Obstructive sleep apnea syndrome among obese individuals: A cross-sectional study

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Summary

Introduction: The obstructive sleep apnea syndrome (OSAS) is a respiratory illness, characterized by recurrent episodes of apnea and hypopnea, leading to reduction or cessation of the airflow. Obesity is one of the major risk factors for the development of OSAS. To help in the diagnosis of this disease, easily applicable and low-cost questionnaries were developed, such as the Berlin Questionnaire (BQ).
Objective: To evaluate the efficacy of the BQ for the screening of OSAS among candidates to bariatric surgery in a multidisciplinary preoperative program.
Method: This is an observational, descriptive and cross-sectional study which evaluated obese individuals that were being prepared for bariatric surgery by means of the BQ.
Results: BQ was able to detect that minimal variations in the body mass index, neck circumference and hip-to-waist ratio lead to changes in the risk to develop OSAS; the higher the values of these variables, the higher the risk for OSAS development.
Conclusion: BQ was an efficient and reliable tool to demonstrate the high risk for OSAS development in individual with obesity.

Keywords: obesity, sleep apnea, obstructive sleep apnea, bariatric surgery, surveys and questionnaires.

Introduction

Obstructive sleep apnea syndrome (OSAS) is a respiratory disorder characterized by recurrent episodes of apnea and hypopnea, which results in the cessation or reduction of airflow and may be accompanied or not by a collapse of the upper airways. It occurs as a consequence of the physiological relaxation of muscles during sleep, for a period greater than or equal to ten seconds, thus leading to a decrease in blood oxygen saturation, i.e. hypoxemia and even hypercapnia, found in patients with severe OSAS and a high body mass index (BMI).[1-5]

The syndrome is identified based on polysomnography results. The technique aims at noninvasively investigating sleep disorders and entails simultaneously recording parameters such as heart and respiratory rates, respiratory flow and effort, pulse oximetry, the quantification of respiratory events (both obstructive and central ones), snoring, levels of brain electrical activity, eye movement and muscle activity. The test is performed during sleep and the parameters are then recorded by sensors attached to various parts of the patient's body using self-adhesive tapes. After analyzing the data, OSAS is classified according to the number of respiratory events and the apnea-hypopnea index (AHI): it is considered mild when 5 to 15 events/hour are recorded; moderate is 15 to 30 events/hour; and severe is a mean of ≥ 30 events/hour.[5-11]

Individuals may have distinct symptoms, namely excessive daytime sleepiness, depressive states, impaired memory and learning abilities, poor concentration and attention span, and cardiovascular diseases, which can culminate in sudden death. OSAS is a progressive chronic disease that directly influences quality of life, given that sleep is a brain function that is essential to life and aids in relieving human stress.[1,7,8,12-14]

While obesity is one of the major risk factors for developing OSAS, it is the only one that is reversible. According to the World Health Organization (WHO), an individual is considered obese when he or she has an

abnormal or excessive energy reserve in the form of fat. Its incidence has been progressively increasing over the last years, having reached epidemic levels worldwide, especially in industrialized countries.[1,2,5] In accordance with WHO guidelines, obesity is classified based on BMI, which is calculated by dividing body weight, in kilograms, by the height squared, in meters.[4] Some authors, in turn, set a cut-off value of BMI > 30 as a risk factor for the development of OSAS. Central obesity is established when the waist-to-hip ratio measurement is greater than 102 cm in males and greater than 88 cm in females something also associated with a neck circumference measurement greater than 40 cm. Neck and abdominal fat accumulation is one of the factors responsible for the syndrome in the obese.[4,8,12,13]

In fact, 70% of all patients diagnosed with OSAS are obese. The incidence of OSAS among patients with class III obesity, i.e. BMI greater than 40, is 12 to 30 times greater than in the general population.[8] The incidence of OSAS is 42-48% in obese males, and 8-38% in obese females.[13,14]

The actual cause of the syndrome remains unknown, but it is known to occur in any age group, becoming more evident among individuals aged 40-50 years. Males are 8 to 10 times more affected than females, due to their hormonal profile, body fat distribution and differences in upper airway anatomy. Females usually have OSAS when they go through menopause, are obese and aged 60 to 69 years.[2,5,6,14]

The incidence and prevalence of OSAS are not fully defined, for there are reports stating that 75% of the population will never be formally diagnosed, which makes treatment difficult and contributes to high morbidity and mortality rates associated with the disease.[2,15,16]

Laboratory-based polysomnography is the gold standard for diagnosing the disease. Disadvantages include its high cost and the discomfort experienced by some individuals during the test; however, devices for home use have been studied that yield satisfactory results when diagnosing OSAS.[13,16] Other methods are intended to assist in diagnosing the disease, such as inexpensive questionnaires that can be easily administered, which is the case of the Berlin Questionnaire (BQ).[17]

The BQ emerged in 1996 in Berlin as a result of a conference on sleep respiratory disorders and primary health care. Created with the objective of tracking the risk of developing OSAS, it is now one of the most recognized instruments in this field. The questionnaire consists of three categories with questions scoring 1 to 2 points according to the response given by the individual being assessed. The first category in the BQ comprises five questions on snoring and witnessed apneas and is considered positive if the sum of the responses reaches 2 points, i.e. when the individual responds with a "yes" if they snore, if their snoring is louder than their voice, if this happens almost every day or at least 3 to 4 times per week, if their snoring has ever disturbed other people and if breathing pauses have been witnessed at least 3 to 4 times per week; the second category has three questions on fatigue early in the morning and during the day, or on whether the individual has ever fallen asleep while driving. If they respond affirmatively to at least two of the questions in this category, it is already considered a positive result that yields 2 points. The third category, in turn, consists of only one question on systemic arterial hypertension and is considered positive if the answer is yes; still, this category can also be considered positive if the individual has a BMI greater than 30 kg/m^2. The assessed individual is considered a high-risk patient when he or she has scored positively in two or more categories, while a low-risk patient is someone who scored positively in none or only one category.[17]

This study is aimed at assessing the BQ's effectiveness in screening the prevalence of the risk of developing OSAS in individuals with obesity grades I, II, III participating in the multidisciplinary preoperative preparation program for bariatric surgery at HC/UNICAMP by correlating their results with anthropometric measurements, age and gender.

Method

This cross-sectional, observational and descriptive study was carried out between February 2015 and February 2016, and involved patients with obesity grades I, II and III of both genders, adults over 18 years of age, who participated in the multidisciplinary preoperative preparation program for bariatric surgery at Hospital de Clínicas – Unicamp. Individuals with previous respiratory illnesses, smokers, those working in sectors with a high occupational risk for lung disease and members of vulnerable groups were excluded from the study.

Study participants were asked to answer the BQ and to fill out the data sheet with information on gender and age. Data on height, weight, BMI and anthropometric measurements, such as neck (NC) and waist (WC) circumferences, and waist-hip ratio (WHR), were collected from each patient's medical records. The study was approved by the Research Ethics Committee at Universidade Estadual de Campinas-Unicamp, opinion No. 1,488,299, with all of its participants having signed a voluntary informed consent form prior to being included in the study. Individuals were classified as being at a high or low risk of developing OSAS by summing up the scores for all three categories in the

QB, with the risk being considered high when they had scored positively in two or more categories, and low when they had scored positively in one or no category at all.

Statistical analysis

Frequency tables with the categorical variables accompanied by absolute (n) and percentage (%) values were made for describing the profile of the sample. A series of descriptive statistics for the variables was calculated and comprised mean, standard deviation, minimum value, maximum value and median. The Mann-Whitney test was used for comparing numerical variables. For the categorical variables, a Chi-squared test was used. A level of significance of 5% was adopted in the study.

Results

Of the 502 individuals who started out participating in the preoperative preparation program for bariatric surgery and filled in the BQ, 29 were excluded due to errors in filling in the questionnaire and divergences in their responses, thus totaling 473 obese individuals. Of these, 414 (82%) were female and 88 (17%) were male; their age and anthropometric characteristics are described in Table 1.

TABLE 1 Age and anthropometric characteristics of individuals.

Variables	Mean (SD)
Age (years)	38±10
Weight (kg)	126.13±29
Height (m)	1.64±0.09
BMI (kg/m^2)	46.91±8
NC (cm)	42.98±5
Waist (cm)	128.05±19
Hip (cm)	142.09±18
WHR	0.90±0.11

BMI: body mass index; NC: neck circumference; WHR: waist-hip ratio. Results presented as mean and standard deviation.

The frequencies of questionnaire responses within each BQ category were analyzed, as seen in Table 2.

In category 1, 473 BQs were analyzed, of which only 363 individuals answered question number 1 with a "yes," indicative of their snoring. The remaining 110 individuals responded to the question with a "no" or a doubt and, with that, did not respond to any further questions in this category.

Category 2 in the BQ is related to daytime sleepiness and, among the 473 individuals who provided answers in this category, there was practically no difference in

TABLE 2 Descriptive frequencies of responses in categories 1, 2 and 3 presented as absolute and relative values.

Category 1	**Freq**	**%**
1. Do you snore?		
Yes	363	74.85
No	52	10.72
I don't know	58	14.43
If you snore:		
2. Your snoring is:		
a. Slightly louder than your breathing.	193	53.42
b. As loud as when you speak	62	16.99
c. Louder than when you speak	22	6.03
d. So loud it can be heard in the other rooms of the house	86	23.56
3. How often do you snore?		
a. Almost every day	265	73.2
b. 3-4 times a week	54	14.92
c. 1-2 times a week	28	7.73
d. 1-2 times a month	6	1.66
e. Never or almost never	10	2.49
4. Has your snoring ever bothered other people?		
a. Yes	257	70.8
b. No	54	14.88
c. I don't know	52	14.43
5. Has anyone noticed that you stop breathing while you sleep?		
a. Almost every day	82	22.53
b. 3-4 times a week	19	5.22
c. 1-2 times a week	32	8.79
d. 1-2 times a month	20	5.49
e. Never or almost never	210	57.97
Score		
Negative	139	29.39
Positive	334	70.61
Category 2		
6. How often do you feel tired or fatigued after a night's sleep?	Freq	%
a. Almost every day	222	47.38
b. 3-4 times a week	42	8.81
c. 1-2 times a week	74	15.51
d. 1-2 times a month	29	6.08
e. Never or almost never	106	22.22
7. During the day, do you feel tired, fatigued or unable to face it?		
a. Almost every day	253	56.45
b. 3-4 times a week	53	10.37
c. 1-2 times a week	65	13.13
d. 1-2 times a month	43	8.06
e. Never or almost never	59	11.98

(*continues*)

TABLE 2 (cont.) Descriptive frequencies of responses in categories 1, 2 and 3 presented as absolute and relative values.

Category 2		
8. Have you ever dozed or fallen asleep while driving?		
a. Yes	29	10.4
b. No	424	89
If your answer was yes		
9. How often does this occur?		
a. Almost every day	10	24.95
b. 3-4 times a week	6	10.17
c. 1-2 times a week	6	10.17
d. 1-2 times a month	5	7.42
e. Never or almost never	22	47.29
Score		
Negative	235	50
Positive	238	50
Category 3		
10. Do you have high blood pressure?	Freq	%
a. Yes	254	53.8
b. No	164	34.6
c. I don't know	55	11.6
Score		
Negative	0	0
Positive	473	100

their scores, since both scored 50% for both the positive and negative categories (Table 2).

Still with reference to Category 2 in the BQ, question number 8, only 49 individuals responded with a "yes," meaning that only these 49 individuals went on to respond to question number 9 (Table 2).

Category 3 has a question on systemic arterial hypertension and can also be considered a positive category when an individual has a BMI greater than 30 kg/m^2, which thus characterizes obesity grade 1. Therefore, in our study, this category was 100% positive (Table 3).

A low or a high risk of OSAS was determined based on the responses in each item category. Of the 473 individuals participating in the study, 80.34% were found to be at a high risk versus 19.66% at a low risk of developing OSAS.

The variables gender, age and anthropometric measurements associated with a high or a low risk of developing OSAS were studied and compared. The variables age, BMI, NC, WC and WHR were statistically different, as seen in Table 3.

When comparing high- and low-risk categorical variables for males (n=71) and females (n=309) in the development of OSAS, we found no significant difference, as seen by the p-value (0.1889), even though females were the majority among all individuals participating in the study.

TABLE 3 Comparison of numerical variables with a high or a low risk of developing OSAS.

Variables	High risk (n=390)		Low risk (n=93)		
	Mean	SD	Mean	SD	p-value
Age (years)	39.95	10.16	34.3	10	<0.0001
Weight (kg)	127.31	30	121.22	28.52	0.1219
Height (m)	1.64	0.09	1.64	0.09	0.1559
BMI	47.32	8.86	44.72	8.81	0.0111
NC	43.5	6.08	41.05	4.67	<0.0001
Waist	129.31	20.11	122.75	17.81	0.008
Hip	142.46	17.68	140.47	19.27	0.1845
WHR	0.91	0.11	0.88	0.11	0.0032
Male	71	85.54	12	14.46	

Results presented in mean, median and standard deviation, p-value for the Mann-Whitney test, p<0.05.

Discussion

There is evidence in the literature that obesity is a risk factor for obstructive sleep apnea, given that overweight acts directly upon the pathophysiology of the narrowing of the upper airways and involvement of the oropharyngeal muscles.[18]

The present study was conducted within a preoperative program for bariatric surgery aimed at preparing individuals with obesity who are candidates for surgery, under the guidance of a multidisciplinary team, in order to provide measures that healthily lead to weight reduction. In this program, the number of obese women is greater than that of obese men, which can be explained by factors that are intrinsic to the female gender and the demand for health services. According to Gomes et al.,[19] this refers to the fact that caring is associated more with women, which is justified by the way females are taught to socialize from an early age.[19] However, the present study showed no difference in the risk of developing OSAS between males and females (p-value=0.188). Some studies reported associations between OSAS and the male gender that were attributed to hormonal profile, anatomical, functional and craniofacial changes and structural differences in the upper airways in men and women during sleep, with more favorable mechanics having been identified in women. This can occur due to the distribution of fat in males, which implies an accumulation of fat tissue in the upper part of their body, thus favoring a greater collapse of the upper airways in males.[20-23]

After evaluating Category 1 in the BQ, we found that 70% of the sample scored positively, which demonstrates that these individuals have snoring symptoms and witnessed apneas. Snoring and sleep apnea are both the progression of a single problem to OSAS. Nevertheless, it is known that,

in the absence of this pathology, a force imbalance in the oropharyngeal muscles – as they relax in the phases of sleep – can favor a collapse of the upper airways.[24,25]

In obesity, it is not only muscles that cause respiratory obstruction, but also a layer of excess fat along the soft palate and the tonsillar region that involves practically all face and neck muscles, leading thus to a narrowing of the throat (pharynx) and giving it a more rounded shape, with the thickness of the fat layer being directly related to the increase in BMI.[24,25]

The gastroesophageal reflux disease present in many patients with obesity, albeit not found in our study, could also explain the snoring and apnea symptoms in these individuals. When there is a collapse of the upper airways, there occurs an increase in the negative intrathoracic pressure during inspiration. This in turn compresses the stomach and causes the gastric acid to be pushed into the esophagus, thereby causing an aspiration; this acid stimulates the pH receptors located in the trachea, and the autonomic nervous system responds with a prolongation of apnea duration, thus acting as a defense mechanism which prevents acid aspiration from being more extensive.[26,27]

Still with regard to Category 1, the question on the loudness of snoring shows that 53% of participants regarded their snoring as "slightly louder than their breathing": this factor is referred to as heavy breathing (snorting) or low-pitched snoring. According to Marcos,[27] individuals who snort do not have OSAS. When snorting becomes as intense as to disturb other people, it is considered a pathological condition and thus deemed snoring.[27]

In our study, 23% of individuals reported that their snoring was "so loud that it could be heard in other rooms of (their) home," whereas 70% reported that they were aware that their snoring had already disturbed other people. The severity of snoring can be established by episodes of apnea. In our study, 22% of participants answered "Almost every day of the week" when asked "Did anyone notice whether you stop breathing while you sleep?" Obese individuals rarely snort, and their snoring is often loud and followed by episodes of apnea and hypopnea occurring with a higher frequency, which increases the risk of developing OSAS.[6,7,27]

When analyzing the responses to the questions in Category 2, 47% of respondents reported that they feel tired or fatigued after a night's sleep, and 56% of them reported that during the day they feel tired, fatigued or unable to cope with their daytime activities.

In Category 2, we found that the quality of sleep directly affects daily life activities and the quality of life (QOL) of obese individuals, who already experience a limitation to their QOL due to excess weight and associated comorbidities.

According to Markwald et al.,[28] sleep plays a key role in energy metabolism, and insufficient sleep can contribute to being overweight, cardiovascular diseases, and psychological disorders such as exhaustion, anxiety, depression and a decrease in school and professional performances. Martins et al.,[1] stated that weight gain occurs because there is a reduction in the amount of leptin, the satiety hormone, produced during sleep. As the individual does not have a good quality of sleep, there is a decrease in the amount of leptin produced during sleep and an increase in the ghrelin hormone which stimulates hunger; hence, the individual does not feel satiated after a meal and therefore increases his or her calorie intake, which, as a consequence, results in an increase in body weight, which in turn favors OSAS, thereby leading to a vicious cycle.[1,28]

In OSAS, apnea and hypopnea lead to hypoxia and hypoxia-reoxygenation states, which, in turn, causes an inflammatory process and oxidative stress and, in combination with obesity, favors the formation of atheroma plaques.[29-31] In our study, we found that 53.8% of obese individuals have systemic arterial hypertension (SAH).

According to Logan et al.,[32] patients with OSAS have a decrease in baroreceptor sensitivity, changes in salt and water metabolism, which may contribute to an increase in systemic arterial hypertension, when they have apnea symptoms, there is a decrease in oxygen saturation and an increase in carbon dioxide levels, which stimulates the carotid chemoreceptors, thereby causing vasoconstriction and a consequent increase in peripheral vascular resistance and systemic blood pressure.[31-33]

In analyzing the BQ scores, we found that the individuals with obesity participating in the multidisciplinary preoperative preparation program for bariatric surgery at Hospital de Clínicas – Unicamp were at a high risk (80.34%) of developing OSAS, versus 19.66% at low risk, thus confirming that obesity is a disease clearly identified as a risk factor for the development of OSAS. Pinto et al.,[34] pointed out controversy as to which are the most significant predictive parameters of obesity leading to this association.

In our study, when correlating the risk of developing OSAS with the variables age, weight, height, BMI, NC, waist circumference, hip circumference and WHR of individuals participating in the study, we found that age and NC had a p-value=0.0001, whereas BMI, waist circumference and WHR had p-values=0.0111; 0.008; 0.0032, respectively, i.e., significant values contributing to a high risk of developing OSAS; nevertheless, weight, height and

hip circumference were not statistically significant for such development.

Ever since 1990, investigators have reported that the variation in NC measurement compared with other anthropometric measurements is the best clinical predictor for the development and severity of OSAS.[34-37]

Katz et al.[38] found that BMI, age and NC are significant predictors of OSAS. The incidence of OSAS peaks in the age group 50-60 years, but in individuals with a high BMI, this trend tends to peak in the age group 40-50. It is a fact, however, that OSAS can affect individuals in any age group.[2,6,14,38]

The presence of only one population sample profile, such as obesity, limits the study with respect to comparing anthropometric characteristics with the risk of developing OSAS. Nevertheless, we were able to detect that minimal variations in BMI, neck circumference, waist circumference, and waist-to-hip ratio may alter the risk of developing OSAS: the higher these values, the greater the risk of developing OSAS. Thus, further studies are needed to compare the BQ responses for different BMI profiles.

Conclusion

The BQ proved to be an effective and reliable tool for demonstrating the high-risk prevalence for developing OSAS in individuals suffering from obesity.

Resumo

Síndrome da apneia obstrutiva do sono em indivíduos portadores de obesidade: um estudo transversal

Introdução: A síndrome da apneia obstrutiva do sono (SAOS) é uma patologia respiratória, caracterizada por episódios recorrentes de apneia e hipopneia, resultando na cessação ou redução do fluxo aéreo. A obesidade é um dos principais fatores de risco para o desenvolvimento da SAOS. Foram criadas formas de auxiliar o diagnóstico da doença por meio de questionários de fácil aplicação e baixo custo, como o questionário de Berlim (QB).
Objetivo: Avaliar a eficácia do QB para rastreamento do risco de desenvolvimento da SAOS em indivíduos portadores de obesidade que participaram do grupo multidisciplinar de preparo pré-operatório para cirurgia bariátrica do Hospital de Clínicas da Universidade Estadual de Campinas (HC-Unicamp).
Método: O estudo foi observacional, descritivo e transversal, e avaliou portadores de obesidade que participavam do Programa multidisciplinar de preparo pré-operatório para cirurgia bariátrica do HC-Unicamp foram avaliados por meio do QB**.**
Resultados: O QB foi capaz de detectar que mínimas oscilações no índice de massa corpórea (IMC), na circunferência cervical (Ccv), na circunferência da cintura e na relação cintura/quadril (RCQ) podem alterar o risco de desenvolvimento de SAOS, sendo que quanto maior esses valores, maior o risco de desenvolvimento de SAOS.
Conclusão: O QB é uma ferramenta eficaz e fidedigna em demonstrar a prevalência do risco alto para o desenvolvimento da SAOS em indivíduos portadores de obesidade, dado esse que, quando correlacionado com IMC, aumento de idade, medida de cintura, Ccv e RCQ, faz o risco tender a aumentar de forma exponencial.

Palavras-chave: obesidade, apneia obstrutiva do sono, apneia, cirurgia bariátrica, inquéritos e questionários.

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