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Biomechanical and organisational stressors and associations with employment withdrawal among pregnant workers: evidence and implications

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ABSTRACT

The distribution of exposure to biomechanical and organisational job stressors (BOJS) and associations with employment withdrawal (antenatal leave, unemployment) was examined in a case-control study of 1114 pregnant workers in California. We performed descriptive and multivariate logistic and multinomial regression analyses. At pregnancy onset, 57% were exposed to one or more biomechanical stressors, including frequent bending, heavy lifting and prolonged standing. One-third were simultaneously exposed to BOJS. Exposure to biomechanical stressors declined as pregnancy progressed and cessation often (41%) coincided with employment withdrawal (antenatal leave and unemployment). In multivariate modelling, whether we adjusted for or considered organisational stressors as coincident exposures, results showed that pregnant workers exposed to biomechanical stressors had increased employment withdrawal compared to the unexposed. Work schedule accommodations moderate this association. Paid antenatal leave, available to few US women, was an important strategy for mitigating exposure to BOJS. Implications for science and policy are discussed.

Practitioner Summary: This case-control study showed that exposure to biomechanical stressors decline throughout pregnancy. Antenatal leave was an important strategy used for mitigating exposure among sampled California women with access to paid benefits. Employment withdrawal among workers exposed to BJOS may be reduced by proactive administrative and engineering efforts applied early in pregnancy.

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Health risks; health and safety; physical fatigue; physical ergonomics; psychological stress; physical work capacity; biomechanical job stressors; employment withdrawal during pregnancy; strenuous work during pregnancy

Introduction

Women of childbearing age have the highest rate of labour force participation of all women in the United States (US), and most no longer leave the workforce during pregnancy (Laughlin 2011). Over 80% of first-time working mothers work well into the third trimester of pregnancy, and the majority are employed full-time (Johnson 2008). Women increasingly play a substantial role in their family's economic well-being, with 40% of mothers in households with children now serving as the primary breadwinner (Wang, Parker, and Taylor 2013). Several work sectors requiring repetitive or intermittent manual lifting, standing and/or bending as well as shift work and effort/reward ratio employ large numbers of reproductive-age women, including health care, retail, manufacturing, clerical and the armed services (DOL 2014).

The US is the only developed nation without a national paid maternity leave programme for working women (OECD 2014). The 1993 Family and Medical Leave Act (FMLA) grants workers 12 weeks of job-protected unpaid leave; however, approximately 40% of US workers are ineligible for benefits due to short work tenure or the exemption of small business (Gornick, Ray, and Schmitt 2008). Some states and private employers have expanded eligibility for family leave, including paid antenatal leave. Connecticut and the District of Columbia provide paid sick-time off for antenatal and post-natal care visits, while in states such as California, New Jersey and Rhode Island, new parents can use statewide paid family leave insurance to receive income support for parental leave after the newborn's arrival; these state programmes also permit pregnant workers to receive partial wage replacement for antenatal leave (National Partnership for Women and Families 2014).

Despite the existence of the FMLA and private and statewide family leave programmes, the majority of women, especially low-wage pregnant workers in the

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US lack access to paid antenatal leave (Laughlin 2011). Antenatal leave taken routinely in uncomplicated pregnancies may protect against obstetric complications during labour and delivery and adverse birth outcomes (Guendelman et al. 2009; Saurel-Cubizolles and Kaminski 1987; Xu, Seguin, and Goulet 2002). The need for antenatal leave may be particularly important for women employed in jobs with high biomechanical demands, given evidence linking bending at the waist, heavy lifting and prolonged standing with adverse foetal health (Bonzini et al. 2009; Mozurkewich et al. 2000; Magann et al. 2005). Few studies have examined the extent to which pregnant workers use antenatal leave as a strategy to mitigate against possible health risks, although at least two European studies report antenatal leave to be more common among women employed in heavy physical work (Koemeester et al. 1997; Saurel-Cubizolles and Kaminski 1987). In the US, disruptions to employment during pregnancy can pose difficulties for women's re-entry into the labour force, reducing their income and access to employer-based health insurance at a time when their financial and health care needs increase, and possibly impacting future earnings potential (Desai and Waite 1991). Job-protected antenatal leave or work schedule accommodations may buffer against the negative economic effects of stopping work altogether. Understanding whether biomechanical job stressors individually or in combination with organisational stressors are antecedents to changes in employment patterns such as antenatal leave or quitting during pregnancy can inform current practices in US workplaces and policy needs.

California is the only state in the US with legislation addressing both antenatal leave (established in 1976 and expanded in 2004) and workplace exposure to biomechanical stressors (established in 1996). Capitalising on a unique data set that contains rich information on working conditions among pregnant women in Southern California, the objectives of this study were to evaluate the magnitude and type of employment pattern changes during pregnancy, examine associations with biomechanical and organisational stressors and explore whether associations are moderated by work schedule accommodations. We hypothesised that exposure to biomechanical job stressors would be associated with employment withdrawal and that employment withdrawal would potentially be moderated by work schedule accommodations (cutting back on work hours or arranging to work from home) and part-time vs. full-time workload.

Methods

Sample

Participants were drawn from the population-based nested case-control study *Juggling Work and Life during Pregnancy*, which was designed to examine the relationship between stress, corticotrophin releasing hormone, antenatal leave and pregnancy outcomes (Guendelman et al. 2008, 2009, 2013). Cases and controls were identified from a cohort created by the linkage of antenatal screening and birth certificate data. Women from three Southern California counties (San Diego, Orange and Imperial) were eligible if they participated in mid-pregnancy in the California Department of Public Health Prenatal Screening Program, delivered live births between July 2002 and December 2003, were at least 18 years old, had a singleton birth without congenital anomalies and had a US mailing address. Eligible cases included all women delivering preterm or low birthweight (PTD/LBW) infants according to last menstrual period and birthweight from birth records registered between July 2002 and December 2003; eligible controls consisted of a random sample of pregnant women delivering normal weight at term (>2500 g and >37 weeks gestation), frequency-matched on race and birth month as reported previously (Guendelman et al. 2006, 2008, 2009, 2013).

Potential participants (7232) were mailed an introductory letter using the address reported on birth certificates. Of the 3655 women who could be reached by telephone, 20% refused to participate and 2915 women were prescreened to ascertain that they had worked 20 h or more per week during the first two trimesters of pregnancy or through the date of prenatal screening. Overall, 1323 of women contacted by phone (45%) met the work eligibility criteria, of which 1214 eligible women completed interviews. Eligibility and refusal rates were similar for cases and controls. We excluded women who were missing data on biomechanical job stressors ($n = 42$), covariates ($n = 54$) or date of delivery ($n = 4$), yielding an analytic sample of 1114 women.

Data collection instrument and measures

Participants were interviewed by telephone post-delivery and were queried about occupational, demographic, behavioural and health characteristics. Mean and median interview time was 4.5 months after childbirth in cases and controls. Bilingual Spanish–English interviewers used computer-assisted telephone interviewing software to enter responses into a database. Participants were offered $10 gift cards in return for a completed interview. The study protocol was approved by the Committee for the Protection of Human Subjects at UC Berkeley (No. C2003-5-115) and by the California Health and Human Services Agency (No. 02-10-18).

The two main *dependent variables* for this study were *employment withdrawal*, a binary variable referring to whether the participant stopped working during pregnancy or worked up to the time of delivery, and *type of withdrawal*, referring to the use of antenatal leave or unemployment (ie participant quit their job or was laid-off or fired; all unemployment categories were combined due to small numbers).

Key independent variables were *biomechanical job stressors* and *organisation stressors* during pregnancy. Participants were asked about exposure to three biomechanical stressors – heavy lifting, frequent bending at the waist and prolonged standing. Women were classified as exposed to strenuous biomechanical stressors if they responded 'yes' to any of the following questions: 'did your work involve carrying or lifting heavy things weighing more than 15 lb on a daily basis?'; 'did your work involve stooping or bending at least 10 times per hour?'; and if they responded 4 or more hours to the question 'how many hours per day were you usually on your feet at work?'. A composite measure of strenuous biomechanical demands was defined as exposure to any three biomechanical stressors and categorised according to the length of exposure during pregnancy: no exposure, exposed in the first or second trimester or remained exposed in the third trimester.

Organisational stressor measures were assessed from participant responses to questions regarding the ratio of work effort (work-related interruptions, responsibility, demands and overtime) and rewards (monetary rewards, esteem, fair treatment, promotion opportunities, position adequately reflects education and training, job security) and shiftwork. Effort was computed as the sum of 4 survey items, and rewards were computed as the sum of 6 items, based on Siegrist's Effort Reward Imbalance Scale (Siegrist 1996; Siegrist et al. 2004). Sum scores were categorised as high and low based on the 75th percentile of the reward score and the 25th percentile of the effort score to account for skewedness in the distributions. The following four categories of effort–reward were defined: low effort–high reward, high effort–high reward, low effort–low reward and high effort–low reward. Internal reliability of the effort and reward scales was assessed by the Cronbach's alpha coefficient, which was 0.70 and 0.72, respectively. Participants work shift status was determined from their response to the question 'during your pregnancy, was your typical work schedule during the… "(response options: day (reference), evening, night, some combination of shifts. A binary shiftwork status variable was used in modelling to signify working a regular day-time shift (reference) or any other shift. To examine the influence of the separate and joint effects of biomechanical and organisational stressors on employment withdrawal, a cumulative index of five job stressors was constructed, comprising 3 biomechanical stressors (lifting, bending and prolonged standing) and 2 other occupational stressors (ie effort/reward ratio and shiftwork). We further created a cumulative index to measure the effect of the number of biomechanical job exposures (0, 1, 2 or 3), both with and without exposure to organisational stressors (effort/reward ratio and work shift).

Occupational covariates included broad occupational category (professional or managerial, clerical, services and manufacturing), company size, work less than or at least 35 h/week (part time vs. full time) and access to schedule accommodations (reported 'cutting back on work hours' and/or 'working from home' in response to a question about work schedule adjustments made during pregnancy).

Data were collected on a range of demographic and health characteristics. *Maternal demographic* covariates included race/ethnicity, annual household income and educational attainment. *Childbearing and health measures* included maternal age at birth, parity, self-reported pre-pregnancy body mass index (BMI), life events distress assessed with the Life Events Inventory modified for use with pregnant populations (Lobel, Dunkel-Schetter, and Scrimshaw 1992) and the number of maternal morbidities experienced during pregnancy (eg self-reports of medicines taken to stop labour or control high blood pressure; complications such as vaginal bleeding, problems with the placenta and/or cervix and premature rupture of membranes).

Data analysis

All statistical analyses were conducted using STATA version 12 statistical software (StataCorp LP, College Station, TX). Point estimates were weighted by the inverse probability of sampling to account for oversampling of cases and frequency matching. Analytic weights reflect known sampling probabilities before the exclusion of non-workers and non-respondents. A descriptive summary of the dependent variables was performed, followed by bivariate analyses to examine the association between employment withdrawal during pregnancy and exposure to biomechanical job stressors and other occupational factors, as well as demographic factors, and childbearing/health characteristics. Logistic regression analyses were performed to estimate associations between biomechanical stressors and employment withdrawal. Multinomial logistic regressions were performed to estimate associations between biomechanical job stressors and type of withdrawal: antenatal leave vs. unemployment (quitting, or being laid-off or fired). Weighted odds ratios (ORs) or relative risk ratios (RRR) and 95% confidence intervals (CIs) were reported, adjusting for potential confounding by demographic, occupational and maternal childbearing/health covariates. RRRs were obtained by exponentiating coefficients from a multinomial regression model. The interpretation of a RRR

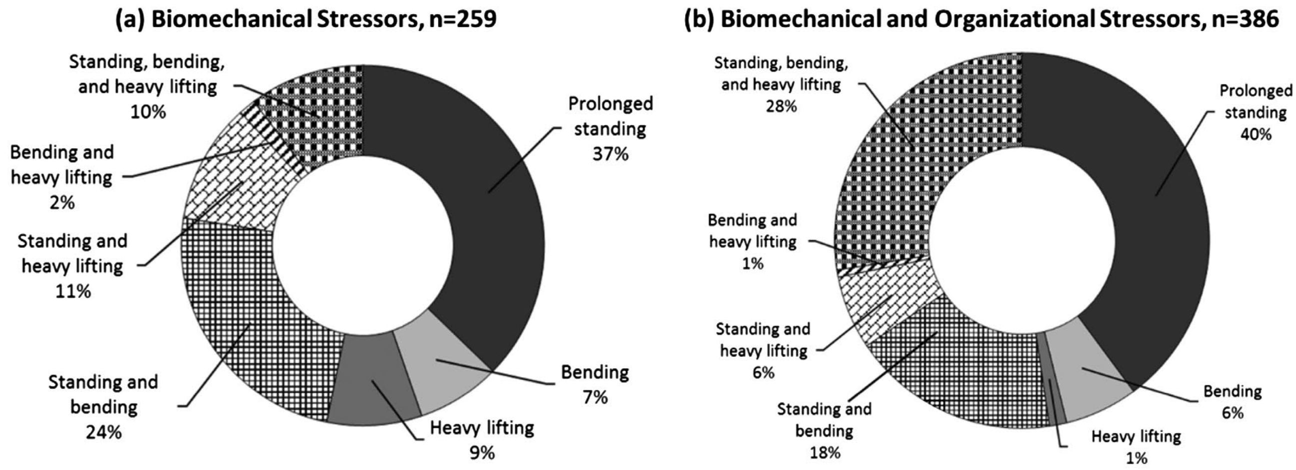

Figure 1. Exposure profile for women exposed to one or more biomechanical job stressors at the start of pregnancy, without (a) and with (b) exposure to at least one organisational stressor, $n = 645$.

is that for a one unit increase in a predictor variable, the relative risk for one group relative to a referent group is expected to change by a factor of the respective parameter estimate holding other predictor variables constant. In models investigating employment withdrawal, covariates were included in the final model if their exclusion changed the effect estimate >10% or if there was some evidence of a bivariate association with the outcome ($p < 0.10$). For consistency, the same covariates were included in the multinomial models even if these criteria were not met. Covariates in the final adjusted models include age, race/ethnicity, education, parity, number of maternal morbidities, BMI, part-time work before 3rd trimester, effort/reward ratio and shift work. Due to evidence of covariation between biomechanical and organisational stressors, an additional model was run examining the separate and joint effects of biomechanical and organisational stressors on employment withdrawal, adjusted for all other covariates. Potential moderating effects of work schedule accommodations and work hours (part-time vs. full-time) were also examined for the association between biomechanical stressors and employment withdrawal (since part-time vs. full-time work hours did not show significant interactions, only interactions with schedule adjustments (ie cut-back work hours and/or worked from home) are reported).

Results

Prevalence of exposure to biomechanical and organisational stressors

At the beginning of pregnancy, a majority of participants (57%) were exposed to one or more biomechanical job stressors – 24% without and 33% with simultaneous exposure to one or more organisational stressors (shiftwork and/or effort–reward imbalance). Those with exposure to three biomechanical stressors (frequent bending, heavy lifting and prolonged standing) were more likely to also be exposed to one or more organisational stressors (28% vs. 10%, $p = 0.0001$ (Figure 1)). Nearly two-thirds (62%) of women exposed to biomechanical stressors at the start of pregnancy reported a cessation of exposure during pregnancy: exposure stopped by the end of the second trimester among 18% and stopped in the third trimester (but before delivery) among an additional 44%. Women exposed to bending, heavy lifting or bending and heavy lifting combined were more likely to stop exposure, especially if they were also exposed to organisational stressors (Figure 2); this pattern was similar for both full-time and part-time workers. Cessation of exposure to biomechanical stressors coincided most often with employment withdrawal (41%) among women exposed to biomechanical stressors. Nearly one-quarter (23%) of exposed women reported exposure cessation not attributable to withdrawal or delivery (possibly due to ergonomic redesign of the work, task restrictions or job reassignment).

Compared with those not exposed to biomechanical stressors, women exposed to heavy lifting, frequent bending and/or prolonged standing were younger (<30 years old), more likely to be Latinas and had lower income and education (Table 1). A higher proportion of exposed women were overweight and reported high distress from life events during pregnancy. In addition, a higher proportion of exposed women were employed in service or manufacturing jobs, worked for small companies, worked

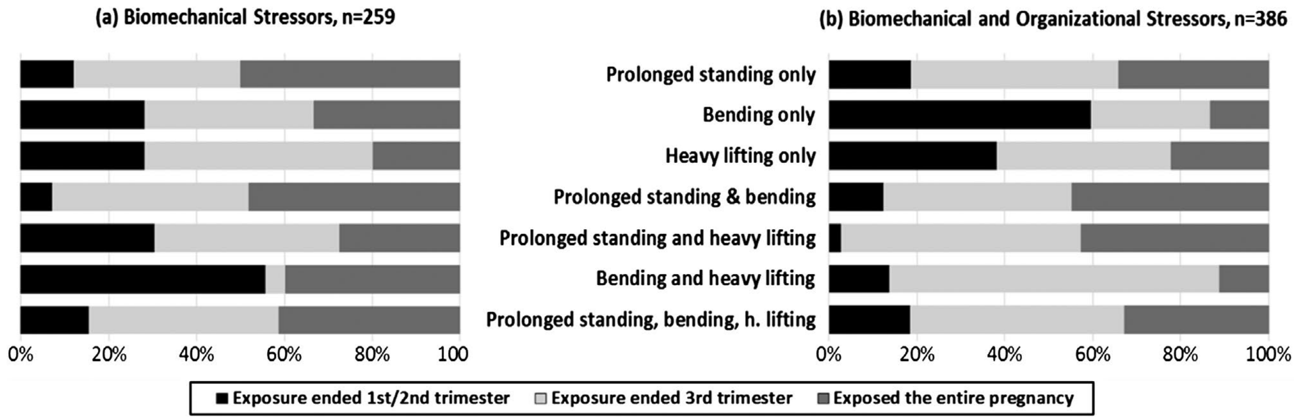

Figure 2. Biomechanical stressor exposure profile by reports of exposure continuity, without (a) and with (b) exposure to at least one organisational stressor, $n = 645$.

part-time and, as reported previously, were more likely to work outside a regular day shift and to be employed in jobs characterised as high effort and low reward.

Employment withdrawal

A higher proportion of women exposed to biomechanical job stressors withdrew from work (ie took antenatal leave or became unemployed), compared with unexposed women (48% vs. 37%); exposed women were both more likely to take antenatal leave (39% vs. 33%) and to become unemployed (9% vs. 4%) (Table 1). Compared to the unexposed, women exposed to biomechanical stressors before the end of the second trimester had more than three times higher odds of experiencing employment withdrawal, in both crude and adjusted models. The modest increased odds of employment withdrawal among women exposed to their third trimester were not significant (Table 2). In sub-analyses examining the influence of each specific biomechanical stressor (alone or in combination with other biomechanical stressors) on employment withdrawal before the third trimester, compared to women with no exposures, the adjusted odds of withdrawal were more than fivefold among women exposed to frequent bending (aOR = 5.89, 95% CI = 2.40–14.48), more than fourfold among women exposed to heavy lifting (aOR = 4.20, 95% CI = 1.98–8.90) and nearly threefold for women exposed to prolonged standing (aOR = 2.91, 95% CI = 1.46–5.77) (data not shown); these results included adjustment for organisational stressors. Comparisons involving the reduced number of women who remained exposed in the third trimester were not statistically significant.

Type of employment withdrawal associated with biomechanical job stressors

Compared with unexposed women, those exposed to biomechanical job stressors before the third trimester had nearly six times higher risk of becoming unemployed (Table 3), after adjustment for other factors associated with higher odds of unemployment, including two or more maternal morbidities, higher parity and working part-time. Older age (>25 years) significantly reduced the risk of unemployment. Factors associated with use of antenatal leave were timing of exposure to biomechanical stressors (before the end of the second trimester), low-reward jobs, having two or more morbidities and working part-time. Conversely, low education (less than a high school diploma) was associated with substantially reduced odds of using antenatal leave.

Of the 52% of women exposed to biomechanical job stressors at the beginning of pregnancy who remained employed until delivery, most (93.8%) delivered full-term (data not shown); approximately one-third of the continuously employed women with full-term pregnancies had their exposure to biomechanical job stressors stop part-way through pregnancy and 8.1% sought schedule accommodations (cutting back hours and/or working from home).

Modification of effect by cutting back hours or working from home

Work schedule accommodations defined as cutting back work hours and/or working from home significantly moderated the association between biomechanical stressors and employment withdrawal ($p < 0.01$) (Table 4). Compared with unexposed women with no schedule accommodations, those exposed to biomechanical stressors in the first two trimesters of pregnancy with no schedule accommodation had more than fivefold increased odds of employment withdrawal after adjusting for covariates, including organisational stressors.

Employment withdrawal by the number of job stressors (biomechanical and organisational)

Women exposed to all 3 biomechanical stressors in the presence of one or both organisational stressors (ie

Table 1. Demographic, health and childbearing, and occupational characteristics by exposure to biomechanical job stressors for pregnant workers in Southern California, 2002-2003.

	Entire Sample		Exposed to biomechanical job stressors					
			No		Yes			
	$N=1114$		$n=469$		$n=645$			
	n	w%	*n*	w%	*n*	w%	Corrected X^2	*p*-value
Demographic Characteristics								
Race/ethnicity								
White Non-Latina	471	49.7	235	56.7	236	44.4		
Latina	426	36.2	124	25.8	302	44.1		
Other	217	14.1	110	17.5	107	11.5	11.9	<.001
Annual household income ($)								
≤25,000	215	17.1	36	5.3	179	26.1		
>25,000 to 50,000	236	19.7	63	10.9	173	26.4		
>50,000 to 75,000	222	20.7	113	23.3	109	18.7		
>75,000	437	42.5	256	60.4	181	28.8	31.2	<.001
Education								
<12	122	10.2	12	1.9	110	16.4		
12	222	19.5	63	12.1	159	25.2		
Some college	273	24.3	130	25.9	143	23.1		
College graduate	497	46.0	264	60.1	233	35.3	22.3	<.001
Childbearing and health characteristics								
Maternal age at birth								
<25	219	17.7	57	10.2	162	23.3		
25 to 29	325	29.9	129	27.7	196	31.5		
30 to 34	415	39.1	210	46.6	205	33.4		
>34	155	13.4	73	15.5	82	11.8	7.4	<.001
Parity								
0	579	50.5	264	54.2	315	47.7		
1	322	31.5	134	30.6	188	32.3		
≥2	213	18.0	71	15.2	142	20.0	1.6	0.20
Body mass index (BMI)								
Normal or underweight	727	66.6	324	71.4	403	62.9		
Overweight	387	33.4	145	28.6	242	37.1	4.5	0.03
# maternal morbidities								
0	585	67.8	238	65.6	347	69.5		
1	328	23.1	146	26.3	182	20.7		
2 or more	201	9.0	85	8.1	116	9.7	1.5	0.23
Life events distress								
None	499	49.6	230	52.8	269	47.2		
Low	186	16.8	70	15.1	116	18.1		
Moderate	194	16.9	103	20.4	91	14.2		
High	235	16.7	66	11.7	169	20.5	3.9	<.01
Organizational Stressors								
Effort/reward ratio								
Low effort/high reward	314	28.0	166	35.2	148	22.5		
High effort/high reward	195	18.8	87	19.3	108	18.4		
Low effort/low reward	219	19.7	95	20.0	124	19.5		
High effort/low reward	386	33.6	121	25.5	265	39.7	5.4	<.01
Type of employment change								
Did not stop working	648	57.1	306	63.3	342	52.4		
Antenatal leave	387	36.3	143	32.7	244	39.1		
Quit	63	5.7	14	3.0	49	7.8		
Fired	16	0.9	6	1.0	10	0.8	4.1	0.01
Occupational characteristics								
Occupation								
Managerial	494	45.7	265	61.3	229	33.7		
Clerical	402	34.3	181	34.7	221	34.0		
Service	162	16.0	12	2.3	150	26.4		
Manufacturing	56	4.1	11	1.7	45	5.9	30.6	<.001
Work shift								
Day	842	77.4	413	88.7	429	68.8		
Evening	33	3.2	8	2.1	25	4.1		
Night	37	3.1	3	0.5	34	5.2		
Variable	202	16.2	45	8.7	157	22.0	12.2	<.001
Company size								
1 to 9	209	18.8	75	15.3	134	21.4		
10 to 49	308	25.9	98	18.0	210	32.0		
50 to 249	252	23.5	108	24.1	144	23.1		
250+	337	31.8	186	42.6	151	23.5	9.8	<.001
Cut back hours or worked from home								
Yes	262	24.2	96	22.5	166	25.5		
No	852	75.8	373	77.5	479	74.6	0.6	0.42
Part-time workload < 3rd trimester								
Yes	333	30.8	93	21.9	240	37.6		
No	781	69.2	376	78.1	405	62.4	15.9	<.001

Table 2. Crude and adjusted[a] odds ratios and 95% confidence intervals for employment withdrawal among pregnant workers in Southern California exposed to biomechanical job stressors by trimesters of pregnancy.

	No withdrawal[b]		Withdrew from employment		Model 1		Model 2	
	N	w%	*n*	w%	OR	95% CI	OR	95% CI
Biomechanical job stressors								
No exposure	306	47.9	163	36.9	Ref		Ref	
Exposed in 1st and/or 2nd trimester	39	5.5	102	16.8	3.95*	(2.18, 7.18)*	3.22*	(1.68, 6.17)*
Remain exposed in third trimester	303	46.6	201	46.3	1.29	(0.90, 1.85)	1.15	(0.78, 1.71)
Effort/reward ratio								
Low effort/high reward	220	33.2	94	21.0			Ref	
High effort/high reward	123	21.1	72	15.6			1.16	(0.69, 1.96)
Low effort/low reward	107	15.7	112	24.0			2.38**	(1.39 4.09)**
High effort/low reward	198	29.9	188	38.4			1.98***	(1.24, 3.16)***
Shift work								
No	512	0.80	330	74.3			Ref	
Yes	136	20.3	136	25.7			0.96	(0.61, 1.51)
Part-time before 3rd trimester								
No	505	76.0	276	60.1			Ref	
Yes	143	24.0	190	39.9			1.92**	(1.28, 2.89)**
Age								
<25	114	14.7	105	21.5			Ref	
25 to 29	192	29.7	133	30.1			0.87	(0.50, 1.52)
30 to 34	246	41.1	169	36.4			0.82	(0.46, 1.45)
>34	96	14.5	59	12.0			0.79	(0.38, 1.63)
Race/ethnicity								
White Non-Latina	281	50.6	190	48.6			Ref	
Latina	236	33.4	190	39.9			0.96	(0.61, 1.51)
Other	131	16.0	86	11.6			0.77	(0.47, 1.28)
Parity								
0	357	51.6	222	49.1			Ref	
1	189	33.1	133	29.4			0.84	(0.55, 1.29)
≥2	102	15.3	111	21.5			1.34	(0.79, 2.25)
Education								
<12	75	11.8	47	8.0			0.41****	(0.20, 0.87)****
12	115	15.4	107	25.1			1.49	(0.83, 2.66)
Some college	149	21.2	124	28.4			1.43	(0.88, 2.31)
College graduate	309	51.6	188	38.5			Ref	
# maternal morbidities								
0	345	72.4	240	61.8			Ref	
1	189	20.9	139	26.1			1.35	(0.89, 2.06)
2 or more	114	6.7	87	12.1			2.24*****	(1.21, 4.13)*****
BMI								
Normal or underweight	445	69.6	282	62.5			Ref	
Overweight	203	30.4	184	37.5			1.36	(0.92, 2.01)

[a]Adjusted for all other variables in the table.
[b]Did not stop working prior to delivery.
*$p < .001$; **$p = .002$; ***$p = .004$; ****$p = .02$; *****$p = .01$.

effort–reward imbalance, shiftwork) showed more than twice the odds of any withdrawal compared to those with no exposure (Table 5). Although exposure to 2 or 3 biomechanical stressors in the absence of organisational stressors showed elevated odds of employment withdrawal, the results were not statistically significant. In analyses of type of withdrawal, women who were exposed to all 3 biomechanical stressors and at least one organisational stressor had over 6 times higher risk of becoming unemployed, compared to women with neither type of job exposure.

Discussion

In this community-based study of 1114 pregnant workers employed in a range of occupations in Southern California, change in the prevalence of exposure to biomechanical job stressors was assessed, and factors associated with withdrawal from employment were identified. Approximately 57% were exposed to prolonged standing, frequent bending and/or heavy lifting at the beginning of pregnancy, and half (50%) of those women were exposed to two or more biomechanical stressors. One-third of all pregnant workers were simultaneously exposed to biomechanical stressors and to one or more organisational stressors. Exposure prevalence declined as pregnancy progressed, with 18% stopping exposure by the end of the second trimester and an additional 44% stopping exposure in the final trimester, but prior to delivery. Exposure cessation coincided most often with employment withdrawal (antenatal leave or becoming unemployed). Nearly half of women exposed

Table 3. Association between type of employment withdrawal and biomechanical job stressors among pregnant workers in Southern California, Relative risk ratios and 95% confidence intervals adjusted for occupational, demographic and health characteristics.[a]

	No Withdrawal[b]		Antenatal leave		Unemployed		Antenatal leave $n = 387$		Unemployed $n = 79$	
	n	w%	*n*	w%	*n*	w%	RRR	95% CI	RRR	95% CI
Biomechanical job stressors										
No exposure	306	47.9	143	38.9	20	26.6	Ref		Ref	
Exposed in 1st and/or 2nd trimester	39	5.5	73	14.1	29	32.1	2.80[*]	(1.41, 5.53)[*]	5.95[**]	(2.17, 16.29)[**]
Remain exposed in 3rd trimester	303	46.6	171	47.0	30	41.4	1.17	(0.78, 1.77)	1.07	(0.46, 2.49)
Effort/reward ratio										
Low effort/high reward	220	33.2	78	20.0	16	25.6	Ref		Ref	
High effort/high reward	123	21.1	64	15.5	8	16.0	1.19	(0.69, 2.06)	1.02	(0.33, 3.14)
Low effort/low reward	107	15.7	95	26.7	17	15.8	2.75[**]	(1.58, 4.79)[**]	0.82	(0.27, 2.43)
High effort/low reward	198	29.9	150	37.9	38	42.5	2.14[***]	(1.32, 3.48)[***]	1.27	(0.50, 3.19)
Shift work										
No	512	79.7	278	76.6	52	61.8	Ref		Ref	
Yes	136	20.3	109	23.4	27	38.2	0.92	(0.57, 1.48)	1.35	(0.65, 2.83)
Part-time before 3rd trimester										
No	505	76.0	239	62.9	37	44.7	Ref		Ref	
Yes	143	24.0	148	37.1	42	55.3	1.79[****]	(1.17, 2.74)[****]	2.90[******]	(1.44, 5.87)[******]
Age										
<25	114	14.7	76	17.2	29	43.4	Ref		Ref	
25 to 29	192	29.7	116	32.0	17	19.2	1.19	(0.66, 2.16)	0.22[*******]	(0.09. 0.55)[*******]
30 to 34	246	41.1	147	39.5	22	22.3	1.12	(0.60, 2.06)	0.19[***]	(0.07, 0.48)[***]
>34	96	14.5	48	11.3	11	15.1	0.98	(0.45, 2.14)	0.40	(0.12, 1.42)
Race/ethnicity										
White Non-Latina	281	50.6	161	49.9	29	39.5	Ref		Ref	
Latina	236	33.4	151	38.6	39	49.2	1.01	(0.63, 1.62)	0.78	(0.35, 1.75)
Other	131	16.0	75	11.5	11	11.4	0.73	(0.44, 1.23)	1.16	(0.42, 3.15)
Parity										
0	372	51.6	184	48.9	38	50.0	Ref		Ref	
1	201	33.1	115	31.9	18	15.6	0.92	(0.59, 1.44)	0.47	(0.19, 1.16)
≥2	108	15.3	88	19.2	23	34.5	1.17	(0.67, 2.05)	2.44[********]	(1.13, 5.30)[********]
Education										
<12	75	11.8	29	5.8	18	22.9	0.30[*****]	(0.13, 0.68)[*****]	1.31	(0.32, 5.27)
12	15	15.4	84	24.8	23	26.0	1.50	(0.82, 2.74)	1.59	(0.49, 5.20)
Some college	149	21.2	108	27.8	16	30.7	1.35	(0.83, 2.21)	2.10	(0.67, 6.55)
College graduate	309	51.6	166	41.6	22	20.4	Ref		Ref	
# maternal morbidities										
0	345	72.4	203	63.5	37	52.2	Ref		Ref	
1	189	20.9	113	25.1	26	32.3	1.28	(0.83, 2.00)	1.88	(0.88, 4.03)
2 or more	114	6.7	71	11.4	16	15.5	2.06[******]	(1.07, 3.97)[******]	3.15[***********]	(1.27, 7.83)[***********]
BMI										
Normal or underweight	445	69.6	231	61.4	51	68.3	Ref		Ref	
Overweight	203	30.4	156	38.6	28	31.7	1.46	(0.97, 2.20)	0.87	(0.44, 1.72)

[a]Adjusted for all other variables in the table.
[b]Did not stop working prior to delivery.
[*]$p = .003$; [**]$p = .001$; [***]$p < .001$; [****]$p = .002$; [*****]$p = .008$; [******]$p = .003$; [*******]$p = .001$; [********]$p = .024$; [*********]$p = .004$; [**********]$p = .03$; [***********]$p = .014$.

Table 4. Adjusted odds ratios (aOR[a]) and 95% confidence intervals for employment withdrawal by work schedule accommodation[b] among pregnant workers, $N = 1114$.

	With schedule accommodation				Without schedule accommodation			
	n	w%	aOR	95% CI	*n*	w%	aOR	95% CI
No biomechanical exposures	96	40.2	Ref		373	44.1	Ref	
Exposed in 1st and/or 2nd trimester	47	13.1	1.04	(0.24, 4.51)	94	9.5	5.23[*]	(2.44, 11.23)[*]
Remained exposed in 3rd trimester	119	46.8	2.94	(0.95, 9.11)	385	46.4	1.00	(0.62, 1.61)

[a]Adjusted for effort/reward ratio, shift work, part-time work before the 3rd trimester, age, race/ethnicity, parity, education, number of maternal morbidities and BMI.
[b]Work schedule accommodation was defined as cutting back on work hours or working from home.
[*]$p < .001$.

to biomechanical stressors at the start of pregnancy who remained employed until delivery stopped exposure (likely through job redesign or an alternative duty assignment; however, these data were not collected) or through a work schedule accommodation. Altogether, the findings suggest dynamic changes in work exposure and employment patterns and also suggest that women actively seek opportunities to avoid or reduce exposure

Table 5. Adjusted[a] odds ratios, relative risk ratios and 95% confidence intervals for any employment withdrawal and type of employment withdrawal among pregnant workers, $N = 1114$.

				Any employment withdrawal		Antenatal leave		Unemployed	
		n	w%	OR	95% CI	RRR	95% CI	RRR	95% CI
Number of biomechanical stressors[b]	Number of organisational stressors[c]								
0	0	307	28.6	Ref		Ref		Ref	
1	0	148	12.8	0.75	(0.41, 1.37)	0.76	(0.41, 1.43)	0.61	(0.14, 2.69)
2 or 3[d]	0	111	11.2	1.68	(0.91, 3.09)	1.60	(0.85, 3.01)	2.32	(0.66, 8.17)
0	1 or 2	162	14.6	0.88	(0.50, 1.56)	0.84	(0.46, 1.53)	1.34	(0.42, 4.27)
1	1 or 2	175	15.6	1.69	(0.95, 2.99)	1.68	(0.93, 3.04)	2.00	(0.59, 6.78)
2	1 or 2	115	8.1	1.25	(0.63, 2.47)	1.34	(0.66, 2.75)	1.09	(0.28, 4.32)
3	1 or 2	96	9.0	2.21*	(1.06, 4.59)*	1.71	(0.77, 3.76)	6.65**	(1.93, 22.93)**

[a]Adjusted for part-time work before the 3rd trimester, age, race/ethnicity, parity, education, number of maternal morbidities and BMI.
[b]Represents all combinations of up to 3 biomechanical stressors (heavy lifting, frequent bending and prolonged standing). See Figure 1 for a summary of the frequency distribution of each exposure combination.
[c]Represents all combinations of one or two organisational stressors: effort/reward ratio and shiftwork.
[d]Exposure conditions and 2 and 3 biomechanical stressors were combined into one group due to small numbers, $n = 83$ (2 stressors) and $n = 28$ (3 stressors).
*$p = .034$; **$p = .003$.

to biomechanical and organisational stressors through a variety of options throughout pregnancy.

Compared with unexposed women, pregnant workers exposed to biomechanical job stressors during the first/and or second trimester of pregnancy had more than three times higher odds of employment withdrawal (antenatal leave or unemployment) during pregnancy, even after adjustment for demographic, occupational, childbearing and health covariates. The odds of employment withdrawal (aOR = 5.2) were even higher among exposed women who were unable to make schedule accommodations.

The prevalence of antenatal leave use in our study was 39% among the biomechanically exposed and 33% among the unexposed. Our findings for the unexposed group are comparable with a US Census report indicating that 33% of first-time pregnant workers in the US took antenatal leave (Laughlin 2011). Previous research suggests that antenatal leave programmes are effective in mitigating the adverse antenatal foetal health outcomes associated with adverse working conditions, such as high physical and psychosocial stressors (Croteau, Marcoux, and Brisson 2006, 2007). Only 2 in 5 study participants exposed to biomechanical stressors took antenatal leave suggesting that pregnant workers may be cautious about participating in California's antenatal leave programme, despite the existence of a paid leave benefit programme providing up to 4 weeks of antenatal coverage. In 1976, California was the first state to enact a statewide paid antenatal leave programme that provides cash benefits from a state-sponsored non-occupational disability insurance (SDI) programme funded through employee payroll deductions for women who elect coverage and who are eligible (ie work for the public sector or for private employers with 5 or more employees). Only four other states in the United States (Hawaii, New Jersey, New York and Rhode Island) and Puerto Rico have established a similar antenatal leave programme (National Partnership for Women and Families 2014). The 2015 Federal Employees Paid Prenatal Leave Act submitted to Congress would provide six weeks of paid time-off for the birth of a new child to federal workers who qualify for the 12 weeks of leave under the FMLA.

Although women in jobs categorised as low rewards (including limited remuneration) were more likely to participate in antenatal leave, economic factors may serve as a barrier to participation. Access to antenatal leave coverage in California requires that workers opt-in to the programme by paying a disability insurance premium from payroll in exchange for future partial wage replacement (up to 55% of salary). Additionally, programme participation requires that workers obtain leave certification from a health provider. Women with low education were significantly less likely to use antenatal leave in our sample. Women exposed to biomechanical and organisational stressors are often employed in the low-wage sector of the economy where employment continuity may be an economic necessity and employment may be insecure. Antenatal leave benefits do not ensure job protection, and some women may fear reprisal in the form of future job loss. Legal status of the mother and lack of awareness of the programme could be other unmeasured deterrents to programme participation. Future studies are needed to examine potential socioeconomic disparities in participation in antenatal leave programmes and to understand modifiable barriers that may improve future access among the most vulnerable pregnant worker groups.

Becoming unemployed during pregnancy is not only accompanied by an immediate loss of income and the potential loss of employer-sponsored health benefits, but may also hinder timely re-entry into the labour force and reduce future income potential. Compared to the unexposed, women exposed to biomechanical job stressors before the third trimester had nearly six times higher risk of becoming unemployed (mostly due to quitting) during pregnancy, after controlling for demographic, occupational, health and childbearing covariates. Furthermore, the risk of becoming unemployed relative to the unexposed was more than 6 times higher among women who were exposed to all 3 biomechanical stressors in the presence of organisational stressors, namely effort–reward and/or shiftwork. These findings suggest that when biomechanical and organisational stressors cluster, the risk of unemployment increases. The findings also confirm the importance of examining covariation of biomechanical stressors and other working conditions as noted in recent studies (Kausto et al. 2011; MacDonald et al. 2001; Tissot, Messing, and Stock 2005). The rates of unemployment among pregnant workers exposed to biomechanical and organisational job stressors (BOJS) in our sample were low, compared to the national rate among all first-time mothers (9.5% vs. 15.9%), which may be explained by a healthy worker selection effect within our sample but may also be partially due to greater access to antenatal leave benefits (Laughlin 2011).

Most associations found between exposure to biomechanical job stressors and employment withdrawal were stronger in women who were exposed prior to the third trimester of pregnancy vs. those who were unexposed or compared with women who remained exposed in the third trimester. Additionally, our multivariate models showed that women with two or more maternal morbidities were 2 times more likely to take antenatal leave and more than 3 times more likely to become unemployed, after adjustment for exposure to biomechanical job stressors and other covariates. Thus, the smaller number of women who remained employed and exposed in late pregnancy had a more robust health profile and therefore may have had greater capacity to tolerate biomechanical stressors. This 'healthy pregnant worker effect' phenomenon has been recognised previously (Croteau, Marcoux, and Brisson 2006).

Women exposed to frequent bending at the waist prior to the third trimester stood the highest odds of withdrawing from work, after adjusting for covariates. The odds of withdrawal were more than fivefold for postural strain due to bending, more than fourfold for heavy lifting and nearly threefold for prolonged standing. Postural stress associated with bending at the waist is a known risk factor for low back pain in the general population (Punnett et al. 1991). Changes in abdominal mass associated with pregnancy have been shown to be associated with back pain (Ostgaard et al. 1993); thus, it seems plausible that pregnant workers exposed to bending during pregnancy may be disproportionately at risk for excess musculoskeletal strain of the low back and/or pelvic girdle pain, although empirical evidence is lacking (Waters et al. 2014). Withdrawal from work among our study participants may have coincided with maternal morbidity conditions such as work-related musculoskeletal disorders (WRMSD), but this could not be evaluated because WRMSD data were not collected in this study. While reproductive health outcomes are outside the scope of this article, it is important to note that exposure to bending at the waist during pregnancy has previously been reported to be associated with preterm delivery (Bonzini et al. 2009) and miscarriage (Florack et al. 1993; Grajewski et al. 2015).

Our study had several limitations. Interviews were conducted after delivery. Recall bias could overestimate the associations if women who withdrew from work were more likely to report exposure to biomechanical and organisational stressors. We were unable to confirm changes in employment status (antenatal leave, unemployment); however, these measures may be less subject to recall bias (Frazier, Ho, and Molgaard 2001). Some non-leave takers could have been misclassified since we were unable to identify women who used sick or vacation days in lieu of antenatal leave. Some non-leave takers may have had less opportunity to take leave due to preterm delivery. However, in a previous study, we estimated that only 0.3% of non-leave takers would have taken antenatal leave had they delivered at term (Guendelman et al. 2006). Although we gathered data on changes in exposure to biomechanical job stressors by trimester and we found that reports of exposure stoppage were most often found to coincide in time (trimester) with withdrawal from work, no direct data, besides work schedule accommodation (cutting back hours or working from home), were available from the study to inform how exposure reduction was accomplished.

Our multivariate models may be over-specified. Because we did not find a significant association between exposure to biomechanical job stressors and maternal morbidity, we subsequently elected to adjust for the number of maternal morbidities experienced when examining the association between biomechanical stressors (alone or coinciding with organisational stressors) and type of employment withdrawal. Potential residual confounding may have attenuated associations between job stressors and employment withdrawal (antenatal leave and unemployment). . While some models in which we adjusted for organisational stressors may be over-specified due to exposure covariation, it is notable that exposure to both biomechanical stressors and effort–reward imbalance were significantly associated with antenatal leave. However, a final model in which the simultaneous effect of the number of biomechanical and organisational stressors was examined, only the condition of 3 biomechanical stressors combined with one or more organisational stressors reached statistical significance. These associations warrant further study with larger study populations.

In conclusion, our report that pregnant workers can experience sizable reductions in exposure to biomechanical job stressors over the course of pregnancy represents an important contribution with implications for science and policy. Epidemiologic investigations assume independence between exposure and health, and our findings suggest that this assumption warrants formal evaluation in research assessing the relationship between biomechanical job stressors, alone and in combination with organisational stressors, and maternal (and foetal) health during pregnancy. By imposing greater rigour in the proper classification and monitoring of exposure changes across gestation, future research will be less prone to exposure misclassification and yield a more robust evidence-base for understanding and ameliorating posited health disparities among pregnant workers exposed to strenuous biomechanical and organisational working conditions. Our study was conducted in California – the first state (of four states total) in the United States to establish a paid antenatal leave programme and the only state with regulations governing worker exposure to biomechanical stressors; thus, the employment benefits and regulatory environment that pregnant workers in our study experienced is unique within the United States, and there may be limitations in the generalisability of our findings to pregnant workers in other parts of the US. Even in a regulatory environment favourable towards reducing ergonomic job hazards, our findings suggest that paid leave is an important mechanism for pregnant workers to mitigate exposure and associated health risks. Still, women in our sample were somewhat cautious in their use of antenatal leave, suggesting the need for further research to identify the extent to which economic, legal status and other unmeasured factors are barriers to participation in the state's 38-year-old paid antenatal leave programme. Universal access and increased utilisation of paid antenatal leave are unmet public health priorities requiring increased attention from the scientific community and policy makers.

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