Is active duty hazardous for pregnant ADF servicewomen?

Commander Michael C O'Connor, MD BS, DDU, DCH, FRCOG, FRACOG, RANR

Servicewomen in the ADF are selected to comprise a body of young, fit, healthy and educated individuals. Such a group of women with ready access to high quality medical care should have few pregnancy complications and good perinatal outcomes.[1] However, there are aspects of active duty and military service that might call this outcome into question.

Reasons why active duty servicewomen might incur unexpectedly high rates of pregnancy complications include:

1 Heavy exercise levels
2 Prolonged standing
3 Stress in the workplace
4 Prolonged working hours, shiftwork, sleep deprivation
5 Toxic exposures.

For the most part, there are no direct studies of these issues as they affect pregnant servicewomen — certainly not in an Australian context. Here I review the evidence that is available from studies of pregnant women at work that might have bearing on the hazards faced by servicewomen on active duty.

Studies of United States servicewomen

In the USA, preterm delivery is the leading cause of perinatal mortality and long-term neurological morbidity.[1] Four retrospective reviews of pregnant active duty servicewomen in the USA have reported higher than expected rates of hypertension and preterm delivery (Table).[3-6] The trends found in these studies (two of which date from the 1970s) did not reach statistical significance. The largest number of active duty pregnant US servicewomen studied in any of these studies was less than 350.

Another US Navy study[7] did not show any difference between pregnant servicewomen on active duty and a group of pregnant women in civilian employment in relation to birthweight and gestational age at delivery. That study did find that active duty military women worked longer into pregnancy and reported lower levels of social support than

Commander Michael C O'Connor has been Consultant Obstetrician and Gynaecologist to the RAN since 1982. He is Visiting Obstetrician and Gynaecologist at The St George Hospital, Kogarah, and Chairman of the Obstetrics and Gynaecology Department at St George Private Hospital. His professional interests include a longstanding concern for Australian Indigenous Women's health.

Synopsis

- Unexpectedly high rates of pregnancy-induced hypertension and preterm delivery have been reported in active duty servicewomen in the USA, but the studies were small and the results are not statistically significant.
- Some studies of working pregnant women show a negative effect of heavy exercise on birthweight. Heavy work may also more than double the rate of preterm delivery.
- Prolonged standing in the workplace appears to reduce fetal growth, particularly for women of low body weight.
- Hypertensive disorders of pregnancy are also increased in working women.
- Stress produced by high demands and poor control may increase spontaneous abortions, reduce fetal growth and increase the rate of preterm deliveries.
- Prolonged hours and regular night time shifts may increase the rate of spontaneous abortion and impair fetal growth.
- Specific workplace hazards in the military include exposure to electromagnetic and ionising radiation. Both forms may impair reproductive outcome.
- Women in the ADF have the benefit of good general health and high quality medical care. To be certain whether active duty poses additional hazards in pregnancy for these women may require a prospective study across Army, Navy and Air Force.

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Rates of preterm delivery and hypertension among active duty servicewomen in the USA

Study	Preterm delivery	Hypertension
US Navy[2]	12% [9.0%]	13% [7%]
US Marines[3]	2.1% [1.2%]	6.6% [3.2%]
US Air Force[4]	13% [2.1%]	13% [6.1%]
US Air Force[5]	6.8% [4.0%]	5.3% [3.4%]

[n]=rate in civilian controls.

their civilian counterparts. Similarly, a review of psychological aspects of pregnancy in the US military identified three types of psychological stress: lack of social supports, pressures of minority status and institutional reactions to gender roles.[8]

Effects of heavy exercise in pregnancy

Low birth weight

Bell et al found that Australian women who exercised vigorously at least four times weekly at or beyond 25 weeks gestation had babies with a mean reduction in birth weight of 315 g.[9] Clapp and Dickstein found an even greater reduction in mean birth weight (500 g) in women who continued to exercise vigorously until at least 28 weeks.[10]

Back in 1950 a study by the Royal College of Obstetricians and Gynaecologists found that low birth weight deliveries were more frequent in primigravidas who worked during the latter part of pregnancy.[11] A US collaborative study in the 1960s[12] associated prolonged standing at work with decreased birthweight and increased rates of placental infarction, but found no effect of work on pre-term delivery rates.

Pre-term delivery

Several French studies have found a higher rate of preterm birth in occupations that involve heavy lifting, prolonged standing and use of vibrating machinery.[13] One of these studies found that women who combined three or four strenuous working conditions (such as prolonged standing, heavy load carrying, assembly line work and physically demanding work) had a prematurity rate of 8% compared with a rate of 4% for women with two or less of those strenuous working conditions.[14]

McDonald et al found a substantial excess of preterm births in Canadian pregnant women employed in occupations which involved heavy lifting and prolonged hours of work (eg: psychiatric nursing).[15]

Homer et al found that American women with jobs characterised by high physical exertion were more likely to have preterm births (<37 weeks) and birthweights below 2500 g (relative risk [RR], 5.1; 95% CI = 1.5–17.7).[16]

One healthy baby on parade…

Blake Tonkin, son of AB Musician Jodie Tonkin and PO Musician Andrew Tonkin, experiences martial music close up, with the assistance of Able Seaman Byron Crump. (Photograph by Chief Petty Officer Cameron Martin, Photographic Unit, Garden Island Naval Base, Sydney.)

A study of pregnant nursing officers in Sri Lanka found that they had five times the rate of preterm delivery of sedentary clerical officers.[17]

Pregnant doctors have been reported to have high rates of preterm delivery, possibly related to stressful and prolonged work schedules.[13]

Pregnancy-induced hypertension

An Italian study found that moderate to heavy physical activity at work doubled the risk of severe pregnancy-induced hypertension.[18] Moderate activity was defined as standing or walking more than 30 hours per week or intense physical effort more than 20 hours per week. Three other studies have shown higher rates of hypertension (mostly double) in working compared with unemployed pregnant women.[19-21]

In Norway, pregnant employees whose work entailed heavy lifting (10–20 kg) or work in which hands were raised above shoulder height had an increased rate of pre-eclampsia (odds ratio [OR], 1.8; 95% CI = 1.2–2.5 and OR, 1.4; 95% CI = 1.0–2.2) respectively).[22]

Effects of prolonged standing

The effect of prolonged standing in relation to fetal growth is controversial: of seven studies described by Fortier et al, [23] only four showed any trend towards increased rates of intrauterine growth restriction. Fortier's own study did show a significant increase in rates of intrauterine growth restriction in the offspring of women who worked more than 6 hours per day in a standing position (OR, 1.42; 95% CI = 1.02–1.95).[23] For women with low pregravid body weights (< 50 kg) the effect of prolonged standing on intrauterine growth was greater (OR, 2.69; 95%CI = 1.79–4.05).

Stress in the workplace

Katz et al studied doctors and nurses working in an intensive care unit while pregnant between 26 and 37 weeks.[24] On working days, the urinary catecholamine levels were 58% greater than on non-working days and 64% greater than those of pregnant women working in unrelated occupations.

Katz argues that decreased uterine blood flow results from both adrenalin (mental stress) and noradrenalin (physical stress): certainly Schnider et al have shown that effect for noradrenalin in pregnant ewes.[25] Katz notes that several studies on pregnant physicians have reported higher than expected rates of pregnancy complications, including antepartum haemorrhage, premature labour and low birthweight.[24]

High job strain, defined as high psychological demands combined with low decisionmaking latitude at work, has not been shown to cause significant differences in arterial blood pressure in women, but there were trends for higher occupational status together with greater skill discretions at work to be associated with higher blood pressure responses at work.[26]

The stress related to occupational noise exposure (< 85 dBALeq) has not been found to be associated with significant changes in birth weight.[27] However, a noisy occupational environment in the second and third trimesters has been associated with an increased rate of arterial hypertension in pregnant French women.[28]

In the USA Landsbergis and Hatch found that stressful jobs characterised by low decisionmaking latitude and low job complexity seemed to increase the rate of gestational hypertension.[29]

A Danish study that retrospectively examined pregnant women in relation to job stress suggested that there were increased rates of spontaneous abortion (OR, 1.28; 95% CI = 1.05–1.57) and low birthweight at term (OR, 1.46; 95% CI = 1.05–2.04) in women employed in high stress occupations.[30] High job stress was defined as increased job demands with decreased job control. Another Danish study has found an association between life events assessed by the subject as highly stressful and an increased risk of preterm delivery (OR, 1.76; 95% CI = 1.15–2.71).[31] This was particularly obvious where highly stressful events occurred between 16–30 weeks' gestation. Social support did not appear to reduce this effect.

One here, one coming…

Petty Officer Medical Angela Kelly (left), Miss Laura Ellen Muller (delivered by Commander Michael O'Connor) and Lieutenant Donna Muller. Photograph by courtesy of Donna Muller.

Regular physical activity in leisure time during the first half of pregnancy may actually reduce the risk of pre-eclampsia (RR=0.67; 95% CI = 0.46–0.96) and gestational hypertension (RR=0.75; 95% CI = 0.54–1.05).[32]

In a review of all articles relating stress to preterm delivery and fetal growth restriction, Hoffman and Hatch concluded that stressful life events do not increase the rate of preterm births.[33] They did note, however, that close social support of pregnant women (even those with apparently few life stresses) improves fetal growth.

Prolonged hours of work, broken shifts, sleep deprivation

There is some evidence that long hours of work do reduce fetal growth. In one study, where pregnant American women worked more than 40 hours per week late into the pregnancy, estimated reductions in birth weight ranged up to 350 g for

some occupations.[34] The authors found that long hours of physically demanding work could lead to significant reductions in fetal growth. They also observed that women working part time had the highest mean birth weights at delivery.

Regular evening or night shifts are also associated with an increased risk of preterm deliveries,[15, 23, 35] and may be more implicated in that complication than shift work alone.[23]

Lawyers in the USA who worked more than 45 hours per week during the first trimester of pregnancy had an increased risk of spontaneous abortion (OR, 3.0; 95% CI = 1.4–6.6).[36]

Toxic exposures at work

Organic solvents

One study has found an association between exposure to organic solvents and hypertensive disorders of pregnancy: [37] solvent-exposed women were about four times more likely to develop pre-eclampsia.

Electromagnetic radiation

A Danish study of pregnant physiotherapists who used devices emitting high frequency electromagnetic radiation at work found that exposed women had a preponderance of female children (less than a quarter of children born to highly exposed mothers were boys) and there was also an association with low birth weight in male offspring.[38]

Ionising radiation

The risks of abortion, fetal malformation (especially microcephaly and mental retardation) and late fetal loss from massive exposure to radiation in pregnancy — such as that experienced by pregnant women in Hiroshima — has been well documented.[39, 40] A dose of 1 Gy received between the 8th and 15th week causes a shift in average intelligence of about 30 points — 45% of newborn offspring resulting from such exposure in early pregnancy will have severe mental retardation.[39] Direct forebrain injury results from large exposures (1.8–5.5 Gy), with further injury resulting from diminished oxygen transport to the fetus (mediated by diminished fetal marrow erythropoiesis[41] and disruption to the pituitary–thyroid axis).[41] Irradiation before eight weeks or after 15 weeks has much less effect on mental retardation or intelligence.[42]

Generally, accidental irradiation of the embryo or fetus of less than 5 cGy is not considered risky enough to warrant therapeutic termination of pregnancy.[39] However, exposures such as would be incurred by high-dose diagnostic x-rays have been related to an increased risk of childhood cancers.[43]

Barotrauma

Decompression sickness in experimental pregnant animals has been found to be associated with major fetal malformations,[44] but uncomplicated simulated "dives" produced no excess in low birthweight, malformation or death.[44,45] A study in humans by Bolton found a slight excess of fetal malformations in women who dived during pregnancy, but the incidence was still within the range for the general population.[46]

Conclusion

Some studies show a negative effect of heavy exercise on birthweight, an effect which is more than twice that produced by smoking a packet of cigarettes daily.[9] Prolonged standing in the workplace appears to reduce fetal growth, particularly for women of low body weight. Heavy work may also more than double the rate of preterm delivery. Hypertensive disorders of pregnancy are also increased in working women.

Although stress in the workplace is difficult to quantify, it does seem that stress produced by high demands and poor control may increase spontaneous abortions, reduce fetal growth and increase the rate of preterm deliveries. Prolonged hours and regular night time shifts may increase the rate of spontaneous abortion and impair fetal growth.

Against these potential hazards of work, servicewomen in the ADF can balance their general good health and ready access to high-quality medical care.

Specific workplace hazards in the military include exposure to electromagnetic and ionising radiation. Both forms may impair reproductive outcome. In the ADF, pregnant women are already formally warned about such hazards and care is taken to minimise their exposure to them.[47]

ADF clinicians are currently less specific about the need to reduce physical activity, hours of work and prolonged standing and to avoid stressful environments while pregnant. However, the current evidence base is not adequate to provide an accurate measure of the hazards experienced by pregnant servicewomen. To answer these questions, a prospective study of active duty pregnant servicewomen in the ADF may be necessary. The number of pregnant active duty servicewomen that would need to be studied to provide an 80% chance of detecting a statistically significant doubling in the rate of pregnancy-induced hypertension or preterm delivery is 428.[48]

References

1. Anon. Preterm Labor. ACOG Technical Bulletin Number 206. *Int J Gynaecol Obstet* 1995; 50: 303-313.
2. Bakketeig LS, Cnattingius S, Knudsen LB. Socioeconomic differences in fetal and infant mortality in Scandinavia. *J Public Health Policy* 1993; 14: 82-90.

3. Spandorfer SD, Graham E, Forouzan I. Pregnancy outcome in active duty seagoing women. *Milit Med* 1996; 161: 214-216.
4. Magann EF, Nolan TE. Pregnancy outcome in an active-duty population. *Obstet Gynecol* 1991; 78: 391-393.
5. Fox ME, Harris RE, Brekken AL. The active-duty military pregnancy: a new high-risk category. *Am J Obstet Gynecol* 1977; 129: 705-707.
6. Kruger PS. Risk factors and pregnancy outcome among Air Force women. *Milit Med* 1979; 144: 788-791.
7. Messersmith-Heroman K, Moore TR, Heroman WM. Pregnancy outcome in military and civilian women. *Milit Med* 1994; 159: 577-579.
8. Tam LW. Psychological aspects of pregnancy in the military: a review. *Milit Med* 1998; 163: 408-412.
9. Bell RJ, Palma SM, Lumley JM. The effect of vigorous exercise during pregnancy on birth-weight. *Aust N Z J Obstet Gynaecol* 1995; 35: 46-51.
10. Clapp JF, Dickstein S. Endurance exercise and pregnancy outcome. *Med Sci Sports Exerc* 1984; 16: 556-562.
11. Douglas JWB. Some factors associated with prematurity. The results of a national study. *J Obstet Gynaecol Br Comm* 1950; 57: 143-170.
12. Naeye RL, Peters EC. Working during pregnancy: effects on the fetus. *Pediatrics*1982; 69: 724-727.
13. Creasy RK. Lifestyle influences on prematurity. *J Develop Physiol* 1991; 15: 15-20.
14. Saurel-Cubizolles MJ, Kaminski M. Pregnant women's working conditions and their changes during pregnancy: a national study in France. *Br J. Indust Med* 1987; 44: 236-243.
15. McDonald AD, McDonald JC, Armstrong B, et al. Prematurity and work in pregnancy. *Br J Indust Med* 1988; 45: 56-62.
16. Homer CJ, Beresford SA, James SA, et al. Work-related physical exertion and risk of preterm, low birthweight delivery. *Paediatr Perinat Epidemiol* 1990; 4: 161-174.
17. Seneviratne SR De A, Fernando DN. Influence of work on pregnancy outcome. *Int J Gynecol Obstet* 1994; 45: 35-40.
18. Spinillo A, Capuzzo E, Colonna L, et al. The effect of work activity in pregnancy on the risk of severe preeclampsia. *Aust N Z J Obstet Gynaecol* 1995; 35: 380-385.
19. Eskenazi B, Fenster J, Sidney S. A multivariate analysis of risk factors for preeclampsia. *JAMA* 1991; 266: 237-241.
20. Klebanoff M, Shiono PH, Rhoads GG. Outcomes of pregnancy in a national sample of resident physicians. *N Engl J Med* 1990; 323: 1040-1045.
21. Marbury MC, Linn S, Monson R et al. Work and pregnancy. *J Occup Med* 1984; 26: 415-21.
22. Wergeland E, Strand K. Working conditions and prevalence of pre-eclampsia, Norway, 1989. *Int J Gynaecol Obstet* 1997; 58: 189-196.
23. 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: 412-418.
24. Katz VL, Jenkins T, Haley L, Bowes WA. Catecholamine levels in pregnant physicians and nurses: a pilot study of stress and pregnancy. *Obstet Gynecol* 1991; 77: 338-342.
25. Schnider SM, Wright RG, Levinson G, et al. Uterine blood flow and plasma norepinephrine changes during maternal stress in the pregnant ewe. *Anesthesiology* 1979; 50: 524-527.
26. Light KC, Turner JR, Hinderliter AL. Job strain and ambulatory work blood pressure in healthy young men and women. *Hypertension* 1992; 20: 214-218.
27. Wu TN, Chen LJ, Lai JS, et al. Prospective study of noise exposure during pregnancy on birth weight. *Am J Epidemiol* 1996; 143: 792-796.
28. Saurel-Cubizolles MJ, Kaminski M, Du Mazaubrun C, Breart G. Working conditions of women with arterial hypertension during pregnancy. *Rev Epidemiol Sante Publique* 1991; 39: 37-43.
29. Landsbergis PA, Hatch MC. Psychosocial work stress and pregnancy-induced hypertension. *Epidemiology* 1996; 7: 346-351.
30. Brandt LP, Nielsen CV. Job stress and adverse outcome of pregnancy: a causal link or recall bias? *Am J Epidemiol* 1992; 135: 302-311.
31. Hedegaard M, Henriksen TB, Secher NJ, et al. Do stressful life events affect the duration of gestation and risk of preterm delivery. *Epidemiology* 1996; 7: 339-345.
32. Marcoux S, Brisson J, Fabia J. The effect of leisure time physical activity on the risk of pre-eclampsia and gestational hypertension. *J Epidemiol Community Health* 1989; 43: 147-152.
33. Hoffman S, Hatch MC. Stress, social support and pregnancy outcome: a reassessment based on recent research. *Paediatr Perinat Epidemiol* 1996; 10: 380-405.
34. 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.
35. Mamelle N, Laumon B, Lazar O. Prematurity and occupational activity during pregnancy. *Am J Epidemiol* 1984; 119: 309-322.
36. Schenker MB, Eaton M, Green R, Samuels S. Self-reported stress and reproductive health of female lawyers. *J Occup Environ Med* 1997; 39: 556-568.
37. Eskenazi B, Bracken MB, Holford TR, Grady J. Exposure to organic solvents and hypertensive disorders of pregnancy. *Am J Indust Med* 1988; 14: 177-188.
38. Larsen AI, Olsen J, Svane O. Gender-specific reproductive outcome and exposure to high-frequency, electromagnetic radiation among physiotherapists. *Scand J Work Environ Health* 1991; 17: 324-329.
39. Vos O. Effects and consequences of prenatal irradiation. *Boll Soc Ital Biol Sper* 1989; 65: 481-500.
40. Mole RH. Severe mental retardation after large prenatal exposures to bomb irradiation. Reduction in oxygen transport to fetal brain: a possible abscopal mechanism. *Int J Radiation Biol* 1990; 58: 705-711.
41. Nyagu AI, Loganovsky KN, Loganovskaja TK. Psychophysiologic aftereffects of prenatal irradiation. *Int J Psychophysiol* 1998; 30: 303-311.
42. Yamazaki JN, Schull WJ. Perinatal loss and neurological abnormalities among children of the atomic bomb. Nagasaki and Hiroshima revisited, 1949 to 1989. *JAMA* 1990; 264: 605-609.
43. Mole RH. Childhood cancer after prenatal exposure to diagnostic x-ray examinations in Britain. *Br J Cancer* 1990; 62: 152-168.
44. Gilman SC, Greene KM, Bradley ME, Biersner RJ. Fetal development: effects of simulated diving and hyperbaric oxygen treatment. *Undersea Biomed Res* 1982; 9: 297-304.
45. Bolton-Klug ME, Lehner CE, Lanphier EH, Rankin JH. Lack of harmful effects from simulated dives in pregnant sheep. *Am J Obstet Gynecol* 1983; 146: 48-51.
46. Bolton ME. Scuba diving and fetal well-being: a survey of 208 women. *Undersea Biomed Res* 1980; 7: 183-189.
47. Australian Defence Health Service Policy on Pregnancy for Members of the Australian Defence Force. Defence Health Policy Directive No 235 March 1999. Canberra: ADF, 1999.
48. Casangrade JT, Pike MC, Smith PG. The power function of the "exact" test for comparing two binomial distributions. *Applied Stat* 1978; 27: 176-180. ❑