Diabetes & Metabolism xxx (2017) xxx–xxx

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Research letter

Characteristics and predictors of obstructive sleep apnoea in patients with type 2 diabetes

Introduction

Obstructive sleep apnoea (OSA) is a chronic condition characterized by upper airways obstruction during sleep, resulting in recurrent hypoxia, hypercapnia and arousals [1]. OSA is highly prevalent in the adult population, affecting one in three people [2], and is directly associated with cardiovascular diseases such as arterial hypertension, atherosclerosis, and cardiac arrhythmias due to sympathetic activation, intermittent hypoxia and neurohumoral activation [1].

There is growing evidence that OSA is commonplace among patients with type 2 diabetes mellitus (T2DM), a population with a high cardiovascular risk, ranging from 30% to 72% [3]. The interaction between OSA and T2DM can have deleterious consequences on the cardiovascular system. Furthermore, a growing number of studies have shown that OSA is associated with insulin resistance, glucose intolerance and T2DM independent of obesity, a growing public-health problem that can serve as a link between OSA and T2DM and cardiovascular disease. However, as quantifying body fat composition through the body mass index (BMI) can underdiagnose obesity, more accurate methods, such as bioelectrical impedance analysis (BIA) and dual-energy X-ray absorptiometry (DEXA), are preferable. Yet, while limited resources and availability of sleep studies can hamper the diagnosis of OSA among patients with diabetes, the recognition of clinical predictors should improve the identification of these patients.

The present sleep study aimed to evaluate the clinical characteristics and predictors of OSA among patients with T2DM.

Methods

Subjects

We recruited consecutive patients with T2DM, aged 30 to 65 years, attending an endocrinology outpatient centre between September 2014 and March 2015. Patients were excluded from the study if they were using insulin therapy. All included participants underwent specific evaluations (see below) the morning after the sleep study. The local ethics committee approved the protocol (Hospital Complex, Oswaldo Cruz University Hospital, University of Pernambuco/UPE/Procape, Approval No. CAAE-33455414.8.0000.5192), and all participants gave their written informed consent.

Blood samples

Venous blood was collected from all participants for measurement of fasting glucose, total cholesterol, low-density lipoprotein (LDL) and high-density lipoprotein (HDL) cholesterol, and glycosylated haemoglobin (HbA_{1c}).

Bioelectrical impedance analysis

A multifrequency BIA system (InBody S10, Model JMW140, Biospace Co., Ltd, Seoul, Korea) was used, according to the manufacturer's guidelines, to assess five segments of the body: the right and left arms; trunk; and right and left legs.

Sleep evaluation

All patients underwent in-home portable sleep recordings, using a validated device (ApneaLink™, ResMed Corp., San Diego, CA, USA), to evaluate oxygen saturation, body position, measurements of airflow (by pressure cannula) and respiratory effort. Apnoea was defined as the total absence of oronasal flow for ≥10 s, and hypopnoea as a clear decrease (>30%) in amplitude of oronasal flow for ≥10 s, followed by 4% desaturation [4]. The apnoea–hypopnoea index (AHI) was then calculated by dividing the total number of apnoea and hypopnoea episodes by total time spent in bed. In addition, subjective daytime sleepiness was evaluated using the Epworth Sleepiness Scale (ESS). In brief, this scale is used to assess the general level of daytime sleepiness by having patients rate the likelihood of dozing during eight different daytime situations. Scores >10 are considered to indicate excessive daytime sleepiness.

Also, the predicted risk for OSA was determined using the Berlin Questionnaire, which is based on responses to three symptom categories: in category 1, high risk is defined as persistent symptoms (>3–4 times/week) for ≥2 questions about snoring; in category 2, high risk is defined as persistent (>3–4 times/week) daytime tiredness or fatigue; and in category 3, high risk is defined as a history of high blood pressure or a BMI >30 kg/m^2. To be considered at high risk of OSA, patients had to respond positively for at least two of the three symptom categories.

Statistical analysis

Normality of distribution was evaluated with the Kolmogorov–Smirnov test, with the results expressed as means ± standard deviation (SD), medians (interquartile range, IQR) or percentages as appropriate. A two-tailed unpaired *t* test or the Mann–Whitney *U* test for independent samples, chi-square test or Spearman's correlation were used to compare variables between patients without and with OSA where appropriate. Univariate and multivariable logistic regression models were used to evaluate OSA (AHI > 15 events/h) predictors, including gender, neck circumference (>41 cm for women and >43 cm for men), waist circumference (>88 cm for women and >102 cm for men), age >50 years, positive ESS and Berlin Questionnaire scores, hypertension, smoking, physical

http://dx.doi.org/10.1016/j.diabet.2017.02.008

activity and BMI > 30 kg/m^2. Data were analyzed using SPSS version 21.0 statistical software (IBM Corp., Armonk, NY, USA), and a two-sided P value <0.05 was considered statistically significant.

Results

Initially, 362 patients were evaluated during the recruitment period and 161 were excluded, resulting in a study population of 200 patients (Fig. 1). These patients were generally middle-aged and overweight, and a slight majority were female (Table 1). OSA (AHI: ≥5 events/h) and moderate/severe OSA (AHI: ≥15 events/h) were diagnosed in 134 [67%; 95% confidence interval (CI): 60–73%] and 55 (27%; 95% CI: 22–34%) patients, respectively. None of our participants had previously had an OSA diagnosis. The anthropometric, clinical and laboratory characteristics of our study population according to OSA severity are presented in Table 1. Compared with T2DM patients without OSA, those with OSA were predominantly male and more obese, with larger neck and waist circumferences, higher body fat percentages and a greater frequency of hypertension. On the other hand, there were no differences in ESS scores between groups, and the lipid and glucose profiles of patients with and without OSA were also similar (Table 1).

There were positive correlations between AHI and BMI for both genders (men: $r = 0.49$, $P < 0.001$; women: $r = 0.48$, $P < 0.001$) as well as between AHI and total body fat (men: $r = 0.43$, $P < 0.001$; women: $r = 0.46$, $P < 0.001$). Moreover, there was a close correlation between total body fat and BMI ($r = 0.84$, $P < 0.001$). On multivariate analyses, neck circumference [odds ratio (OR): 8.82; 95% CI: 3.15–24.70; $P < 0.001$], male gender (OR: 4.49; 95% CI: 2.05–9.85; $P < 0.001$), hypertension (OR: 3.74; 95% CI: 1.17–11.94; $P = 0.03$) and BMI (OR: 2.70; 95% CI: 1.25–5.80; $P = 0.01$) were all associated with OSA. However, the Berlin Questionnaire and ESS demonstrated poor sensitivity and specificity (62% and 58%, and 31% and 57%, respectively) for predicting OSA (AHI ≥ 5 events/h).

Discussion

This study evaluated OSA among patients with T2DM and the findings are of interest. First, a high prevalence of OSA was confirmed in T2DM patients (67%) and, importantly, none of them had been previously diagnosed with OSA. Second, patients with T2DM and OSA presented with classic OSA phenotypes, such as being predominantly male with a greater frequency of obesity and hypertension. Moreover, both BMI and BIA were reasonably correlated with the AHI. Third, there was no association

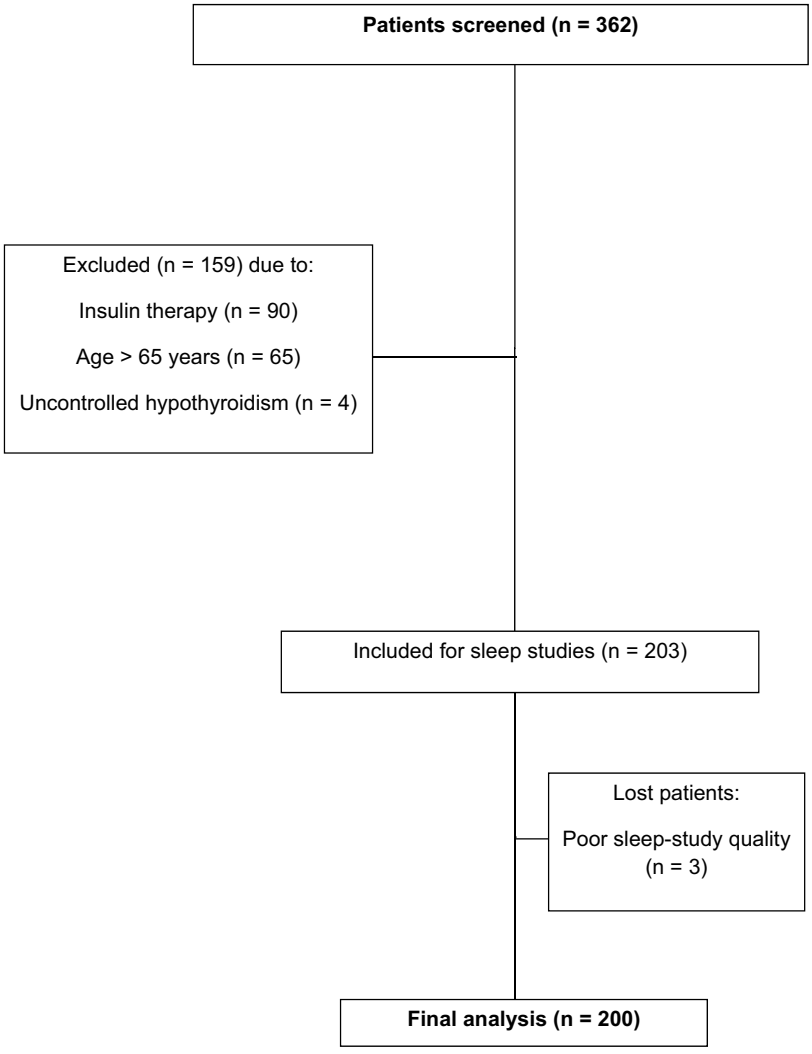

Fig. 1. Flowchart of patient recruitment for the sleep study.

Please cite this article in press as: Souza MJMC, et al. Characteristics and predictors of obstructive sleep apnoea in patients with type 2 diabetes. Diabetes Metab (2017), http://dx.doi.org/10.1016/j.diabet.2017.02.008