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The measurement of mental fatigue following an overnight on-call duty among doctors using electroencephalogram

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Abstract

This study aimed to measure the spectral power differences in the brain rhythms among a group of hospital doctors before and after an overnight on-call duty. Thirty-two healthy doctors who performed regular on-call duty in a tertiary hospital in Sarawak, Malaysia were voluntarily recruited into this study. All participants were interviewed to collect relevant background information, followed by a self-administered questionnaire using Chalder Fatigue Scale and electroencephalogram test before and after an overnight on-call duty. The average overnight sleep duration during the on-call period was 2.2 hours ($p<0.001$, significantly shorter than usual sleep duration) among the participants. The mean (SD) Chalder Fatigue Scale score of the participants were 10.8 (5.3) before on-call and 18.4 (6.6) after on-call (p-value < 0.001). The theta rhythm showed significant increase in spectral power globally after an overnight on-call duty, especially when measured at eye closure. In contrast, the alpha and beta rhythms showed reduction in spectral power, significantly at temporal region, at eye closure, following an overnight on-call duty. These effects are more statistically significant when we derived the respective relative theta, alpha, and beta values. The finding of this study could be useful for development of electroencephalogram screening tool to detect mental fatigue.

Introduction

Although sleep deprivation and mental fatigue are two distinguishable conditions [1], they often occurred together in real life, especially among occupations requiring overnight on-call, extended shift, and shift work. Sleep deprivation is a continuous and prolonged period of lack of sleep whereas mental fatigue implies reduced psychophysiological efforts due to prolonged and demanding mental activities [1]. Despite the scientific distinction, both conditions contribute to performance impairments and are often considered interchangeable.

Overnight on-call doctors typically experiencing mental fatigue in addition to sleep deprivation due to the nature of the demanding and busy hospital workload. Overnight on-call causes disturbed sleep [2], and is associated with higher medication errors among doctors [3,

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4], procedural errors [5], stress reactivity [6], and impairment of attentional networks [7]. Nevertheless, not all post-call doctors are sleepy, mentally fatigue and is at risk of inflicting errors in carrying out their tasks. Hence, from the perspective of occupational health and safety, as well as patient's safety, it is of utmost importance to find a method to detect mental fatigue following sleep deprivation due to overnight on-call duty among doctors, to prevent them from carrying out emergency and surgical procedures which might impose danger to themselves and others.

Electroencephalography (EEG) has been widely used in the evaluation of sleep [8–12], alertness [13–16], and mental fatigue [17–20], especially in the field of transportation medicine [17, 20–24]. There has never been a study to evaluate EEG changes following an overnight on-call duty among the doctors. In this study, we compared the EEG characteristics among the doctors before and after an overnight on-call duty, to identify differences that could be useful for future brain-computer interface system development to detect resting state drowsiness or mental fatigue following overnight on-call duty for healthcare personnel. The objective of this study is to determine the significant differences in the power spectral of EEG rhythms at different brain regions before and after an overnight on-call duty among a group of doctors who actively perform on-call work on regular basis. The findings of this study could contribute to address the gap in the literature by evaluating EEG changes following overnight on-call duty among doctors and develop a brain-computer interface system to detect mental fatigue and drowsiness in healthcare personnel.

Materials and methods

This was a repeated cross-sectional study on a group of doctors who performed overnight on-call duty in a tertiary government hospital in Sarawak, Malaysia. The inclusion criteria were all doctors who are on a regular on-call work schedule with a working period of more than 12 hours during the overnight calls. We excluded the participants with any history of organic neurophysiological or developmental disorders, neurophysiological injuries, psychiatric illness, taking regular medication, pregnancy at the time of recruitment and illnesses that may affect the neurophysiological function of the brain. All doctors fitting the inclusion and exclusion criteria were invited to participate in the study and the acceptance was voluntary. The participants were free to decide on an on-call day which they would like to carry out this study, but they must ensure that they were present for two sessions, before, and after their on-call work schedule. Prior to the start of the study, all participants would be interviewed to collect the information on their age, gender, education level, duration of work, usual overnight sleep duration, medical history, and alcohol, tea, and smoking consumption. This was followed by the first EEG recording prior to the on-call duty. The participants were then released to perform usual on-call duty and were asked to return on the following day for the second EEG recording. The participants were asked to answer a the Chalder Fatigue Scale [25] questionnaire before and after on-call, prior to the EEG test. The duration of sleep during the overnight on-call duty was determined by self-reporting.

The Chalder Fatigue Scale questionnaire consists of 11 items assessing symptoms of fatigue, such as lack of strength in the muscles, tiredness, lack of energy, sleepiness, memory, and difficulties in concentration, requiring a participant to rate each item on its frequency of occurrence: less than usual, no more than usual, more than usual, and much more than usual. With the use of the Likert scoring system, a score ranging from 0 to 3 is given. The total score of the scale is calculated by adding the rating for each item, which ranges from 0 to 33. With the use of the Likert scale, a score of less than 15 is considered to have 'no fatigue' and 15 and above means 'fatigue' is present. A study by Wessely et al. to distinguish between mild and severe