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Original Article

Effects of aging on sleep structure throughout adulthood: a population-based study

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ABSTRACT

Objective: Although many studies have shown the evolution of sleep parameters across the lifespan, not many have included a representative sample of the general population. The objective of this study was to describe age-related changes in sleep structure, sleep respiratory parameters and periodic limb movements of the adult population of São Paulo.

Methods: We selected a representative sample of the city of São Paulo, Brazil that included both genders and an age range of 20–80 years. Pregnant and lactating women, people with physical or mental impairments that prevent self-care and people who work every night were not included. This sample included 1024 individuals who were submitted to polysomnography and structured interviews. We subdivided our sample into five-year age groups. One-way analysis of variance was used to compare age groups. Pearson product–moment was used to evaluate correlation between age and sleep parameters.

Results: Total sleep time, sleep efficiency, percentage of rapid eye movement (REM) sleep and slow wave sleep showed a significant age-related decrease ($P < 0.05$). WASO (night-time spent awake after sleep onset), arousal index, sleep latency, REM sleep latency, and the percentage of stages 1 and 2 showed a significant increase ($P < 0.05$). Furthermore, apnea–hypopnea index increased and oxygen saturation decreased with age. The reduction in the percentage of REM sleep significantly correlated with age in women, whereas the reduction in the percentage of slow wave sleep correlated with age in men. The periodic limb movement (PLM) index increased with age in men and women.

Conclusions: Sleep structure and duration underwent significant alterations throughout the aging process in the general population. There was an important correlation between age, sleep respiratory parameters and PLM index. In addition, men and women showed similar trends but with different effect sizes.

1. Introduction

The understanding of sleep alterations related to aging is important to interpret clinical sleep conditions as normal or pathological. As aging is not a uniform process among individuals and populations, age-related changes in sleep patterns may differ according to the population studied. Epidemiological studies suggest that many sleep alterations typical in elderly people are related to comorbidities present in this age group [1,2]. Some age-related alterations in polysomnographic parameters have been consistently shown, including reductions in total sleep time, sleep efficiency and slow wave sleep, and an increase in WASO (night-time spent awake after sleep onset) [3–8]. Other parameters, such as sleep latency, rapid eye movement (REM) sleep, and stages 1 and 2, showed less consistent correlations [9–11]. Possible reasons for these results are related to methodological limitations, including small samples and confounding factors, such as diseases, substance use, and sleep disturbances. Ohayon et al. performed a large meta-analysis studying sleep structure across the lifespan; even among studies included in this meta-analysis, there were limitations that included small samples and selection biases [3]. To our knowledge, there is a dearth of studies in large adult samples of all ages that are representative of the general population. For this reason, we proposed a study to evaluate the sleep structure in adults (20–80 years) in a representative sample of São Paulo, the largest city in Brazil. Similarly to previous studies we gathered stratified and combined data for each gender in order to highlight gender-specific effects of aging on sleep structure [3].

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2. Methods

The present study is part of EPISONO (São Paulo Epidemiologic Study) whose methodology has already been published [12]. Sao Paulo is the largest city in Brazil with 11,253,503 inhabitants [13]. The DATAFOLHA Poll Institute selected a representative sample from all areas of the city that included both genders and all ethnicities [12]. Households were selected if they were permanently occupied private homes. The selection process was random and dwellers of each house were selected by means of random tables. Pregnant and lactating women, individuals with mental and physical disturbances that limit independence and night workers were not included in this sample; further details about sampling procedures are provided in the methodology paper [12]. In all, 165 volunteers were substituted by individuals who matched the same sampling criteria. A total of 1101 questionnaires were delivered at home, and 1042 individuals underwent polysomnography (PSG). Details about inclusion and exclusion criteria and home questionnaires have been described by Santos-Silva et al. regarding the methodology of EPISONO [12]. The protocol was approved by the Ethics Committee of Universidade Federal de São Paulo (CEP 0593/06) and registered at ClinicalTrials.gov (NCT00596713).

2.1. Polysomnography

At the sleep laboratory, the habitual bedtime was observed. A complete full-night PSG was performed using an EMBLA® digital system (EMBLA S7000, Embla Systems Inc., Broomfield, CO, USA) in a sleep laboratory. The following physiological parameters were monitored: four-channel electroencephalography (EEG) (C3–A2, C4–A1, O1–A2 and O2–A1), two-channel electro-oculography (EOG), four-channel surface electromyography (EMG) (submentonian and anterior tibialis), one-channel electrocardiography, an airflow thermistor sensor, a nasal cannula, thoracic and abdominal piezoelectric straps to assess respiratory movements, a snore sensor, a body-position sensor and an oximeter. All recordings were digitally stored, and sleep staging was performed according to standardized criteria [14]. Arousals, respiratory events and limb movements were visually scored according to the American Academy of Sleep Medicine Manual [14]. PSG sleep staging and event scoring were performed by four skilled technicians.

2.2. Statistics

Individuals were grouped into five-year age intervals for both genders. Between-group differences in sleep parameters were analyzed by one-way analysis of variance using Statistica 7 software (Stat Soft Inc., Tulsa, OH, USA). Pearson correlations were calculated between sleep parameters and age. Effect sizes were considered small for $\eta^2 \leqslant 0.01$, moderate for $\eta^2 \geqslant 0.06$ and high for $\eta^2 \geqslant 0.14$ [15].

3. Results

The study included 468 men and 574 women. Both genders showed no significant differences in mean ± SD body mass index (men, 26.6 ± 0.25; women, 27.0 ± 0.22) and sleep duration assessed by PSG (men, 5.7 ± 0.06 h; women, 5.7 ± 0.05 h). As expected, the average age of women was older than that of men (men, 40.7 ± 0.66 years [range, 20–79]; women, 43.7 ± 0.60 [range, 20–80]; $P < 0.05$, *t*-test).

In the general population (men and women), a large effect size was observed for the age-related increase in the arousal index and WASO although increase in arousal index was mainly due to respiratory arousals (Figs 1 and 2, Table 1). Non-respiratory arousal index was different among age groups but showed no clear tendency to increase after the fifth decade (Table 1). A small effect size was observed for the increase in sleep latency, REM sleep latency and percentage of stages 1 and 2 (Table 1). Age-related reduction in total sleep time, sleep efficiency and slow wave sleep duration had a moderate effect size (Fig. 3, Table 1). A small effect size was observed for the reduction in the duration of stage 2, duration of REM sleep, percentage of REM sleep, and percentage of slow-wave sleep (Table 1). There was no significant difference between genders in the following sleep parameters: total sleep time, sleep latency, REM latency, sleep efficiency, periodic limb movement (PLM) index, stages 1, 2, slow wave sleep and REM sleep percentage and time (*t*-test). Sleep stages, WASO and sleep latency results are summarized in Fig. 4.

With respect to respiratory sleep parameters, there was a significant age-related increase in apnea–hypopnea index (AHI) (large effect size, Table 2). There was also an age-related increase in B90, desaturation time, and desaturation index (moderate effect size,

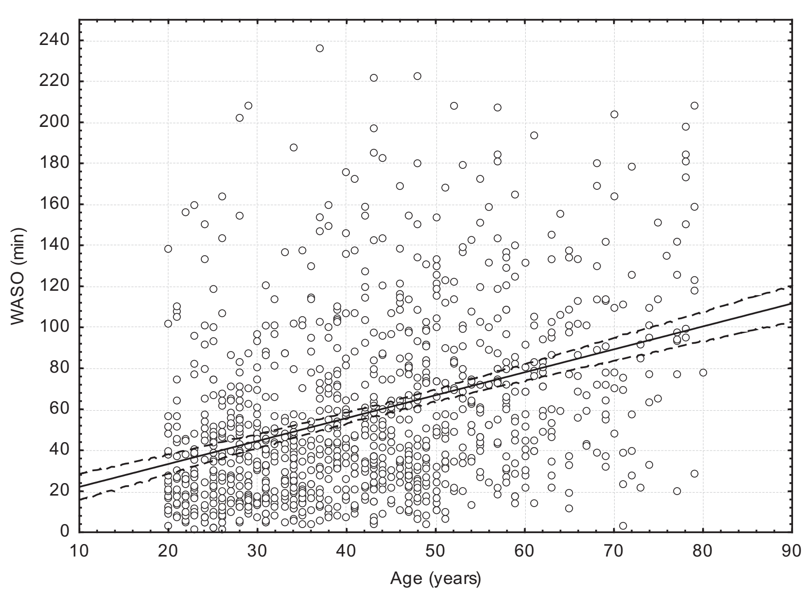

Fig. 1. Correlation between WASO (night-time spent awake after sleep onset) and age.