Assessment of fitness to perform using a validated self-test in obstetric and gynecological night shifts in the Netherlands

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EDUCATION

Assessment of fitness to perform using a validated self-test in obstetric and gynecological night shifts in the Netherlands

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BACKGROUND: The field of obstetrics and gynecology requires complex decision-making and skills because of unexpected high-risk situations. These skills are influenced by alertness, reaction time, and concentration. Night shifts result in sleep deprivation, which might impair these functions, although it is still unclear to what extent.

OBJECTIVE: This study aimed to investigate whether a night shift routinely impairs the obstetrics and gynecology consultants' and residents' fitness to perform and whether this reaches a critical limit compared with relevant frames of reference.

STUDY DESIGN: Residents (n=33) and consultants (n=46) in obstetrics and gynecology conducted multiple measurements (n=415) at precall, postcall, and noncall moments with the fitness to perform self-test. The self-test consists of an adaptive pursuit tracking task that is able to objectively measure alertness, reaction time, concentration, and hand-eye coordination and Visual Analog Scale tests to subjectively score alertness. The test is validated with a sociolegal reference of a 0.06% ethanol blood concentration (the peak level after 2 units of alcohol, the legal driving limit). This equals −1.37% on the objective score and −8.17 points on subjective alertness. Linear mixed models were used to analyze the difference within subjects over a night shift, integrating repeated measures over time.

RESULTS: The overnight objective difference between postcall and precall measurements was −0.62 ($P<.05$) for residents and 0.28 (P=NS) for consultants, both not exceeding the sociolegal reference as a group. Objective impairment exceeded the reference for 31% of the residents and 28% of the consultants. Subjective alertness decreased in residents (−18.26; $P<.001$) and consultants (−10.85; $P<.001$), both exceeding the reference. No residents had to continue work postcall versus 7.8% of the consultants. None of the consultants that had to continue work were in an objective critically impaired state.

CONCLUSION: This study provides insight and awareness of individual performance after night shifts with clear frames of reference. The performance of residents is negatively and significantly affected by night shifts; therefore, a scheduled day off after a night shift is justified. Consultants showed no overall impairment; however, a quarter did exceed the alcohol limit reference after their night shift. If not logistically feasible to schedule a protected day off after a night shift, our group recommends safe shift scheduling, including options to transfer care after a demanding night shift to prevent working in a compromised state.

Key words: fatigue, obstetrics and gynecology, patient safety, performance measures, quality improvement

Introduction

The field of obstetrics and gynecology requires around-the-clock complex decision-making and prompt surgical and obstetrical interventional skills. These skills are influenced by alertness, reaction time, and concentration, which are impaired by sleep deprivation and fatigue.[1] This impairment can exceed the impairment in performance observed after alcohol intoxication above the legal limit for safe driving.[2] Therefore, sleep deprivation could increase the rate of attentional failures and clinical misjudgment.[3–6] As obstetrical care continues around the clock, impaired performance owing to sleep deprivation is a likely factor affecting patient safety in obstetrics and gynecology.[7]

In response to concerns about sleep deprivation in medical care, the Accreditation Council for Graduate Medical Education limited work hours to 80 hours per week and 24 hours per shift[8] and the European Working Time Directive limited work hours to 48 hours a week.[9] Although these initiatives were intended to improve patient safety, the actual effect has been debated.[10,11] In addition, published studies on the effect of fatigue on physician performance show varying results,[12] possibly because of the absence of a real-time, objective measurement tool to use in prospective clinical setting. Therefore, the Fit to Perform (FTOP) tool was designed and validated to assess the state of alertness.[2]

This study aimed to investigate the effect of night shifts on objective and subjective performance in a cohort of Dutch residents and consultants in obstetrics and gynecology and to determine whether this reaches critical limits.[2]

Materials and Methods

Study design

For this national prospective multicenter study, residents and consultants were recruited in collaboration with the Association of Gynecologists in the Netherlands. To acquire a representative sample of Dutch gynecologic care, we chose to include doctors from both academic and affiliated teaching hospitals.

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AJOG at a Glance

Why was this study conducted?

This study was conducted to investigate whether a night shift routinely impairs the obstetricians' or gynecologists' fitness to perform and whether this reaches a critical limit compared with relevant frames of reference, such as the legal alcohol limit.

Key findings

Resident performance is negatively affected by night shifts, by both objective and subjective measures. Overall, consultants showed no objective impairment, although 28% of consultants did exceed the alcohol limit reference. Subjectively, they showed significant impairment overall.

What does this add to what is known?

Subjects served as their own control and data included objective and subjective measurements of fitness to perform, therefore gaining valuable insight into clinical practice, the objective influence of night shifts, and the self-perception of night shifts. Safe shift scheduling, including options to transfer care after a demanding night shift, is advised to prevent working in a diminished state.

All residents and consultants working in these hospitals were approached to participate. Participation was voluntary. Informed consent was obtained, and a personal anonymized demographic questionnaire was conducted.

Here, 8-minute self-measurements were performed using the FTOP testing tool on site, which consist of objective and subjective parts. The objective part is an adaptive pursuit tracking task reflecting alertness, concentration, hand-eye coordination, and reaction time.[2] The score reflects a modified percentage of success of the task. Subjective effects were assessed using Visual Analog Scale (VAS) questionnaires, measuring alertness, contentedness, and calmness, with scores ranging from 0 to 100 (Supplemental Table 1).[13] This paper focused on VAS alertness scores only. This tool has been validated in laboratory and clinical settings, using socio-legal (alcohol legal driving limit, 0.06% ethanol blood concentration) and professional (operative skills) frames of reference, and was used before in the FTOP study on surgeons.[2,14] The socio-legal reference is used for clinical relevance. This equals −1.37% on the tracker and −8.17 points on subjective alertness.[2] Demographic and shift characteristics were assessed by a questionnaire (Supplemental Table 2).

Obstetrics and gynecologic shifts were organized differently for Dutch consultants and residents. Residents were in-housed for a maximum of 12 hours during the night. They have protected time off after a night shift and usually perform floats of consecutive shifts. Consultants supervise the residents and work only on demand. Consultant shifts may be scheduled differently among hospitals. Most consultants perform on-call night shifts following their regular day shift. Some consultants are scheduled to continue work directly following their night shift, performing another regular day shift, whereas others have a protected day off. By asking shift characteristics via a questionnaire after the night shift, the activities during a shift and necessity to continue work afterward were clear.

A measurement block consisted of 3 measurements: noncall (on a random workday), precall, and postcall. Subjects functioned as their own control, assessing personal impairment or improvement. Subjects received a reminder (telephone call, text message, and/or email) during on-call days to perform the FTOP test.

Precall measurements for by residents were performed before the night shift (usually around 10 PM), and postcall measurements were performed at the end of their shift (around 8 AM). Consultants performed precall measurements at the change of day shift to being on-call for the night (around 5 PM). Postcall measurements were performed at the change of night shift to day shift (around 8 AM). Participants were asked to perform the precall and postcall measurements within 1 hour before or after the change of shifts. There were no dietary or behavioral restrictions before the measurement. Noncall measurements were performed during a dayshift at the participants' convenience, with the advice to perform this on a Monday morning after a free weekend.

The subjects received direct feedback on the tracker score, without interpretation of the results. The participants were allowed to perform the test during several shifts. Test sets were formed, consisting of combined precall and postcall measurements during 1 night shift supplemented with a noncall measurement taken near the shift.

According to the Dutch Medical Research Involving Human Subjects Act, this study did not require submission to an ethics committee.

Statistical analysis

Outcome measures were reported as mean and standard deviation (SD). Differences are given as the average and the 95% confidence interval of the difference. SPSS Statistics (version 23; IBM, Amsterdam, NL) was used for acquiring linear mixed models to analyze the difference within subjects over a night shift, integrating repeated measures over time with subject factor and including the potential learning effect. Factors of influence for an impaired alertness after a night shift were determined using the calculated difference between precall and postcall alertness with linear mixed model regression analysis. The Pearson correlation analysis, without subject factor, was used to describe the relationship between objective and subjective performance on a group level. Chi-square and McNemar tests were conducted on categorical variables. Posthoc sensitivity analyses were performed to determine the impact of outliers if present. Outliers were defined as values greater than the mean plus or minus 3 SD.

Results

Demographics

The study included 79 participants (33 residents and 46 consultants) from 4 centers, completing 415 measurements (Supplemental Table 3). Consultants were 13 years older than residents. Sex, work, and sleep hours per week did not differ between groups (Table 1). All gynecologic specialties involved are shown in Supplemental Table 4.

Shift characteristics

At the beginning of a night shift, consultants had already worked 7 hours more than residents and were awake for 11.40 hours vs 6.25 hours. Shift duration differed by 8 hours, and hours of sleep during a shift differed by 4.5 hours (Table 2, Supplemental Figure 2). All activities during the night shift showed significant differences between groups, with residents acting more of their shift in the emergency room or delivery room and consultants performing more surgeries (Figure 1). Consultants were able to take more rest and were scheduled to continue work in 7.8% (n=5) after a shift vs none of the residents. All residents in this cohort performed floats of consecutive shifts.

Objective measurements

Comparing precall and postcall measurements, there was a decrease in objective alertness over the course of a resident night shift (−0.62; *P*=.035) (Figure 2, A; Table 3), but this did not exceed the alcohol limit reference. Residents showed more impairment than consultants who had no significant decrement in performance (consultants, 0.28 [*P*=.293]; difference in the performance of residents vs performance of consultants, −0.90 [*P*=.024]) (Figure 2, B; Table 3). The difference between noncall and precall measurements was 0.67 (*P*=.293) for residents and 0.043 (*P*=.928) for consultants. Objective impairment after the night shift exceeded the alcohol limit reference for 31% of all resident shifts and 28% of the consultant shifts, but none of them had to continue working a day shift immediately following their night shift.

TABLE 1
Demographics

Variable	Consultants	Residents	95% CI	P value
Subjects	n=46	n=33		
Sex				
Male	12 (26.1)	8 (24.2)		
Female	34 (73.9)	25 (75.8)		
Age	47.1 (8.2)	33.8 (2.9)	10.7−15.9	<.001
Position				
Partnership	12 (26.1)	0		
Salaried employment	34 (73.9)	33 (100.0)		
Hours of work per week[a]	43.9 (7.7)	46.9 (6.2)	−6.4 to 0.5	.088
Hours of sleep per night[b]	6.8 (0.7)	6.8 (0.8)	−0.4 to 0.4	.993
Experience in years[c]	11 (9)	7 (3)	1.3−7.1	.009

Data are presented as number (percentage) or mean (standard deviation).

[a] Consultants (n=39) and residents (n=30); [b] Consultants (n=40) and residents (n=39); [c] Consultants, experience in years as specialized attending; residents, experience in years as resident.

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Subjective measurements

Both residents and consultants demonstrated decreased alertness in the postcall measurement compared with alertness in both residents and consultants in the precall measurement (−18.26 [*P*<.001] and −10.85 [*P*<.001]) and in noncall measurement (−23.38 [*P*<.001] and −15.15 [*P*<.001]) in the VAS questionnaires[2] (Figure 2, C and D; Table 3). Residents were more impaired after a night shift than consultants (−7.41; *P*=.01). Here, 69% of the residents and 60% of the consultants showed subjective decreased alertness during a night on call with values exceeding the sociolegal alcohol limit reference. Only 6.3% of the subjectively impaired consultants had to continue work, but none of them showed decreased objective performance exceeding the reference.

Self-assessment of performance

After a night shift, many consultants and residents felt fit to perform outpatient clinical tasks (57% vs 69%; *P*=.206) and surgery (60% vs 70%; *P*=.272) (Figure 2, E). However, after 53 resident shifts (79%), residents preferred to cancel elective surgery vs 37 consultant shifts (58%) (*P*=.014). Comparing this perception within consultants and residents, both groups reported feeling similarly fit to perform surgery compared with performing outpatient clinical tasks (*P*=.791 for residents and *P*=1.000 for consultants), but there was a difference in the perception of feeling fit for surgery and the preference to cancel planned surgery for both groups (both groups, *P*<.001). Interestingly, 68% and 47% of all residents and consultants that considered themselves fit to operate preferred to cancel elective surgery. For both groups, there was no correlation between objective and subjective alertness on all 3 measurements. However, for residents, there was a correlation between postcall subjective alertness and overnight change in objective performance (r=0.30; *P*=.025).

Factors affecting performance

The number of hours awake before starting a shift was the only shift characteristics that negatively influenced individual change in objective performance after a night shift for residents (r=−0.17 [−0.34 to −0.001]; *P*=.048) (Supplemental Tables 5 and 6). This led to a calculated alertness below the alcohol limit reference after being awake for 11 hours before

TABLE 2
Shift characteristics

Characteristic	Consultants	Residents	95% CI	P value
Noncall measurement				
Hours slept	6.7 (1.7)	7.5 (1.3)	−1.9 to 0.3	.119
Precall measurement				
Hours worked	7.6 (4.6)	0.5 (1.1)	6.2−8.0	<.001
Hours awake	11.4 (3.7)	6.3 (3.6)	4.1−6.2	<.001
Night shift[a]	1 (0.0)	3 (2.0)	−2.3 to −1.3	<.001
Postcall measurement				
Hours awake	3.6 (6.5)	15.5 (5.4)	−14.0 to −9.8	<.001
Hours slept	4.9 (1.9)	0.4 (1.2)	4.0 to 5.1	<.001
Night shift[a]	1 (0.0)	3(2.0)	−2.3 to −1.4	<.001
Total length of shift	18 (6.0)	10 (1.0)	6.2 to 9.4	<.001

Data are presented as mean (standard deviation).

[a] Number of consecutive night shift.

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starting the night shift. However, this relation seemed to be largely the result of an individual very low objective performance after a long awake time before the night shift (Supplemental Table 7, Supplemental Figure 1). Hours of sleep during a night shift positively influenced consultants' subjective alertness, with impairment comparable with 2 units of alcohol after less than a calculated 6 hours of sleep (r=2.77 [0.83−4.71]; *P*=.006). In contrast, hours spent in the operation theater negatively influenced subjective alertness (r=−0.19 [−0.32 to −0.05]; *P*=.006) (Supplemental Table 8).

Discussion

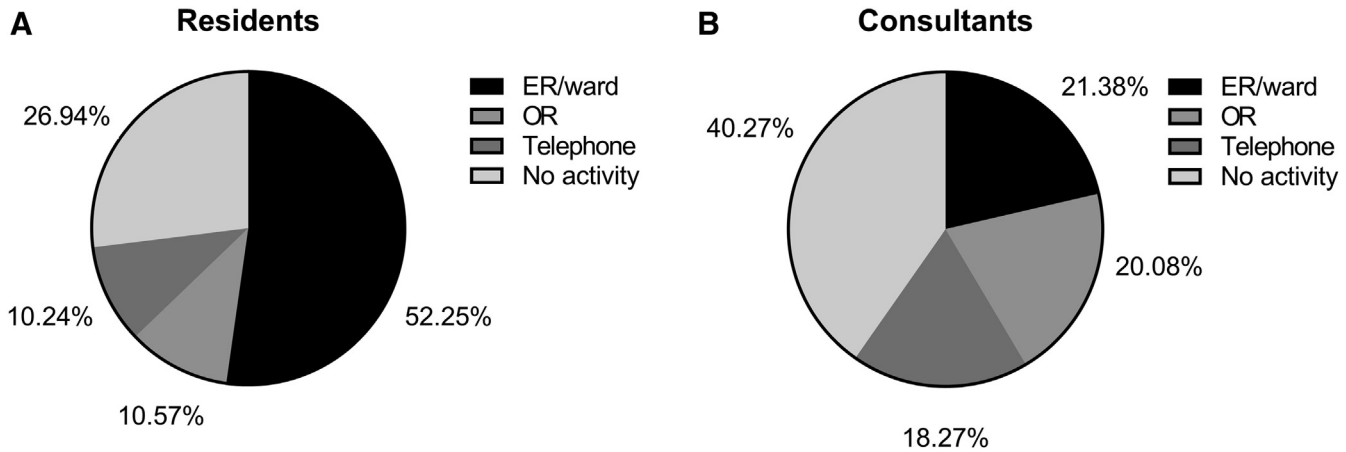
Principal findings

In this study, a validated tool was used in a multicenter setting to assess both obstetrical and gynecologic consultants and residents. Subjects served as their own control and data included objective and subjective measurements of fitness to perform, therefore gaining valuable insight into clinical practice, the objective influence of night shifts, and the self-perception of night shifts. Residents had an impaired objective performance after a night shift; however, consultants were less affected. Both groups showed impaired subjective performance after a night shift, exceeding the alcohol limit reference. Residents seemed capable of estimating a significant change in objective alertness after a night on call.

Results in the context of what is known

The awareness of one's own alertness is an important part of professional behavior.[15] In this respect, this study showed 2 important findings. Firstly, although only a quarter of consultants showed a decreased objective alertness after call, almost two-thirds of consultants reported a subjective decreased alertness exceeding the alcohol limit reference. Precall characteristics of sleep before and during consultant night shifts were comparable with our previous surgical cohort, whereas the

FIGURE 1
Shift characteristics



Characteristics of 64 consultant night shifts and 67 resident night shifts in the Netherlands. All shift activities show significant (*P*<.05) differences between groups.

ER, emergency room; *OR*, operation room.

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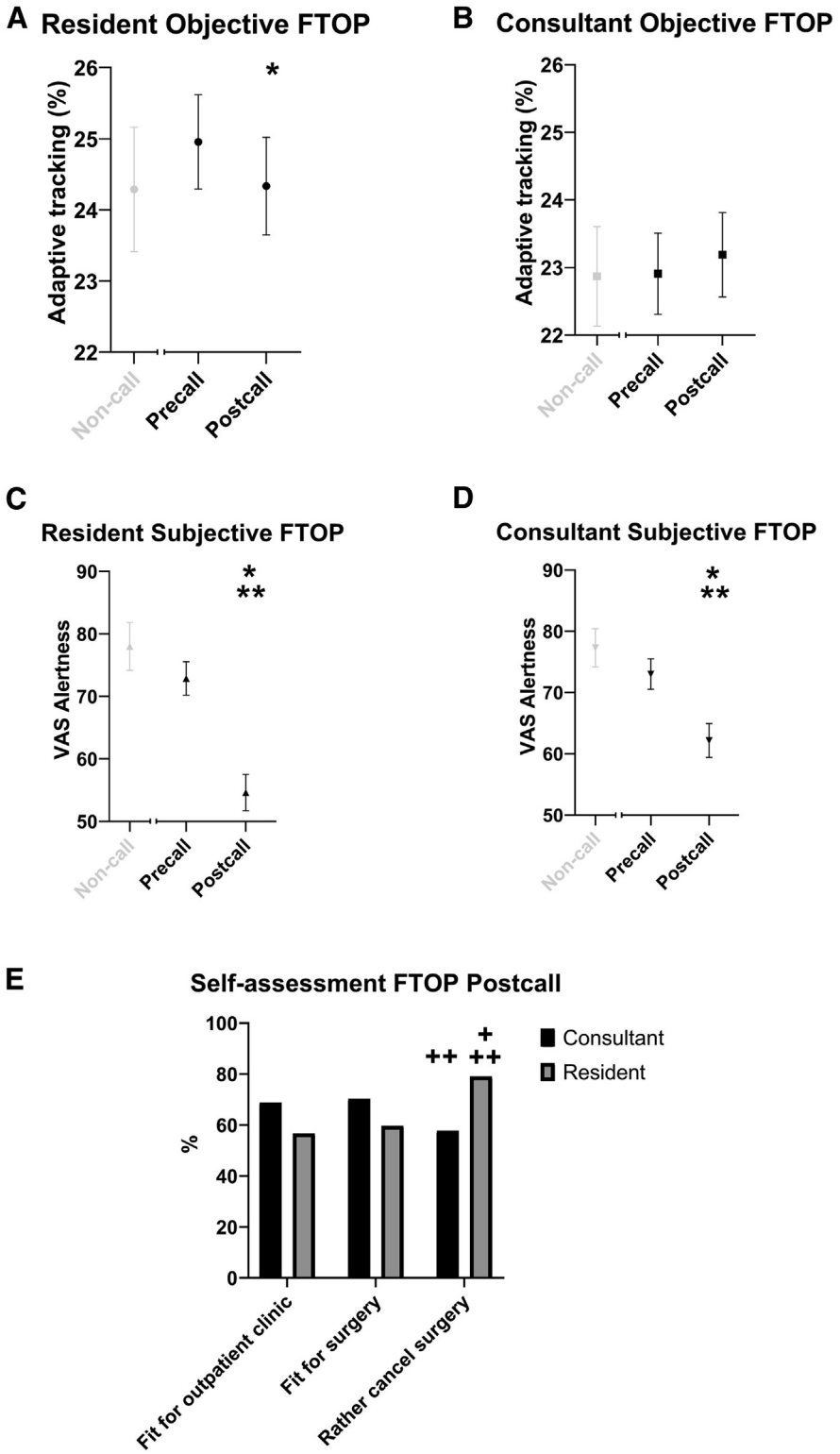
FIGURE 2
Measurements of FTOP before and after calls



considerable subjective decrease in alertness was not observed in surgeons.[14] Next to the fact that surgeons may be less prone to admit that they are tired,[16] the larger decrement of subjective alertness in the gynecologic consultants indicates that gynecologic night shifts are being experienced as highly demanding. Secondly, although residents showed insight in their alertness decrement overnight, both consultants and residents stated being fit to perform surgery after a night shift while subjectively being seriously impaired. However, when asked whether one would transfer a surgical case to a colleague or would cancel the case if this was without further consequence, more than half of the study population would do so. This discrepancy shows that there still is a culture of constantly exhibiting the ability to perform surgery independent of time and personal condition. These findings highlight the importance of studies like the present to increase awareness of fitness to perform on an individual level.

Sleep hours were assessed in 2 ways in this study: extended wakefulness before a first night on call and the lack of sleep during a night on call. Previous studies have shown that this extended wakefulness before and during the first shift specifically leads to a significant decrease in objective performance in a laboratory setting[17] and a decrease in subjective performance in a clinical setting.[18] This

Consultants generally tend to remain adequately fit, whereas residents show significant impairment of objective alertness over the course of a night shift (**A, B**). Both residents and consultants show subjective impairment (**C, D**). There was a difference in perception of FTOP surgery and the preference to cancel surgery (**E**). Data are represented as mean, standard deviation (**A**—**D**), or percentages (**E**). *Represents $P<.05$ vs precall; **Represents $P<.05$ vs noncall; +Represents $P<.05$ vs consultants; ++Represents $P<.05$ vs fit for surgery.

FTOP, fitness to perform.

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TABLE 3
Objective and subjective measurements of alertness

Variable	Consultant	95% CI	Resident	95% CI
Precall vs postcall				
Objective	0.282 (0.27)	−0.25 to 0.81	−0.620 (0.30)[a]	−1.20 to −0.044
Subjective	−10.847 (1.55)[a]	−13.91 to −7.78	−18.259 (1.62)[a]	−21.46 to −15.06
Noncall vs precall				
Objective	0.043 (0.47)	−0.91 to 1.01	0.666 (0.62)	−0.60 to 1.93
Subjective	−4.303 (2.32)	−8.98 to 0.38	−5.123 (3.08)	−11.32 to 1.08
Noncall vs postcall				
Objective	0.326 (0.54)	−0.76 to 1.41	0.047 (0.68)	−1.32 to 1.42
Subjective	−15.150 (2.73)[a]	−20.60 to −9.70	−23.383 (3.41)[a]	−30.20 to −16.57

Data are presented as mean (standard deviation). Objective measurements represent tracker scores; subjective measurements represent Visual Analog Scale alertness.

[a] $P<.05$.

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study adds to this evidence as it shows that for gynecologic residents, being awake for a prolonged period before starting a night shift results in further objective impairment over a shift. This must be interpreted with caution as this calculation is largely based on a single performance after a long awake time precall. However, such extremes do occur during shifts, and larger studies are required to accurately assess the maximum time awake and minimum hours of sleep before starting a night on call. Our study provides an accurate methodology to accomplish this. Furthermore, hours of sleep during a night shift proved to be a factor of influence for subjective consultant alertness. Sleep deprivation was common in more than half of the consultants getting less than 6 hours of sleep per night shift and in 18% of the consultants getting 3 hours or less. Most gynecologic residents did not sleep at all during a shift hampering a proper analysis of the influence of sleep in this group. Although a relationship between hours of sleep and objective alertness could therefore not be established in this study, previous studies have shown the importance of getting at least 4 to 5 hours of sleep per night shift to perform at an acceptable level.[14,19] For an adequate subjective alertness, 6 hours of sleep during a night shift proved to be critical in this study.

Clinical implications

The data have shown that protected days off for residents are justified. Further research is warranted on the timing of excessive loss of alertness during resident shifts to investigate whether care might be compromised during the night. Our previous work suggested that this happens during the last 3 hours of a 14-hour night shift,[2] and current gynecologic resident night shifts are limited to 12 hours. Although no decrease of objective alertness was observed on a group level, a quarter of consultants showed overnight decrement exceeding the alcohol limit reference. None of them had to continue work after call, which implies that awareness of working schedules within this cohort has already been well established. In addition, more than half of the consultants exceeded the alcohol limit subjectively. As protected days off for consultants are not standard in the Netherlands, an approach where flexible, transferrable tasks are scheduled the day after a night on call might be an alternative to adequately protect doctors from working in an impaired state.

Strengths and limitations and research implications

The strength of this study is the use of the validated FTOP tool in a clinical multicenter setting, measuring both consultants and residents. Data were compared between and within subjects and included objective and subjective measurements of fitness to perform, therefore gaining valuable insight into clinical practice, the objective influence of night shifts, and the self-perception of night shifts.

Potential limitations of the study include the voluntary inclusion that might have led to either an under- or overestimation of the mean alertness as discussed earlier.[14] However, because of the adaptive nature of the tracker, deliberately negatively affecting the objective results is easily detected and hardly possible. In addition, we did not correlate the results to patient outcomes because this would have required a very large sample size. Furthermore, the nature of the correlation could have been seen as personally threatening and could have negatively influenced inclusion of participants. We have previously correlated the FTOP test results to multiple frames of reference, including laparoscopic proficiency,[2] and such outcomes could serve as surrogate measures of patient safety. Lastly, the noncall measurements were mostly taken during a normal working day and therefore not in a true rested state. This might explain the higher objective precall scores compared with noncall scores for residents, as this measurement was performed immediately before the night shift. For future

studies, an at-home measurement of the true rested state of physicians will be incorporated to serve as a baseline fit comparison.

Conclusion

The performance of residents is negatively affected by night shifts; therefore, a scheduled day off after a night shift is justified. Consultants showed no overall objective impairment; however, a quarter of these subjects did exceed the alcohol limit reference after their night shift. In this cohort, all consultants had a day off following their shift. Scheduling a protected day off would be desirable. If this is logistically not feasible, our group opts for safe shift scheduling, including options to transfer care after a demanding night shift to prevent working in a compromised state.

Highlights

- The performance of residents is negatively affected by night shifts.
- Consultants showed no overall objective impairment, although a quarter of these subjects did exceed the alcohol limit reference.
- Safe shift scheduling is advised to prevent working in a compromised state. ■

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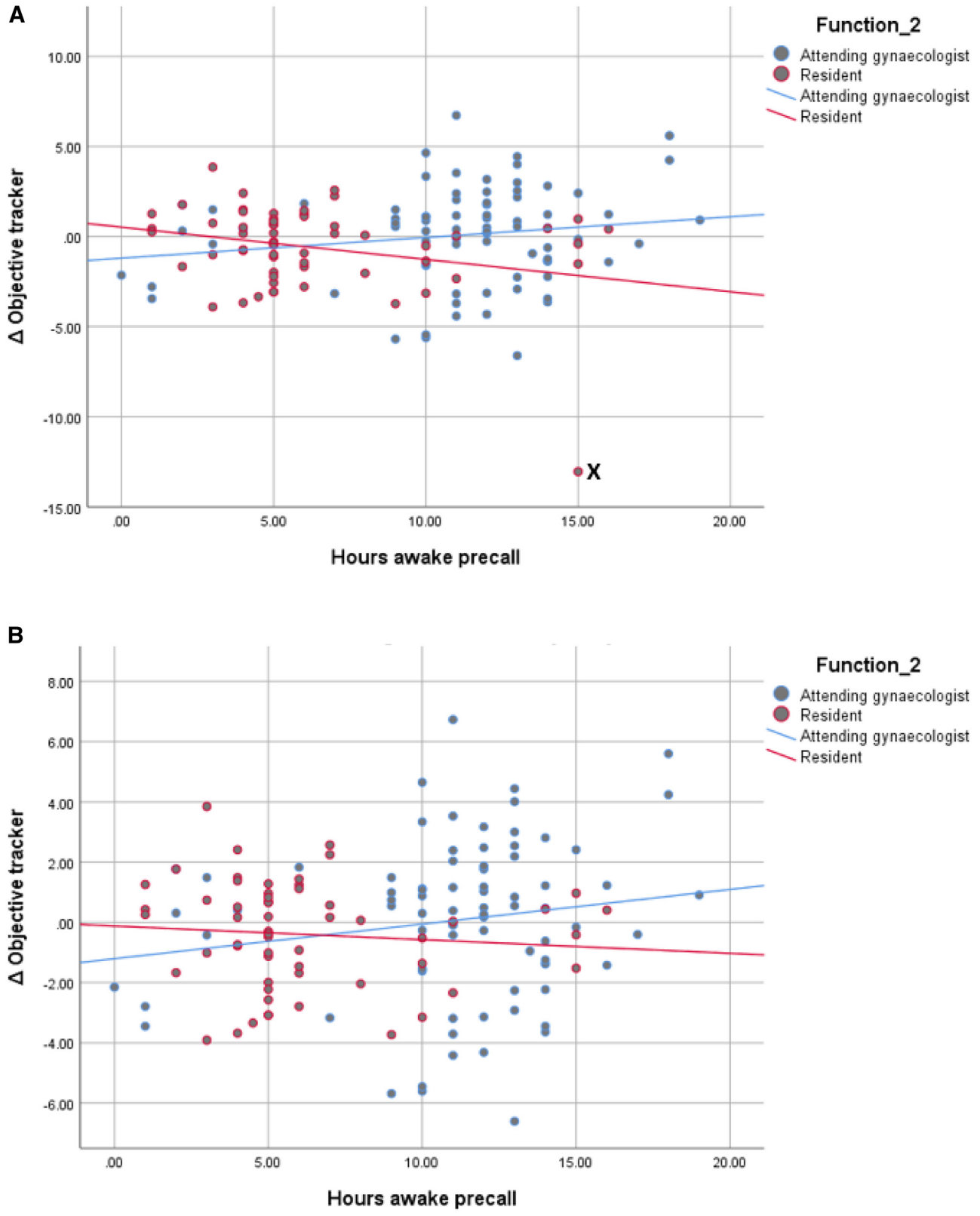
SUPPLEMENTAL FIGURE 1
Regression analysis objective performance residents



Data show standard analysis (**A**) and sensitivity analysis (**B**). The impact of the outlier measurement (X) (**A**) on the regression analysis is shown.

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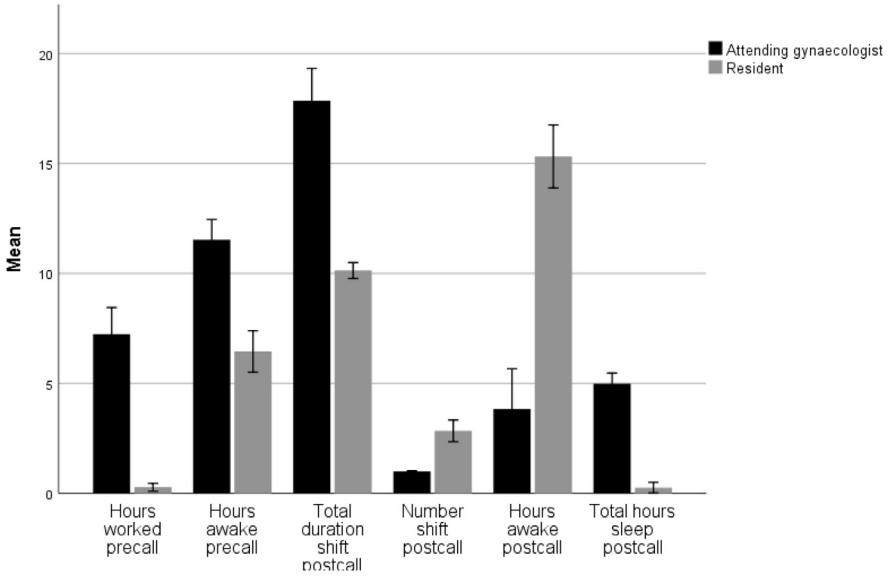
SUPPLEMENTAL FIGURE 2
Shift characteristics



Data reflect means.

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SUPPLEMENTAL TABLE 1

The VAS scores according to Bond and Lader and calculation into their respective domains

Bond and Lader VAS	
VASBL01	Alert or drowsy
VASBL02	Calm or excited
VASBL03	Strong or feeble
VASBL04	Confused or clear-headed
VASBL05	Well coordinated or clumsy
VASBL06	Lethargic or energetic
VASBL07	Contented or discontented
VASBL08	Troubled or tranquil
VASBL09	Mentally slow or quick witted
VASBL10	Tense or relaxed
VASBL11	Attentive or dreamy
VASBL12	Incompetent or proficient
VASBL13	Happy or sad
VASBL14	Antagonistic or amicable
VASBL15	Interested or bored
VASBL16	Withdrawn or gregarious

Each scale displays a 100-mm line. The scales are scored measuring the distance from the end of the line to the subjects' mark.

VAS, Visual Analog Scale.

VAS alertness=100−([VASBL01]+[VASBL03]+100-[VASBL04]+[VASBL05]+100−[VASBL06]+100−[VASBL09]+[VASBL11]+
100−[VASBL12]+[VASBL15])/9.

VAS contendness=100−([VASBL07]+100−[VASBL08]+[VASBL13]+100−[VASBL14]+100−[VASBL16])/5.

VAS calmness=100−([VASBL02]+100−[VASBL10])/2.

Adapted from Bond and Lader.[13]

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SUPPLEMENTAL TABLE 2
The FTOP questionnaire to record demographic and shift characteristics

FTOP questionnaire

Personal and experience data
- Function
  - ○ Attending or resident (AIOS or ANIOS)
- In case of an attending: subspecialty
- Man or woman
- Years of experience
  - ○ In case of attending
    - ☐ Year of graduation residency
  - ○ In case of resident
    - ☐ Year of graduation medical doctor
- Partnership or salaried employment
- Hours of sleep per night (estimated mean last 4 wk)
  - ○ Numeric
- Hours of work per week (estimated mean last 4 wk)
  - ○ Numeric

Shift characteristics
- Type of measurement
  - ○ Noncall, precall, or postcall measurement
- Do you qualify yourself as fit to perform surgery
  - ○ Yes or no
- Do you qualify yourself as fit to see patients at the outpatient clinic
  - ○ Yes or no
- Would you prefer to move a planned surgery, or let someone else perform the surgery?
  - ○ Yes or no
- In case of noncall measurement
  - ○ Hours slept
    - ☐ Numeric
- In case of precall
  - ○ Hours already worked
    - ☐ Numeric
  - ○ Hours already awake
    - ☐ Numeric
  - ○ Number of consecutive night shift
    - ☐ Numeric
- In case of postcall
  - ○ Total hours of shift
    - ☐ Numeric
  - ○ Number of consecutive night shift
    - ☐ Numeric
  - ○ Hours awake
    - ☐ Numeric
  - ○ Hours slept
    - ☐ Numeric
  - ○ Percentage activity during shift (calls, operation room, or emergency room or ward or nothing)
    - ☐ Numeric, total max of 100%
  - ○ Do you need to continue work activities?
    - ☐ Yes or no

AIOS, resident in training; *ANIOS*, resident not in training; *FTOP*, fit to perform.

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SUPPLEMENTAL TABLE 3
Overview of measurements

Measurements	Total	Consultants	Residents
Noncall	42	25 (59.5)	17 (40.5)
Precall	208	113 (54.3)	95 (45.7)
Postcall	165	88 (53.3)	77 (46.7)
Consecutive precall-postcall (during 1 shift)	141	81 (57.4)	60 (42.6)
Test set per person	2 (1−12)	2 (1−8)	2.5 (1−12)

Values are presented as number (percentage) or median (interquartile range).

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SUPPLEMENTAL TABLE 4
Subspecialties

Variable	Consultant (n=46)	Resident (n=33)
Perinatology (maternal-fetal medicine)	14	0
Gynecology-oncology	3	0
Urogynaecology	5	0
Fertility	3	0
Benign gynecology	2	1
Minimal invasive gynecological surgery	3	0
Unspecified or no subspecialty	17	32

The numbers add up more than participants, because 1 consultant had 2 subspecialties.

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SUPPLEMENTAL TABLE 5
Variables (shift characteristics) analyzed with regression analysis

Shift characteristics
Hours worked before night shift
Hours awake before night shift
Hours slept during night shift
Number of consecutive night shift
Total length of shift
Percentage activities[a]
Emergency room or ward
Operation room
Telephone
No activity
Test set

[a] All percentages add up to 100%.

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SUPPLEMENTAL TABLE 6
Regression coefficients for objective alertness

Variable	Consultant	CI	Resident	CI
Hours awake before night shift	0.13 (0.074)a_1	−0.01 to 0.28	−0.17 (0.08)a_2[a]	−0.34 to −0.001
Constant	−1.29c_1		0.49c_2	

Data are presented as mean (standard deviation). Equation for consultants is a1x + b1y + c1 = z. Equation for residents is a2x + b2y + c2 = z. a is the coefficient hours awake; c is the constant; and z is the tracker difference.

CI, confidence interval.

[a] $P<.05$.

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SUPPLEMENTAL TABLE 7
Sensitivity analysis for regression coefficients for objective alertness

Variable	Consultant	CI	Resident	CI
Hours awake before night shift	0.14 (0.066)a_1[a]	0.0066 to 0.2695	−0.023 (0.080)a_2	−0.1787 to 0.1332
Constant	−1.29c_1		−0.29c_2	

Data are presented as mean (standard deviation). Posthoc sensitivity analysis without 1 outlier measurement (Δ objective tracker precall vs postcall, 4.9 standard deviation). Equation for consultants is a1x + b1y + c1 = z. Equation for residents is a2x + b2y + c2 = z. a is the coefficient hours awake; c is the constant; and z is the tracker difference.

CI, confidence interval.

[a] $P<.05$.

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SUPPLEMENTAL TABLE 8
Regression coefficients for subjective alertness

Variable	Consultant	CI	Resident	CI
Hours of sleep during night shift	2.77 (0.98)a_1[a]	0.83−4.71	−0.49 (2.06)a_2	−4.59 to 3.61
Percentage of shift in the OR	−0.19 (0.07)b_1[a]	−0.32 to −0.05	0.07 (0.09)b_2	−0.12 to 0.25
Constant	−20.87c_1		−20.27c_2	

Data are presented as mean (standard deviation). Equation for consultants is a1x + b1x + c1 = z. Equation for residents is a2x + b2x + c2 = z. a is the coefficient hours of sleep; b is the coefficient percentage call to the OR; c is the constant; and z is the VAS difference.

CI, confidence interval; *OR*, operation room; *VAS*, Visual Analog Scale.

[a] $P<.05$.

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