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ORIGINAL ARTICLE

How does sleep deprivation during 24 h on call duty affect the cognitive performance orthopaedic residents? ☆



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KEYWORDS

Sleep;
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Abstract

Introduction: Sleep deprivation is usually present in residents during their training programme. The purpose of our study was to analyse the cognitive performance of a group of orthopaedic residents before and after 24 h on call duty.

Methods: We include orthopaedic residents and their cognitive functions were evaluated by the following tests: Continuous Performance Test (CPT 2), Digit Span (Versión 5), 1 letter Fonologic Fluency y Pasat Test. All the tests were done after a sleeping period at home of at least 6 h and after being on call (sleeping less than 3 h).

Results: Nineteen residents were included in the study. The median age was 27 ± 1.89 and 15 were male. The mean hours of sleeping at home was 6.5 (range 6–8) and after on call duty was 1.5 (range 0.5–3). Statistical difference were found in CPT 2 test in terms of correct answers ($p = 0.007$), omissions ($p = 0.004$) and perseverations ($p = 0.036$). No significant differences were found in the other tests.

Conclusion: Sleep deprivation after 24 h on call duty affects cognitive performance of orthopaedic residents, increasing the number of errors and omissions.

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PALABRAS CLAVE

Sueño;
Residencia;
Funciones cognitivas

¿Cómo afecta la privación de sueño durante una guardia de 24 h las funciones cognitivas de los residentes de ortopedia y traumatología?

Resumen

Introducción: La falta de sueño suele presentarse regularmente en los residentes de especialidades médicas durante su proceso de formación. El objetivo principal de nuestro estudio fue comparar las funciones cognitivas basales y después de la privación de sueño posguardia en residentes de ortopedia y traumatología.

Material y métodos: Se han incluido en el estudio a residentes de ortopedia y traumatología y se evaluaron la atención y funciones cognitivas a través de los siguientes test: *Continuous Performance Test (CPT 2)*, *Digit Span Directo e Inverso (Versión 5)*, *Fluencia Fonológica de 1 letra* y *Pasat Test*. Todas las evaluaciones basales se realizaron después de un periodo de descanso en domicilio de al menos 6 h y las evaluaciones posguardia fueron realizadas en residentes con menos de 3 h de sueño.

Resultados: Diecinueve residentes fueron incluidos en el estudio. La edad media de la serie fue de $27 \pm 1,89$ años y 15 eran de sexo masculino. El promedio de horas de sueño basal fue de 6,5 h (rango 6–8) y posguardia de 1,5 h (rango 0,5–3). En la evaluación de CPT2 se han encontrado diferencias significativas en el número de aciertos ($p = 0,007$), número de omisiones ($p = 0,004$) y perseveraciones ($p = 0,036$) a la consigna planteada. No hemos encontrado diferencias significativas en los otros test.

Conclusión: La falta del sueño posterior a una guardia de 24 h de ortopedia y traumatología afecta la atención de los residentes, aumentando el número de errores y omisiones.

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Introduction

Sleep deprivation induces attention deficit, low cognitive performance and deterioration in the capacity for exercising judgement.^{1,2} This situation regularly occurs for residents of medical specialties who throughout their training have to perform obligatory and active 24 h on call duty followed by the continuation of regular employment duties the following day. Long working days combined with a lack of sleep in medical training programmes have come under scrutiny for several years.³ The strongest arguments against them are medical errors and putting the patient's safety at risk.⁴ As a result, in USA and Europe the maximum working hours per week have been stipulated for all residents.^{5,6} However, many people consider that the working hour restriction in the resident programmes has damaged the professional training of residences with no benefit for patients.^{7–10}

Over the last decade different studies have attempted to determine whether a lack of sleep affects the performance of residences and health professionals.^{11–13} It has been reported that being on call duty without being able to sleep increases the number of errors made and reduces the individual's capacity to pay attention and react to levels which are comparable to a 0.5 g/l alcohol/blood level.¹⁴ Many articles published over the last few years analyse the relationship between a lack of sleep and cognitive and practical abilities in different residences (internal medicine, family care, general surgery or cardiovascular surgery) in USA and Europe. Few records exist, however, with regards to orthopaedic residents in particular.^{11–13}

The main objective of our study was to compare baseline cognitive functions and post on call duty sleep privation functions in orthopaedic residents.

Materials and methods

First, 2nd, 3rd, and 4th year resident orthopaedic students from a single university hospital in Argentina (South America) were included in the study. They met the following inclusion criteria: they performed active 24 h on call duty and their post on call duty activity continued for at least 8 h. The following residents were excluded from the study: those who refused to participate in the process or who did not sign the informed consent form, those who presented with insomnia or sleep disturbances, those under medical treatment with drugs which could interfere in their normal circadian cycle (anti-histamines, muscle relaxants, tranquilisers, antidepressants), those who were pregnant or had visual or hearing difficulties which would have complicated taking the tests. All participants were not allowed to have consumed energy drinks, carbonated drinks or coffee 5 h prior to the assessment. The 1st and 2nd year residents were classified as junior residents and the 3rd and 4th years as senior residents.

Each orthopaedic on call duty of the hospital comprises: a medical specialist in orthopaedics, a senior resident and 2 junior residents. They are in charge of outpatient consultations (on average 150 consultations), control hospitalised patients (on average 45 patients) and perform surgical activity on demand. All activity performed by junior residents is supervised by a senior resident and medical specialist.

Assessment of performance regarding attention and cognitive functions were included in the following tests: Continuous Performance Test (CPT 2), Digit Span Direct and Reverse (version 5) Test, 1 letter Phonological Fluency Test and the Pasat Test. All tests were performed on Thursdays and Fridays between 13.00 and 15.00 h by two separate assessors specialised in neuroscience (C.F. and L.Z.). The order of the baseline and post on call duty assessments was randomly defined for each participant so as not to be biased towards either of the 2 phases and therefore avoid any previous knowledge of the tests. All the baseline assessments were made following a period of rest at home of at least 6 h and post on call duty assessments in residents with less than 3 h of sleep. The components of the neurocognitive assessments are described below.

CPT 2: assesses overall attention capacity, impulsivity and inhibitory response of participants. It provides information on the capacity for sustained attention (ability to focus on a task for a prolonged period of time), flexibility and selective attention (ability to respond to the presence of relevant/discriminatory stimuli). This is a computerised, individually administered test with presentation of letters on the screen (one per time) for 15 min. The participant's task will be to press the space bar (only once) of the keyboard as fast as possible each time a letter appears on the screen and not press it when the letter 'X' appears. As the exercise progresses the time of letter presentation also varies. Scores are given for correct moves, omission errors (not clicking on the space bar when required to), commission errors (pressing the space bar when not required) and perseverations (pressing the space bar more than once, not realising the error). Scores range from 0% to 100%, with 0% a perfect result and 100% the worst result possible.^{15,16}

Digit Span Direct and Inverted response (version 5): this is used to measure sustained attention and the working memory. Participants are presented with a series of digits (for example, '8.4') which they have to repeat in the order in which they appear. They begin with two series of 2 digits, then two series of 3 digits and so on successively until one series fails. In a second instance the participant is asked to repeat the sequences again but this time in reverse order to which they hear them, thus increasing the number of digits. The number of correct sequences repeated by each participant is collected.¹⁷

Phonological Fluency Test (one letter): this assesses the speed of processing verbal information. The subject is asked to say the greatest number of words beginning with a certain letter for 1 min, omitting names and word groups. The number of correct words is counted. If the letters 'F', 'S' or 'A' were used by this sample, these were varied for the baseline and post on call duty test to prevent any learning effect.¹⁸

Pasat Test: this test combines assessment of two cognitive components, working memory and the speed of processing auditory information, in addition to mathematical calculation skills. The test requires the use of sound reproduction. The subject is informed that they will hear a series of digits of a number which will be presented to them every 3 s. They must listen for the first two digits, add them up and give an answer. When they hear the following number they must add it to the one they have just heard previously. They will continue adding the following number to the

Table 1 General sample characteristics.

Characteristic	Resident (n = 19)
Age	27 ± 1.89 (range between 24 and 29)
Male	15 (79%)
Residency year	
First	7 (37%)
Second	7 (37%)
Third	2 (10.5%)
Fourth	3 (15.5%)
Marital status: single	18 (95%)
Children	0 (0%)
Tobacco consumption	2 (10.5%)

previous one. They will not be asked to give a total accumulative number, but the sum of the two numbers which are consecutively given. At least one practice number will be given prior to performing the complete test.¹⁹

The differences between the baseline scores and the post on call duty scores were compared with the *t* test for the paired data. A lineal regression model of random effects with random origin for estimating a measure of association between the scores and on call duty was used, considering the natural grouping of the measurements of the same individual. The model co-efficients was presented with their 95% confidence intervals. Statistical analysis was made using version 12 STATA software.

Results

Out of a total of 37 orthopaedic residents from the university hospital, 19 were included in the study. The mean age of the series was 27 ± 1.89 (range 24–32 h) and 15 were male. The average hours of baseline sleep (at home) was 6.5 h (range 6–8 h) and post on duty call was 1.5 h (range 0.5–3) (Table 1).

Conners continuous performance test (CPT 2)

The successes obtained under baseline conditions of appropriate sleep and after an active on call duty of 24 h in the residents analysed demonstrated a statistically significant differences in favour of the first group ($p = 0.007$). The number of omissions to the test put forward was considerably higher when the test was made after on call duty ($p = 0.004$), as was the number of perseverations ($p = 0.036$). We did not record any differences regarding commission errors ($p = 0.06$) (Table 2).

Digit Span Test: no significant differences were found between the two groups analysed ($p = 0.83$) (Table 2).

Pasat Test: no significant differences were present between the two groups analysed ($p = 0.76$) (Table 2).

Phonological Fluency: the average results of the series analysed were: 12.37 words under baseline conditions and 12.68 under post on call duty conditions. No significant difference was found ($p = 0.75$) (Table 2).

Table 2 Results of the neurological test in baseline state (>6 h sleep) and post duty (<3 h sleep).

Test	Baseline	Post duty	<i>p</i>	Coefficient (95% CI)	Function assessed
<i>CPT 2</i>					
Correct	46.4	66.24	0.007	19.8 (95% CI 7.51–32.1)	Overall attention
Omissions	40.11	66.5	0.004	26.38 (95% CI 11.01–41.76)	Overall attention
Commissions	37.04	49.55	0.06	12.51 (95% CI 0.79–24.23)	Impulsiveness
Perseverations	43.24	62.94	0.036	19.69 (95% CI 4–35.38)	Inhibitory Control
<i>Digit span</i>					
Direct	6.47	6.53	0.83	0.05 (95% CI 0.4–0.5)	Attention
Inverted	4.47	4.32	0.52	–0.16 (95% CI 0.6–0.29)	Work memory
<i>PF 1 letter</i>	12.37	12.68	0.75	0.31 (95% CI 1.59–2.22)	Verbal or processing speed
<i>Pasat</i>	50.47	51.06	0.76	0.38 (95% CI 3.08–3.85)	Aural or processing speed

CPT 2: results are expressed in scores of 0–100, with 0 being the best possible result and 100 the worst; PF: phonological fluency; CI: confidence interval.

Discussion

Long working days, 24 h duty and obligation to continue working until the following day were and continue being a constant in many orthopaedic residents' programmes. The said rules are accepted as normal by residents, ward doctors and those in charge of training programmes. Different approaches and changes in this regard have been put forward in countries such as USA, which, from 2003 stipulated a maximum of 30 h of continuous work or a maximum of 80 h weekly for all residents, or Spain, where a weekly schedule of not over 48 h was fixed for associates and doctors in training.^{5,6} However, sleep deprivation and the tiredness factor in doctors who are in training continues to be an issue under debate.

Sleep deprivation undoubtedly leads to alterations and affects our neurocognitive abilities.²⁰ The alteration of the circadian rhythm and lack of rest affects concentration, memory and psychomotor activity, increasing the possibility of committing errors.²¹ Results in the medical area are, however, contradictory. On the one hand, Arnedt et al. reported that the response capacity of resident paediatricians after a 24 h on call duty is comparable to having blood/alcohol of 0.5 g/l and Barger et al. concluded that the long working days for residents increased the number of errors, complications and lapses in attention.^{13,14} Furthermore, Rothschild et al. did not find a higher percentage of complications in the procedures performed after having performed resident duty hours of 24 h.⁴

The results of the lack of sleep, particularly in surgical performance (psychomotor activity) are even more ambiguous. Sharpe et al. reported that there were no differences in terms of complications and readmissions of patients to surgery of those performed by doctors who had been on duty for 24 h the previous night.²² However, O'Brien et al. demonstrated a lack of cognitive response of orthopaedic surgeons who had slept less than 4 h, without specifying whether this would have repercussions on the surgical output.¹⁰

We decided to analyse the response to the lack of sleep specifically in a group of orthopaedic residents of a single university hospital. The authors were unaware of any report in Spain regarding the effect of sleep deprivation in the orthopaedic residents. A total of 19 residents were assessed,

14 were in their first and second years (1st and 2nd year) and 5 were in their last years (3rd and 4th year). We found a difference regarding attention, impulsiveness and inhibitory response when the residents were assessed after an active duty of 24 h through the CPT2 test. We found that sleep had increased the number of errors and omissions recorded which corresponded to a lack of attention due to lowered information processing. The increase in the number of perseverations is usually due to a lack of inhibition, associated with a change in the frontal lobe, which in this case was physiological due to a lack of sleep. Regarding commissions (pressing the space bar more times than was necessary), no significant differences were found. This pattern is generally more common in compulsive disorders than in those associated with attention deficit. In addition, the Digit Span, PF and Pasat tests did not show up any differences, possibly due to the fact that the sensitivity of said assessments is lower in that of a healthy population.

Getting used to tiredness over time was reported, as was personal individual vulnerability due to lack of sleep.²¹ The effect of becoming used to this could be regarded as represented in the results obtained from different years, but our sample size does not permit us to reach any definitive conclusions in this regard. A larger sample-sized study thus needs to be carried out to obtain more definitive results.

Due to logical ethical questions it has not been possible to carry out prospective, randomised and comparative studies on patients surgically treated by doctors who were well rested and those who had had less than 3 h sleep. For this reason, tests were performed with simulators in different surgical specialties such as cardiovascular surgery, surgery of the thorax, abdominal surgery or laparoscopy.^{23–28} Outcomes are very different, with articles which describe sleep deprivation as a preponderant factor for a reduced psychomotor response and a higher rate of errors, whilst others find no difference whatsoever and some publications even consider this a positive factor.^{23,25–28}

In 2014, a systematic review of 135 articles on working hours being restricted to 80 h per week for residents was published, and concluded that no improvements were consistently associated with resident well-being, and that they had recorded a negative impact on the performance in certification exams.⁶ Analysis of the first group of surgical specialist residents who were trained with the new

hour restrictions reduced their contact with patients and the time spent in surgery.⁷ Moreover, exhaustion and thoughts about giving up did not diminish even under the new paradigm of the working hour reduction.²⁹ Residents of internal medicine, family care, paediatrics, general surgery and orthopaedics in the USA concluded that the working hour restrictions had not improved the level of attention or resident training.^{6–9} Specifically in the area of orthopaedics, a systematic review was published in 2015, which aimed at determining the effect of the working hour restriction on quality of life, patient safety, education and surgical abilities of residents. Although it is difficult to obtain a specific outcome, an improvement in quality of life (reduction in fatigue and increase in hours of sleep) was observed, but a reduction in the development of surgical skills was also noted.³⁰ There is no doubt that the areas of “surgical faculties” is where the most negative effects were noted from timetable restrictions in residents’ training programmes.^{7,30,31} For this reason the European Union proposed the modification for surgical specialties, adding the “48+12” option. With this, 12 h are added to the official timetable but are reserved for training activities, with no performing of night duty or routine work.^{19,32}

We are aware of our study limitations with its small sample only from one university hospital, and no analysis of practical capacity, but we do however believe that the design and methodology of the study render our outcome valid in the little researched area of orthopaedic residents. We believe there is the need for several multicentre studies which include the objective assessment of medical practice outcome in order to observe the real effect of lack of sleep in this group of residents.

Conclusion

Lack of sleep after a 24 h on call duty in orthopaedics affects residents’ attention, increasing the number of errors and omissions. However, seemingly, working memory and speed of procedure are not affected. We believe the right balance in residents’ programmes needs to be discussed between the authorities of the medical community, residents and educators, in order for patient safety and that of residents or be guaranteed, without their training being affected.

Ethical disclosures

Protection of human and animal subjects. The authors declare that no experiments were performed on humans or animals for this investigation.

Confidentiality of data. The authors declare that they have followed the protocols of their work centre on the publication of patient data.

Right to privacy and informed consent. The authors must have obtained the informed consent of the patients and/or subjects mentioned in the article. The author for correspondence must be in possession of this document.

Conflict of interest

The authors have no conflict of interest to declare.

References

- Goel N, Rao H, Durmer JS, Dinges DF. Neurocognitive consequences of sleep deprivation. *Semin Neurol.* 2009;29:320–39.
- Luber B, Steffener J, Tucker A, Habeck C, Peterchev AV, Deng ZD, et al. Extended remediation of sleep deprived-induced working memory deficits using fMRI-guided transcranial magnetic stimulation. *Sleep.* 2013;36:857–71.
- Gohar A, Adams A, Gertner E, Sackett-Lundeen L, Heitz R, Engle R, et al. Working memory capacity is decreased in sleep deprived internal medicine residents. *J Clin Sleep Med.* 2009;5:191–7.
- Rothschild JM, Keohane CA, Rogers S, Gardner R, Lipsitz SR, Salzberg CA, et al. Risks of complications by attending physicians after performing nighttime procedures. *JAMA.* 2009;302:1565–72.
- Statement of justification/impact for the final approval of common standards related to resident duty hours. Chicago: Accreditation Council for Graduate Medical Education; 2003.
- The European working time directive and the effects on training of surgical specialists (doctors in training). *Acta Neurochir (Wien).* 2006;148:1130–6.
- Ahmed N, Devitt KS, Keshet I, Spicer J, Imrie K, Feldman L, et al. A systematic review of the effects of resident duty hour restrictions in surgery: impact on resident wellness, training, and patient outcomes. *Ann Surg.* 2014;259:1041–53.
- Drolet BC, Sangisetty S, Tracy TF, Cioffi WG. Surgical residents’ perceptions of 2011. Accreditation council for graduate medical education duty hour regulations. *JAMA Surg.* 2013;148:427–33.
- Drolet BC, Anandarajah G, Fischer SA. The impact of 2011 duty hours requirements on family medicine residents. *Fam Med.* 2014;46:215–8.
- Mir HR, Cannada LK, Murray JN, Black KP, Wolf JM. Orthopaedic resident and program director opinions of resident duty hours: a national survey. *J Bone Joint Surg Am.* 2011;93:e1421–9.
- O’Brien MJ, O’Toole RV, Newell MZ, Lydecker AD, Nascone J, Sciadini M, et al. Does sleep deprivation impair orthopaedic surgeons’ cognitive and psychomotor performance? *J Bone Joint Surg Am.* 2012;94:1975–81.
- Barger LK, Ayas NT, Cade BE, Cronin JW, Rosner B, Speizer FE, et al. Impact of extended duration shifts on medical errors, adverse events, and attentional failures. *PLoS Med.* 2006;3:e47.
- Antiel RM, Reed DA, Van Arendonk KJ, Wightman SC, Hall DE, Porterfield JR, et al. Effects of duty hour restrictions on core competencies, education, quality of life, and burnout among general surgery interns. *JAMA Surg.* 2013;148:448–55.
- Arndt JT, Owens J, Crouch M, Stahl J, Carskadon MA. Neurobehavioral performance of residents after heavy night call vs. after alcohol ingestion. *JAMA.* 2005;294:1025–33.
- Arán Filippetti V, Daniel Mías D. Neuropsicología del trastorno por déficit de atención/hiperactividad: subtipos predominio déficit de atención y predominio hiperactivo-impulsivo. *Rev Argent Neuropsicol.* 2009;13:14–28.
- Etchepareborda MC. Bases experimentales para la evaluación de la atención en el trastorno por déficit de atención con hiperactividad. *Rev Neurol.* 2004;38:137–44.
- Schroeder RW, Twumasi-Ankrah P, Baade LE, Marshall PS. Reliable Digit Span: a systematic review and cross-validation study. *Assessment.* 2012;19:21–30.
- Spreen O, Strauss EA. Compendium of neuropsychological tests. Administration, norms, and commentary. New York: Oxford University Press; 1998.

19. Tombaugh TN. A comprehensive review of the Paced Auditory Serial Addition Test (PASAT). *Arch Clin Neuropsychol*. 2006;21:53–76.
20. Lobato RD, Fernández-Alén J, Alday R. The impact of resident work hour limitations on medical student clerkships in Spain. *Neurocirugia (Astur)*. 2008;19:213–7.
21. Pilcher JJ, Huffcutt AI. Effects of sleep deprivation on performance: a meta-analysis. *Sleep*. 1996;19:318–26.
22. Durmer JS, Dinges DF. Neurocognitive consequences of sleep deprivation. *Semin Neurol*. 2005;25:117–29.
23. Sharpe JP, Weinberg JA, Magnotti LJ, Nouer SS, Yoo W, Zarzaur BL, et al. Outcomes of operations performed by attending surgeons after overnight trauma shifts. *J Am Coll Surg*. 2013;216:791–7.
24. DeMaria EJ, McBride CL, Broderick TJ, Kaplan BJ. Night call does not impair learning of laparoscopic skills. *Surg Innov*. 2005;12:145–9.
25. Ellman PI, Law MG, Tache-Leon C, Reece TB, Maxey TS, Peeler BB, et al. Sleep deprivation does not affect operative results in cardiac surgery. *Ann Thorac Surg*. 2004;78:906–11.
26. Taffinder NJ, McManus IC, Gul Y, Russell RC, Darsi A. Effect of sleep deprivation on surgeons' dexterity on laparoscopy simulator. *Lancet*. 1998;352:1191.
27. Grantcharov TP, Bardram L, Funch-Jensen P, Rosenberg J. Laparoscopic performance after one night on call in a surgical department: prospective study. *BMJ*. 2001;323:1222–3.
28. Uchal M, Tjugum J, Martinsen E, Qiu X, Bergamaschi R. The impact of sleep deprivation on product quality and procedure effectiveness in a laparoscopic physical simulator: a randomized controlled trial. *Am J Surg*. 2005;189:753–7.
29. Kahol K, Leyba MJ, Dekka M, Dekka V, Mayes S, Smith M, et al. Effect of fatigue on psychomotor and cognitive skills. *Am J Surg*. 2008;195:195–204.
30. Antiel RM, Reed DA, van Arendonk KJ, Wightman SC, Hall DE, Porterfield JR, et al. Effects of duty hour restrictions on core competencies, education, quality of life, and burnout among general surgery interns. *JAMA Surg*. 2013;148:448–55.
31. Harris JD, Staheli G, LeClere L, Anderson D, McCormick F. What effects have resident work-hour changes had on education, quality of life, and safety? A systematic review. *Clin Orthop Relat Res*. 2015;473:1600–8.
32. Jamal MH, Rousseau MC, Hanna WC, Doi SA, Meterissian S, Snell L. Effect of the ACGME duty hours restrictions on surgical residents and faculty: a systematic review. *Acad Med*. 2011;86:34–42.