Sleep Medicine 15 (2014) 1219–1224

Contents lists available at ScienceDirect

Sleep Medicine

journal homepage: www.elsevier.com/locate/sleep

Original Article

Effects of different sleep deprivation protocols on sleep perception in healthy volunteers

Leonardo I. Goulart [a,*], Luciano R. Pinto Jr [c], Michael L. Perlis [b], Raquel Martins [c], Luis Otavio Caboclo [a], Sergio Tufik [c], Monica L. Andersen [c]

[a] Departamento de Neurofisiologia Clínica, Hospital Israelita Albert Einstein, São Paulo, Brazil
[b] Behavioral Sleep Medicine Program, Department of Psychiatry, University of Pennsylvania, School of Medicine, Philadelphia, PA, USA
[c] Departamento de Psicobiologia, Universidade Federal de São Paulo, São Paulo, Brazil

ARTICLE INFO

Article history:
Received 10 February 2014
Received in revised form 11 May 2014
Accepted 16 May 2014
Available online 30 June 2014

Keywords:
Total sleep deprivation
REM sleep
Sleep perception
Insomnia
Sleep deprivation
Sleep misperception

ABSTRACT

Objectives: To investigate whether different protocols of sleep deprivation modify sleep perception.
Methods: The effects of total sleep deprivation (TD) and selective rapid eye movement (REM) sleep deprivation (RD) on sleep perception were analyzed in normal volunteers. Thirty-one healthy males with normal sleep were randomized to one of three conditions: (i) normal uninterrupted sleep; (ii) four nights of RD; or (iii) two nights of TD. Morning perception of total sleep time was evaluated for each condition. Sleep perception was estimated using total sleep time (in hours) as perceived by the volunteer divided by the total sleep time (in hours) measured by polysomnography (PSG). The final value of this calculation was defined as the perception index (PI).
Results: There were no significant differences among the three groups of volunteers in the total sleep time measured by PSG or in the perception of total sleep time at baseline condition. Volunteers submitted to RD exhibited lower sleep PI scores as compared with controls during the sleep deprivation period ($P < 0.05$). Both RD and TD groups showed PI similar to controls during the recovery period.
Conclusion: Selective REM sleep deprivation reduced the ability of healthy young volunteers to perceive their total sleep time when compared with time measured by PSG. The data reinforce the influence of sleep deprivation on sleep perception.

1. Introduction

The factors that determine how an individual makes judgments about sleep continuity are the subject of speculation. That is, it is still not clear how an individual determines how long it takes to fall asleep, the frequency of awakening, the amount of time awake during the night of sleep, and how much sleep is obtained. It might be expected that a normal perception of sleep time would be the value that was closest to the objective evaluation. Nevertheless, when objective measures of sleep obtained by polysomnographic measures of sleep continuity are compared with their subjective equivalents, they are often discordant [1]. The reasons for this disparity involve the intrinsic mechanisms of perception of time during sleep that are related to the ability to subjectively estimate time-intervals and to differentiate states of consciousness (sleep and wakefulness).

When using two different methods for measuring the same variable, a certain degree of discordance may be expected. Here, discordance is even more likely since one measurement method is objective and the other is subjective. More specifically, polysomnography (PSG) is an 'online'/prospective evaluation of concrete data (rule-based judgments of a discrete representation of a biological state) in which assessments are made every 30 s. Conversely, there is also the subjective estimation of the total sleep time by the individual. This subjective perception can be understood as an 'offline'/retrospective evaluation, in which the data are based on memory for assessments of biological states in which the precision is unknown – thought to be ≥3 min [2]. In addition, several studies have clearly shown that good sleepers cannot recall information from periods immediately prior to sleep [3], during sleep [4–6], or from brief arousals which occur during the night [7,8].

Classical studies in healthy good sleepers suggest that some stages of sleep are more readily perceived as sleep whereas others are not: behavioral signaling and forced awakening studies, although providing variable outcomes for different stages of sleep, suggest uniformly that slow wave sleep is most readily perceived as sleep, followed by rapid eye movement (REM) sleep and then stage 2 [9–12]. More recent studies suggest that, in healthy good

* Corresponding author at: Departamento de Neurofisiologia Clínica – Hospital Israelita Albert Einstein, Avenida Albert Einstein, 627, 05652-900, São Paulo, Brazil. Tel.: +55 11 2151 0420; fax: +55 11 2151 9715.
E-mail address: leonardoierardi@yahoo.com.br (L.I. Goulart).

http://dx.doi.org/10.1016/j.sleep.2014.05.025
1389-9457/

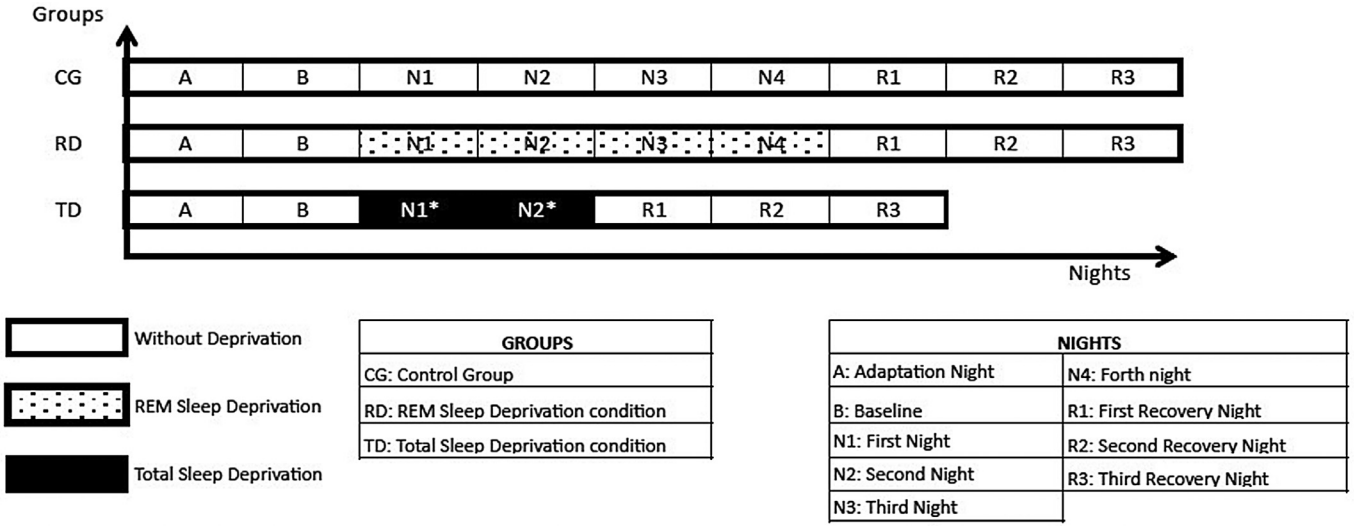

Fig. 1. Study design. All volunteers were evaluated daily by polysomnography (PSG) during the night and perception of total sleep time upon waking in the morning, except nights N1 and N2 for the total sleep deprivation (TD) condition. N1*/N2*, total sleep deprivation procedure for the TD condition; there was no PSG or evaluation of the perception of the total sleep time. REM, rapid eye movement sleep.

sleepers, the ability to estimate the passage of time during the night, in the absence of temporal clues, correlates positively with the percentage of slow wave sleep and negatively with the percentage of REM sleep [13,14].

To the best of our knowledge, no studies have been conducted on the effects of sleep restriction or sleep deprivation on the perception of sleep in healthy subjects. The aim of the present study was to analyze the effect of REM sleep deprivation (RD) and total sleep deprivation (TD) on the perception of total sleep time in healthy volunteers.

2. Methods

2.1. Study overview

The present study used data obtained from structured questionnaires and the same protocol of sleep deprivation utilized in a previous study, conducted at the Sleep Laboratory of the Departamento de Psicobiologia of the Universidade Federal de São Paulo. Details regarding the original investigation by Martins et al. have been published [15].

In brief, all volunteers underwent a rigorous screening protocol and, following the establishment of eligibility, spent seven to nine days in the laboratory (not including the screening PSG). All subjects were allowed to sleep from 23:00 to 08:00, except during the sleep deprivation nights. Day naps were not permitted. Behavioral stress and stressful exercise were avoided throughout the experimental protocol. The sequence of nights was as follows: adaptation, baseline, first to fourth nights (N1 to N4, respectively), and first to third recovery nights (R1 to R3, respectively).

In the control condition (first condition), subjects slept undisturbed for eight consecutive nights. Subjects allocated in the RD group (second condition) underwent four consecutive nights of REM sleep deprivation followed by three nights of recovery (undisturbed sleep). In the TD group (third condition), subjects underwent two consecutive nights of total sleep deprivation, totaling ~60 h of continuous wakefulness, followed by three nights of undisturbed sleep. All conditions entailed morning assessments of the volunteer's subjective impression of total sleep time. Figure 1 illustrates the study design.

2.2. Participants

Participants were recruited via e-mail, banners and personal contact from a pool of volunteers aged between 18 and 30 years. All participants signed the informed consent form. This study was approved by the institutional Ethics Committee (CEP/UNIFESP #1262/09).

The inclusion criteria were as follows: male gender, 18–30 years of age, education of ≥11 years (high school level or higher), normal sleep schedule/period, average sleep duration of 7–9 h, and normal scores on the Pittsburgh Sleep Quality Index [16], Epworth Sleepiness Scale [17], Beck Depression Inventory [18], and State-Trait Anxiety Inventory [18]. The parameters for normality on the aforementioned questionnaires were defined according to previously reported standards.

The exclusion criteria were as follows: history of neurological or psychiatric disorders, use of psychotropic medication, chemical dependence (alcohol, tobacco, or illicit drugs), presence of a sleep disturbance as assessed by clinical evaluation and/or PSG [19], shift work, extreme morningness-eveningness, organic disease, and/or any medical treatment known to affect sleep continuity, sleep architecture, and/or sleep perception.

2.3. Evaluation instruments and interventions

2.3.1. Polysomnography (PSG)

As noted above, each participant stayed 7–9 h in the laboratory for PSG studies (not including the screening PSG). The first recording was used as an initial screening for occult sleep disorders, and the second as an adaptation night. Baseline measures were obtained in the third night of recording. The sleep deprivation conditions were applied in the following four nights (N1 to N4), followed by three nights of recovery (R1 to R3). In the RD group, subjects were submitted to REM sleep deprivation during the four recording nights (N1 to N4). The TD group underwent total sleep deprivation for two consecutive nights (N1 and N2). Finally, the control group had their sleep undisturbed.

All PSG were performed using Embla Digital A10 recording/amplifier polygraph and Somnologica software (Flaga h.f., Reykjavík, Iceland). Standard adult gold cup electrodes were used to record