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Free-living sleep, food intake, and physical activity in night and morning shift workers

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Abstract

Objective: Shift work is associated with risk for adverse health outcomes including cardiovascular disease, type 2 diabetes, cancer, and obesity. Short sleep duration combined with disruptions to the circadian system may alter factors involved with the behavioral regulation of energy intake and expenditure. We aimed to determine how shift work affects sleep, food intake, and physical activity.

Methods: This was a field-based observational study using objective assessments of sleep and physical activity and a 24-hour dietary recall in shift workers. Day (n=12) and night (n=12) hospital shift workers (nurses and technicians) who were women had their free-living sleep and physical activity tracked via accelerometry, and completed a computer-assisted 24-hour food recall, during a series of work shifts.

Results: Compared to day workers, night workers had significantly shorter sleep duration and reported more premature awakenings and feeling less refreshed upon awakening. Daily self-reported energy and macronutrient intakes were not different between groups, although the night shift workers reported a significantly longer total daily eating duration window than day workers. Objectively recorded physical activity levels were not different between groups.

Conclusions: The present findings confirm that sleep is disturbed in women night workers, while there are relatively less effects on objectively recorded physical activity and self-reported food intake. We also observed a prolonged daily eating duration in night vs. day workers. These observations can help inform the design of novel behavioral interventions, including, potentially, time restricted feeding approaches (e.g., by limiting daily eating episodes to within a 10–12 h window), to optimize weight management in shift workers.

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Keywords

shift work; sleep; food intake; physical activity; obesity

Introduction

Shift work, defined as work times that are outside of the standard 9:00 am to 5:00 pm period, and which encompasses early morning work, evening or swing shift, night shifts, and rotating shift schedules, is pervasive in our 24/7 society. Shift work is common, with nearly a third of U.S. workers engaged in alternative or non-standard shift schedules [1]. Shift work has been associated with risk for adverse health outcomes like cardiovascular disease, type 2 diabetes, and cancer [2], and shift work in general, and night shift work in particular, are associated with risk of overweight and obesity [3, 4]. Since obesity is likely in the causal pathway leading to the aforementioned adverse health outcomes, we conducted work to explore some of the factors which can contribute to the heightened risk for weight gain in shift workers.

One of the main consequences of night shift work is chronic short sleep duration [5]. Several observational and laboratory-based mechanistic studies have demonstrated that habitual short sleep duration or sleep restriction, respectively, are associated with signs of positive energy balance including increased food intake [6]. Since shift workers can often experience a curtailment of their sleep duration by up to 4 h/day [7], working abnormal shift schedules may be associated with alterations in food intake regulation. Other external or environmental factors that shift workers must contend with, such as limited or inadequate food options during non-standard working hours, may also contribute to changes in food intake. The effects of short sleep duration on body weight regulation may be worsened in shift workers since both the sleep-wake and feeding-fasting cycles are displaced, which leads to a misalignment between circadian physiology and behavior. This circadian misalignment may contribute to obesity and worsened metabolic health as a result of changes in the dynamics of food intake and energy metabolism [8].

The goal of this current report was to investigate how behavioral components of energy balance regulation, namely food intake and physical activity, are affected by shift work. As opposed to a laboratory-based shift work simulation study, we took a real-life approach to track free-living behaviors in actual shift workers. Researchers are becoming increasingly aware of how the timing of food intake affects health [9], and work has been done to document food intake patterns in shift workers [10]. We add to this growing and important body of work with the current report. However, relatively less work has been done to simultaneously monitor food intake and objectively-assessed physical activity levels in these individuals. This line of research begins to take into account a more complete picture of energy intake and expenditure and has implications for health in shift working individuals who are at heightened cardiometabolic risk. To this end, we conducted a field-based observational study using objective assessment of sleep and physical activity and a computer-assisted 24-hour dietary recall in shift working individuals, to determine how night compared to day shift work impacts these parameters. Our investigation focused on women who are night shift workers conducting patient-oriented or medical technician roles in a hospital setting. These individuals therefore provide an essential service with high responsibility and burden. We hypothesized that night vs. day shift workers would experience shorter sleep duration, diets characterized by increased energy and fat intake, and lower physical activity levels.

Materials and Methods

Participants

Participants were nurses (n=8 day and n=6 night) and medical staff/technicians (n=4 day and 6 night) at New York-Presbyterian Hospital/Columbia University Medical Center, an urban tertiary academic medical center. Eligible individuals worked consistently on a schedule of day-oriented or night-oriented shifts, of either 8 or 12 hours duration. For the day worker group, shifts started between 07:00–08:00 and concluded between 15:00 and 20:00. For the night worker group, shifts started between 19:00–23:00 and concluded at 07:00.The proportion of individuals working either 8-hour shifts (day: 50% vs. night: 33.3%) or 12-hour shifts (day: 50% vs. night: 66.6%) did not differ between day and night groups (p=0.41). Other inclusion criteria included body mass index (BMI) ≥25 kg/m^2, age ≥18 y, and female sex. We included only overweight females in an attempt to reduce inter-individual variability within the relatively small sample. We also used these specific inclusion criteria to increase the external validity of the observations, considering the high amounts of female shift working nurses, the prevalence of overweight in shift workers, and the heightened risk of developing metabolic disorders in overweight individuals. Exclusion criteria were working on rotating shift schedules, presence of major psychiatric or medical problems (by self-reported health history), travel across time zones within 4 weeks of study, currently being pregnant, currently breastfeeding, or having a child less than 1 year old at home. A total of 24 female day (n=12) and night (n=12) shift workers were recruited and completed participation in this study. In the day group, 10 participants were studied in spring/summer and 2 participants were studied in winter. In the night group, 11 participants were studied in spring/summer and 1 participant was studied in winter. The Institutional Review Board of Columbia University Medical Center approved the study procedures, and all participants provided written informed consent.

Design and main outcome measures

This was a field-based observational study in which free-living behaviors were monitored in actual shift workers while participants were engaging in a series of real-life work shifts. This approach enhanced external validity of the findings as measures were recorded with minimal interruption and reflect the individual's free-living patterns of behavior. Tracking of participants was done over a 2- or 3-day period while working on their respective shift schedules (i.e. day or night). The main outcome measures that were monitored in these shift workers during their work periods were sleep, physical activity, and food intake. Sleep and physical activity were assessed in real-time via wrist-accelerometry during the series of work shifts, and food intake from the last day of the work series was assessed retrospectively on the following day.

Sleep and physical activity throughout the entire work period were monitored objectively with the use of wrist-accelerometry. Participants wore an Actigraph wGT3X-BT monitor (ActiGraph, Pensacola, FL) 24-h/day over the course of their consecutive work periods, beginning wear at the start of their scheduled work shift. This device is a small (4.6 × 3.3 × 1.5 cm), lightweight (19 g), triaxial accelerometer. In a diary provided by study staff, participants were asked to record any times they took off the monitor along with the times that they went to sleep and woke up. The accelerometer was placed on the participant's non-dominant wrist by a member of the research team, who then instructed the participant on its use and precautions. Participants were instructed to wear the accelerometer on the non-dominant wrist for 24-h/day throughout the full work period and to only remove the device for water-based activities (showers, swimming, etc.). Accelerometry devices began their recording at the start of the work shift period and recorded continuously until awakening from the sleep episode following the final work shift of work period. Participants were asked to continue usual daily activities and their normal sleep-wake patterns throughout the recording period. At the conclusion of the tracking period, participants returned to the laboratory where the accelerometer was removed by a member of the research team, and data were then downloaded.

The raw accelerometer data were integrated into 60-second epochs and processed as accelerometer data files (AGD files) using ActiLife software (ActiLife v6.13.3; Pensacola, FL, 2016). Data were screened for wear time using standard methods with a threshold of ≥10 hours of wear time required for data to be considered for analysis. Based on recommendations for processing wrist-worn accelerometer data, the Choi algorithm [11] was used with 90 minutes of consecutive zero counts (using vertical axis data) classified as non-wear time [12]. The Cole-Kripke algorithm (which classifies epochs as sleep vs. wake) was used to classify sleep to determine a probability-based sleep score for each minute (i.e., each minute is scored as "sleep" or "wake") [13]. Wrist actigraphy has high validity and reliability, and high sensitivity (>90%) for detecting sleep as compared with polysomnography [14]. Sleep onset was identified as the first minute scored as sleep following the reported bedtime. Sleep time was marked as non-wear time when calculating physical activity behaviors for each individual. Time spent in light, moderate and vigorous-intensity physical activity was estimated using established cut-points [15]. The following summary metrics were estimated: 1) Minutes the monitor was worn on valid days; 2) sedentary time (counts per minute [cpm] <100); 3) light activity (cpm between 100 and 1951) time; 4) moderate activity (cpm between 1952 and 5724) time; 5) vigorous (cpm ≥5725) time; and 6) daily step counts. Physical activity-related energy expenditure was assessed from accelerometry data using Freedson criteria [15], which takes into account body weight. Mean values of sleep and physical activity recorded throughout the work period are presented. Wrist-accelerometry has been shown to accurate and valid for assessing physical activity and physical activity-related energy expenditure [16–18].

Dietary intake (energy and macronutrients) over the final 24-hour period including the last work shift of the work period was assessed with the Automated Self-Administered 24-hour (ASA24) Dietary Assessment Tool [19]. After awakening from the sleep episode following the final work shift in the series of shifts, participants came to the laboratory and completed the ASA24, reflecting food intake over the complete preceding 24-hour period. The ASA24 is a web-based food tracking tool developed by the National Cancer Institute in which participants are guided through a photography-based 24-hour recall interview based on the USDA Automated Multiple-Pass Method [20]. The Automated Multiple-Pass Method on which the ASA24 is based has been validated [21]. Participants completed the ASA24 while in the laboratory under the supervision of research staff (in an adjacent room). Before the start of the ASA24 assessment, participants were instructed on the procedures to complete the assessment by staff. Research staff were also available to answer any questions during the assessment. Dietary analyses were conducted by two nutrition masters students (SL, YC).

Statistical analyses

Data are expressed as mean ± standard deviation (SD) or as n (%), as indicated. Between-group comparisons were conducted using two-tailed unpaired samples t-tests. Adjustments for multiple t-tests (for objective sleep parameters, dietary intakes, and physical activity measures) were made with the Benjamini-Hochberg method, with a false discovery rate of 0.05. Cohen's d was calculated to determine effect sizes for mean differences. Analyses were conducted using SPSS Statistics for Windows, Version 24.0 (IBM Corp., Armonk, NY, USA).

Results

Participant characteristics

Participant characteristics are shown in Table 1. No differences between day and night shift workers were seen for any of the demographic factors, including: age (day: 32.5 ± 7.4 y, night: 37.0 ± 7.5 y; p=0.15), BMI (day: 28.2 ± 3.1 kg/m^2, night: 30.6 ± 4.0 kg/m^2, p=0.12), race/ethnicity, number of dependents living with participant, and marital status.

Sleep

The prevalence of shift-work related sleep complaints in day and night workers based on the Bergen Shift Work Sleep Questionnaire are shown in Table 2. Premature awakening (>30 min) was reported in 41.7% of the night shift workers and in none of the day workers (p=0.01). There was no difference in the prevalence of the other sleep complaints between shift groups.

Objective sleep parameters throughout the work period are shown in Table 3. Mean bedtimes and wake-times were 23:03 ± 1:11 and 5:50 ± 0:51 for day workers, and were 10:13 ± 0:51 and 15:32 ± 1:30 for night workers (p-values =0.003). Total sleep time was significantly longer in day workers compared to night workers (353.1 ± 81.0 min vs. 271.3 ± 78.2 min, p=0.04, d=1.03). There were no statistically significant between-group differences in sleep onset latency (day: 3.64 ± 3.00 min vs. night: 6.00 ± 6.77 min, p=0.21, d=0.45), sleep efficiency (day: 86.7 ± 4.7 % vs. night: 85.2 ± 8.2 %, p=0.60, d=0.22), or wake after sleep onset (day: 50.7 ± 22.7 min vs. night: 41.5 ± 24.5 min, p=0.42, d=0.39).

Day shift workers reported feeling more refreshed, when completing a 7-point Likert scale (1: “not at all” to 7: “extremely”) upon awakening from the sleep episode (day: 4.2 ± 1.1 vs. night: 3.3 ± 1.1, p=0.05, d=0.82).

Food intake

Total daily dietary intakes in night and day workers during the 24-hour including the final work shift in the shift tracking period are shown in Table 4. There were no statistically significant differences in total energy (day: 1665.5 ± 566.4 kcal vs. night: 1666.0 ± 893.0 kcal, p=0.99, d=0.001), total fat (day: 62.7 ± 25.5 g vs. night: 73.4 ± 52.7 g, p=0.92, d=0.26), carbohydrate (day: 190.1 ± 78.0 g vs. night: 191.7 ± 114.8 g, p=0.99, d=0.02), sugar (day: 86.5 ± 51.7 g vs. night: 99.4 ± 69.2 g, p=0.92, d=0.21), protein (day: 87.2 ± 40.7 g vs. night: 65.9 ± 39.0 g, p=0.63, d=0.53) or fiber (day: 16.9 ± 6.2 g vs. night: 12.5 ± 6.0 g, p=0.54, d=0.72).

The duration of the eating period (i.e. time spanning first food intake to final intake during the 24-h period) was significantly (p=0.02, d=0.76) longer in the night workers (14.2 ± 3.8 h) compared to day workers (12.0 ± 1.5 h).

Physical activity

Objective physical activity levels and sedentary behavior throughout the work period are shown in Table 5. There were no statistically significant between-group differences in step counts per day (day: 13585 ± 3722 vs. night: 12240 ± 3959, p=0.53, d=0.35), sedentary activity (day: 271.8 ± 74.5 min/d vs. night: 309.1 ± 130.2 min/d, p=0.53, d=0.35), light intensity physical activity (day: 530.4 ± 81.4 min/d vs. night: 510.9 ± 133.8, p=0.59, d=0.18), moderate intensity physical activity (day: 205.6 ± 79.5 vs. night: 184.3 ± 96.2, p=0.55, d=0.24), or physical activity-related energy expenditure (day: 1071.8 ± 492.9 kcal vs. night: 1074.9 ± 549.6, p=0.98, d=0.006). No vigorous physical activity was recorded in either group.

Discussion

This study examined the impact of night vs. day shift work on the sleep, food intake and free-living physical activity levels. Compared to day workers, night shift workers reported worsened sleep quality, feeling less rested, and experienced sleep that was of shorter duration and drastically delayed in its timing. We did not observe statistically significant between-group differences in food intake or physical activity, although the duration of the daily eating period was longer, and the amount of sedentary behavior was slightly higher, in night vs. day workers.

Consistent with prior findings [22], night workers had significantly shortened sleep duration than day workers when assessed objectively with wrist-accelerometry. Sleep disturbances are often observed as a result of a shift work-related circadian misalignment, particularly when the individual attempts to sleep during the daytime when the circadian system promotes wakefulness [23]. Sleep restriction has been shown in observational and interventional studies to affect energy intake [24]. Increases in energy intake as a result of short sleep may be due to an imbalance in hormones regulating hunger and satiety or by increasing hedonic or non-homeostatic drive for food intake [24].

Contrary to the above hypothesis however, we did not observe differences in food intake between the shift groups. This finding is consistent with other observational studies in shift workers that similarly used self-report to assess food intake and observed no effect of night vs. day work on energy or macronutrient intakes [10, 25]. An important limitation in current and prior work is the use of self-report measures of food intake, which are criticized as being inaccurate, subject to bias, and possibly not an ideal representation of food intake [26, 27]. Novel methods to objectively assess food intake across a 24-h day, as well as measures of hormones regulating hunger and satiety, should be used in these individuals. To our knowledge, our group's earlier report is the only study which used objective measures to compare food intake between day and night working individuals [28]. There, we observed significantly lower protein intake in a laboratory-based ad libitum test meal, in night vs. day workers [28]. We observed a similar effect of reduced (albeit not statistically significantly) daily protein intake (~20 g) here in night vs. day workers when assessing total daily intake from a 24-h food recall (ASA24). The recommended optimal level of protein intake in adults is 0.8 g/kg [29]. This equates to ~64 g per day in the current participants. A reduction of recommended protein by close to 70% is therefore not trivial. More work should be done to accurately and objectively monitor total daily food intake in free-living shift workers.

Separately from total daily energy and macronutrient intake, alterations to the timing and duration of food intake in night vs. day workers can provide another potential explanation for the increased risk of obesity in shift workers. In a shift work model, mice fed selectively during their subjective night (inactive/light phase) gained more weight and tended to have a greater percent body fat, despite similar energy intakes and physical activity as compared with mice fed selectively during their subjective daytime (active/dark phase) [30]. Furthermore, with ramifications for shift workers who are exposed to light throughout their night shifts, mice maintained in constant light or on a light/dim light cycle rather than a standard light/dark cycle also demonstrated increased weight gain and impaired glucose tolerance [31]. Increased food consumption during the habitual inactive phase was correlated with body weight, and restricting food intake to the active phase in these mice prevented body weight gain [31]. In humans, prolonging food consumption into the late hours and for more than 14 h per day is thought to contribute to dysmetabolism [32]. Moreover, a human trial of time restricted feeding, in which individuals with habitual eating duration >14 h per day were requested to limit eating episodes to within a 10–12 h window, found that limiting the duration of daily intake reduced body weight [33]. It is therefore possible that the extended daily eating duration window in night workers (~14 h per day in night workers vs. 12 h in day workers), as well as alterations to the temporal distribution of eating episodes (i.e. eating at night, or the "wrong" circadian phase) can account for increased risk of obesity in night shift workers even with similar energy intake to day workers.

We did not observe significant between-group differences in free-living physical activity levels throughout a series of work shifts. Reduced physical activity has been proposed as a potential mechanism linking shift work to cardiometablic risk [34], yet much of the prior work which assessed physical activity via self-reported found no effect of shift work [35–

37]. In a recent prospective observational study, van de Langenberg et al. observed no difference in accelerometer-derived physical activity levels between a group of night working and non-night working female healthcare workers [38]. Analyzing data from the National Health and Nutrition Examination Survey (NHANES), night workers, compared to day workers, had no difference in overall levels of physical activity or sedentary behavior, although they had fewer bouts of moderate-to-vigorous physical activity [39]. Finally, two additional studies using accelerometry reported no difference between shift and non-shift workers for leisure-time physical activity or sedentary behavior [40, 41]. While it appears that physical activity and sedentary behavior are not drastically affected by shift work, there is evidence that physical activity-based interventions may be beneficial for these individuals to mitigate some of the adverse effects of shift work on body weight, cardiovascular outcomes, and sleep quality [42].

The ActiGraph accelerometer was chosen for this analysis as it is widely used across research and has been found to be a valid measure of physical activity and sleep [43]. While the device was worn on the hip in many earlier studies, it has been used as a wrist-worn physical activity measurement device more frequently in recent years and in projects such as the 2011–2014 NHANES cycles [44]. The small sample size may account for the lack of statistically significant differences in activity measures, and this work should be replicated in a larger group of night and day working individuals.

We conducted a field-based assessment of sleep, physical activity, and food intake in free-living shift working women. This applied science approach helps enhance external validity and focus on factors contributing to health risks in these individuals. Shift workers are susceptible to various risks, including depression, anxiety, cognitive impairment and workplace accidents, as well as other chronic diseases like cancer and heart disease [45, 46]. We aimed to understand some factors which may be related to cardiometabolic risk and body weight gain. Present findings confirm that sleep is disturbed in night workers, while there are relatively less effects on objectively-recorded physical activity and self-reported food intake. We observed a prolonged daily eating duration, in night vs. day workers. Others have reported that late circadian timing of food intake is associated with increased body fat [47], and have proposed that prolonged daily eating duration contributes to obesity and dysmetabolism [32, 33]. Current findings can help inform the design of novel behavioral interventions. including, potentially, time restricted feeding (e.g., by limiting daily eating episodes to within a 10–12 h window), to optimize weight management in shift workers.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1:

Participant characteristics for the full sample and by shift work type.

Characteristic	Full sample (n=24)	Day shift (n=12)	Night shift (n=12)	P-value
Age, years	34.8 (7.6)	32.5 (7.4)	37.0 (7.5)	0.153
Body mass index, kg/m^2	29.4 (3.7)	28.2 (3.1)	30.6 (4.0)	0.115
Race/ethnicity[a]				
White, n (%)	6 (25.0%)	4 (33.3%)	2 (16.7%)	0.358
Black, n (%)	8 (33.3%)	5 (41.7%)	3 (25.0%)	0.396
Hispanic, n (%)	8 (33.3%)	2 (16.7%)	6 (50.0%)	0.090
Other, n (%)	2 (8.3%)	1 (8.3%)	1 (8.3%)	1.00
Number of dependents currently living with	1.29 (1.40)	1.25 (1.48)	1.33 (1.37)	0.888
Marital status[a]				
Married/living with a partner, n (%)	8 (33.3%)	5 (41.7%)	3 (25.0%)	0.396
Single, n (%)	15 (62.5%)	7 (58.3%)	8 (66.7%)	0.677
Separated/divorced/widowed, n (%)	1 (4.2%)	0 (0%)	1 (8.3%)	0.318

Data are expressed as mean (SD) or n (%).

[a]Race/ethnicity and marital status proportions between groups analyzed with chi-squared test.

Table 2:

Prevalence of shift work-related sleep complaints based on the Bergen Shift Work Sleep Questionnaire.

Sleep complaint	Full sample (n=24)	Day shift (n=12)	Night shift (n=12)	P-value
1. Sleep onset latency > 30 min	8 (33.3%)	4 (33.3%)	4 (33.3%)	1.00
2. Wake after sleep onset > 30 min	6 (25%)	4 (33.3%)	2 (16.7%)	0.36
3. Premature awakening > 30 min	5 (20.8%)	0 (0%)	5 (41.7%)	0.01
4. Not feeling adequately rested following sleep	9 (37.5%)	5 (41.7%)	4 (33.3%)	0.68
5. Feeling tired/sleepy at work	12 (50%)	5 (41.7%)	7 (58.3%)	0.43
6. Feeling tired/sleepy on free time on weekdays	5 (20.8%)	3 (25.0%)	2 (16.7%)	0.62
7. Feeling tired/sleepy on rest days/vacation	3 (12.5%)	2 (16.7%)	1 (8.3%)	0.54
Positive for shift-related insomnia	11 (45.8%)	6 (50%)	5 (41.7 %)	0.69

Data are expressing the number (%) of workers who report “often” or “always” experiencing the given sleep or sleepiness-related problem related to their shift work type (items 1–7). Presence of shift-related insomnia (bottom row) is based on report of “often” or “always” on at least one of items 1–4 (sleep complaints) and at least one of items 5–7 (sleepiness).

Table 3:

Objective (actigraphic) sleep parameters throughout the shift period.

Sleep parameter	Day shift (n=12)	Night shift (n=12)	P-value	Cohen's d
Bed time, h:m	23:03 (1:11)	10:13 (0:51)	0.003	12.46
Wake time, h:m	5:50 (0:51)	15:32 (1:30)	0.003	7.96
Sleep onset latency, min	3.64 (3.00)	6.00 (6.77)	0.21	0.45
Total sleep time, min	353.1 (81.0)	271.3 (78.2)	0.04	1.03
Sleep efficiency, %	86.7 (4.7)	85.2 (8.2)	0.60	0.22
Wake after sleep onset, min	50.7 (22.7)	41.5 (24.5)	0.42	0.39

Actigraphic (wrist-mounted) measures are mean throughout each shift working period. Data are expressed as mean (SD). P-values are Benjamini-Hochberg adjusted values, with a false discovery rate set at 0.05.

Table 4:

Total daily dietary intakes in night and day workers

Dietary parameter	Day shift (n=12)	Night shift (n=12)	P-value	Cohen's d
Energy, kcal	1665.5 (566.4)	1666.0 (893.0)	0.99	0.001
Protein, g	87.2 (40.7)	65.9 (39.0)	0.63	0.53
Total Fat, g	62.7 (25.5)	73.4 (52.7)	0.92	0.26
Carbohydrate, g	190.1 (78.0)	191.7 (114.8)	0.99	0.02
Sugar, g	86.5 (51.7)	99.4 (69.2)	0.92	0.21
Fiber, g	16.9 (6.2)	12.5 (6.0)	0.54	0.72

Dietary intakes were assessed throughout the 24-h including the final work shift in the shift tracking period. Intakes were assessed with the ASA24 Dietary Assessment Tool. Data are expressed as mean (SD). P-values are Benjamini-Hochberg adjusted values.

Table 5:

Physical activity, sedentary behavior, and physical activity-related energy expenditure throughout the shift period.

Variable	Day shift (n=12)	Night shift (n=12)	P-value	Cohen's d
Physical activity variables *				
Sedentary time, min/d	271.8 (74.5)	309.1 (130.2)	0.53	0.35
Light intensity PA, min/d	530.4 (81.4)	510.9 (133.8)	0.59	0.18
Moderate intensity PA, min/d	205.6 (79.5)	184.3 (96.2)	0.55	0.24
Step counts per day	13585 (3722)	12240 (3959)	0.53	0.35
PA-related energy expenditure, kcal	1071.8 (492.9)	1074.9 (549.6)	0.98	0.006

PA: Physical activity. Values are mean throughout the ambulatory recording period. Data are expressed as mean (SD). P-values are Benjamini-Hochberg adjusted values.

* = No vigorous PA was recorded in either group.