different risks if it occurred late in pregnancy as compared with only a few weeks after conception. And we highlighted a need for "well-designed cohort studies in which relevant exposures are assessed prospectively at different stages of pregnancy and subsequent health outcomes are systematically ascertained"[2].

Another limitation in the evidence base on occupational activities relates to birth anthropometrics. Small head circumference at birth can be related to higher blood pressure in childhood[7] and adulthood[8], impaired glucose tolerance[9], and a higher prevalence and mortality from cardiovascular disease[10,11], while lower abdominal circumference at birth predicts raised serum concentrations of blood lipids in later life[12]. However, occupational studies have almost never considered head or abdominal circumference as clinical outcomes in their own right.

To address these various gaps in the evidence base we conducted a cohort study with exposures defined for different trimesters of pregnancy and outcomes encompassing birth anthropometrics as well as SGA and pre-term delivery.

MATERIALS AND METHODS

Our study used data from the Southampton Women's Survey (SWS), a longitudinal study that aimed to recruit all women aged 20-34 years, who were resident in the city of Southampton, England during 1998-2002[13]. At entry to the SWS, each of the 12,583 participants was interviewed and examined by a research nurse, and those who subsequently became pregnant were followed up with further interviews at 11 and 34 weeks gestation. Details of the birth were than abstracted from obstetric records, and anthropometric measurements were made on the new-born babies.

The analysis presented in this paper focused on singleton pregnancies leading to a live birth between 1 June 1999 and 31 December 2003, after longer than 34 weeks gestation, in Caucasian women who did not suffer from diabetes or pre-eclampsia, and who undertook paid employment at some time during pregnancy. Where a woman had more than one baby during this period, only the first eligible pregnancy was included.

From the interview and examination at entry to the SWS, we obtained information about the mother's date of birth, alcohol consumption, smoking habits, education, parity, height and weight. Alcohol consumption was classified in two bands (<14 and ≥14 units per week), and education was graded to six levels according to the highest academic qualification obtained. Height was measured to the nearest millimetre with a stadiometer, and weight to the nearest 0.1 kg with electronic scales (after removal of shoes and heavy clothing). These measurements were used to calculate body mass index (BMI).

Occupational activities during pregnancy were ascertained through the interview conducted at 34 weeks gestation. Women were asked whether they were in paid work at each of 11, 19 and 34 weeks gestation; and where they had held jobs at one or more of these times, they were asked how many hours per week they worked, whether the work included night shifts, and whether or not an average day at work involved each of four physical activities (standing or walking for more than four hours in total, kneeling or squatting for more than an hour in total, standing or sitting with the trunk bent forward (illustrated in a diagram) for more than an hour in total, and lifting or carrying weights of 25 kg or more by hand).

Data abstracted from hospital records at birth included the baby's sex and birth weight. We collected detailed menstrual and ultrasound data in early pregnancy[13] and set the estimated date of conception using an algorithm that combined menstrual and ultrasound data. Deliveries were classed as pre-term if they occurred before 260 days (37 weeks) gestation. Birth weights were measured with digital scales, and babies were classed as small for gestational age (SGA) if, after account was taken of gestational age and sex, the weight was in the lowest 10% of the standard British distribution in 1990[14].

In addition to the abstraction of these routinely recorded clinical data, a research nurse from the study team measured the baby's head circumference and upper abdominal circumference (at the level of the xiphisternum) within 48 hours of birth. These measurements were made to the nearest millimetre with a tape measure, using a standardised technique. Head circumference was assessed against the standard British distribution in 1990, according to gestational age and sex[14]. For abdominal circumference there were no satisfactory external reference values, and the expected sex-specific distribution by gestational age was therefore derived by applying random-effects regression to internal SWS data using the method of Royston[15]. Small head and abdominal circumference were defined as being below the 10th centile of the reference population.

Statistical analysis was carried out with Stata 10.0 software. Risk factors for each of four adverse outcomes of pregnancy (pre-term delivery, SGA, small head circumference and small abdominal circumference) were examined by logistic regression, and associations were summarised by odds ratios (ORs) and associated 95% confidence intervals (CIs). We first explored associations with non-occupational risk factors, using a single regression model for each adverse outcome. Variables that were associated with an outcome ($p < 0.2$) were then carried forward as factors of adjustment in subsequent analyses of occupational risk factors.

Having assessed the risk of each outcome according to whether or not the mother was in any form of work at 34 weeks gestation, we examined associations with exposure to specific occupational activities at three different points in pregnancy (11, 19 and 34 weeks). In these analyses, we compared women who were exposed to an activity with those who were in work at the same stage of pregnancy but unexposed to the activity. Each activity was analysed independently with adjustment for potential non-occupational confounders.

Finally, to address the possibility that some women may have ceased one or more occupational activities because of early complications of pregnancy, we looked for evidence of healthy worker selection by comparing mothers who carried out an occupational activity at 34 weeks gestation with mothers who were in work at 34 weeks gestation but had not been exposed to the activity at any stage of pregnancy.

RESULTS

A total of 1327 pregnancies met the criteria for inclusion in our analysis (Table 1). The ages of the mothers ranged from 21 to 38 years (mean 30 years), and 54% were primiparous.

Almost all were in paid work at 11 and 19 weeks gestation, and 797 (60%) were working at 34 weeks gestation. Pre-term delivery occurred in 46 (3%) of pregnancies, and 89 (7%) babies were small for gestational age.

Table 2 shows the relation of birth outcomes to the non-occupational risk factors examined. The strongest associations were for primiparity with SGA (OR 2.62, 95%CI 1.55-4.42) and small abdominal circumference (OR 2.22, 95%CI 1.46-3.37), In addition, weaker associations, but with $p < 0.2$ were observed for maternal age, pre-pregnancy BMI and smoking with SGA; primiparity and maternal educational level with small head circumference; and maternal age and smoking with small abdominal circumference. These variables were therefore carried forward as factors of adjustment when looking at occupational risk factors.

In comparison with mothers who had stopped working before 34 weeks gestation, those who remained in employment showed no statistically significant differences in the risk of adverse birth outcomes. After adjustment for potential confounding factors, the odds ratios were 0.76 (95%CI 0.41-1.37) for pre-term delivery, 1.25 (95%CI 0.79-1.99) for SGA, 1.04 (95%CI 0.72-1.51) for small head circumference, and 1.21 (95%CI 0.82-1.77) for small abdominal circumference.

Risk of pre-term delivery was elevated in women whose work entailed sitting or standing with the trunk bent forward for more than an hour per day (Table 3), and this association was particularly strong when the activity occurred at 34 weeks gestation (OR 2.92, 95%CI 1.27-6.70). Other occupational activities showed no clear relation to pre-term delivery.

Tables 4-6 summarise the relation of occupational activities to SGA, small head circumference and small abdominal circumference. No statistically significant associations were seen with SGA or small abdominal circumference, all ORs being less than 1.4. However, small head circumference was more common in babies born to women who worked for > 40 hours per week (ORs 1.51 to 1.72). In addition, there was a suggestion of an increased risk of small head circumference in relation to standing or walking for >4 hours per day during the first two trimesters (ORs 1.36 to 1.40), and in relation to lifting weights of >25 kg by hand, and especially in the last trimester (ORs 1.64 to 2.52). However, these findings did not reach statistical significance.

To explore possible healthy worker effects, we repeated the analyses for women who were in work at 34 weeks gestation, comparing those who carried out an activity late in pregnancy with those who had not been exposed to the activity at any of 11, 19 or 34 weeks gestation.

This analysis confirmed the association between preterm delivery and sitting or standing with the trunk bent forward (OR 2.66, 95%CI 1.15 – 12.6). A relation between small head circumference and working more than 40 hours a week was again observed but did not quite reach statistical significance at the 5% level (OR 1.71, 95%CI 0.94-3.11).

DISCUSSION

Our findings suggest an increased risk of preterm delivery in women whose work entails trunk bending for >1 hour per day, especially after 34 weeks of gestation, and of low head circumference in women working >40 hours per week during pregnancy. However, in keeping with our earlier review, pre-term delivery showed little association with prolonged working hours, lifting, or standing, and the relative risk (RR) for shift work was similar to the previous pooled estimate of 1.20 to 1.26[2].

The present study had the advantage of a prospective design, with exposures assessed pre-delivery and outcomes ascertained objectively, with reasonable precision of measurement and blinded to occupational history. Relevant personal risk factors that could confound associations (such as smoking and maternal BMI) were ascertained before pregnancy and controlled for where relevant in subsequent analysis. Risk estimates were also presented separately for exposures in each trimester of pregnancy, whereas in our earlier review we rarely found reporting at this level of detail[16-19]. And finally, we studied some clinically important outcomes for which there is almost no occupational risk information (head and abdominal circumference), as well as at least one occupational exposure for which research on adverse pregnancy outcomes appears very sparse (trunk bending).

One limitation of our investigation was the reliance on self-reported exposures, with the possibility of either differential or non-differential measurement error. The former appears less likely, however, as exposures were ascertained before outcomes. The latter may be greater for exposures that are difficult to self-estimate, such as weights lifted or time spent standing, than for those that are simpler to judge (e.g. working hours, night shift working). However, non-differential measurement error is unlikely to explain the positive associations that we observed.

A second limitation was our capacity to assess exposures only by questions at the 34 week interview, without tracking job changes and their reasons. Healthy worker selection bias could arise if women with complications of pregnancy dropped out of work altogether, or changed the work they did, to avoid certain activities. The likely impact would be to obscure risks of work later in pregnancy, and once again such bias to the null would not explain the positive associations of pre-term delivery with truck bending. Similarly, the elevated risk of small head circumference, which was apparent in relation to prolonged working hours in each of the trimesters requires an alternative explanation.

Of more concern in the context of healthy worker selection bias is the interpretation of null findings, such as the lack of association between standing and pre-term delivery. In the main analyses we compared women who were exposed to a given activity with those who were in work at the same stage of pregnancy but not exposed to that activity. To explore the impact of selection effects, we also conducted a sensitivity analysis comparing mothers who carried out an occupational activity at 34 weeks gestation with mothers who were in work at that stage but had not been exposed to the activity at *any* stage of pregnancy. The associations between trunk bending and preterm delivery and between working hours and low head circumference were little changed, suggesting that healthy worker selection did not have a strong influence on the findings. In principle, our comparison group (women in work at the same stage of pregnancy but unexposed to a given occupational activity) could have been exposed to other occupational activities that confer risk. If so, then the risk of pre-term delivery with trunk bending in late pregnancy would be underestimated. In practice, however, any bias is likely to be small given evidence from our previous systematic review[2] and from the current analysis that the exposures in question are relatively weak risk factors.

A third limitation of our study concerns the power to detect associations in a relatively healthy cohort (outcome prevalences 3 to 10%) among whom exposures such as night shift work and lifting were reported by ≤10% of women. This meant that for some of the exposures investigated, 95%CIs were relatively wide. Thus, for example, although night shift work at 11 weeks of gestation was associated with a 14% increase in risk of pre-term delivery (5 exposed cases), the 95% confidence limits were compatible with a 57% protective effect or a near tripling of risks. Other exposures, such as standing or walking and trunk bending, were more common (24-45%), however, allowing risks to be estimated with greater precision.

The stepwise selection strategy used in our analysis, which was based upon statistical significance testing, could in theory discard factors showing strong but imprecise associations; but no factor with these characteristics was omitted (Table 2) and in practice, such a factor would most probably have a low prevalence and a limited potential to confound.

Finally, it should be noted that our entry criterion for analysis, which required interview data at 34 weeks of gestation, precluded exploration of the risks of early fetal loss, as well as reducing the rate of pre-term deliveries in our study population.

Notwithstanding these limitations, our findings on occupational activity and SGA, and on working hours, standing, lifting, shift work and preterm delivery, are broadly consistent with earlier research. Previously, in relation to SGA, we described seven studies on working hours, five with RRs close to unity, and eight reports on standing, seven with RRs ≤1.4; and in relation to preterm delivery, 11 of 12 studies on lifting carried RRs <1.4, while the pooled estimates of RR for prolonged working hours, standing and shift work ranged from 1.2 to 1.3[2].

In this study we found that trunk bending in late pregnancy (in occupations such as nursing, work with small children (child minders, nannies, teachers), catering, cleaning and shop work) carried a nearly three-fold elevation in risk of preterm delivery. Although linked in a few reports with a greater risk of spontaneous abortion[20-22], we know of no other study of trunk bending and preterm delivery.

This omission seems important to rectify. Raised intra-abdominal pressure, consequent on trunk bending, is a biologically plausible risk factor for pre-term labour, especially in the last trimester when space within the abdominal cavity is maximally constrained. Moreover, obesity, a non-occupational cause of raised intra-abdominal pressure, has also been linked with pre-term birth, albeit inconsistently in a small literature.[23] Hence, our observations on trunk bending in late pregnancy require confirmation in other studies.

Additionally, after adjustment for educational attainment and primiparity, we found associations of prolonged working hours with small head circumference. We are aware of only one other occupational study concerning this outcome, in low-income mothers from Boston[24]. No significant association was found between standing at work and small head circumference at birth though the odds ratios were elevated and close to statistical significance for exposures in the first two trimesters. Contrary to our finding, an inverse relationship between maternal physical activity (not specifically work activity) in the first two trimesters and small head circumference has been reported in villagers from rural India[16]. Such inconsistencies and the paucity of reports underscore the need to interpret our data with caution. If true, however, our observations could be clinically relevant, as small head circumference at birth has been linked with a doubling of risks of prevalent coronary heart disease in middle age[10], a significantly higher cardiovascular mortality among working-aged men[11], and a significantly higher adult systolic blood pressure[7]. Moreover, in a survey of 50-year olds from Preston, UK, those with impaired glucose tolerance or non-insulin dependent diabetes mellitus had a significantly smaller head circumference at birth[9]. In most of these studies, definitions of restricted head circumference were less stringent in percentile terms than our own.

The mechanism by which prolonged working hours and other occupational activities might affect birth anthropometrics is unknown, and in the absence of strong prior expectations our findings on head circumference should be viewed only as hypothesis-generating at this stage. Further research is warranted. However, a higher priority is the need to assess further the risks of preterm labour in mothers who bend their trunk late in pregnancy. Our other

findings, on preterm delivery and on occupational physical activities and SGA, add to a growing body of evidence that is broadly reassuring to pregnant workers.

What this paper adds

Why the study was needed

Few reports of occupational physical activity and adverse pregnancy outcome present risk estimates by birth anthropometry or explore the risks of trunk bending.

What we found

Risk of preterm delivery was elevated three-fold in women whose work at 34 weeks entailed trunk bending for >1 hour/day. Small head circumference was more common in babies born to women who worked for >40 hours/week, but other findings were broadly reassuring.

Policy implications

More research is needed on trunk bending late in pregnancy, and on the relation of work to reduced head circumference.

Acknowledgments

We thank the general practitioners and midwives in Southampton for their support. We are grateful to the staff of the SWS Study Group for all their work in recruiting and interviewing the participants, and processing the data and the samples. Finally, we are grateful to the participants in the SWS who have given so much time and information about themselves to the Survey.

FUNDING Financial support for this work was provided by the UK Medical Research Council, the University of Southampton and the Dunhill Medical Trust.

REFERENCES

1. European Union Council Directive 92/85/EEC. Accessed 31st March 2008The introduction of measures to encourage improvements in the safety and health at work of pregnant workers and workers who have recently given birth or are breastfeeding. Oct 19.1992 Available at: http://www.dehp-facts.com/upload/documents/document39.pdf
2. Bonzini M, Coggon D, Palmer KT. Risk of prematurity, low birth weight, and pre-eclampsia in relation to working hours and physical activities: A systematic review. Occup Environ Med. 2007; 64:228–243. [PubMed: 17095552]
3. Berkowitz GS, Papiernik E. Epidemiology of preterm birth. Epidemiol Rev. 1993; 15:414–443. [PubMed: 8174665]
4. Moser K, Li L, Power C. Social inequalities in low birth weight in England and Wales: trends and implications for future population health. J Epidemiol Community Health. 2003; 57:687–91. [PubMed: 12933774]
5. Barker, DJB., editor. Fetal and infant origins of adult disease. BMJ Publishing Group; London: 1992.
6. Mozurkewich EL, Luke B, Avni M, Wolf FM. Working conditions and adverse pregnancy outcome: A meta-analysis. Obstet Gynecol. 2000; 95:623–634. [PubMed: 10725502]
7. Barker DJ, Godfrey KM, Osmond C, Bull A. Maternal and fetal influences on blood pressure. Arch Dis in Childhood. 1991; 66:1291–5. [PubMed: 1755640]
8. Barker DJ, Shiell AW, Barker ME, Law CM. Growth in utero and blood pressure levels in the next generation. J Hypertension. 2000; 18:843–6.
9. Phipps K, Barker DJ, Hales CN, Fall CH, Osmond C, Clark PM. Fetal growth and impaired glucose tolerance in men and women. Diabetologia. 1993; 36:225–8. [PubMed: 8462770]

Europe PMC Funders Author Manuscripts

10. Stein CE, Fall CH, Kumaran K, Osmond C, Cox V, Barker DJ. Fetal growth and coronary heart disease in south India. Lancet. 1996; 348:1269–73. [PubMed: 8909379]
11. Barker DJ, Osmond C, Simmonds SJ, Wield GA. The relation of small head circumference and thinness at birth to death from cardiovascular disease in adult life. BMJ. 1993; 306:422–6. [PubMed: 8461722]
12. Barker DJ, Martyn CN, Osmond C, Hales CN, Fall CH. Growth in utero and serum cholesterol concentrations in adult life. BMJ. 1993; 307:1524–7. [PubMed: 8274921]
13. Inskip HM, Godfrey KM, Robinson SM, Law CM, Barker DJP, Cooper C, the SWS Study Group. Cohort profile: The Southampton Women′s Survey. Int J Epidemiol. 2006; 35:42–48. [PubMed: 16195252]
14. Cole TJ, Freeman JV, Preece MA. British 1990 growth reference centiles for weight, height, body mass index, and head circumference fitted by maximum penalized likelihood. Stat in Med. 1998; 17:407–429. [PubMed: 9496720]
15. Royston P. Calculation of unconditional and conditional reference intervals for foetal size and growth from longitudinal measurements. Stat in Med. 1995; 14:1417–1436. [PubMed: 7481181]
16. Rao S, Kanade A, Margetts BM, Yajnik CS, Lubree H, Rege S, Desai B, Jackson A, Fall CHD. Maternal activity in relation to birth size in rural India. The Pune maternal nutrition study. Eur J Clin Nutr. 2003; 57:531–542. [PubMed: 12700614]
17. Pompeii LA, Savitz DA, Evenson KR, Rogers B, McMahon M. Physical exertion at work and the risk of preterm delivery and small-for-gestational age birth. Obstet Gynecol. 2005; 106:1279–1288. [PubMed: 16319253]
18. Hatch M, Ji BT, Shu XO, Susser M. Do standing, lifting, climbing, or long hours of work during pregnancy have an effect on fetal growth? Epidemiology. 1997; 8:530–536. [PubMed: 9270955]
19. Axelsson G, Rylander R, Molin I. Outcome of pregnancy in relation to irregular and inconvenient work schedules. Br J Ind Med. 1989; 46:393–398. [PubMed: 2818973]
20. Florack EI, Zielhuis GA, Pellegrino JE, Rolland R. Occupational physical activity and the occurrence of spontaneous abortion. Int J Epidemiol. 1993; 22:878–84. [PubMed: 8282467]
21. Fenster L, Hubbard AE, Windham GC, Waller KO, Swan SH. A prospective study of work-related physical exertion and spontaneous abortion. Epidemiology. 1997; 8:66–74. [PubMed: 9116099]
22. El-Metwalli AG, Badawy AM, El-Baghdadi LA, El-Wehady A. Occupational physical activity and pregnancy outcome. European J Obstetrics. 2001; 100:41–45.
23. Galtier-Dereure F, Boegner C, Bringer J. Obesity and pregnancy: complications and costs. American Journal of Clinical Nutrition. 2000; 71:1242S–1248s. [PubMed: 10799397]
24. 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. [PubMed: 3960614]

Europe PMC Funders Author Manuscripts

Europe PMC Funders Author Manuscripts

Table 1

Characteristics Of Study Cohort

	Mean	Standard deviation	Range
Maternal age (years)	30.3	3.8	20.8-38.5
Maternal BMI before pregnancy	25.4	4.8	16.2-48.9
Infant birth weight (grams)	3495	478	1676-5296
Infant head circumference (cm)	35.0	1.3	30.0-38.7
Infant abdominal circumference (cm)	33.5	1.7	25.9-39.4

	N	%
Female baby	621	47
Mother consumed ≥14 units of alcohol per week before pregnancy	267	20
Mother smoked before pregnancy	349	26
Maternal educational level		
No qualifications	21	2
CSE or equivalent	115	9
O level or equivalent	386	29
A level or equivalent	398	30
HND or equivalent	109	8
Degree	294	22
Primiparous	710	54
Mother worked at 11 weeks gestation	1318	99
Mother worked at 19 weeks gestation	1287	97
Mother worked at 34 weeks gestation	797	60
Pre-term delivery	46	3
Small for gestational age	89	7
Small head circumference	132	10
Small abdominal circumference	131	10

Europe PMC Funders Author Manuscripts

Table 2

Associations of Birth Outcomes With Non-Occupational Risk Factors

Risk factor	Pre-term delivery		Small for gestational age		Small head circumference		Small abdominal circumference	
	OR[a] (95% CI)	P	OR[a] (95% CI)	P	OR[a] (95% CI)	P	OR[a] (95% CI)	P
Maternal age[b]	1.01 (0.93-1.10)	0.8	1.04 (0.98-1.11)	0.2	0.99 (0.95-1.04)	0.8	1.05 (1.00-1.10)	0.07
Female baby	1.04 (0.58-1.89)	0.9	-		-		1.22 (0.85-1.76)	0.3
Consumed ≥14 units of alcohol per week before pregnancy	0.73 (0.33-1.63)	0.4	1.23 (0.74-2.04)	0.4	0.81 (0.50-1.31)	0.4	1.00 (0.64-1.57)	1.0
Smoked before pregnancy	0.63 (0.29-1.36)	0.2	1.59 (0.98-2.58)	0.06	1.08 (0.71-1.65)	0.7	1.43 (0.94-2.17)	0.09
Educational level[d]	0.89 (0.70-1.12)	0.3	0.90 (0.75-1.07)	0.2	0.87 (0.75-1.01)	0.07	0.93 (0.81-1.08)	0.3
Primiparous	2.03 (1.04-3.95)	0.04	2.62 (1.55-4.42)	<0.001	1.51 (1.01-2.25)	0.04	2.22 (1.46-3.37)	<0.001
Maternal BMI before pregnancy[e]	0.96 (0.89-1.03)	0.2	0.94 (0.89-1.00)	0.04	0.98 (0.94-1.02)	0.3	0.99 (0.95-1.03)	0.7

[a] For each outcome, all risk factors were examined in a single logistic regression model, and odds ratios are therefore mutually adjusted.

[b] Maternal age was analysed as a continuous variable. Risk estimates are for a one year increase in age.

[c] Not applicable because outcome was adjusted for the sex of the baby.

[d] Educational level was analysed as an ordinal variable with six levels defined as in Table 1. Risk estimates are for an increase of one level.

[e] Maternal BMI was analysed as a continuous variable. Risk estimates are for an increase of 1 kg/m^2.

Europe PMC Funders Author Manuscripts

Table 3

Associations of Pre-Term Delivery With Occupational Activities

Occupational activity	11 weeks gestation			19 weeks gestation			34 weeks gestation		
	No. exposed	No. exposed cases	OR[a] (95% CI)	No. exposed	No. exposed cases	OR[a] (95% CI)	No. exposed	No. exposed cases	OR[a] (95% CI)
Worked ≥40 hrs/week	244 (19%)	10	1.03 (0.49-2.15)	236 (18%)	9	1.01 (0.47-2.17)	130 (16%)	3	0.59 (0.17-2.03)
Standing or walking >4 hrs/day in total	484 (37%)	16	0.92 (0.49-1.70)	432 (34%)	12	0.76 (0.39-1.49)	201 (24%)	6	0.99 (0.39-2.51)
Kneeling/squatting >1 hr/day in total	219 (17%)	6	0.77 (0.32-1.84)	209 (16%)	6	0.86 (0.36-2.06)	82 (10%)	3	1.25 (0.37-4.28)
Trunk bent forward for >1 hr/day in total	589 (45%)	23	1.25 (0.69-2.26)	569 (44%)	23	1.47 (0.80-2.71)	315 (39%)	16	2.92 (1.27-6.70)
Lifting weights of ≥25 kg by hand	121 (9%)	3	0.69 (0.21-2.26)	83 (6%)	3	1.10 (0.33-3.63)	24 (3%)	1	- -
Night shifts	131 (10%)	5	1.14 (0.43-2.93)	116 (9%)	4	1.07 (0.37-3.05)	33 (4%)	2	- -

[a]Each risk factor was examined in a separate logistic regression model with adjustment for primiparity. Risk estimates are for those exposed to the risk factor relative to those who were in work at the relevant stage of pregnancy but unexposed.

Europe PMC Funders Author Manuscripts

Table 4

Associations of Low Birth Weight (Small for Gestational Age) With Occupational Activities

Occupational activity	11 weeks gestation			19 weeks gestation			34 weeks gestation		
	No. exposed	No. exposed cases	OR[a] (95% CI)	No. exposed	No. exposed cases	OR[a] (95% CI)	No. exposed	No. exposed cases	OR[a] (95% CI)
Worked ≥40 hrs/week	242 (19%)	22	1.11 (0.66-1.88)	233 (18%)	22	1.19 (0.70-2.01)	127 (16%)	14	1.29 (0.67-2.47)
Standing or walking >4 hrs/day in total	476 (36%)	31	0.93 (0.59-1.46)	425 (33%)	30	1.06 (0.67-1.69)	196 (24%)	13	0.86 (0.45-1.64)
Kneeling/squatting >1 hr/day in total	218 (17%)	16	1.21 (0.68-2.15)	208 (16%)	14	1.10 (0.60-2.00)	81 (10%)	6	1.06 (0.43-2.60)
Trunk bent forward for >1 hr/day in total	581 (44%)	37	0.88 (0.56-1.37)	561 (44%)	35	0.85 (0.54-1.33)	309 (39%)	25	1.16 (0.67-2.01)
Lifting weights of ≥25 kg by hand	121 (9%)	9	1.09 (0.53-2.27)	83 (7%)	6	1.06 (0.44-2.55)	24 (3%)	2	- -
Night shifts	130 (10%)	8	0.92 (0.43-1.97)	114 (9%)	7	0.92 (0.41-2.06)	32 (4%)	2	- -

[a]Each risk factor was examined in a separate logistic regression model with adjustment for maternal age, primiparity and maternal BMI and smoking before pregnancy, all classified as in Table 2. Risk estimates are for those exposed to the risk factor relative to those who were in work at the relevant stage of pregnancy but unexposed.

Europe PMC Funders Author Manuscripts

Table 5

Associations Of Small Head Circumference With Occupational Activities

Occupational activity	11 weeks gestation			19 weeks gestation			34 weeks gestation		
	No. exposed	No. exposed cases	OR[a] (95% CI)	No. exposed	No. exposed cases	OR[a] (95% CI)	No. exposed	No. exposed cases	OR[a] (95% CI)
Worked ≥40 hrs/week	238 (18%)	36	1.71 (1.11-2.63)	230 (18%)	35	1.72 (1.11-2.65)	126 (16%)	18	1.51 (0.84-2.70)
Standing or walking >4 hrs/day in total	475 (36%)	57	1.40 (0.97-2.02)	423 (33%)	51	1.36 (0.94-1.98)	195 (24%)	21	1.16 (0.68-1.97)
Kneeling/squatting >1 hr/day in total	216 (17%)	22	1.02 (0.63-1.65)	206 (16%)	20	0.95 (0.57-1.58)	79 (10%)	8	1.02 (0.47-2.21)
Trunk bent forward for >1 hr/day in total	581 (45%)	52	0.82 (0.57-1.19)	561 (44%)	47	0.72 (0.50-1.06)	310 (39%)	29	0.92 (0.57-1.50)
Lifting weights of ≥25 kg by hand	120 (9%)	18	1.64 (0.96-2.81)	82 (6%)	13	1.71 (0.91-3.19)	23 (3%)	5	2.52 (0.90-7.10)
Night shifts	129 (10%)	8	0.59 (0.28-1.24)	114 (9%)	5	0.41 (0.16-1.03)	32 (4%)	0	- -

[a]Each risk factor was examined in a separate logistic regression model with adjustment for educational level and primiparity, both classified as in Table 2. Risk estimates are for those exposed to the risk factor relative to those who were in work at the relevant stage of pregnancy but unexposed.

Europe PMC Funders Author Manuscripts

Table 6

Associations of Small Abdominal Circumference With Occupational Activities

Occupational activity	11 weeks gestation			19 weeks gestation			34 weeks gestation		
	No. exposed	No. exposed cases	OR[a] (95% CI)	No. exposed	No. exposed cases	OR[a] (95% CI)	No. exposed	No. exposed cases	OR[a] (95% CI)
Worked ≥40 hrs/week	240 (18%)	31	1.16 (0.74-1.82)	232 (18%)	32	1.31 (0.84-2.04)	127 (16%)	16	1.02 (0.56-1.86)
Standing or walking >4 hrs/day in total	479 (37%)	54	1.25 (0.86-1.82)	427 (33%)	48	1.23 (0.84-1.80)	198 (24%)	23	1.13 (0.68-1.88)
Kneeling/squatting >1 hr/day in total	217 (17%)	22	1.09 (0.67-1.78)	207 (16%)	20	1.03 (0.62-1.71)	80 (10%)	8	1.02 (0.47-2.24)
Trunk bent forward for >1 hr/day in total	584 (45%)	51	0.76 (0.52-1.10)	564 (44%)	47	0.69 (0.47-1.01)	312 (39%)	30	0.78 (0.48-1.25)
Lifting weights of ≥25 kg by hand	120 (9%)	10	0.79 (0.40-1.55)	82 (6%)	5	0.55 (0.22-1.39)	23 (3%)	3	1.16 (0.33-4.08)
Night shifts	130 (10%)	11	0.83 (0.43-1.59)	115 (9%)	9	0.79 (0.39-1.60)	33 (4%)	4	1.32 (0.45-3.91)

[a]Each risk factor was examined in a separate logistic regression model with adjustment for maternal age, smoking and primiparity, all classified as in Table 2. Risk estimates are for those exposed to the risk factor relative to those who were in work at the relevant stage of pregnancy but unexposed.