The American Journal of Surgery (2010) 200, 814–819

The American Journal of Surgery®

# Effects of duty hours and time of day on surgery resident proficiency

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**KEYWORDS:**
Fatigue;
Cognitive skills;
Psychomotor skills;
Proficiency;
Night float

**Abstract**

**BACKGROUND:** Night floats have evolved in the era of limited resident work hours. This study was designed to define the effect of restricted nighttime duty hours on the psychomotor and cognitive skills of surgery residents.

**METHODS:** To quantify the effect of fatigue on the skills of residents on day-shift and night-float rotations, residents were asked to complete visuohaptic simulations before and after 12-hour duty periods and to rate their fatigue level with questionnaires.

**RESULTS:** Both groups showed significant decrements in proficiency measures after their shifts compared with baseline. The night-float group showed more significant declines ($P < .05$) in all areas assessed than the day-shift group. The night-float group was significantly less proficient in cognitive tasks after their shifts compared with the day-shift group.

**CONCLUSIONS:** The deterioration of surgical proficiency is to a degree dependent on the time of day during which call occurs, not solely on the length of call.


Night floats were designed to alleviate the demands on residents during night shifts.[1] Night-float residents do not have daytime duties and provide coverage for inpatient services during night hours. This differs from on-call residents, who are assigned both daytime and nighttime duties. The system was introduced to address growing concerns of the effect of fatigue on residents' psychomotor and cognitive skills. There have been mixed reports on the impact of the night-float system and its ability to limit the deleterious effects of fatigue.[2–6] Several studies have reported a positive effect of night float on nurses' perceptions of patient care.[5,7] Conversely, multiple studies using resident self-reporting of fatigue contend that a night-float system severely effects resident neuropsychological functioning and may have a negative impact on clinical abilities.[1–4] Although these studies provide valuable information on the perception of night-float rotations, they lack objective measurements of fatigue and consequently fatigue-related errors.

There have been some attempts to understand the impact of fatigue on the clinical skills of residents and attending physicians,[8–13] yet there are few objective data on psychomotor function of night-float residents. Although these residents are theoretically well rested, there may yet exist cognitive and motor declines due to interruption of circadian rhythms.

A large part of surgical training and education is guided toward honing residents' ability to combine both psychomo-

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Manuscript received March 5, 2010; revised manuscript June 15, 2010

0002-9610/$ - see front matter © 2010 Published by Elsevier Inc.
doi:10.1016/j.amjsurg.2010.06.009

tor and cognitive skills in an intensive work environment such as taking trauma call. Laparoscopic surgical skills have both cognitive and psychomotor dimensions, and studies using laparoscopic simulators have introduced several validated, objective measures of proficiency.[14] Both instrument movements and hand movements are representative of economy of motion and overall smoothness in execution; their construct validity has been established.[14] Senior surgeons tend to show high hand movement smoothness and instrument movement smoothness, while novices tend to have lower values.[15]

To better measure cognitive function, we previously developed variations of laparoscopic simulation using neuropsychological methods.[14] These modified tasks focus on cognitive abilities such as attention, visuospatial tracking, and intermodal transfer, and they replicate the work environment of surgeons by offering exercises that require both psychomotor and cognitive dimensions.[16]

We hypothesized that when measured with novel laparoscopic simulator tasks, night-float residents would experience psychomotor and cognitive deficits compared with day-shift residents.

## Methods

All experiments were conducted with the approval of the Banner Good Samaritan Medical Center Institutional Review Board. During academic years 2007 to 2009, with informed consent, 14 first-year surgical residents (10 men) were enrolled in the study and assigned to 1 of 2 experimental groups according to their preassigned rotation schedules. All residents underwent 4 sessions of practice (each 10–15 minutes in duration, with 6 iterations of the simulation exercises) during the daytime hours and within 3 days of the beginning of their preassigned experimental rotations. These 4 sessions allowed users to learn the simulation and ensured that the main experiment focused on the effect of fatigue on learned procedures.

During the experiment, each participant was involved in 8 sessions. Four of the sessions were held at baseline, before the start of their shift (preshift), and 4 sessions were held at the end of their shift (postshift). Each session was held within the time window of 5:30 to 6:30 AM (preshift) and 5:30 to 6:30 PM (postshift). Each of the paired sessions was conducted at random, but within that 1-month rotation. Before the the experiment, subjects completed 2 questionnaires, the first designed by Behrenz et al[17] to assess fatigue and the second to report sleep hours and caffeine consumption during call.

A simulation was designed for the virtual ring transfer task that is a modification of the validated basic laparoscopic course offered by ProMIS and FLS Simulator. In the virtual ring transfer task, residents were tasked with grasping a series of "virtual" rings and placing each on randomly, and briefly, highlighted pegs on a board. The simulation was implemented using the Sensable haptic joystick and OpenHL programming, which allow for measurement of the instrument tip in the virtual environment. Additionally, the subjects wore the Cyberglove and Polhemus Liberty Tracker that allowed for capture of hand movements. The basic task involved placing 10 rings on virtual pegs. We then modified this basic validated laparoscopic exercise to include 8 cognitive variations as previously described and validated in our laboratory.[14]

For measuring laparoscopic proficiency, we used a combination of hand movement and instrument movement analysis. Smoothness measures varied between 0 (least) and 1 (most). The time required to complete a task was also recorded. Further cognitive errors were recorded for every type of exercise quantified by the number of times the resident attempted to place a ring on a nonhighlighted peg. These 4 objective measures were also supplemented with gesture-level proficiency measures. The previously described algorithm, using task decomposition, generates a score between 0 (least proficiency) and 10 (greatest proficiency) for an entire exercise.[18]

These 5 measures of proficiency (gesture-level proficiency, hand movement smoothness, instrument movement smoothness, time elapsed, and cognitive errors) provide a broad framework for evaluation and, when coupled with fatigue and sleep deprivation measures through the questionnaire, allow for holistic evaluations.

Iterations of exercises performed preshift were compared with iterations of the exercises performed postshift. Analysis of variance was used to separately study the difference between the 5 proficiency measures of surgical skills. These measures enabled a study of the overall effect of night float on the surgical skill of the residents. A $P$ value $< .05$ was accepted as a statistically significant difference. As with the previous methodology, the exercises in the preshift condition and the postshift condition were not matched to account for learning effect.

## Results

There were no significant ($P = .40$) differences between any of the performance measures of the night-float and day-shift groups in the baseline, preshift condition. In the postshift condition, each group showed significant ($P < .05$) deterioration in all 5 measures compared with its respective preshift baseline (Fig. 1). There was a more significant decline from baseline performance of night-float residents in gesture proficiency ($P < .04$), hand movement smoothness ($P < .05$), tool movement smoothness ($P < .01$), and cognitive errors ($P < .01$) compared with the day-shift group. Of note, both groups completed tasks significantly faster ($P < .05$) in the postshift condition.

As shown in Figure 2, there were no significant preshift differences between day-shift and night-float resident scores on exercises with psychomotor or cognitive focus. In con-