

Original research

Occupational physical demands and menstrual cycle irregularities in flight attendants and teachers

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ABSTRACT

Objectives Flight attendants perform physically demanding work such as lifting baggage, pushing service carts and spending the workday on their feet. We examined if more frequent exposure to occupational physical demands could explain why previous studies have found that flight attendants have a higher reported prevalence of menstrual cycle irregularities than other workers.

Methods We conducted a cross-sectional analysis of 694 flight attendants and 120 teachers aged 18–44 years from three US cities. Eligible participants were married, had not had a hysterectomy or tubal ligation, were not using hormonal contraception and were not recently pregnant. Participants reported menstrual cycle characteristics (cramps, pain, irregular cycles, flow, bleed length, cycle length) and occupational physical demands (standing, lifting, pushing/pulling, bending/twisting, overall effort). We used modified Poisson regression to examine associations between occupation (flight attendant, teacher) and menstrual irregularities; among flight attendants, we further examined associations between occupational physical demands and menstrual irregularities.

Results All occupational physical demands were more commonly reported by flight attendants than teachers. Flight attendants reported more frequent menstrual cramps than teachers, and most occupational physical demands were associated with more frequent or painful menstrual cramps. Lifting heavy loads was also associated with irregular cycles.

Conclusions Occupational physical demands were associated with more frequent and worse menstrual pain among flight attendants. The physical demands experienced by these workers may contribute to the high burden of menstrual irregularities reported by flight attendants compared with other occupational groups, such as teachers.

INTRODUCTION

In the 1960s, the first reports of menstrual cycle irregularities in flight crew appeared in the scientific literature. In England, the former Soviet Union, Switzerland and the USA, flight attendants and flight nurses reported heavy menstrual flow, long bleed lengths, irregular cycles and severe menstrual cramps after flying.^{1–4} In studies over the next 40 years, flight attendants in Mexico, Italy and China continued to report menstrual cycle irregularities they believed were associated with their work.^{5–7} Menstrual cycle irregularities and menstrual

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ For decades, studies have reported menstrual irregularities among flight attendants. Few studies, however, identified potential occupational causes.

WHAT THIS STUDY ADDS

⇒ Flight attendants had a greater prevalence of menstrual cramps than teachers. Among flight attendants, multiple types of occupational physical demands were associated with more frequent and severe menstrual cramps.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The occupational physical demands required by flight attendants might explain the higher prevalence of menstrual cycle irregularities in this occupational group. Identifying ways to reduce occupational physical demands and menstrual irregularities among workers could benefit a large proportion of the workforce.

symptoms are responsible for considerable pain and disability, loss of productivity, and lower quality of life for the majority of menstruating people.⁸ New research also demonstrates that menstrual cycle irregularities are associated with increased risks for chronic diseases later in life, including cancer and cardiovascular diseases.^{9–11}

Despite consistent reports of menstrual irregularities among flight attendants over half a century, the sum of the epidemiological evidence is weak. The articles referenced above represent the studies of menstrual function among flight attendants that have been conducted to date. Among them, few presented formal statistical analyses and only one adjusted for potential confounders such as age.⁶ Specific occupational exposures were rarely investigated, although two studies found that menstrual cycle irregularities were more common among flight attendants working on jet versus propeller aircraft.^{2,3} Commercial flights on jet aircraft are typically longer, at higher altitudes and have more passengers than propeller aircraft, but it is unclear from these studies if menstrual cycle irregularities are associated with properties of the aircraft environment or the increased occupational physical demands that accompany longer flights on jet aircraft.



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Contemporary employment as a flight attendant involves performing physically demanding job tasks that include lifting passenger baggage (typically over shoulder height), loading and pushing service carts, and spending most of the workday on their feet. Previous studies have found that strenuous occupational physical demands are associated with menstrual cycle irregularities across multiple different occupations, suggesting that the physical demands common to flight attendants are potential determinants of menstrual cycle irregularities. A study among slaughterhouse and cannery workers found that heavy lifting at work was associated with worse menstrual cramps.¹² Among nurses, heavy lifting was associated with worse menstrual cramps, irregular cycles and short cycles; heavy physical exertion was associated with long cycles; and prolonged standing was associated with short cycles.^{13–15}

The goal of this study was to address methodological limitations of the epidemiological evidence regarding menstrual cycle irregularities among flight attendants, particularly related to confounder control and investigation of specific occupational exposures. We focused on two questions: if flight attendants have a higher prevalence of menstrual cycle irregularities than teachers, and if occupational physical demands are associated with menstrual cycle irregularities among flight attendants.

METHODS

This was a secondary analysis of data from a study of occupational exposures and pregnancy outcomes among female flight attendants and teachers.¹⁶ Flight attendants aged 18–45 years were selected from employee rosters from three airlines operating in three US cities. Flight records were obtained from study airlines for those flight attendants who worked at least 1 month between August 1992 and July 1996. A comparison group of female teachers aged 18–45 years and teaching grades 5–12 was selected from local school districts in the same cities. The original study team selected teachers as the comparison group because, based on Census data, they were a female-dominated workforce with similar socioeconomic status to flight attendants but with few of the same occupational exposures related to flight, such as cosmic radiation exposure and circadian rhythm disruption. Because the primary objective of the original study was to investigate pregnancy-related outcomes, the study population in the original study included only women who were married and had no hysterectomy or tubal ligation at study entry. Between November 1999 and April 2001, the flight attendants and teachers were invited to complete a computer-assisted telephone interview that asked about their current work, menstrual function and reproductive histories. This interview was the source of data for the present analysis.

Outcome: menstrual cycle characteristics

We analysed six menstrual cycle characteristics experienced over the 12 months preceding the interview: (1) frequency of menstrual cramps (never, sometimes, often, always); (2) menstrual pain (none, mild, moderate, severe); (3) irregular cycles (yes (≥ 8 days between shortest and longest cycles), no (≤ 7 days between shortest and longest cycles)); (4) menstrual flow (light, moderate, heavy) (5) bleed length (short (1–3 days), medium (4–7 days), long (≥ 8 days)) and (6) cycle length (short (≤ 25 days), medium (26–31 days), long (≥ 32 days)). The full interview questions and original response options are available in online supplemental materials.

Exposure: occupational physical demands

We examined five occupational physical demands as reported in the questionnaire: (1) overall physical effort (self-reported

as either light/moderate or hard), (2) standing (≤ 8 , ≥ 9 hours per day), (3) frequency of lifting loads weighing ≥ 15 pounds (≥ 6.8 kg) (< 1 , 1–5, 6–10, ≥ 11 times per day), (4) frequency of pushing or pulling loads with ≥ 15 pounds (≥ 6.8 kg) of effort (< 1 , 1–9, 10–19, 20–30, ≥ 31 times per day) and (5) frequency of bending or twisting at the waist (< 1 , 1–25, 26–50, 51–75, ≥ 76 times per day). The full interview questions and original response options are available in online supplemental materials.

Statistical analyses

In our first analysis, we compared the prevalence of the six menstrual characteristics between flight attendants and teachers. We used modified Poisson regression to estimate prevalence ratios (PRs) and 95% CIs for associations between working as a flight attendant and each menstrual cycle characteristic. For multinomial outcomes, we created dichotomous outcomes for analysis by contrasting each non-reference group separately against the reference group. We included study city (A, B, C), age at interview (continuous), body mass index (BMI; continuous) and race/ethnicity (non-Hispanic white, all other) in the multivariable models based on directed acyclic graphs (DAGs).

Our second analysis—examining the relationship between occupational physical demands and menstrual cycle characteristics—was restricted to flight attendants because teachers reported a low prevalence of occupational physical demands and to avoid confounding by unmeasured differences between flight attendants and teachers. We used modified Poisson regression to estimate PRs and 95% CIs for associations between each

Table 1 Sociodemographic and reproductive characteristics of flight attendants and teachers included in the analyses

	Flight attendants (n=694)		Teachers (n=120)		P value
	n	%	n	%	
Study site					0.02
City A	270	39	63	53	
City B	292	42	42	35	
City C	132	19	15	12	
Age (years)					0.09
24–34	143	21	29	24	
35–39	305	44	40	33	
40–44	246	35	51	43	
Race/ethnicity					0.10
Non-Hispanic white	551	79	103	86	
All other groups	143	21	17	14	
Body mass index ≥ 25 kg/m ²					<0.01
No	622	90	75	63	
Yes	72	10	45	37	
Household income (US\$)					<0.01
<US\$75 000	290	43	78	66	
\geq US\$75 000	387	57	41	34	
Missing	17		1		
Age at menarche (years)					<0.01
<12	75	11	23	20	
12–13	368	53	71	60	
≥ 14	248	36	24	20	
Missing	3		2		
Pregnancies					0.80
0	140	20	23	19	
≥ 1	554	80	97	81	

measure of occupational physical demands and each menstrual cycle characteristic. The final models included study city (A, B, C), age at interview (continuous), BMI (continuous), race/ethnicity (non-Hispanic white, all other), and household income (<US\$75 000, ≥US\$75 000, not adjusted for inflation) as covariates based on DAGs. The covariates included in this model and the one described above differed because their DAGs differed. For example, income was on the causal pathway between exposure and outcome in the first model, but not the second. Age at menarche is presented in the participant characteristics but was not included in the models because it is correlated with BMI. We conducted all analyses in R V.4.0.4.

Inclusion and exclusion

We excluded participants for the following eight reasons: (1) no longer flight attendants or teachers at interview; (2) recruited as flight attendants but changed careers and became teachers by the time of the interview, and vice versa; (3) aged ≥45 years at interview; (4) no menstrual periods in the past 12 months; (5) pregnant or breast feeding within the past 6 months; (6) used hormonal contraception, hormonal medication or intrauterine device (IUD) in the past 12 months; (7) self-reported endometriosis and (8) missing data on any of the inclusion/exclusion criteria variables or variables included in the multivariable models.

For each menstrual characteristic separately, we additionally excluded participants who had missing data on the outcome or who reported implausible or contradictory information about their menstrual cycles (eg, bleed length longer than cycle length).

RESULTS

In the original study, 5096 flight attendants were contacted to participate in the study, 2595 were eligible and 2226 (86%) completed the interview; among teachers, 1582 were contacted, 466 were eligible and 376 (81%) completed the interview. Of the 2602 participants completing the interview, we excluded 1788 from all analyses. The top reasons for exclusion were: no

longer working as a flight attendant or teacher at the time of the interview (n=463); hormone or IUD use (n=457); age ≥45 years (n=345); and recent pregnancy or breast feeding (n=238). Participant flow charts in online supplemental materials describe these and additional exclusions in more detail. Following exclusions, 814 participants (694 flight attendants and 120 teachers) were included in one or more analyses.

Flight attendants and teachers differed on most sociodemographic characteristics (table 1). Compared with teachers, flight attendants were younger, were more likely to be of minority race/ethnicity, had lower BMI, had higher household incomes and had later age at menarche. Occupational physical demands also differed markedly between flight attendants and teachers (table 2). Sixty-one per cent of flight attendants described their job as involving hard physical effort compared with 12% of teachers. For each of standing, lifting, pushing or pulling, and bending or twisting, a larger proportion of flight attendants reported greater physical demands than did teachers.

Menstrual cycle irregularities were common (table 3). Over half of participants reported menstrual cramps often or always, with 61% of flight attendants and 51% of teachers usually experiencing moderate to severe pain. About one in five participants had short cycles, irregular cycles or long bleed lengths. Nearly half reported heavy menstrual flow.

Compared with teachers, flight attendants were more likely to report never having menstrual cramps (adjusted PR 2.4, 95% CI 1.0 to 6.3, never vs sometimes); however, among those who reported cramps, flight attendants had them more frequently than teachers (adjusted PR 1.6, 95% CI 1.2 to 2.1, always vs

Table 2 Usual daily occupational physical exertion reported by flight attendants and teachers

	Flight attendants (n=694)		Teachers (n=120)		P value
	n	%	n	%	
Overall effort					<0.01
Light, moderate	271	39	105	88	
Hard	423	61	15	12	
Standing					<0.01
0–8 hours	249	36	108	90	
>8 hours	445	64	12	10	
Lifting ≥15 pounds (≥6.8 kg)					<0.01
0–5 times	166	24	112	93	
6–10 times	234	34	6	5	
>10 times	294	42	2	2	
Pushing or pulling					<0.01
0–19 times	222	32	115	96	
20–30 times	133	19	2	2	
>30 times	339	49	3	2	
Bending or twisting					<0.01
0–50 times	257	37	95	79	
51–75 times	146	21	15	13	
>75 times	291	42	10	8	

Table 3 Menstrual cycle characteristics reported by flight attendants and teachers

	Flight attendants		Teachers		Adjusted prevalence ratio* (95% CI)
	n	%	n	%	
Cramps					
Never	57	8	5	4	2.4 (1.0 to 6.3)
Sometimes	245	35	54	45	1.0 (Ref)
Often	128	19	27	23	1.0 (0.7 to 1.5)
Always	264	38	34	28	1.6 (1.2 to 2.1)
Menstrual pain					
None	57	8	5	4	1.4 (0.6 to 3.3)
Mild	209	31	53	45	0.6 (0.5 to 0.8)
Moderate	341	50	48	41	1.0 (Ref)
Severe	74	11	12	10	0.8 (0.5 to 1.5)
Irregular cycles					
No	491	78	89	82	1.0 (Ref)
Yes	138	22	20	18	1.1 (0.7 to 1.8)
Menstrual flow					
Light	108	16	15	13	0.8 (0.5 to 1.3)
Moderate	299	44	48	41	1.0 (Ref)
Heavy	275	40	55	46	1.0 (0.7 to 1.3)
Bleed length					
Short	64	9	8	7	1.4 (0.7 to 3.1)
Average	508	74	86	71	1.0 (Ref)
Long	116	17	26	22	0.8 (0.5 to 1.2)
Cycle length					
Short	125	18	28	24	0.8 (0.5 to 1.1)
Average	513	75	84	71	1.0 (Ref)
Long	44	7	6	5	1.5 (0.6 to 3.9)

*Adjusted for study site, age, race/ethnicity and body mass index.

Table 4 Associations between daily occupational physical exertion and frequency of menstrual cramps and severity of menstrual pain among flight attendants

	Frequency of cramps adjusted PR (95% CI)*			Menstrual pain adjusted PR (95% CI)*		
	Never versus sometimes	Often versus sometimes	Always versus sometimes	None versus moderate	Mild versus Moderate	Severe versus moderate
Overall effort						
Light, moderate	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)
Hard	0.8 (0.5 to 1.3)	1.1 (0.8 to 1.4)	1.2 (1.0 to 1.5)	0.6 (0.4 to 1.0)	0.9 (0.7 to 1.1)	1.4 (0.9 to 2.2)
Standing						
0–8 hours	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)
>8 hours	0.9 (0.5 to 1.4)	0.9 (0.7 to 1.2)	1.2 (1.0 to 1.5)	0.7 (0.4 to 1.2)	0.8 (0.7 to 1.0)	1.9 (1.1 to 3.2)
Lifting ≥15 pounds						
0–5 times	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)	1.00 (Ref)	1.0 (Ref)
6–10 times	1.3 (0.7 to 2.4)	1.0 (0.7 to 1.4)	1.0 (0.8 to 1.3)	1.3 (0.7 to 2.5)	1.0 (0.8 to 1.3)	1.1 (0.6 to 2.1)
>10 times	1.0 (0.6 to 2.0)	1.0 (0.7 to 1.4)	1.1 (0.9 to 1.4)	0.8 (0.4 to 1.6)	0.8 (0.7 to 1.1)	1.3 (0.8 to 2.1)
Pushing/pulling						
0–19 times	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)
20–30 times	0.8 (0.4 to 1.5)	1.2 (0.8 to 1.8)	1.0 (0.8 to 1.3)	0.7 (0.4 to 1.4)	0.9 (0.7 to 1.3)	1.1 (0.6 to 2.1)
>30 times	0.7 (0.4 to 1.2)	1.1 (0.8 to 1.5)	1.1 (0.9 to 1.3)	0.5 (0.3 to 0.9)	0.8 (0.7 to 1.1)	1.3 (0.8 to 2.1)
Bending						
0–50 times	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)
51–75 times	0.7 (0.4 to 1.4)	0.9 (0.6 to 1.4)	1.1 (0.9 to 1.4)	0.5 (0.3 to 1.1)	0.7 (0.5 to 0.9)	1.1 (0.6 to 1.9)
>75 times	0.8 (0.4 to 1.3)	0.9 (0.6 to 1.2)	1.0 (0.9 to 1.3)	0.6 (0.4 to 1.1)	0.8 (0.6 to 1.0)	1.1 (0.7 to 1.8)

*Adjusted for study site, age, race/ethnicity, income and body mass index.
PR, prevalence ratio.

sometimes). Flight attendants were also less likely to have mild menstrual pain than teachers (adjusted PR 0.6, 95% CI 0.5 to 0.8, vs moderate pain) (table 3). Menstrual flow and irregular cycles did not differ between flight attendants and teachers. Our estimates for bleed length and cycle length were imprecise because of small sample size.

We then restricted the analyses to flight attendants to investigate associations between specific occupational exposures and menstrual cycle irregularities. Flight attendants were more likely to always (vs sometimes) have cramps if their job involved overall hard physical effort (PR 1.2, 95% CI 1.0 to 1.5 vs light to moderate effort) or if they reported standing more than 8 hours per workday (PR 1.2, 95% CI 1.0 to 1.5 versus ≤8 hours) (table 4). All measures of occupational physical demands were associated with either greater likelihood of severe menstrual pain (vs moderate pain) or lower likelihood of having no or mild menstrual pain (vs moderate pain), with more physically demanding work associated with greater menstrual pain.

Irregular cycles were most strongly associated with lifting, with PR 2.1 (95% CI 1.3 to 3.4) and PR 1.8 (95% CI 1.1, 2.8) among participants who lifted heavy loads 6–10 times and >10 times per day (table 5). We also found suggestive associations between irregular cycles and frequent pushing or pulling and bending or twisting, but these estimates were imprecise. Menstrual flow was not associated with any measure of occupational physical demands. Short and long bleed lengths and menstrual cycles were fairly uncommon in our population, which made our estimates for these associations difficult to interpret because they were imprecise (online supplemental table A1).

DISCUSSION

An estimated 85% of US women suffer from painful periods, with over one-third of all women unable to perform daily activities, including work, because of their symptoms.⁸ In this

population of working flight attendants and teachers, menstrual pain was common, affecting 92% of flight attendants and 96% of teachers. Flight attendants with the greatest occupational physical demands were the most likely to have menstrual cramps, menstrual pain and irregular cycles.

Table 5 Associations between daily occupational physical exertion and irregular cycles and menstrual flow among flight attendants

	Irregular cycles adjusted PR (95% CI)*	Menstrual flow adjusted PR (95% CI)*	
		Light versus moderate	Heavy versus moderate
Overall effort			
Light, moderate	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)
Hard	0.8 (0.6 to 1.1)	0.9 (0.7 to 1.3)	1.0 (0.8 to 1.2)
Standing			
0–8 hours	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)
>8 hours	0.9 (0.6 to 1.2)	1.0 (0.7 to 1.4)	0.9 (0.7 to 1.0)
Lifting ≥15 pounds			
0–5 times	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)
6–10 times	2.1 (1.3 to 3.4)	0.9 (0.6 to 1.5)	0.9 (0.7 to 1.1)
>10 times	1.8 (1.1 to 2.8)	0.9 (0.6 to 1.4)	0.9 (0.7 to 1.1)
Pushing/pulling			
0–19 times	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)
20–30 times	1.3 (0.8 to 2.0)	0.8 (0.5 to 1.3)	0.9 (0.7 to 1.1)
>30 times	1.3 (0.9 to 1.9)	1.0 (0.7 to 1.5)	0.9 (0.7 to 1.0)
Bending			
0–50 times	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)
51–75 times	1.1 (0.7 to 1.6)	1.0 (0.7 to 1.5)	1.0 (0.8 to 1.3)
>75 times	1.3 (0.9 to 1.8)	0.9 (0.6 to 1.2)	0.9 (0.7 to 1.0)

*Adjusted for study site, age, race/ethnicity, income and body mass index.
PR, prevalence ratio.

Our results are consistent with reports dating to the 1960s in which flight attendants and flight nurses reported more frequent occurrence of menstrual cramps, menstrual pain and irregular cycles when working on jet vs propeller aircraft, when on-duty versus off-duty, or when compared with non-flight attendants.^{2-4 6 7} We found that flight attendants were more likely to report always having menstrual cramps than teachers, but due to the small number of teachers in the study the analysis was underpowered for most of our outcomes. Additional differences might exist between the two groups that we were unable to detect in this study.

We used data from a study conducted between 1999 and 2001, and the working conditions of flight attendants could have changed in the intervening years. If work became less physically demanding over time (eg, less pushing and pulling of service carts due to reductions in meal service), we would expect to see fewer flight attendants in the highest exposure category. Generally, our results were similar in the middle-exposure and highest-exposure categories (tables 4 and 5), suggesting that the same associations might hold in lower exposed populations. Some exposures—such as prolonged standing—have likely not changed over time. If the prevalence of menstrual cycle irregularities changed over time, because our results are presented as PRs (whose maximum value is determined by the baseline prevalence), we might expect the associations to remain in the same direction although the magnitude of the association might be different.

Studies of occupational physical demands and menstrual cycle characteristics have been conducted in other worker populations, but differences in exposure definition, outcome definition and confounder control make it difficult to directly compare our numeric results to those from previous studies. For example, one of the largest studies of occupational physical exertion and menstrual cycle characteristics among nurses defined lifting as the frequency of lifting loads ≥ 25 pounds (≥ 11.3 kg) (0, 1–5, 6–15 or >15 times per day) and allowed study participants to self-define irregular cycles.¹⁵ In contrast, we defined lifting as lifting a load of ≥ 15 pounds (≥ 6.8 kg) (0–5, 6–10, or >10 times per day) and irregularity as ≥ 8 days between the shortest and longest menstrual cycles within the past year. Despite these differences, our results are consistent with evidence from several studies indicating that frequent lifting is associated with greater menstrual pain and irregular menstrual cycles.^{13 15 17}

Few previous studies have examined occupational physical demands aside from lifting. Two studies found no association between standing and irregular cycles; we also found no association.^{15 17} Strenuous occupational activity was associated with long cycles in one study, but the estimate was imprecise due to small sample size (risk ratio 1.6, 95% CI 0.7 to 4.2).¹⁴ We have seen no prior studies of occupational pushing, pulling or bending to which we can compare our results.

We minimised confounding from healthy worker effects by restricting the analysis of physical factors to flight attendants only—who likely differ from teachers on unmeasured socio-demographic factors—in addition to controlling for measured potential confounders. Our analyses comparing flight attendants to teachers, however, might be subject to residual confounding. Although teachers were selected as a comparison group because they were thought to be sociodemographically similar to flight attendants, there are differences between these populations. For example, we did not have information on work schedules, work hours and other occupational exposures that differ between these two occupational groups and that might be associated with menstrual cycle irregularities. This limitation also likely

affected our analysis restricted to flight attendants, in that we were unable to determine if the associations we observed with occupational physical demands were in part explained by other correlated occupational exposures.

Using self-reported measures of menstrual characteristics and occupational physical demands could have led to bias from misclassification, although for some of our measures—such as menstrual pain—self-reported outcomes are the best available. Previous studies have found that self-reported cycle length in particular is not always accurately reported, especially for those with the shortest or longest menstrual cycles.^{18 19} The higher prevalence of physical demands among flight attendants than teachers in our study is consistent with data from the Occupational Information Network, which shows that compared with teachers, flight attendants expend a higher overall physical effort; spend more time standing, bending or twisting; and perform more manual material handling (a measure of lifting).²⁰ Previous studies have found that participants generally accurately report sitting (ie, not standing), overall physical activity and lifting.²¹ There is evidence that workers with musculoskeletal pain report occupational physical demands less accurately than those with no pain; we do not know if this would also be true for participants who have menstrual pain.^{22 23}

Like most studies of menstrual cycles, we had to exclude participants with hormone or IUD use, as these are commonly used to treat irregular cycles, heavy flow and painful cramps. We were concerned that this exclusion could cause selection bias (collider stratification bias). For selection bias to occur, there had to be an association between occupational physical demands and hormone or IUD use. We found no association (online supplemental table A2), meaning that this exclusion likely did not cause selection bias in our study. We do not know the extent to which our study population is representative of all flight attendants or teachers at risk for menstrual cycle irregularities, with our exclusions related to hormone or IUD use meaning that we did not have information from workers who experienced occupational exposures prior to their initiation of hormone or IUD use.

One variable that we did not consider in our analysis was circadian rhythm disruption, either through jet lag (crossing time zones) or working at night. In other occupational groups, circadian disruption through night shift work is associated with irregular cycles and short cycle length.^{24 25} Circadian disruption was also hypothesised to be responsible for the more severe menstrual disruptions reported by flight attendants working on jet versus propeller aircraft because flights that cross multiple time zones were more likely to use jet engines.² An analysis of circadian disruption and menstrual cycles among flight attendants could provide additional explanation for the increased risk for menstrual cycle irregularities in this worker population. Similarly, we did not have work hours in the analysis, which has previously been associated with cycle length.¹⁵ Non-occupational factors such as nutrition and other potential predictors of menstrual cycles were also not considered and could contribute to residual confounding.

Occupational physical demands may contribute to the high burden of menstrual cramps, menstrual pain and irregular cycles among flight attendants. Identifying ways to reduce occupational physical demands and menstrual irregularities among workers could benefit a large proportion of the workforce.

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All authors critically reviewed the manuscript and have read and approved the final manuscript. BG and EAW are retired.

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Competing interests None declared.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants and the study was approved by the institutional review board of the National Institute for Occupational Safety and Health (protocol 96-DSHEFS-12). Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available on reasonable request. This study is covered by an Assurance of Confidentiality and data cannot be freely shared. Those interested in data access may contact the corresponding author for further information.

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