

A Prospective Observational Study Comparing Effects of Call Schedules on Surgical Resident Sleep and Physical Activity Using the Fitbit

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ABSTRACT

Background Surgical residency training has an extended tradition of long hours. Residency programs use a variety of call schedules to combat resident fatigue and sleep deprivation while maintaining adherence to duty hour restrictions. Nonetheless, there is a paucity of data regarding objective measurements of sleep during the different call schedules included in general surgery training.

Objective The primary objective of this study was to compare the quantity of sleep in 24-hour time frames across all types of shifts worked by general surgery residents at our institution. The secondary objective was to measure activity level in total steps during various time frames.

Methods This prospective observational study was performed between April 4 and August 26, 2018, with general surgery residents. Each resident was assigned a Fitbit Charge 2 to wear during all rotations, including general surgery and subspecialty services.

Results Twenty-six out of 31 residents voluntarily participated in the study (84%). In-house call (IHC) had significantly less sleep in a 24-hour time frame than home call and night float (144 vs 283 vs 246 minutes, $P < .001$ and $P < .028$). IHC had significantly more steps than home call (11 245 vs 8756 steps, $P = .039$). The smallest number of steps was obtained when residents were not working (7904 steps).

Conclusions Our data demonstrate that surgical residents on IHC have significantly less sleep compared to all other types of on-call time frames. Residents on IHC have the most steps across all time frames.

Introduction

The Accreditation Council for Graduate Medical Education (ACGME) implemented duty hour restrictions in 2003. Duty hour reform continued in 2017, after the Flexibility in Duty Hour Requirements for Surgical Trainees (FIRST) Trial, with the re-institution of 24-hour shifts for first-year residents.¹⁻⁴ The FIRST Trial compared a standard-policy group and flexible-policy group. There were no significant differences in patient outcomes, resident well-being, or education. However, residents with flexible duty hour policies perceived negative effect on time with family, rest, and health.³ Variation in call schedules are still used to accommodate duty hour restrictions and improve resident sleep.

Commercial fitness trackers represent potential tools for sleep evaluation.⁵⁻⁷ The use of Fitbit to measure sleep has not yet been as rigorously studied as polysomnography or actigraphy, but a growing

body of evidence suggests that Fitbit fitness trackers are suitable for evaluating total sleep time and have high consistency between devices.⁸⁻¹¹ A novel study using the WHOOP wearable device demonstrated that the majority of orthopedic residents and surgeons sleep less than 7 hours per night (66.7%).¹² In this previous study, there was no analysis regarding the call schedules of participants and the effect on sleep time variability.¹² The primary objective of our study was to compare the quantity of sleep in a 24-hour time frame across all types of shifts worked by general surgery residents at our institution. The secondary objective was to measure activity level in total steps during various time frames.

Methods

A prospective observational study was performed between April 4 and August 26, 2018, with general surgery residents at a hybrid community-academic residency program. The study was introduced during weekly general surgery educational conference. If residents volunteered, they were consented for enrollment into the study. Each resident was assigned a Fitbit Charge 2.

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Editor's Note: The online version of this article contains tables of minutes of sleep by postgraduate year (PGY), minutes of sleep by surgical service, steps by PGY, and steps by surgical service.

The study included 3 on-call time frames and 4 off-call time frames. On-call time frames included: in-house 24-hour call (IHC), home call, and night float (NF). IHC included 24-hour call shifts, approximately every third day, with an additional 4 hours for continuing patient care. NF included 6PM–8AM shifts, Sunday through Thursday, with Friday and Saturday as days off. Home call included a 12-hour day shift with potential for return overnight and responsibilities of answering floor calls for a 24-hour time frame. Home call occurs on vascular, colorectal, thoracic, and pediatric surgery services. Off-call time frames included: post-call from IHC (PC24), post-call from home call (PCHC), not working, and not on call. PC24 and PCHC included a 24-hour time frame after the associated on-call time frame (IHC or home call). Not working included days off and not on call time frames included day shifts (6AM–6PM) where residents are responsible for covering cases and clinic. All time frames were on general surgery services at 3 university-affiliated community hospitals including Level 1 and 2 trauma centers. To ensure validity of data, we excluded 24-hour time frames that contained a step count < 1000 steps and sleep equal to 0 minutes. Both metrics were used to define that the Fitbit was not worn for the entirety of the time frame. Burn and outpatient surgery services were excluded because the total number of 24-hour time frames including all residents was less than 20.

Analyses included total sleep time and step counts in 24-hour time frames and were run as a mixed-effects negative binomial regression model. The Fitbit data variable (minutes asleep and steps) were the dependent variables, while the independent variables were 24-hour time frame, rotation type, postgraduate year (PGY), and sex. The random effect was the individual. Pairwise differences between the call shifts were determined using the Šidák modification. Marginal means with 95% confidence intervals are reported. $P < .05$ was considered significant. Analyses were performed using Stata version 15.1 (StataCorp LLC, College Station, TX). The study was reviewed and approved by the Institutional Review Board.

Results

Twenty-six residents (of 31, 84%) voluntarily participated in the study. Three did not consent for enrollment. Data of 2 residents were excluded since the Fitbit was not worn during the designated study period. The male to female ratio was 1:1 and the average age of participants was 30.1 ± 1.8 years. A total of 1439 individual 24-hour time frames were analyzed; the number of time frames based on PGY

TABLE 1

Postgraduate Year (PGY) Level, Surgical Service, and On-Call and Off-Call Time Frames

PGY Level, Surgical Service, Time Frame	No. (%) of 24-Hour Time Frames
Resident level	
PGY-1	251 (17)
PGY-2	300 (21)
PGY-3	315 (22)
PGY-4	360 (25)
PGY-5	213 (15)
Surgical service	
General surgery 1	136 (9)
Emergency general surgery	307 (21)
General surgery 2	225 (16)
Trauma	165 (11)
Elective	29 (2)
Colorectal	106 (7)
Vascular 1	40 (3)
Vascular 2	28 (2)
Pediatric surgery	38 (3)
Breast	36 (3)
Surgical oncology	71 (5)
Surgical intensive care unit	150 (10)
Thoracic surgery	35 (2)
Safety	22 (2)
Endoscopy	27 (2)
Chief clinic	24 (2)
On-call time frame	
Home call	190 (13)
In house call (IHC)	137 (10)
Night float	89 (6)
Off-call time frame	
Not working (day off)	273 (19)
Not on call (operating or clinic)	532 (37)
Post-call from IHC	131 (9)
Post-call from home call	87 (6)

Note: On-call time frames include each assigned shift; off-call time frames include each assigned shift.

level, surgical service, on-call, and off-call are listed in TABLE 1.

Minutes of Sleep During On-Call and Off-Call Time Frames

Minutes of sleep during on-call and off-call time frames are shown in TABLE 2. IHC had significantly less sleep in a 24-hour time frame than home call and NF (IHC 144 vs home call 283, $P < .001$; IHC 144 vs NF 246 minutes, $P < .028$). The sleep obtained by residents during the not working and not on call time

TABLE 2

Total Minutes of Sleep Recorded by Fitbit Charge 2 in General Surgery Residents During On-Call and Off-Call Time Frames^a

Time Frame	Marginal Mean ^b (min), 95% CI	Significant Comparisons ^c
On-call time frames		
Home call	283 (228–339)	vs IHC, $P < .001$; vs PC24, $P = .036$
NF	246 (183–309)	vs IHC, $P = .028$; vs PC24, $P = .004$
IHC	144 (113–175)	...
Off-call time frames		
PC24	461 (362–561)	vs IHC, $P < .001$
PCHC	382 (284–479)	vs IHC, $P < .001$
Not on call	320 (285–355)	vs IHC, $P < .001$
Not working	316 (271–361)	vs IHC, $P < .001$

Abbreviations: CI, confidence interval; NF, night float; IHC, 24-hour in-house call; PC24, post call from 24-hour in house call; PCHC, post-call from 24-hour home call.

^a Each time frame includes 24 hours and the designated type of shift.

^b Marginal mean is the average mean for each time frame, averaged for all levels of the other factors (eg, PGY, sex, surgical service) from the mixed-effects negative binomial regression model.

^c All pairwise comparisons not listed were not statistically significant ($P > .05$).

frames were similar (316 vs 320 minutes, $P > .05$). There were no significant differences in the amount of sleep obtained during off-call time frames when compared to other off-call time frames.

Activity Level

Activity level for each time frame was measured by total step count and is shown in TABLE 3. IHC had significantly more steps than home call (11 245 vs 8756 steps, $P = .039$). The smallest number of steps was obtained when residents were not working (7904 steps). NF demonstrated the second highest number of steps in a 24-hour time frame (9293 steps).

Sleep and Activity by PGY Level and Surgical Service

There were no statistically significant differences in minutes of sleep or step counts between PGY levels or surgical services (available as online supplemental data).

Discussion

This study was designed to quantify the sleep time of surgical residents across all 24-hour time frames using a Fitbit Charge 2. We found that IHC had significantly less sleep in a 24-hour time frame than home call and night float. A common concern regarding long work hours during IHC is physician performance

TABLE 3

Total Steps Recorded via Fitbit Charge 2 by General Surgery Residents During On-Call and Off-Call Time Frames^a

Time Frame	Marginal Means ^b (min), 95% CI	Significant Comparisons ^c
On-call time frames		
IHC	11245 (9637–12852)	...
NF	9293 (7753–10834)	...
Home call	8756 (7574–9939)	vs IHC, $P = .039$
Off-call time frames		
Not on call	9106 (8133–10080)	vs IHC, $P = .017$
PCHC	8497 (7149–9844)	vs IHC, $P = .040$
PC24	8133 (6973–9293)	vs IHC, $P < .001$
Not working	7904 (6984–8822)	vs IHC, $P < .001$

Abbreviations: CI, confidence interval; NF, night float; IHC, 24-hour in-house call; PC24, post-call from 24-hour in house call; PCHC, post-call from 24-hour home call.

^a Each time frame includes 24-hours and the designated type of shift.

^b Marginal mean is the average mean for each time frame, averaged for all levels of the other factors (eg, PGY year, sex, surgical service) from the mixed-effects negative binomial regression model.

^c All pairwise comparisons not listed were not statistically significant ($P > .05$).

during prolonged hours of sleep deprivation.^{13,14} Specifically, interns were found to be at higher risk for motor vehicle accidents after extended work hours (> 24 hours).¹⁵ The NF system can be an attractive alternative to IHC by reducing the time frames with extended work hours and allowing time for family events and sleep.¹⁶ In our study, NF time frames had more sleep than IHC. However, the NF system is disruptive of circadian rhythm and residents on NF showed deterioration of surgical proficiency.^{6,17} The best type of call schedule is debated in the literature.^{3,13–20} More importantly, our study demonstrated that sleep deprivation is common across all on-call and some off-call time frames in general surgery residents.

The Centers for Disease Control (CDC) reports that adults should sleep 420 minutes or more per night for optimal health.^{21,22} The only 24-hour time frame that residents obtained the CDC's recommended sleep was during the post-call from 24-hour in-house call (PC24) time frame. A contributing factor may be the sleep debt surgical residents accumulate during extended work hours, which is remedied by increased total sleep time when not working or post-call. Sleep debt is measured as the cumulative hours of sleep loss relative to daily sleep.^{22–25} Dunn et al concluded that a 3-day period of recovery is insufficient for restorative sleep.²⁶ Therefore, post-call days and days off may not allow for complete recovery of the sleep debt accumulated by surgical residents. Given the negative effects on health,^{27,28} residents and faculty should engage in ongoing assessment of fatigue to facilitate optimizing recovery periods.

Using the Fitbit, we were able to measure the total steps during each time frame as a proxy for activity level. The least number of steps were achieved during days off (7904 steps), which is still considered above sedentary (< 5000 steps/day).^{27,29} The overall cause of the reduced step count is not clear in our study; however, this could be attributed to many factors, including overall resident fatigue, the need for recuperation and recovery, relaxing on a day off, socializing and family activities, or a small living space. However, step-based movement has been shown to have a linear relationship with cardiometabolic risk factors and more steps are associated with lower all-cause mortality.^{28–30} The overall effect of fluctuating step counts on resident health and well-being was not examined in this study. Future studies could focus on specific health-related outcomes in surgical residents.

The main limitation of this study is that it was completed at a single institution. The validity of the data is limited by the small sample size and individual

experience of each resident. Additionally, these data include 3 hospitals and subspecialty services which lead to inherent heterogeneity within this study. Lastly, compliance with wearing the Fitbit was not measured.

The results regarding global sleep deprivation across most time frames in our population warrants additional investigation. The impact of changing sleep patterns, sleep deprivation, and existing sleep debt on health, wellness, and work-life balance should be the focus of future studies.

Conclusions

To our knowledge, this is one of the first studies to use a Fitbit Charge 2 to compare general surgery resident sleep during both on-call and off-call time frames. The sleep time and step count of surgical residents are impacted by on-call and off-call time frames. Surgical residents rarely obtain the recommended amount of sleep.

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