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Long-term follow-up of sleep disordered breathing in older adults

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Abstract

Objective: The current study was designed to determine whether, with increasing age, sleep apnea improves, becomes worse, or stays the same.

Background: There is a high prevalence of sleep disordered breathing (SDB) in older adults, but little is known about longitudinal changes. This study followed older adults to examine the natural history of SDB.

Methods: Subjects were randomly selected community-dwelling elderly ($n = 427$). A subset of subjects was studied approximately every 2 years over an 18-year period. Overnight sleep recordings and sleep questionnaires were completed at each time point.

Results: Multiple linear regression showed that three variables were associated with change in respiratory disturbance index (RDI):body mass index (BMI) at initial visit ($P = 0.001$), change in BMI ($P = 0.02$), and a consistent self-report of high blood pressure ($P = 0.005$). RDI increase was associated with BMI increase and presence of self-reported high blood pressure.

Conclusions: The changes in RDI that occurred were associated only with changes in BMI and were independent of age. This underscores the importance of managing weight for older adults, particularly those with hypertension.

Keywords: Sleep disordered breathing; Aging; Longitudinal; Natural history; Body mass index; Hypertension; Apnea

1. Introduction

Epidemiological studies have shown that 15% of men and 5% of women between the ages of 30 and 60 years have sleep disordered breathing (SDB), defined as a respiratory disturbance index of 10 or greater [1]. Using a similar definition of an index of 20 or greater, adults over the age of 65 have considerably higher prevalence rates, reaching 70% for men and 56% for women [2]. Kripke et al. [3] found rates of 10.9% for men and 5.3% for women between the ages of 40 and 60 years using an index of 20 or greater based on oxygen desaturations. Untreated SDB can lead to negative consequences such as heart disease [4], hypertension [5], and shorter survival [6]. Change in weight can also effect the severity of SDB [7], with increased weight being associated with increased severity of SDB. Recent studies have suggested that people with even mild SDB are at greater risk at follow-up for developing hypertension [8,9].

The amount of apnea frequently varies from night

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to night [3], so evidently some variation will be observed from year to year [3]. Few studies have followed untreated people with SDB over long time periods. One limitation of the existing literature is that there has been little or no follow-up of untreated patients beyond 5 years. In addition, most studies followed fairly small samples which were selected based on specific criteria such as an initial severity of SDB. These factors may have limited the generalizability of these findings to the older population at large.

Ancoli-Israel and colleagues began studying a large cohort of 427 randomly selected community-dwelling elderly in 1981 [2]. The results from the first visit showed that sleep apnea was extremely common with 24% of the sample meeting a criterion of five or more apneas per hour of sleep, and the majority having greater than ten per hour [2]. The sleep apnea was associated with self-report of nocturnal wandering or confusion, reports of breathing cessation at night, increased daytime sleepiness, greater weight, and more depression. A subset of the sample was followed and re-studied repeatedly. At the first 8.5 year follow-up, there were no significant changes in apnea index (AI) or respiratory disturbance index (RDI) from the initial recording [10]. The current study was designed to determine whether, with increasing age, sleep apnea improved, became worse, or stayed the same.

2. Methods

2.1. Subjects

The community-dwelling elderly sample consisted of 427 men and women over the age of 65 years in the San Diego metropolitan area who were randomly selected and studied between 1981 and 1985 [2]. Participants were screened over the telephone and then extensively interviewed in their homes about sleep and health. All had one or two overnight sleep recordings in their home. Beginning in 1985, those with the more severe SDB were re-contacted every 2 years and asked to participate again in interviews and sleep recordings. For those who agreed, studies were repeated during 1985–1988, 1990–1991, 1992–1993, and 1994–1995.

Some subjects from the original sample who did not participate in the first follow-up were re-contacted for later follow-up visits. The number of people studied and the sample characteristics at each time point are listed in Table 1. All research was approved by the UCSD Committee on the Investigation of Human Subjects, and written consent was obtained from all participants.

2.2. Apparatus

All subjects had their sleep recorded with the modified Respitrace/Medilog portable recording system [11]. The system records two channels of respiration (thoracic and abdominal), one channel of electromyography (EMG) from the tibialis muscle, and, to assist with determinations of sleep and wake, one channel of wrist activity. This methodology has been validated against standard polysomnography and been found to be highly reliable [12]. Data were stored on an analog tape-recorder and played back onto a Grass model 78 polygraph.

In addition, measurements of blood oxygen saturation were recorded during visits 3–5. A portable finger pulse oximeter (Ohmeda 3700) and portable notebook computer were used. The oximeter recorded blood oxygen saturation every 2 s throughout the night. Data were saved in memory and on disk and then scored using the PROFOX oximetry program [13].

2.3. Procedure

When initially recruited, subjects were administered a sleep questionnaire and were recorded for two nights [2]. For each follow-up, subjects were contacted and asked if they were interested in partici-

Table 1
Sample size and mean age (S.D.) of subjects at each visit

Visit	1981–1984	1985–1988	1990–1991	1992–1993	1994–1995
Gender (F/M)	205/184	33/24	20/14	57/17	48/10
Mean age (years) (S.D.)	72.5 (6.1)	74.4 (4.5)	78.4 (3.0)	80.2 (4.2)	81.7 (3.3)

pating again. Those who agreed were visited at home, re-administered the sleep questionnaire and asked about changes in their health and medication use. Two nights of sleep recordings and one night of oximetry were repeated at each visit. The Geriatric Depression Scale (GDS) [14] and Mini-Mental Status Examination (MMSE) [15] were added at visit 3.

Each sleep record was scored and standard sleep variables were computed: total sleep time (TST), wake after sleep onset (WASO), number of awakenings, number, duration and type of apneas and hypopneas, number of desaturations, mean SaO_2, percent time at $SaO_2 > 90\%$ and number of leg movements. The indices AI (number of apneas per hour of sleep), RDI (number of apneas and hypopneas per hour of sleep) and myoclonus index (MI; number of leg jerks per hour of sleep) were computed.

2.4. Data analyses

All statistical analyses were performed using mixed linear model procedures in SAS [16]. For each subject, a linear regression model was used to represent the potential change of RDI measures with age. For each of the variables listed below, an analogous linear regression was performed using normal scores transformed data: a linear regression of the variable vs. age was computed, and the slope and intercept were retained for subsequent analysis. For example, each subject's systolic blood pressure was regressed vs. age, and the mean systolic pressure and the rate of systolic blood pressure change were retained for analysis as independent variables. Slope was analyzed instead of 'change', since equal changes could occur over unequal time periods, and a rapid change was potentially different from a slow change. Also, for people who had 3–5 measurements, slope was a more reliable estimate of change with time than simple change. The mean and rate of change (slope) of systolic pressure (and every other variable) were then used as independent variables in regression analyses with rate of change of RDI as a dependent variable. Gender and race were included as covariates.

The potential predictors of RDI change were TST, body mass index (BMI; weight (kg)/height $(m)^2$), number of packs of cigarettes smoked each day, the self-reported presence of a diagnosis of high blood pressure and/or heart disease, neck size, MMSE, GDS, MI and total time spent napping.

3. Results

There was no statistically significant effect of age on RDI ($t_{201} = -0.91$, $P = 0.3651$); that is, RDI did not consistently change with age. Figs. 1 and 2 show the individual fitted regression lines of RDI vs. age for women and men, respectively. Multiple linear regres-

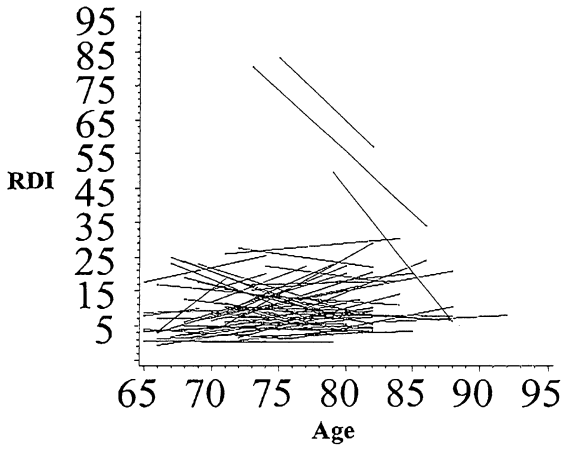

Fig. 1. RDI vs. age for women. Note that the women whose RDI decreased with age all lost a significant amount of weight during that time period.

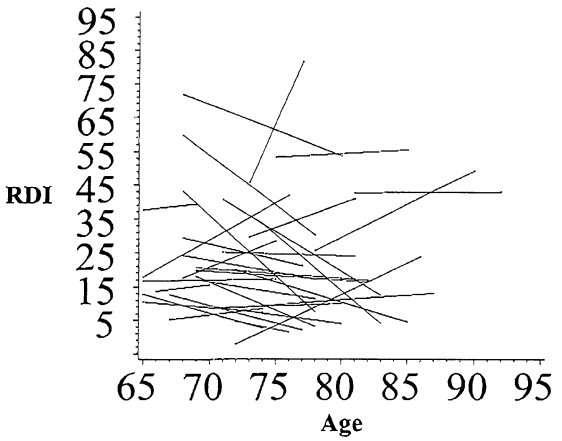

Fig. 2. RDI vs. age for men. Note the high rate of variability.

sion showed that three variables were associated with change in RDI: BMI at initial visit ($P = 0.001$), change in BMI ($P = 0.02$), and a consistent self-report of high blood pressure ($P = 0.005$). These effects were slight, with R^2 values of 9.5, 5.5, and 8.0%, respectively. The effect of initial BMI was due principally to a small number of (mostly) female patients who had very high initial BMI values and who lost weight while enrolled in the study (see Fig. 1). The joint effects of BMI change and consistent self-reported high blood pressure are difficult to display graphically since they are so slight. RDI decrease was associated with BMI decrease and absence of self-reported high blood pressure, whereas RDI increase tended to be associated with BMI increase and presence of self-reported high blood pressure.

Self-reported heart disease was also associated with increases in RDI, but self-reported heart disease was highly associated with self-reported high blood pressure, so only self-reported high blood pressure was retained in the general linear model for these subjects. No other variables contributed significantly to the regression model.

4. Discussion

Several studies have followed small cohorts of older adults over time periods of up to 5 years and have reported either small changes or no change in SDB over time. The current study found similar results in a larger cohort studied over an 18-year period. With increasing age, RDI stayed relatively stable. Any changes seen in RDI were not a function of age, but rather a function of changes in BMI.

Bliwise et al. followed older subjects for 2.8 years and found a slight worsening of apnea index from 2.3 to 3.8 [17]. Similar results were found in a 3-year follow-up study by Phoha et al. [18]. In a 5-year follow-up of 32 untreated, middle-aged patients with obstructive sleep apnea, Sforza et al. did not find any significant changes in RDI [19]. Similar negative results were obtained by Hoch et al. [20] in a 3-year study of 50 healthy older adults. Rosenthal et al. on the other hand, found an improvement in SDB independent of weight change in 23 patients studied over 2 years and being treated behaviorally (weight loss, reduced alcohol intake, and increased time spent in bed) [21]. The ages of the subjects from these studies ranged from middle-aged to elderly. Rosenthal et al. controlled for weight [21], but others did not. There were also methodological differences in the type of sample used, i.e. community dwelling vs. patients. Overall, the pattern of findings that emerged, however, were suggestive of SDB remaining relatively stable over time periods up to 5 years. Our results suggest that even with increasing age, SDB remains stable after as long as 18 years.

The higher prevalence rates of SDB in older adults

compared to younger adults may represent a qualitative difference in respiratory physiology that occurs with age in a portion of the population, rather than a quantitative decline of normal respiratory processes over time. Malhotra et al. [22] using MRI assessment of the airway, found that in older adults as compared to younger adults, the soft palate was longer, pharyngeal fat pads increased in size, the shape of the bony structures around the pharyngeal airway changed, and the response of the genioglosus muscle to negative pressure stimulation diminished. These types of changes would be conducive to the development of SDB. If these changes, however, do not continue to get worse above age 65, that may explain why the overall prevalence of SDB increases up to about age 65, but does not continue to get progressively higher.

Since untreated SDB has been associated with increased risk of death, the question arises as to whether those with worsening RDI might have had increased attrition in this cohort. We have already shown that in this cohort, those with RDI ≥ 30 had significantly shorter survival than those with less severe SDB; however, RDI was not an independent predictor of death [23]. In the cohort of those being followed, the change in RDI from visit 1 to visit 2 did not differ between subjects who died during the study and those who did not ($P > 0.2$).

Another possible confound would have been if those with increasing RDI had a higher rate of attrition after their second visit. In order to determine whether attrition from the study was related to change in RDI, the rate of change from visit 1 to visit 2 was compared for those subjects who only participated in two visits (but refused to participate for reasons other than death) and for those who participated in three or more visits. The Wilcoxon test on ranks showed that those who only participated in two visits had a slight positive trend in RDI, i.e. RDI slightly increased, whereas the others had a slightly greater negative trend in RDI, i.e. RDI slightly decreased. However, within each group the trend was not different from 0, and the difference between groups was slight ($P < 0.1$, one-tailed). Differential rates of attrition therefore, do not account for the observed lack of progressive worsening of RDI observed in this study.

These results suggest that the presence of mild SDB that may occur as an individual ages is not necessarily a precursor of a more serious breathing disturbance. The natural history of SDB in a patient population has not been examined, other than to examine effects of untreated SDB on mortality. It is likely that changes in SDB in patient samples might also be secondary to changes in BMI, and would not progress as a function of age.

In summary, the changes in RDI that did occur were associated only with changes in BMI and were independent of age. These results suggest that as long as weight remains stable, RDI will also remain stable over time. For those with both high RDI and high BMI without hypertension, weight loss may reduce the severity of SDB. Individuals with hypertension may be at greater risk. This underscores the importance of managing weight for older adults, particularly those with hypertension.

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