

## THE INFLUENCE OF STRESS ON THE MENSTRUAL CYCLE AMONG NEWLY INCARCERATED WOMEN

Jenifer E. Allsworth, PhD<sup>a\*</sup>, Jennifer Clarke, MD, MPH<sup>b,c</sup>, Jeffrey F. Peipert, MD, MPH<sup>a</sup>,  
Megan R. Hebert, MA<sup>d</sup>, Amy Cooper, CRNP<sup>e</sup>, and Lori A. Boardman, MD, ScM<sup>c,e</sup>

<sup>a</sup>Department of Obstetrics and Gynecology, Washington University School of Medicine, St. Louis, Missouri

<sup>b</sup>Memorial Hospital of Rhode Island, Pawtucket, Rhode Island

<sup>c</sup>Brown Medical School, Providence, Rhode Island

<sup>d</sup>Rhode Island Hospital, Providence, Rhode Island

<sup>e</sup>Department of Obstetrics and Gynecology, Women and Infants Hospital, Providence, Rhode Island

Received 1 May 2006; revised 3 November 2006; accepted 25 January 2007

**Objective.** We sought to estimate the association of stressful life events on menstrual function in incarcerated women.

**Methods.** Project CONNECT is a study of reproductive health needs of incarcerated women conducted between June 2002 and December 2003. This analysis examines menstrual function in 446 women from this cohort who were under the age of 45. Regularity was defined as menses between 26 and 35 days long. Amenorrhea was defined as  $\geq 90$  days since last menstruation. Measures included stressful experiences and deprivation (e.g., physical or sexual abuse, stressful living conditions, exchanging sex for drugs or money, or having had an incarcerated parent).

**Results.** Menstrual dysfunction was common in this population. Nine percent reported amenorrhea, and 33% reported menstrual irregularity. A number of stressors were associated with menstrual irregularity, including having a parent with history of alcohol or drug problems (relative risk [RR] = 1.34; 95% confidence interval [CI], 1.00–1.80), childhood physical or sexual abuse (RR = 1.48; 95% CI, 1.03–2.13), or any sexual abuse (RR = 1.49; 95% CI, 1.03–2.14) after adjusting for age, race/ethnicity, smoking status, and recent drug use. These effects were attenuated somewhat when excluding women who had reported any hormonal contraceptive use in the past 3 months.

**Conclusion.** Incarcerated women have high rates of amenorrhea and menstrual irregularity and the prevalence may be associated with certain stresses. Further research on the causes and consequences of menstrual dysfunction in this underserved population is needed.

Menstrual cycle characteristics such as amenorrhea, cycle irregularity, and menstrual cycle length are important women's health issues. Although the first modern study of menstrual function began in 1935 with the Tremin Trust (Mansfield & Brackin, 2003; Voda, Morgan, Root, & Smith, 1991)—an observational study that collected menstrual diaries on

nearly 2000 women for up to 42 years—there is much that remains unknown. In a recent study, Lisabeth, Harlow, Lin, Gillespie, and Sowers (2004, p. 795) conclude that “studies evaluating potentially modifiable host and environmental factors that may affect menstrual function remain limited, and basic research is still needed on patterns of change in menstrual function . . . especially among women of non-European descent.”

Menstrual cycle characteristics, in addition to being associated with future reproductive outcomes like fertility and timing of menopause, are associated with a number of other health-related outcomes. Increased

\* Correspondence to: Jenifer E. Allsworth, PhD, Division of Clinical Research, Department of Obstetrics and Gynecology, Washington University School of Medicine, Campus Box 8219, 4533 Clayton Avenue, St. Louis, MO 63110.

E-mail: allsworthj@wudosis.wustl.edu.

menstrual cycle length at age 30 correlates with increased postmenopausal fracture risk (Cooper & Sandler, 1997) and longer duration of menstrual bleeding has been linked to an increased risk of adult onset diabetes (Cooper, Ephross, & Sandler, 2000). Further, both longer duration of menstrual bleeding and cycle irregularity are associated with major depression (Harlow, Cohen, Otto, Spiegelman, & Cramer, 2004). In addition to future morbidity, menstrual cycle characteristics are also associated with a number of important factors predictive of future health outcomes, such as weight, smoking, alcohol intake, exercise, race/ethnicity, and stress (Cohen, Kamarck, & Mermelstein, 1983; Fenster et al., 1999; Harlow & Campbell, 1994; Harlow, Campbell, Lin, & Raz, 1997; Matteo, 1987; Rowland et al., 2002; Symons, Sowers, & Harlow, 1997).

Although the literature on stress and reproductive function has principally focused on ovarian aging and menopause, a number of earlier studies looked at the relationship between stress and menstrual cycle characteristics. For example, Matteo (1987) and Harlow and Matanoski (1991) found that self-reported measures of stress correlated with longer menstrual cycles. In contrast, Fenster and associates (1999) found that women who reported that their jobs were characterized by high stress but low control over their work environment had a higher risk of short cycles. Finally, menstrual cycle characteristics have not only been shown to be associated with self-reported levels of stress, but also with physiologic measures of stress. Sanders and Bruce (1999) found that cortisol levels were highest among women with long menstrual cycles. These studies, however, have focused principally on short-term stressors among populations of women who were not socioeconomically deprived, making their generalizability to long-term chronic stressors unclear.

Incarcerated women represent a population experiencing significant levels of stress stemming from multiple sources. In addition to the stresses of incarceration (Fogel, 1993), incarcerated women are more likely to have experienced past stressful life events such as violence and economic deprivation. Further, the population of incarcerated women includes a disproportionate number of racial and ethnic minorities. According to data tabulated from the 2000 Census by Human Rights Watch, approximately 39 per 100,000 White women were incarcerated, in contrast with 99 per 100,000 for Hispanic women and 492 per 100,000 for Black women (Human Rights Watch, 2002).

Previous studies have found that incarcerated women have significantly higher rates of stress and anxiety disorders than the general population (Jordan, Schlenger, Fairbank, & Caddell, 1996; Teplin, Abram, & McClelland, 1996; Zlotnick, 1997). A study of women in pretrial detention found that 1 in 3 met

criteria for posttraumatic stress disorder (PTSD) at some point in their lives; in contrast, a study of incarcerated women in Rhode Island found almost half met criteria for PTSD and an additional 20% had met criteria for PTSD at some other time (Zlotnick, 1997). Further, many incarcerated women have experienced stressful or traumatic life events. A history of traumatic events, with or without PTSD, was reported by 78–87% (Jordan et al., 1996; Zlotnick, 1997) of incarcerated women. Although no studies have yet examined the relationship with reproductive function, stress during incarceration has been shown to be associated with depression, weight gain, and number of physical symptoms reported (Fogel, 1993).

We hypothesize that menstrual dysfunction is highly prevalent among incarcerated women in Rhode Island. This study examines the association between menstrual irregularity and amenorrhea and stressful life experiences in a population of newly incarcerated women.

## Methods

Project CONNECT (CONtraceptive Needs Evaluation and Community Transition) was designed to evaluate the reproductive health needs of incarcerated women as well as to evaluate a recently created postincarceration family planning program (Clarke, Hebert et al., 2006; Clarke, Rosengard et al., 2006). Between June 1, 2002, and December 31, 2003, 484 women were enrolled in Project CONNECT. The recruitment source was the Rhode Island Adult Correctional Institute (ACI), a unified correction system serving as a combined prison and jail, holding all pretrial and sentenced inmates in the state. Women entering the ACI were recruited into Project CONNECT from both the sentenced population and those awaiting trial. The enrollment process included a preliminary review of traffic sheets (daily listing of all female inmates committed to or released from the facility) Monday (which included weekend traffic) through Friday. This preliminary review allowed research assistants to compile a list of women who had not been previously screened or enrolled for an eligibility screening interview.

To be eligible for inclusion in Project CONNECT, women had to be  $\geq 18$  years old, housed in the general facility population, and able to communicate in English and complete the informed consent process. If a woman was unable to be screened secondary to being housed in segregation, ill, or in acute withdrawal from drugs and/or alcohol, her status was followed daily until she was released or could be evaluated for eligibility.

Of the 2,298 women committed during the recruitment period, 707 were released before research staff

could approach them. Of the women screened, 40 were excluded for either being incompetent or housed in segregation and 35 were excluded because they were non-English speaking. *Incompetent* was defined as evidence of either mental illness or acute drug withdrawal that impacted a woman's comprehension of the consent process and was ascertained by a trained research assistant. We excluded 721 women who 1) had a hysterectomy or tubal ligation or 2) wanted to become pregnant in the first 6 months after their release from prison. Of the remaining 795 women, 484 (61%) participated in the study. The 446 women  $\leq 45$  years old were included in this analysis. Participants completed a 45-minute in-person interview that assessed medical and reproductive histories, current pregnancy intention, substance use, physical and sexual abuse histories, as well as mood and health-related attitudes and behaviors.

Approval for this evaluation was obtained from the Miriam Hospital Institutional Review Board, the Office for Human Research Protection, and the Medical Research Advisory Group at the ACI before study initiation. In addition, a Certificate of Confidentiality was obtained from the federal government to further ensure participant privacy. Additional information on the Project CONNECT cohort and baseline characteristics has been published elsewhere (Clarke, Hebert et al., 2006; Clarke, Rosengard et al., 2006).

The current analyses present data from the 446 nonpregnant women enrolled in Project CONNECT who were  $\leq 44$  years old at the time of the baseline interview. We limited these analyses to women under the age of 45 to exclude changes in menstruation related to the onset of menopause (Ferrell et al., 2006; Gold et al., 2001). Project CONNECT sought to minimize respondent burden during the interview process by including both long and short versions of the interview. As a result, questions on menopause and hysterectomy were not asked of all women. Therefore, all analyses of amenorrhea are based on the subset of 285 women who completed the long form, and analyses of menstrual regularity are based on the entire sample of 446 women.

In this study, we evaluated 2 measures of menstrual function: menstrual regularity and amenorrhea. Menstrual regularity was a dichotomous variable determined by the woman's response to the question: "Are your periods usually regular (every 26–35 days)?" *Amenorrhea* was defined as  $>90$  days since the time of last menstruation.

We examined the association between a number of stressful life experiences and menstrual function. Conceptually, our measures were both direct stressful experiences (e.g., physical or sexual abuse) as well as measures that reflected stressful living conditions and/or deprivation (e.g., having exchanged sex for

drugs or money or having a parent with an alcohol or drug problem). Stressors included the following experiences: 1) living in foster care; 2) exchanging sex for drugs or money; 3) feeling unsafe in living arrangement before incarceration; 4) living with someone with an alcohol and/or drug problem; 5) having a parent who was incarcerated; 6) having a parent with an alcohol and/or drug problem; and 7) experiencing physical and/or sexual abuse. Further, among those reporting abuse, we categorized abuse by age at first experience of abuse (childhood [ $\leq 16$  years old] vs. adulthood [ $\geq 17$  years old]) and type of abuse (any sexual abuse vs. physical abuse only).

Covariates analyzed include demographic characteristics, health behaviors, and reproductive history. Demographic measures included age (in years); race/ethnicity (White, non-Hispanic; Black, non-Hispanic; Hispanic; or other); high school graduate/GED (yes/no); length of longest held job (in months); homelessness before incarceration (yes/no); has health insurance (yes/no); and has usual source of medical care (yes/no). Health behaviors included current smoking status, drinking alcohol to intoxication in the past 90 days, any illicit drug use in the past 90 days, and lifetime number of sexual partners. Reproductive history included age at menarche; whether the respondent noticed changes in menstrual function when using drugs or methadone (yes/no); ever pregnant (yes/no); age of first pregnancy; and number of pregnancies, deliveries and terminations.

#### *Statistical methods*

Demographic characteristics, health behaviors, and reproductive factors were compared between the 2 measures of menstrual irregularity and amenorrhea. Continuous variables were compared using *t* tests (age, number of pregnancies, etc.) or the Wilcoxon rank-sum test (lifetime sexual partners). Categorical variables were compared using a  $\chi^2$  test. In an isolated number of comparisons owing to small cell sizes, Fisher's exact tests were used. Relative risks for the association with stressful life events and menstrual regularity were estimated using a log-binomial regression model. This approach was used because the prevalence of menstrual irregularity was  $>30\%$  and logistic regression may have overestimated the size of the effect (McNutt, Wu, Xue, & Hafner, 2003). We calculated 3 estimates of relative risk for each stressful life event: 1) a crude estimate; 2) an estimate adjusted for age, race/ethnicity, smoking status and drug use; and 3) an adjusted estimate in the subsample of women who reported no hormonal contraceptive use in the past 3 months. All analyses were conducted using SAS (version 9.1; SAS Institute, Cary, NC).

**Table 1.** Demographic Characteristics and Health Behaviors by Menstrual Regularity and Amenorrhea

	Amenorrhea (n = 285)				Menstrual Cycle Regularity (n = 446)		
	All Women (N = 446)	No Amenorrhea (n = 260)	Amenorrhea (n = 25)	p-Value	Regular (n = 300)	Irregular (n = 146)	p-Value
<b>Demographic characteristics</b>							
Age, mean (± SD) (yrs)	31 ± 9	26 ± 6	25 ± 6	.23	30 ± 7	29 ± 8	.16
Race/ethnicity, n (%)							
White, non-Hispanic	243 (54)	130 (50)	20 (80)	<.01*	91 (62)	152 (51)	.07
Black, non-Hispanic	69 (15)	48 (18)	0		19 (13)	50 (17)	
Hispanic	84 (19)	45 (17)	4 (16)		26 (18)	58 (19)	
Other/Missing	50 (11)	37 (14)	1 (4)		10 (7)	40 (13)	
High school/GED, n (%)	187 (42)	95 (37)	11 (44)	.46	132 (44)	55 (38)	.20
Homeless, n (%)	72 (16)	37 (14)	6 (24)	.19	44 (15)	28 (19)	.22
Usual source of medical care, n (%)	319 (72)	184 (71)	16 (64)	.48	215 (72)	104 (71)	.92
Has health insurance, n (%)	198 (45)	109 (42)	9 (36)	.55	133 (45)	65 (45)	.97
Longest job held in months, mean (±SD)	38 (44)	28 (34)	24 (18)	.38	39 (40)	29 (41)	.02
<b>Health behaviors</b>							
Current smoker, n (%)	356 (80)	209 (80)	18 (72)	.32	241 (80)	115 (79)	.70
Alcohol intoxication last 90 days, n (%)	133 (30)	93 (36)	4 (16)	.05*	83 (27)	50 (35)	.15
Drug use last 90 days, n (%)	232 (52)	139 (53)	16 (64)	.31	148 (49)	84 (56)	.10
Total sexual partners, median	7	8	10	.52**	7	8	.49**

\*p-Value estimated from Fisher exact test.

\*\*p-Value estimated from rank-sum test.

**Results**

Demographic characteristics, health behaviors and reproductive history are summarized in Tables 1 and 2, and comparisons with stressful life events are presented in Table 3. The mean age of participants was 28 years. Over half of the sample reported their race/ethnicity as White, non-Hispanic (54%), 15% were Black, non-Hispanic, and 19% were Hispanic. Two fifths of the sample had graduated from high school or obtained a GED, and 16% reported recent homelessness. Eighty percent were current smokers and more than half had consumed alcohol to intoxication or used drugs in the last 90 days. Finally, the average age at menarche was 12.6 years; 83% reported that they had been pregnant at least once.

*Amenorrhea*

Nine percent of women in the sample reported that their most recent period was ≥90 days ago. The majority of women reporting amenorrhea reported their race/ethnicity as White, non-Hispanic. Women with amenorrhea were less likely to have used alcohol to intoxication in the last 90 days, but were slightly more likely to report recent drug use. Finally, women with amenorrhea were more likely to report that menstruation ceased with drug or methadone use.

Although there was limited power to detect differences in history of stressful experiences between the groups with and without amenorrhea, several differences did emerge. When compared with women without amenorrhea, women with amenorrhea were more

**Table 2.** Reproductive History by Menstrual Regularity and Amenorrhea

	Amenorrhea (n = 285)				Menstrual Cycle Regularity (n = 446)		
	All Women (n = 446)	No Amenorrhea (n = 260)	Amenorrhea (n = 25)	p-Value	Regular (n = 300)	Irregular (n = 146)	p-Value
<b>Reproductive history</b>							
Age of menarche, mean ± SD (yrs)	13 ± 2	12 ± 2	12 ± 2	.25	13 ± 3	13 ± 2	.20
Among users, periods cease with recreational drug or methadone use (n = 314), n (%)	122 (39)	66 (36)	15 (79)	<.001*	68 (33)	54 (51)	<.01
Ever pregnant, n (%)	370 (83)	197 (76)	20 (80)	.64	249 (83)	121 (83)	.92
Age of first pregnancy, mean (± SD)	18 (4)	18 (3)	19 (4)	.10	18 (4)	18 (4)	.95
Number of deliveries (mean ± SD)	2.2 ± 1.7	1.8 ± 1.4	1.3 ± 1.3	.16	2.3 ± 1.7	1.9 ± 1.4	.01
Number of terminations (mean ± SD)	0.7 ± 1.1	0.7 ± 1.1	0.8 ± 0.8	.70	0.7 ± 1.0	0.8 ± 1.2	.34

**Table 3.** Lifetime Stressful Life Experiences by Menstrual Function

Social Context	All Women ( <i>n</i> = 446) <i>n</i> (%)	Amenorrhea ( <i>n</i> = 285)		<i>p</i> -Value	Menstrual Regularity		<i>p</i> -Value
		No Amenorrhea ( <i>n</i> = 260) <i>n</i> (%)	Amenorrhea ( <i>n</i> = 25) <i>n</i> (%)		Regular ( <i>n</i> = 300) <i>n</i> (%)	Irregular ( <i>n</i> = 146) <i>n</i> (%)	
Childhood							
Ever lived in foster care	114 (26)	81 (31)	3 (12)	.06	77 (26)	37 (25)	.94
Adulthood							
Had sex for drugs or money	109 (35)	64 (33)	10 (48)	.17	72 (34)	37 (37)	.54
Feel safe where living	280 (63)	177 (68)	17 (68)	.10	195 (65)	85 (58)	.17
In 3 months before incarceration lived with someone with an alcohol or drug problem	135 (30)	86 (33)	10 (40)	.49	84 (28)	51 (35)	.12
Lifetime							
Parent alcohol/drug problem	272 (61)	169 (65)	19 (76)	.27	172 (57)	100 (68)	.02
Parent incarcerated	170 (38)	11 (43)	14 (56)	.20	110 (37)	60 (41)	.37
Age at first abuse							
Never abused	112 (25)	64 (25)	7 (28)	.71	85 (28)	27 (18)	.03
Childhood	263 (59)	163 (63)	14 (56)		164 (55)	99 (68)	
Adult	71 (16)	33 (13)	4 (16)		51 (17)	20 (14)	
Type of abuse							
Any sexual	230 (52)	131 (51)	14 (56)	.65	143 (48)	87 (60)	.04
Physical only	104 (23)	63 (24)	4 (16)		72 (24)	32 (22)	

\**p*-value estimated from Fisher's exact test.

likely to be living with someone with a drug problem and more often reported that a parent had an alcohol or drug problem. Women with amenorrhea were less likely to report a history of foster care and somewhat more likely to have exchanged sex for drugs or money. Further, among women with amenorrhea, similar numbers reported never having been abused (no amenorrhea, 25% vs. amenorrhea, 28%).

#### Menstrual Regularity

In this sample, almost one third of women reported that their menstrual cycles were irregular (not within 26–35 days). Women who reported that their menstrual cycles were currently irregular did not differ significantly in age, but reported having worked for shorter durations during their longest jobs than women with irregular cycles. Although the 2 groups were similar in terms of current smoking, women with irregular cycles reported more recent alcohol and drug use than women with regular cycles. The median number of sexual partners was not significantly higher among women with irregular cycles. Among women who reported drug or methadone use, women with irregular cycles were also more likely to report that their cycles ceased with drug use. Finally, although women with irregular cycles were similar to women with regular cycles in terms of number of pregnancies, women with irregular cycles had fewer deliveries (1.9 vs. 2.4; *p* = .01).

Women with menstrual irregularity were somewhat less likely to be living in a safe environment, slightly more likely to be living with someone with an alcohol or drug problem, and significantly more likely to

report a history of paternal alcohol or drug problems (Table 3). Among those with menstrual irregularity, 68% reported being abused as children, compared with 55% for those with regular cycles. Furthermore, 60% of women with irregularity reported a history of sexual abuse, compared with 48% among those with regular cycles. Finally, having lived in foster care, living with someone with an alcohol or drug problem, or having 1 or both parents with a history of incarceration were not associated with menstrual irregularity.

Crude and adjusted relative risks (RR) for the association between stressful life events and menstrual regularity are presented in Table 4. In crude analyses, women who reported a parent with an alcohol or drug use problem, a history of childhood physical or sexual abuse or any lifetime sexual abuse had higher risk for menstrual irregularity. When adjusting age, race/ethnicity, smoking status, and recent drug use, having a parent with a history of alcohol or drug problem (RR, 1.34; 95% confidence interval [CI], 1.00–1.80) was associated with a slightly higher risk of menstrual irregularity. First abuse in childhood (RR, 1.48; 95% CI 1.03–2.13), and any history of sexual abuse (RR, 1.49; 1.03–2.14) remained significantly associated with menstrual irregularity in the adjusted analysis. Although none of the women were current hormonal contraceptive users at the time of the interview, some women had recently stopped use. When the analyses were limited to women with no hormonal contraceptive use in the past 3 months, having had a parent with an alcohol/drug problem and having a history of childhood abuse or sexual abuse had elevated, but not

**Table 4.** Association of Stressful Life Events and Menstrual Irregularity, Crude and Adjusted Relative Risks and 95% Confidence Intervals

	Crude RR (95% CI)	All Women: Adjusted* RR (95% CI)	Women With No Recent Hormonal Contraceptive Use <sup>†</sup> : Adjusted* RR (95% CI)
Ever in foster care	0.99 (0.73–1.34)	0.98 (0.72–1.32)	0.99 (0.71–1.38)
Had sex for drugs or money	1.11 (0.80–1.55)	1.21 (0.82–1.78)	1.25 (0.82–1.90)
Feel safe where living	0.61 (0.37–1.00)	0.59 (0.34–1.02)	0.54 (0.32–0.92)
In 3 months before admittance lived with someone with an alcohol or drug problem	1.25 (0.95–1.64)	1.14 (0.85–1.51)	1.05 (0.77–1.43)
Parent alcohol/drug problem	1.39 (1.04–1.86)	1.34 (1.00–1.80)	1.34 (0.97–1.81)
Parent incarcerated	1.13 (0.87–1.48)	1.10 (0.83–1.46)	1.05 (0.77–1.43)
Age at first abuse (referent, never abused)			
Childhood	1.56 (1.09–2.25)	1.48 (1.03–2.13)	1.40 (0.96–2.05)
Adulthood	1.17 (0.71–1.92)	1.07 (0.65–1.76)	1.08 (0.65–1.79)
Type of abuse (referent, never abused)			
Any sexual	1.57 (1.09–2.27)	1.49 (1.03–2.14)	1.39 (0.95–2.05)
Physical only	1.28 (0.82–1.98)	1.18 (0.77–1.82)	1.19 (0.76–1.85)

\*Characteristics adjusted for age, race/ethnicity, smoking status, and drug use in the last 90 days.

<sup>†</sup>Women who reported any hormonal contraceptive use in the past 3 months were excluded.

statistically significant, associations with menstrual irregularity.

## Discussion

Incarcerated women are a vulnerable population that has experienced significantly higher rates of social disruption and trauma than the general population. Almost 1 in 4 had at some point in their lives been in foster care, one third has exchanged sex for drugs or money, and 1 in 5 had lived in the past 3 months with someone with an alcohol or drug problem. Rates of physical and sexual abuse were similarly elevated. Nearly 70% reported having been physically abused at some point in their lives, with a mean age at first abuse of approximately 13 years. Over half of the women reported a history of sexual abuse, with a mean age at first sexual abuse occurring at roughly 12 years of age.

This population of incarcerated women reported high rates of menstrual dysfunction. Approximately 9% of women reported amenorrhea and 33% reported that their menstrual cycles were irregular. In contrast, data from the National Health Examination and Nutrition Survey (NHANES) collected during 2001 and 2002 found that among nonpregnant reproductive age women aged 44 and younger with no medical or surgical cause for irregularity, <3% reported their last period  $\geq 3$  months ago, and 13% had irregular menstrual cycles in the past year. Although it is not possible to identify a similarly disadvantaged population using the NHANES dataset, the prevalence of menstrual irregularity among those living under the federal poverty level or who had not completed high school, was 16–17% (unpublished data). The prevalence of menstrual dysfunction observed in this population is 2 times that observed in low socioeconomic

groups and as much as 3 times as the prevalence in the general population.

How stress impacts the reproductive function, specifically the menstrual cycle, of women remains unclear. One mechanism linking stress with menstrual function occurs via dysregulation of the body's stress responses, particularly along the hypothalamic–pituitary–adrenal (HPA) axis (Lemieux & Coe, 1995; Yehuda, Giller, Southwick, Lowy, & Mason, 1991). The hypothalamus regulates menstrual function by secreting gonadotropin-releasing hormone in pulses, which stimulates the periodic release of both follicle-stimulating hormone and luteinizing hormone from the pituitary gland. Follicle-stimulating hormone is necessary for follicular maturation, and luteinizing hormone, which stimulates estradiol secretion by the maturing follicle, is necessary for ovulation and after ovulation helps to maintain the corpus luteum (Williams & Wilson, 1998). Once this cycle is disrupted, maintenance of regular menstrual function temporarily ceases; the nature and length of cessation depends on the continuation of the initiating stressful event.

## Limitations

As discussed in an analysis of the association of physical and sexual abuse with the timing of menopause (Allsworth et al., 2004), the basic biology underlying the study of stress and menstrual function is incompletely understood. The predominant paradigm is that stress stimulates HPA axis function, resulting in earlier menopause. However, in the menopause literature there is evidence consistent with an alternative biologic mechanism, possibly involving underactivity of the HPA axis (Allsworth et al., 2004; Heim, Ehler, & Hellhammer, 2000; King, Mandansky, King, Fletcher, & Brewer, 2001; McEwen, 1998). Under the

underactivity paradigm, prolonged or severe stress may lead to suppression of the HPA axis, which results in fewer ovulatory cycles and reduced follicle depletion. According to Heim, Ehler, Rexhausen, Hanker, and Hellhammer (1997) and Gunnar and Vazquez (2001), underactivity of the HPA axis may be more common than previously understood, especially among individuals exposed to chronic stress. Previous studies of incarcerated males lend credence to this hypothesis. Culpepper and Froom (1980, pp. 573–574) conducted a study among incarcerated men and reported that “inmates maintain significantly lower blood pressures and prevalence of hypertension than age-race matched non-prisoners rais[ing] the possibility that inmates represent a population which does not increase blood pressure in response to stress.”

Proving such causality is clearly limited by the design of our study. First, this is a cross-sectional study with simultaneous ascertainment of both exposure and outcomes. As such, we are not able to establish temporality. Furthermore, we do not have information on the perceived stressfulness of the events studied in individual women or potential resources (e.g., social support) available to aid them in coping with stressful experiences.

Given that this is a secondary analysis of a randomized trial, the information on menstrual function was limited. The definition of menstrual regularity used in this study (defined as cycles occurring every 26–35 days), we were not able to differentiate women with frequent menstruation from those with longer cycles. Moreover, menstrual function information may be subject to misclassification. Although the agreement of menstrual function characteristics has been shown to be low for unstructured questions, Smith-DiJulio, Mitchell and Woods (2005) found that agreement improved considerably when the definition of menstrual function characteristics was included in the question, as was done in this study. Given the relative deprivation of this population, it is possible that nondifferential misclassification of menstrual dysfunction may have resulted in diminished power to detect a significant difference. The selection of this cohort may limit its generalizability. The cohort was selected to include women at risk for unintended pregnancy and therefore excluded non-sexually active women and those with prior hysterectomy. However, if women with menstrual dysfunction may have been more likely to receive hysterectomy, menstrual dysfunction may have been underestimated in this cohort.

## Conclusion

Although stress has been linked to menstrual dysfunction in a number of studies, these populations have

predominately been more socioeconomically advantaged than incarcerated women. Although our power was limited to detect significant differences, there was a suggestion that lifetime histories of certain stressors may be related to menstrual irregularity. Women who reported a parent with an alcohol/drug problem, sexual abuse, or any abuse during childhood had slightly elevated risks than women without similar histories. Menstrual dysfunction is an important source of morbidity as well as an indicator of women's reproductive health and aging.

Incarcerated women are uniquely vulnerable—they often have histories of deprivation and violence and then may experience considerable stress as a consequence of their incarceration. Health care providers should consider routine evaluation of reproductive and menstrual function at admission and during incarceration to better care for this population. Future studies are needed to understand the role of stress and menstrual function in both the incarcerated and general population. Improved knowledge of the impact of stress on women's health can direct health interventions and policy initiatives that can improve the lives of incarcerated women, both inside and outside of prison.

## Acknowledgments

The work described was supported by grant number HD01472-01A1 and FPR PA 002044-01 from the Center for Child Health and Human Development. Dr Boardman is a recipient of a K23 grant from NICHD (HD01307), which partially supported this work. Dr Peipert is a recipient of a K24 grant from NICHD (HD01298), which partially supported this work. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the awarding agencies.

## References

- Allsworth, J. E., Zierler, S., Lapane, K. L., Krieger, N., Hogan, J. W., & Harlow, B. L. (2004). Longitudinal study of the inception of perimenopause in relation to lifetime history of sexual or physical violence. *Journal of Epidemiology and Community Health*, 58, 938–943.
- Clarke, J. G., Hebert, M. R., Rosengard, C., Rose, J. S., DaSilva, K. M., & Stein, M. D. (2006). Reproductive health care and family planning needs among incarcerated women. *American Journal of Public Health*, 96, 834–839.
- Clarke, J. G., Rosengard, C., Rose, J., Hebert, M. R., Phipps, M. G., & Stein, M. D. (2006). Pregnancy attitudes and contraceptive plans among women entering jail. *Women & Health*, 43, 111–130.
- Cohen, S., Kamarck, T., & Mermelstein, R. (1983). A global measure of perceived stress. *Journal of Health and Social Behavior*, 24, 385–396.
- Cooper, G. S., Ephross, S. A., & Sandler, D. P. (2000). Menstrual patterns and risk of adult-onset diabetes mellitus. *Journal of Clinical Epidemiology*, 53, 1170–1173.
- Cooper, G. S., & Sandler, D. P. (1997). Long-term effects of reproductive-age menstrual cycle patterns on peri- and postmenopausal fracture risk. *American Journal of Epidemiology*, 145, 804–809.

- Culpepper, L., & Froom, J. (1980). Incarceration and blood pressure. *Social Science & Medicine*, 14A(6), 571–574.
- Fenster, L., Waller, K., Chen, J., Hubbard, A. E., Windham, G. C., Elkin, E., et al. (1999). Psychological stress in the workplace and menstrual function. *American Journal of Epidemiology*, 149, 127–134.
- Ferrell, R. J., Simon, J. A., Pincus, S. M., Rodriguez, G., O'Connor, K. A., Holman, D. J., et al. (2006). The length of perimenopausal menstrual cycles increases later and to a greater degree than previously reported. *Fertility and Sterility*, 86, 619–624.
- Fogel, C. I. (1993). Hard time: The stressful nature of incarceration for women. *Issues in Mental Health Nursing*, 14, 367–377.
- Gold, E. B., Bromberger, J., Crawford, S., Samuels, S., Greendale, G. A., Harlow, S. D., et al. (2001). Factors associated with age at natural menopause in a multiethnic sample of midlife women. *American Journal of Epidemiology*, 153, 865–874.
- Gunnar, M. R., & Vazquez, D. M. (2001). Low cortisol and a flattening of expected daytime rhythm: potential indices of risk in human development. *Development and Psychopathology*, 13, 515–538.
- Harlow, B. L., Cohen, L. S., Otto, M. W., Spiegelman, D., & Cramer, D. W. (2004). Early life menstrual characteristics and pregnancy experiences among women with and without major depression: The Harvard study of moods and cycles. *Journal of Affective Disorders*, 79, 167–176.
- Harlow, S. D., Campbell, B., Lin, X., & Raz, J. (1997). Ethnic differences in the length of the menstrual cycle during the postmenarcheal period. *American Journal of Epidemiology*, 146, 572–580.
- Harlow, S. D., & Campbell, B. C. (1994). Host factors that influence the duration of menstrual bleeding. *Epidemiology*, 5, 352–355.
- Harlow, S. D., & Matanoski, G. M. (1991). The association between weight, physical activity, and stress and variation in the length of the menstrual cycle. *American Journal of Epidemiology*, 133, 38–49.
- Heim, C., Ehlert, U., & Hellhammer, D. H. (2000). The potential role of hypocortisolism in the pathophysiology of stress-related bodily disorders. *Psychoneuroendocrinology*, 25(1), 1–35.
- Heim, C., Ehlert, U., Rexhausen, J., Hanker, J. P., & Hellhammer, D. H. (1997). Psychoendocrinological observations in women with chronic pelvic pain. *Annals of the New York Academy of Science*, 821, 456–458.
- Human Rights Watch. (2002). Race and incarceration in the United States. Available: [www.hrw.org/background/usa/race](http://www.hrw.org/background/usa/race). Accessed March 12, 2007.
- Jordan, B. K., Schlenger, W. E., Fairbank, J. A., & Caddell, J. M. (1996). Prevalence of psychiatric disorders among incarcerated women. II. Convicted felons entering prison. *Archives of General Psychiatry*, 53, 513–519.
- King, J. A., Mandansky, D., King, S., Fletcher, K. E., & Brewer, J. (2001). Early sexual abuse and low cortisol. *Psychiatry and Clinical Neurosciences*, 55(1), 71–74.
- Lemieux, A. M., & Coe, C. L. (1995). Abuse-related posttraumatic stress disorder: evidence for chronic neuroendocrine activation in women. *Psychosomatic Medicine*, 57, 105–115.
- Lisabeth, L., Harlow, S. D., Lin, X., Gillespie, B., & Sowers, M. (2004). Sampling strategies for prospective studies of menstrual function. *American Journal of Epidemiology*, 159, 795–802.
- Mansfield, P. K., & Brackin, S. J. (2003). *Trenin: A history of the world's oldest study of menstruation and women's health*. Lemont, PA: East Rim Publishers.
- Matteo, S. (1987). The effect of job stress and job interdependency on menstrual cycle length, regularity and synchrony. *Psychoneuroendocrinology*, 12, 467–476.
- McEwen, B. S. (1998). Protective and damaging effects of stress mediators. *New England Journal of Medicine*, 338, 171–179.
- McNutt, L. A., Wu, C., Xue, X., & Hafner, J. P. (2003). Estimating the relative risk in cohort studies and clinical trials of common outcomes. *American Journal of Epidemiology*, 157, 940–943.
- National Health Examination and Nutrition Survey (NHANES). National Health and Nutrition Examination Survey: 2001–200. Available from <http://www.cdc.gov/nchs/about/major/nhanes/nhanes01-02.htm>. Accessed on March 12, 2007.
- Rowland, A. S., Baird, D. D., Long, S., Wegienka, G., Harlow, S. D., Alavanja, M., et al. (2002). Influence of medical conditions and lifestyle factors on the menstrual cycle. *Epidemiology*, 13, 668–674.
- Sanders, K. A., & Bruce, N. W. (1999). Psychosocial stress and the menstrual cycle. *Journal of Biosocial Science*, 31, 393–402.
- Smith-Dijulio, K., Mitchell, E. S., Woods, N. F. (2005). Concordance of retrospective and prospective reporting of menstrual irregularity by women in the menopausal transition. *Climacteric*, 8(4), 390–397.
- Symons, J. P., Sowers, M. F., & Harlow, S. D. (1997). Relationship of body composition measures and menstrual cycle length. *Annals of Human Biology*, 24(2), 107–116.
- Teplin, L. A., Abram, K. M., & McClelland, G. M. (1996). Prevalence of psychiatric disorders among incarcerated women. I. Pretrial jail detainees. *Archives of General Psychiatry*, 53, 505–512.
- Voda, A. M., Morgan, J. M., Root, J., & Smith, K. R. (1991). The Tremin Trust: An intergenerational research program on events associated with women's menstrual and reproductive lives. In D. L. Taylor & N. F. Woods (Eds.), *Menstruation, health, and illness* (pp. xvi). New York: Hemisphere.
- Williams, R. H., & Wilson, J. D. (1998). *Williams textbook of endocrinology* (9th ed.). Philadelphia: Saunders.
- Yehuda, R., Giller, E. L., Southwick, S. M., Lowy, M. T., & Mason, J. W. (1991). Hypothalamic-pituitary-adrenal dysfunction in post-traumatic stress disorder. *Biological Psychiatry*, 30, 1031–1048.
- Zlotnick, C. (1997). Posttraumatic stress disorder (PTSD), PTSD comorbidity, and childhood abuse among incarcerated women. *Journal of Nervous and Mental Disease*, 185, 761–763.

---

## Author Descriptions

Jenifer E. Allsworth, PhD, is an epidemiologist in the Division of Clinical Research, Department of Obstetrics and Gynecology at Washington University in St. Louis School of Medicine. Her research interests focus on the impact of social factors on women's reproductive health.

Jennifer G. Clarke, MD, MPH, is an Assistant Professor of Medicine and Obstetrics and Gynecology at Brown Medical School. She is an internist at the women's prison/jail in Rhode Island and her primary research interests are in the reproductive health needs of incarcerated women.

Jeffrey F. Peipert, MD, MPH, is the Robert J. Terry Professor and Vice Chair of Clinical Research in the Department of Obstetrics and Gynecology at the Washington University in St. Louis School of Medicine. His research interests include clinical epidemiology, family planning, and sexually transmitted infections.

Lori Boardman, MD, ScM, is an Associate Professor of Obstetrics and Gynecology at Women and Infants Hospital of Rhode Island/Brown Medical School and Clinical Care Director of the Brown University/Women and Infants Hospital National Center of Excellence in Women's Health. Her research interests include HPV infection and lower genital tract neoplasia, particularly in adolescents and HIV-infected women.

---