Association of Shift Work With Physical Activity Among Police Officers

The Buffalo Cardio-Metabolic Occupational Police Stress Study

Claudia C. Ma, MS, MPH, Cecil M. Burchfiel, PhD, MPH, Desta Fekedulegn, PhD, Michael E. Andrew, PhD, Luenda E. Charles, PhD, MPH, Ja K. Gu, MSPH, Anna Mnatsakanova, MS, and John M. Violanti, PhD

Objective: To examine relations of shift work with occupational, sports, and household physical activity (PA) among police officers. **Methods:** Self-reported PA was assessed among 350 male and female officers (aged 27 to 66). Day, afternoon, or midnight shift was identified from daily payroll records. **Results:** Shift work was associated with prevalence of hard-intensity (occupational and sport) PA among men, and very hard-intensity sport PA among women, with afternoon workers reporting the highest prevalence. Shift work was independently associated with total hours of hard-intensity PA among men and very hard-intensity PA among women, with afternoon workers reporting the most hours. **Conclusion:** Results indicated that hard and very hard-intensity PA varied significantly across shifts with afternoon workers being the most active.

Shift work is relatively common in the workforce. The Bureau of Labor Statistics showed that about 2% to 10% of employees in almost any occupation worked in evening, night, or rotating shifts.[1] The Office of Technology Assessment of the US Congress documented the consequences of nonstandard schedules, including circadian rhythm disruption, sleep disruption and fatigue, and social and domestic disturbances, as well as a variety of health problems caused by the combination of these factors.[2] Epidemiological studies reported that shift work was associated with decreased sleep quantity and quality,[3] the metabolic syndrome,[4,5] metabolic risk factors for cardiovascular disease,[6] and prostate cancer.[7]

A consensus has been established that physical activity (PA) is an effective method to improve health and prevent disease following the publication of the 1996 US Surgeon General's Report on Physical Activity and Health. At least moderate-intensity activity of 30 minutes on most days of a week is necessary for maintenance of general health and improvement of health-related quality of life by enhancing psychological well-being.[8] Longitudinal studies reported that moderate and high levels of occupational PA decreased cardiovascular disease (CVD) and all-cause mortality by 21% to 27% in both sexes,[9] and were associated with lower breast cancer risk compared with those who worked in sedentary jobs.[10] Regular leisure-time fitness training could improve the level of CVD risk factors,[11–13] decrease the risk of colon cancer,[14] and lower the risk of non–insulin-dependent diabetes.[15] Recently, moderate-to-hard-intensity household PA was reported to protect against all-cause and CVD mortality.[16,17] Physical activity level was also found to be inversely associated with mortality because of CVD.[18]

A recent study has suggested that overweight and obesity were more prevalent among law enforcement retirees than the general population,[19] and lack of regular physical exercise is one of the occupational risk factors contributing to the higher prevalence of elevated blood pressure, metabolic syndrome, and CVD among emergency responders such as police officers.[20] Nevertheless, few studies have focused on associations of shift work with PA including occupational, sports, and household PA. To help police officers remain or improve their health status, it is essential to understand how much PA the police officers have engaged in during work and leisure time. The present study examined the associations of shift work with prevalence and duration of PA from occupational, sport, and household domains among Buffalo male and female police officers.

METHODS

Study Population

The initial examinations for the Buffalo Cardio-Metabolic Occupational Police Stress (BCOPS) study took place during the period of June 4, 2004 to October 2, 2009. The study design was cross-sectional and the overall goal was to examine associations between physiological biomarkers of stress, subclinical metabolic and vascular disease markers, life style, and psychosocial factors among police officers. A total of 810 police officers in the Buffalo Police Department were invited to participate in examinations. One hundred officers were on long-term sick leave and were not able to participate. Of the remaining officers, 466 chose to participate. Exclusions included two pregnant officers, yielding a cohort of 464 participants who completed examinations for the BCOPS study. This study was approved by the internal review board of the State University of New York at Buffalo, and the human subjects review board of the National Institute for Occupational Safety and Health.

Shift Work and Physical Activity Assessment

In 1994, a rotating shift schedule was changed to a fixed schedule that included day, afternoon, and night shift. The categorizations of the three shifts have been previously described.[3,5] Briefly, work schedules that started from 4 AM to 11:59 AM were classified as day shift, from 12 PM to 7:59 PM as afternoon shift, and from 8 PM to 3:59 AM as night shift. The majority of officers started the day, afternoon, or night shift at 8 AM, 4 PM, and 12 AM, respectively. Shift for each officer was retrieved from daily payroll records for the 2-week period prior to date of examination. On the basis of the payroll records, the total hours worked on each shift were calculated for each participant, and were standardized to weekly basis. Day, afternoon, or midnight shift was identified for each officer on the basis of the

From the Biostatistics and Epidemiology Branch, Health Effects Laboratory Division, National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention, Morgantown, West Virginia (Ms Ma, Mr Gu, and Ms Mnatsakanova and Drs Burchfiel, Fekedulegn, Andrew, and Charles); and Department of Social and Preventive Medicine, School of Public Health and Health Professions, State University of New York at Buffalo, Buffalo (Dr Violanti).

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Address correspondence to: Claudia C. Ma, MS, MPH, National Institute for Occupational Safety and Health, HELD/BEB, MS L-4050,1095 Willowdale Rd, Morgantown, WV 26505 (iia4@cdc.gov).

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largest percentage of hours that he or she worked on a given shift during the 2-week period. Shift status for participants who had equal percentages on any two shifts was identified on the basis of the schedule of the previous week prior to the 2-week period.

Total hours of PA during the previous weekday and weekend were estimated from the 7-day Physical Activity Recall (PAR) questionnaire.[21] This questionnaire was designed for the Stanford Five-City Project to assess PA habits in a large population health survey. Compared with other available PA assessment methods, this questionnaire has several advantages. First of all, it quantifies a measure of PA by asking the amount of time spent performing various activities. Second, it characterizes the intensity of activity as moderate, hard, or very hard. Third, the 7-day PAR specifies the types of activities as occupational, sports, or household. Finally, a study[22] showed that this method has adequate reliability ($r = 0.99$ test-retest estimate and $r = 0.86$ between two interviewers). A validation study[23] has reported that the measure of PA through the 7-day PAR is reasonably accurate in men but perhaps less so in women, as the men performed statistically more hard/very hard-intensity PA than the women in the sample that Richardson et al[23] studied. Nevertheless, the validity in women in the present study was expected to be higher than in the study by Richardson et al,[23] since female and male police officers spent almost equal time performing hard/very hard-intensity PA (4.20 and 4.40 hr/wk for women and men, respectively, $P = 0.772$). Therefore, it provides researchers an opportunity to investigate the association between a specific type or intensity of PA and chronic disease.

Based on the 7-day PAR questionnaire, participants reported the hours spent for three types of PA (occupational, sports, and household) during week days and weekend separately, at each of the following intensity: moderate, hard, and very hard. Since some officers also worked for a second or a third job, and time spent on occupational PA was not reported separately for each job, time spent on occupational PA in the present analysis referred to the activities from all paid jobs. Examples of different kinds of occupational, sports, and household activities for each intensity level are provided in Table 1.

Ascertainment of Demographic, Lifestyle, and Anthropometric Information

Questionnaires were administered to collect demographic and lifestyle information including age, gender, education, race/ethnicity, police rank, years of service, hours worked for a second job, number of children, alcohol consumption, marital status, and smoking status. Race/ethnicity included white, African-American, and Hispanic. Anthropometric measurements were obtained by trained technicians and included height, weight, abdominal height, and waist circumference. Height and weight were measured with shoes removed and recorded to the nearest half centimeter and rounding up to the nearest quarter of a pound, respectively, then BMI was calculated as kilograms per meter squared. Abdominal height (anteroposterior diameter) was derived from an average of three measurements, which were within 0.5 cm of each other. Each measurement was taken to the nearest 0.1 cm at the level of iliac crest ($L_{4\text{-}5}$) while participants were in the supine position on the table and with clothing adjusted so that the top of both hips and midsection were visible. The technician palpated the right and left iliac crest, marking each area and used an abdominal caliper to measure the midsection, allowing the caliper arm just to touch slightly but not to compress the abdomen. Waist circumference was the mean of two measurements, which differed less than 0.5 cm. If the two measurements differed by more than 0.5 cm from each other, a third reading was performed. For each measurement, a cloth tape was used to measure around the abdomen horizontally at the midpoint between the highest point of iliac crest and lowest part of the costal margin in the midaxillary line. Overtime and hours of regular work time were obtained from payroll records. In this cohort, overtime was not measured using conventional definition of more than 40 work hours per week. It was defined as the hours worked before or after each scheduled shift, and the hours worked on days off, such as time in court, regardless of whether 40 hr/wk had been exceeded or not. Hours of sleep in the past week were obtained during weekdays and weekends separately. Then average sleep duration per 24 hours in the past week was derived on the basis of the weighted average over five weekdays and two weekend days.

TABLE 1. Classification Criteria for Types and Levels of Physical Activity, BCOPS Study, 2004-2009

	Level		
Type	**Moderate**	**Hard**	**Very hard**
Occupational	Delivering or patrolling on foot	Heavy carpentry	Very hard physical labor, digging or chopping with heavy tools.
	House painting	Construction work, doing physical labor	Carrying heavy loads such as bricks or lumber.
	Truck driving (making deliveries, lifting, and carrying light objects)		
Sports	Volley ball, Ping-Pong	Tennis doubles	Jogging or swimming.
	Brisk walking or to work*	Disco, square, or folk dancing	Singles tennis.
	Golf, walking, and pulling or carrying clubs	Cross-country skiing	Racquetball.
		Downhill skiing—moderate/vigorous effort	Soccer.
	Callisthenic exercises		Cross-country skiing if indicate hard and fast.
	Downhill skiing—light effort		
Household	Raking the lawn	Scrubbing floors	Not applicable.
	Sweeping and mopping	Shoveling in winter	
	Mowing the lawn with a power mower		
	Cleaning windows		

*3 miles/hr or 20 min/km.

Statistical Analysis

Descriptive statistics of potential confounders across day, afternoon, and midnight shift were used to characterize this study population by gender. Prevalence of occupational, sport, and household PA was calculated at three levels across the three shifts for men and women separately. Analysis of variance and analysis of covariance were conducted to compare unadjusted and adjusted mean hours of PA by type (occupational, sport, and household activity) and intensity (moderate, hard, and very hard) across shift categories. The SAS MIXED procedure (Version 9.2, SAS Institute, Cary, NC) was used to deal with unequal variance of hours of PA across shifts. Variables that were related to both shift work and PA were included in regression models as potential confounders. Test of interactions between gender and shift, and sleep duration and shift were conducted. To assess whether sleep duration modified the association of shift work with PA, sleep duration was dichotomized using a cut point of 6 hr/d, consistent with a previous study.[5] Results were reported as total hours per week spent on each type and level of PA. A P value of 0.05 was considered statistically significant. All analyses were conducted using SAS software, version 9.2.

RESULTS

Among the 464 police officers, 33 were removed from this analysis because their dates of retirement were at least 6 months prior to date of examination. Exclusion also included 81 officers who did not have information on either shift work or PA. Therefore, the final sample size for the present analysis was 350 including 250 male and 100 female officers.

Descriptive statistics of the demographic and lifestyle characteristics are presented separately for men and women by shift work status (Table 2). Among male officers, the following potential confounders were significantly associated with shift work status: age, sleep duration, years of service, overtime, race/ethnicity, and police rank. On average, male officers working the afternoon shift worked more overtime ($P = 0.016$). Officers working the midnight shift were the youngest ($P < 0.001$), had the shortest length of police service ($P < 0.001$), and the fewest hours of sleep ($P = 0.009$). The distribution of race/ethnicity and police rank also differed significantly by shift, with dominant Hispanic officers working in the day shift and detectives not working in the night shift. Among female officers, the following potential confounders were significantly associated with shift work status: age, alcohol consumption, regular work time, years of service, and race/ethnicity. On average, female officers working the afternoon shift were younger ($P = 0.039$) and consumed more alcohol ($P = 0.045$). Female night shift workers had fewer hours of sleep, longer hours of regular work time ($P = 0.005$), and fewer mean number of years of police service ($P = 0.042$).

The prevalence of moderate-intensity PA (for occupational, sports, and household activities) was higher than hard-intensity and very hard-intensity activity among both men and women regardless of shift work status (Table 3). Among male police officers, shift work was significantly associated with both hard-intensity occupational and hard-intensity sports PA ($P = 0.032$ and 0.013, respectively), with the highest prevalence occurring among afternoon shift workers. Among female officers, shift work was significantly associated with very hard-intensity for sports and moderate-intensity for household activity ($P < 0.001$ and 0.028, respectively), with the highest prevalence occurring among afternoon and day shift workers respectively.

Unadjusted and adjusted mean hours spent on each type and level of PA, stratified by shift work and gender, are reported in Table 4. Among male officers, shift work was independently and significantly associated with total weekly hours of hard-intensity PA ($P = 0.018$), with officers on the afternoon shift reporting the most hours. Among female officers, a significant association was observed between shift work and total weekly hours of moderate-intensity PA ($P = 0.048$), but the association was attenuated after adjustment for age ($P = 0.090$) and all other potential confounders ($P = 0.242$). In addition, shift work was independently and significantly associated with total hours of very hard PA ($P = 0.042$); female officers who worked the afternoon shift reported the most hours of very hard activity. No interaction was found between sex and shift in relation to PA.

Effect modification by sleep duration was assessed for the association between shift work and PA (Table 5). Among officers reporting less than 6 hours of sleep per night on average, an unadjusted significant association was detected between shift work and total weekly hours of very hard-intensity PA ($P = 0.036$), but the association was attenuated after adjustment for age and sex ($P = 0.086$) and all potential confounders ($P = 0.431$). Among officers reporting 6 or more hours of sleep, shift work was independently and significantly associated with hard-intensity PA ($P < 0.001$), with officers on the afternoon shift reporting the most hours. Tests for interaction were statistically significant using $P < 0.20$ as a criterion when the influence of sleep duration on the associations of shift work with sports ($P = 0.059$) and hard PA ($P = 0.182$) was examined.

DISCUSSION

Moderate-intensity PA was generally more prevalent than hard or very hard PA among Buffalo male and female police officers. Shift work was associated with the prevalence of hard-intensity occupational and sport PA among male officers, with the highest prevalence among afternoon shift workers. Shift work was associated with the prevalence of very hard sports and moderate household activity among female officers, with the highest prevalence occurring among afternoon and day shift workers, respectively. In addition, shift work was independently and significantly associated with the total weekly hours of hard PA among men, very hard PA among women, and hard PA among officers reporting more than 6 hours of daily sleep. Among officers reporting less than 6 hours of sleep, the association between shift work and total weekly hours of very hard PA was attenuated with adjustment for age and sex, and other potential confounders.

The associations between shift work status and PA occurring in occupational, sports, or the household setting observed in the present study have not been reported in the literature to our knowledge. Although we did not observe significant associations between shift work and hours of occupational PA in male and female officers, Esquirol et al[4] reported that rotating male shift workers had higher at-work PA compared with day workers in a natural gas plant in southern France. Classification of officers by their dominant shift used in the present analysis might underestimate the association of shift work with PA to some degree compared with that in the study by Esquirol et al.[4] In the study by Esquirol et al[4] study, day workers had not previously worked the afternoon or night shift. In the present study, night shift workers also worked on occasion during the day and the afternoon shift (12.5% and 8.3% over the 2-week period, respectively). Nevertheless, officers classified as day and afternoon shift workers were less likely to work in the night shift (1.6% and 3.8%, respectively).

Despite the nonsignificant associations between shift work and total hours of occupational PA, male officers working the afternoon shift and female officers working the midnight shift reported the most hours of occupational PA. Time spent for occupational PA included three components in the present study. One was weekly regular work hours for police work, another component was weekly overtime worked as an officer, and the last component was from any paid second or third job that the officers reported on a weekly bases. Further analysis revealed that shift work was significantly associated with overtime ($P < 0.001$, data not shown) after adjustment for age among men, with officers on the afternoon shift reporting the most hours. Among women, the age-adjusted association between shift

TABLE 2. Demographic and Lifestyle Characteristics of Police Officers by Shift Work and Gender, BCOPS Study, 2004-2009*

	Men				Women				
Variable	Day ($n = 109$)	Afternoon ($n = 84$)	Midnight ($n = 57$)	*P*	Day (n = 77)	Afternoon (n = 8)	Midnight (n = 15)	*P*	Total (n = 350)
Age, yrs	43.6 (0.7)	40.2 (0.6)	38.4 (0.9)	<0.001	41.9 (0.6)	37.6 (1.7)	38.5 (1.8)	0.039	41.2 (6.6)
Abdominal height, cm	22.2 (0.3)	21.8 (0.3)	21.2 (0.4)	0.153	18.3 (0.4)	17.6 (0.9)	17.4 (0.9)	0.530	20.8 (3.5)
BMI, kg/m^2	30.5 (0.4)	30.9 (0.5)	29.9 (0.6)	0.416	26.3 (0.5)	26.4 (1.1)	25.2 (1.5)	0.767	29.2 (4.9)
Waist circumference, cm	100.1 (1.0)	100.9 (1.3)	97.4 (1.6)	0.221	81.6 (1.4)	80.4 (4.3)	76.7 (2.7)	0.311	94.3 (14.5)
Alcohol (drink per week)	7.0 (1.3)	6.2 (0.9)	4.8 (0.8)	0.255	2.6 (0.5)	8.9 (2.2)	4.1 (1.3)	0.045	5.4 (9.3)
Sleep duration, hr/d	6.3 (0.1)	6.3 (0.1)	5.8 (0.1)	0.009	6.4 (0.1)	6.3 (0.5)	5.6 (0.3)	0.057	6.2 (1.2)
Regular work time, hr/wk	28.9 (0.4)	29.3 (0.4)	29.0 (0.6)	0.682	27.6 (0.5)	30.3 (0.7)	30.5 (0.8)	0.005	28.8 (3.9)
Second job, hr/wk	4.7 (0.7)	7.1 (1.1)	4.4 (0.9)	0.100	1.9 (0.6)	1.0 (1.0)	3.5 (1.5)	0.429	7.4 (4.4)
Years of service	17.5 (0.6)	14.3 (0.7)	11.0 (0.8)	<0.001	14.7 (0.7)	11.8 (2.2)	9.5 (1.8)	0.042	14.5 (6.8)
Overtime, hr/wk	3.2 (0.2)	4.2 (0.3)	3.6 (0.3)	0.016	2.0 (0.2)	2.5 (0.5)	2.1 (0.3)	0.668	3.2 (2.1)
Education (%)									
≤High school/GED	14.0	9.5	14.0	0.279	5.2	0.0	0.0	0.527	10.1
College < 4 yrs	60.8	53.6	47.4		59.7	50.0	80.0		57.2
College ≥ 4 yrs	25.2	36.9	38.6		35.1	50.0	20.0		32.8
Race/ethnicity (%)									
White	69.5	88.1	79.0	0.013	63.6	100.0	86.7	0.033	75.7
African-American	24.8	10.7	21.1		36.4	0.0	13.3		22.3
Hispanic	5.7	1.2	0.0		-	-	-		2.0
Marital status (%)									
Single	6.5	9.6	14.0	0.561	18.2	37.5	46.7	0.087	13.5
Married	83.3	78.3	73.7		64.9	50.0	33.3		73.6
Divorced	10.2	12.1	12.3		16.9	12.5	20.0		12.9
Number of children (%)									
0	6.7	15.9	23.6	0.088	16.0	62.5	46.7	0.057	16.8
1	13.5	17.1	14.6		21.3	12.5	13.3		16.2
2	37.5	26.8	29.1		33.3	12.5	20.0		31.3
≥ 3	42.3	40.2	32.7		29.3	12.5	20.0		35.7
Police rank (%)									
Police officer	58.1	76.2	82.5	0.001	79.2	87.5	80.0	0.497	72.8
Sergeant /lieutenant /captain	21.9	13.1	17.5		11.7	0.0	20.0		16.2
Detective/other	20.0	10.7	0.0		9.1	12.5	0.0		11.0
Second job (%)									
Yes	38.0	48.2	42.9	0.366	16.0	12.5	33.3	0.237	
Smoking status (%)									
Current	11.1	11.2	17.5	0.505	21.6	37.5	40.0	0.449	15.9
Former	22.2	19.0	17.5		33.8	37.5	20.0		22.8
Never	66.7	69.8	64.9		44.6	25.0	40.0		61.3

*Values are means (standard deviations) and percentages. *P*-values: One-way analysis of variance for continuous variables and χ^2 or Fisher exact test for categorical variables.

work and total regular work time was significant ($P = 0.035$, data not shown), with officers on the night shift reporting the most hours. Therefore, overtime for men and regular work time for women might have a greater influence on the association of shift work and occupational PA. Although shift work was not significantly associated with hours worked on a second job among men ($P = 0.100$), the total number of hours worked for a second job (5.4 hrs/wk) among men was greater than that for overtime (3.6 hrs/wk) (data not shown). Therefore, a second job might account for a greater proportion of occupational PA than overtime. There is a need to assess separately the occupational PA derived from police work and that from a second or third job in future studies.

We expected that officers working the day shift would be more likely to participate in sports and spend more time performing regular physical exercise. Nevertheless, the present analysis demonstrated that both male and female officers working the afternoon shift reported the highest percentage of hard and very hard-intensity sport participation respectively. Also, shift work was not associated with total weekly hours spent on sports activity for both sexes. These results were not consistent with a recent review,[24] which indicated that shift work generally decreased participation in sports. This conclusion might not be applicable for police officers for several reasons. First, police officers are more physically active than most of the other occupational groups. Since the primary task of police work is to

TABLE 3. Prevalence of Physical Activity Level by Type of Activity, by Shift and Gender, BCOPS Study, 2004-2009*

	Men				Women			
	Day ($n = 109$)	Afternoon ($n = 84$)	Midnight ($n = 57$)	*P*	Day ($n = 77$)	Afternoon ($n = 8$)	Midnight ($n = 15$)	*P*
Occupation								
Moderate	59.6	67.9	63.2	0.501	61.0	50.0	60.0	0.823
Hard	9.2	11.9	0.0	0.032	1.3	0.0	13.3	0.074
Very hard	9.2	15.5	10.5	0.383	5.2	12.5	6.7	0.553
Sport								
Moderate	63.3	56.0	63.2	0.536	67.5	87.5	73.3	0.546
Hard	7.3	21.4	19.3	0.013	19.5	12.5	13.3	0.900
Very hard	45.0	38.1	54.4	0.162	23.4	87.5	40.0	<0.001
Household								
Moderate	69.7	60.7	57.9	0.239	85.7	50.0	73.3	0.028
Hard	41.3	45.2	49.1	0.617	53.3	62.5	73.3	0.327

*Values are percentages. *P* value: χ^2 or Fisher exact test for difference across shifts.

TABLE 4. Unadjusted and Adjusted Mean Hours of Physical Activity for Police Officers by Shift Work and Gender, BCOPS Study, 2004–2009*

		Men				Women				
Physical Activity		Day ($n = 109$)	Afternoon ($n = 84$)	Midnight ($n = 57$)	*P*†	Day (n = 77)	Afternoon (n = 8)	Midnight (n = 15)	*P*†	*P*‡
Occupation	Model I§	5.4 (0.7)	9.2 (1.7)	5.6 (0.9)	0.103	5.9 (1.0)	4.8 (1.8)	7.5 (2.0)	0.599	0.931
	Model II¶	5.3 (0.7)	9.3 (1.7)	5.7 (0.9)	0.090	5.7 (1.0)	5.3 (1.9)	7.9 (2.0)	0.573	
	Model III‖	5.6 (0.8)	8.7 (1.7)	6.4 (0.9)	0.266	5.8 (1.1)	7.0 (2.5)	8.1 (2.3)	0.705	
Sports	Model I	4.6 (0.4)	4.1 (0.5)	4.3 (0.6)	0.774	4.3 (0.5)	4.9 (0.8)	5.4 (1.5)	0.700	0.750
	Model II	4.5 (0.4)	4.1 (0.5)	4.4 (0.6)	0.870	4.3 (0.5)	4.9 (0.9)	5.4 (1.5)	0.700	
	Model III	4.5 (0.5)	3.9 (0.5)	4.5 (0.7)	0.625	4.6 (0.7)	2.7 (1.0)	5.5 (1.5)	0.191	
Household	Model I	4.6 (0.6)	4.0 (0.6)	3.8 (0.9)	0.713	7.4 (1.0)	3.7 (1.6)	8.5 (2.1)	0.133	0.257
	Model II	4.3 (0.6)	4.1 (0.6)	4.1 (0.9)	0.967	7.3 (1.0)	4.1 (1.6)	8.8 (2.3)	0.181	
	Model III	4.1 (0.6)	4.5 (0.7)	3.8 (0.9)	0.799	6.8 (1.0)	6.1 (2.1)	8.5 (2.3)	0.725	
Moderate-intensity	Model I	10.7 (0.9)	11.5 (1.7)	10.0 (1.4)	0.771	14.0 (1.6)	7.9 (1.8)	14.7 (3.2)	0.048	0.736
	Model II	10.4 (0.9)	11.7 (1.7)	10.4 (1.4)	0.787	13.9 (1.6)	8.3 (2.1)	14.9 (3.3)	0.090	
	Model III	10.6 (1.0)	11.2 (1.8)	10.9 (1.5)	0.953	13.3 (1.7)	9.3 (3.0)	16.6 (3.2)	0.242	
Hard-intensity	Model I	2.3 (0.4)	3.9 (0.6)	1.9 (0.5)	0.036	2.9 (0.6)	2.8 (1.7)	4.7 (1.8)	0.670	0.277
	Model II	2.2 (0.4)	4.0 (0.6)	2.1 (0.5)	0.034	2.9 (0.6)	3.1 (1.7)	4.9 (1.8)	0.594	
	Model III	2.4 (0.5)	4.2 (0.7)	1.7 (0.5)	0.018	3.3 (0.7)	3.3 (1.9)	3.4 (1.9)	0.998	
Very hard-intensity	Model I	1.4 (0.2)	1.8 (0.3)	1.8 (0.4)	0.529	0.7 (0.1)	2.6 (0.6)	2.1 (0.8)	0.014	0.243
	Model II	1.5 (0.2)	1.8 (0.3)	1.7 (0.4)	0.745	0.6 (0.2)	2.6 (0.6)	2.1 (0.8)	0.011	
	Model III	1.5 (0.2)	1.6 (0.4)	1.8 (0.4)	0.750	0.7 (0.2)	2.6 (0.7)	2.0 (0.8)	0.042	

*Values are means (standard deviations) for the unadjusted models and means (standard errors) for the adjusted models.
†Test any mean difference across shifts.
‡ Interaction test involving sex and shift was adjusted for age, abdominal height, hours of sleep per day, overtime per week, regular work hours per week, hours worked at a second job, alcohol intake (drinks per week), number of children, education, and smoking status.
§Unadjusted models.
¶Age-adjusted models.
‖Multivariable models include age, abdominal height, hours of sleep per day, overtime per week, regular work hours per week, hours worked at a second job, alcohol intake (drinks per week), number of children, education, and smoking status.

TABLE 5. Unadjusted and Adjusted Mean Hours of Physical Activity for Police Officers by Shift Work and Sleep Duration, BCOPS Study, 2004-2009*

		Sleep < 6 hrs				Sleep ≥ 6 hrs				
Physical Activity		**Day ($n = 60$)**	**Afternoon ($n = 41$)**	**Midnight ($n = 38$)**	**P†**	**Day ($n = 125$)**	**Afternoon ($n = 51$)**	**Midnight ($n = 34$)**	**P†**	**P‡**
Occupation	Model I§	4.8 (0.9)	11.3 (3.0)	5.9 (1.1)	0.118	6.0 (0.7)	6.8 (1.3)	6.1 (1.2)	0.857	
	Model II¶	4.3 (1.0)	11.7 (3.0)	6.3 (1.1)	0.057	5.8 (0.8)	7.1 (1.3)	6.6 (1.3)	0.697	
	Model III‖	5.3 (1.1)	10.3 (3.2)	6.7 (1.2)	0.333	5.7 (0.8)	7.5 (1.4)	6.8 (1.3)	0.557	0.233
Sports	Model I	4.2 (0.5)	3.7 (0.6)	4.2 (0.6)	0.746	4.6 (0.4)	4.6 (0.6)	4.9 (1.0)	0.958	
	Model II	4.0 (0.6)	3.8 (0.7)	4.3 (0.6)	0.834	4.5 (0.4)	4.7 (0.7)	5.1 (1.0)	0.846	
	Model III	3.7 (0.6)	3.9 (0.7)	4.5 (0.6)	0.628	4.8 (0.4)	4.1 (0.7)	5.0 (1.1)	0.720	0.059
Household	Model I	6.8 (1.1)	4.3 (0.9)	6.0 (1.4)	0.187	5.3 (0.6)	3.8 (0.7)	3.4 (0.9)	0.131	
	Model II	6.5 (1.2)	4.5 (1.0)	6.2 (1.4)	0.396	4.5 (0.6)	4.9 (0.8)	4.5 (0.8)	0.935	
	Model III	5.6 (1.3)	5.2 (1.0)	6.6 (1.5)	0.754	4.3 (0.5)	4.9 (0.9)	4.3 (0.8)	0.849	0.849
Moderate-intensity	Model I	11.7 (1.3)	13.3 (3.2)	10.5 (1.7)	0.713	12.4 (1.1)	9.6 (1.2)	11.5 (2.0)	0.228	
	Model II	10.9 (1.4)	13.7 (3.2)	11.3 (1.7)	0.729	11.4 (1.1)	10.9 (1.3)	13.0 (2.0)	0.651	
	Model III	11.0 (1.7)	12.7 (3.7)	12.2 (1.9)	0.878	11.3 (1.1)	11.0 (1.6)	13.1 (2.1)	0.686	0.507
Hard-intensity	Model I	3.3 (0.7)	3.4 (0.8)	3.9 (1.0)	0.885	2.3 (0.4)	4.1 (0.9)	0.9 (0.2)	<0.001	
	Model II	2.9 (0.8)	3.9 (0.8)	3.9 (1.0)	0.648	2.2 (0.4)	4.2 (0.9)	1.0 (0.2)	<0.001	
	Model III	2.9 (0.9)	4.2 (0.9)	3.8 (1.1)	0.635	2.3 (0.4)	4.2 (0.9)	1.0 (0.2)	<0.001	0.182
Very hard-intensity	Model I	0.9 (0.3)	2.5 (0.6)	1.7 (0.4)	0.036	1.2 (0.2)	1.4 (0.3)	2.0 (0.5)	0.354	
	Model II	1.0 (0.3)	2.4 (0.6)	1.7 (0.4)	0.086	1.3 (0.2)	1.2 (0.3)	1.8 (0.4)	0.581	
	Model III	1.2 (0.3)	1.9 (0.6)	1.8 (0.4)	0.431	1.3 (0.2)	1.1 (0.3)	2.0 (0.6)	0.429	0.717

*Values are means (standard deviations) for the unadjusted models and means (standard errors) for the adjusted models.

†Test any mean difference across shifts.

‡Interaction test involving sleep duration and shift was adjusted for age, sex, abdominal height, overtime per week, regular work hours per week, hours worked at a second job, alcohol intake (drinks per week), number of children, education, and smoking status.

§Unadjusted models.

¶Age and sex adjusted models.

‖Multivariable adjusted models included age, sex, abdominal height, overtime per week, regular work hours per week, hours worked at a second job, alcohol intake (drinks per week), number of children, education, and smoking status.

pursue and apprehend individuals who break the law, police officers are required to be physically healthy. Officers were required to pass fitness qualifications before they were considered for employment.[25] Second, worksite facilities for fitness training might be more accessible for this cohort than for other occupational groups. A third possible reason involves the higher educational attainment of officers than the general population. The prevalence of sports (leisure time PA) increased with increasing educational level[26] and the prevalence of having attained at least some college education among this cohort was 90%, which was higher than that reported for the general working population (60.1%).[27] The higher educational attainment might make officers more aware of the consequences of working an atypical schedule compared with general shift workers.[28] Therefore, officers working an atypical shift might spend more time on sport activities in an effort to overcome the adverse effects of shift work.

Household activities such as vacuuming, gardening, or other activities that cause small increases in heart rate have been included in the Behavioral Risk Factor Surveillance System since 2001,[29] and have been documented to have health benefits.[16,17] Nevertheless, we were unable to find any previous studies examining the association of shift work with household activities. Although the associations between shift work and hours spent performing household activities among male and female officers were not statistically significant in our analysis, the female officers working in the midnight shift spent 3.0 and 2.6 more hours per week on household activity than day and afternoon workers, respectively, and the percentage of female officers who engaged in moderate household activities differed significantly across shifts.

Further exploration of the mean values for overtime, regular work time, and time worked on a second job across shifts after adjustment for age and sex revealed that officers reporting less than 6 hours of sleep and working the afternoon shift had the largest mean hours compared with the officers on day and midnight shift, respectively, for overtime (4.3, 2.6, and 3.4, $P = 0.004$), regular work time (29.4, 27.7, and 28.5, $P = 0.114$), and a second job (9.1, 4.2, and 4.8, $P = 0.056$). These results might explain the borderline significant association between shift work and the total weekly hours of occupational PA after adjustment for age and sex in Table 5. The relationship of shift work with occupational, sport, and household PA after adjustment for age and sex was also evaluated at moderate-, hard-, and very hard-intensity level stratified by sleep duration (data not shown). Lack of sufficient numbers of officers who performed hard and very hard-intensity of the three types of PA precluded a more in-depth assessment of the association of shift work with each type of PA at the three levels using multivariable adjusted models.

Several potential limitations should be considered. Although the 7-day PAR questionnaire has been used in many studies,[23] it has not yet been used to assess PA for shift workers. Since one shift cycle for this specific cohort was 15 days, the 7-day PAR questionnaire captured activity in only half the work cycle. Therefore, it might increase intra-individual variability in PA. In addition, self-reported hours spent on PA that were rounded to the nearest half hour and collected from a questionnaire developed in the 1980s might not be as precise as those using the standard format developed in 1997, when time spent on PA was reported in minutes.[30] A questionnaire designed specifically to assess relations between shift work and PA

may be beneficial. The dominant shift, which was defined on the basis of the proportion of hours worked on each shift might not exactly reflect the actual exposure to atypical work hours, and might result in an underestimation of associations. Another limitation was that occupational PA was not obtained separately for police work and work from a second job. Finally, because of the cross-sectional study design, causal inferences could not be made concerning relationships between shift work and PA. In addition, the findings in the present study may be generalizable to other police departments of similar size. Additional studies in police departments of different sizes and with differing characteristics will be useful in determining the extent to which findings from the present study may be generalizable.

Nevertheless, several strengths of the present study should also be mentioned. First of all, the shift work data were collected from detailed daily work history records. This objective measure removed any possible information bias that might exist with self-reported data. Secondly, the association of shift with PA was investigated from three PA dimensions including prevalence, duration, and intensity, capturing most of officers' daily activities including those derived from occupation, sports, and housework. Finally, the present study reported the association of shift work and PA for men and women separately rather than for men only, [4, 31] or a combination of men and women.[32]

In conclusion, shift work was associated with prevalence of hard-intensity occupational and sport PA among male police officers, and with very hard-intensity sport PA among female officers, with afternoon shift workers reporting the highest prevalence. Shift work was associated with the prevalence of moderate-intensity household activity only among female officers, with day shift workers reporting the highest prevalence. Shift work was also independently associated with the mean hours of hard-intensity PA among men and very hard-intensity PA among women, with afternoon shift workers reporting the most hours. Sleep duration significantly modified the association of shift work status, with PA in that shift work associated with mean hours of hard-intensity PA among officers reporting 6 or more hours of sleep but not among those reporting fewer than 6 hours of sleep per day. Future studies are recommended that (1) take into account the percentage of work time on each shift, (2) use a more objective measure of PA, (3) have a larger sample size of female officers, and (4) examine whether those working in the afternoon shift have a more favorable CVD risk factor profile.

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