RBSO Revista Brasileira de Saúde Ocupacional
ISSN: 2317-6369 (online)
http://dx.doi.org/10.1590/2317-6369000026317

Assorted topics/Article

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Article based on the results obtained by the Projeto Prevenção da Fadiga (Fadigue Preventing Project), Laboratório de Cardiometabolismo - Project: 1325, supported by Fundação Educativa de Ouro Preto. George Luiz Lins Machado-Coelho and Fernando Luiz Pereira de Oliveira received financial support from Conselho Nacional de Desenvolvimento Científico e Tecnológico - CNPq (projects PQ 306467/2018-6 and PQ 300825/2016-1). The project received support from the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) - Code 001 ".

The authors report that this study was not presented in scientific events.

The authors declare no conflict of interest.

Received: 10/24/2017
Reviewed: 06/11/2018
Accepted: 06/19/2018

Adiposity indicators as a screening method for polysomnography in shift workers

Indicadores de adiposidade como método de rastreamento para polissonografia em trabalhadores de turno

Abstract

Objective: to verify the discriminatory power of adiposity indicators in the prediction of obstructive sleep apnoea (OSA) in shift workers. *Methods:* a cross-sectional study carried out in an iron ore extraction company, in Minas Gerais, Brazil. Anthropometric data were collected and polysomnography (PSG) was performed in 118 male shift workers who owned at least one overall risk factor for cardiovascular disease. *Results*: the OSA prevalence in the sample was 84.7%. Among the adiposity indicators used to predict OSA (≥ 5 events/hour), body mass index (BMI), waist circumference (WC), waist-to-height ratio (WHtR), and total body fat (TBF) showed sensitivity values higher than 70%. Visceral fat (VF), neck circumference (NC), and neck-to-height ratio (NHtR) were the most effective in correctly identifying workers without OSA (specificity values higher than 70%). The areas under the receiver operating characteristic (ROC) curves for WC and NHtR were greater than 0.7, which indicated the test was effective in discriminating individuals with OSA. *Conclusions*: alterations in abdomen and neck adiposity indicators have a significant relationship with the presence of OSA and showed effectiveness as a screening method for PSG. WC and NHtR are considered good indicators for OSA prediction.

Keywords: obesity; circadian rhythm; sleep-wake disorders; snoring; occupational health.

Resumo

Objetivo: *verificar o potencial discriminatório dos indicadores de adiposidade na predição da apneia obstrutiva do sono (AOS) em trabalhadores de turnos.* Métodos: *estudo transversal realizado em uma empresa de extração de minério de ferro, em Minas Gerais, Brasil. Dados antropométricos foram coletados e polissonografia (PSG) foi realizada em 118 trabalhadores de turno do sexo masculino que possuíam ao menos um fator de risco global para doença cardiovascular.* Resultados: *a prevalência de AOS na amostra foi de 84,7%. Entre os indicadores de adiposidade usados para predizerem a AOS (≥ 5 eventos/hora), o índice de massa corporal (IMC), a circunferência da cintura (CC), a relação cintura/estatura (RCE) e a gordura corporal total (GCT), revelaram valores de sensibilidade acima de 70%. Gordura visceral (GV), circunferência do pescoço (CP) e relação pescoço-estatura (RPE) foram as mais efetivas em identificar corretamente trabalhadores sem AOS (valores de especificidade acima de 70%). As áreas sob a curva de Característica de Operação do Receptor (COR) para CC e RPE foram maiores que 0,7, o que indicou que o teste foi eficaz na discriminação de indivíduos com AOS.* Conclusões: *alterações nos indicadores de adiposidade abdominal e cervical têm relação significativa com a presença de AOS e demostraram eficácia como método de rastreamento para PSG. CC e RPE são considerados bons indicadores para predizerem a AOS.*

Palavras-chave: *obesidade; ritmo circadiano; transtorno do ciclo vigília-sono; ronco; saúde ocupacional.*

Introduction

Obstructive sleep apnoea (OSA) is a health chronic condition with a multifactorial aetiology, including obesity, age, sex, genetics, and anatomical factors[1]. Desynchronization of the circadian cycle caused by shift work schedule may lead to OSA. Studies have observed a high prevalence of sleep disorders in shift workers. A study using polysomnography (PSG) has shown an OSA prevalence of 32.8% in a representative sample of adults from the city of São Paulo, Brazil[2]. Another Brazilian study has found an OSA prevalence of 35.03% among railroad shift workers[3].

Shift work is a way of labor organization with the aim of ensuring non-stop, 24 hour-a-day production of goods and / or services. Work schedule is organized as permanent (fixed working hours, whether morning, afternoon or evening) or rotation (alternating between morning, afternoon and night). This kind of work organization causes changes in workers' sleep cycle and circadian rhythm, and damages their physiological and metabolic functions[4,5].

Sleep alterations have been associated with neurohormonal effects that increase calorie intake, due to ghrelin raise and leptin production decrease. Both hormones act as peripheral signals and contribute to the central food intake regulation[6]. Thus, a change in appetite-regulating endocrine signalling, which may lead to weight gain[6], is one of the several consequences of shift work. A study by Grundy *et al.*[7], with 1,561 men, demonstrated an association between obesity and shift work, mainly if it includes rotating shifts. Another study, by Mazucca *et al.*[8], demonstrated that different anthropometric parameters related to body adiposity are associated to a greater severity of OSA in men.

Obesity is an anatomical risk factor for OSA when fat accumulates in the abdominal and neck regions. Fat increase in the abdominal region reduces the diaphragm activity and the inspired air volume, consequently, contributing to an upper airway obstruction[1]. Accumulation of fat around the pharynx region decreases the calibre of the airways and contributes to the collapse of the pharynx, consequently leading to decreased lung capacity and volume, as well as to repetitive respiratory blockages during sleep[9]. Therefore, the body fat distribution observed in overweight individuals with respiratory sleep disorders has led to a hypothesis that fat excess in the neck region and an increased waist/hip ratio are also risk factors for OSA[10].

The clinical evaluation of OSA is based on symptoms commonly present in sleep disorders, such as excessive daytime sleepiness, headache, fatigue, restless sleep, sensation of shortness of breath, cognitive alterations, and especially snoring, which is produced by the vibration of soft pharyngeal structures, resulting from low airflow through narrow airways[11]. Clinical evaluation and physical examination are not sufficient for the diagnosis. The reference standard for the diagnosis of sleep disorders is PSG[12].

Despite the high reliability of PSG for the detection of sleep disorders, this test has a high cost[13]. Currently, PSG is indicated whenever clinical and physical assessments suggest sleep respiratory disorders, especially OSA, based on the presence of snoring and excessive daytime sleepiness[9]. However, these clinical and physical assessments are subjective and show little effectiveness in the identification of sleep disorders[14]. Thus, another less subjective screening method should be developed to assess the risk of OSA and to indicate the achievement of PSG.

Pacients' screening for polysomnography examination can be defined by anthropometric indicators such as NC, waist circumference (WC) and body mass index (BMI), which are used to define the risk of OSA[15]. For instance, an increased neck circumference (NC), greater than or equal to 40 cm for men, has been used as a clinical parameter in screening for PSG[9].

The obesity may increase upper airway resistance either by fat accumulation in the area surrounding the more easily collapsible region of the pharynx (NC) and / or decrease diaphragmatic activity, as a result of fat excess in the abdominal wall (WC)[1,9].

Studies show that these circumferences are predictive measures for OSA[16-19] thus, the hypothesis raised in this study was that the adiposity indicators are effective as screening tests for OSA, indicating the need to perform PSG.

The use of adiposity indicators as an effective criterion for indication of PSG will decrease the number of polysomnographic exams and the corresponding cost, besides allowing implementing preventive actions. Therefore, this study aimed at verifying the discriminatory power of adiposity indicators in the prediction of obstructive sleep apnoea (OSA) in shift workers.

Methods

A cross-sectional study was performed on workers of an iron ore extraction company from the region of Inconfidentes, Minas Gerais, Brazil. The study population consisted of male off-road truck operators who worked in alternate shifts.

The company's rotating shift schedule is six hours of work, followed by 12 hours of rest. All participants work four shifts on the following schedule: 7 p.m. to

1 a.m., 1 p.m. to 7 p.m., 7 a.m. to 1 p.m., and 1 a.m. to 7 a.m. After completing the four-shift weekly cycle, they have a day off.

The participants had been previously evaluated in a research entitled "Metabolic syndrome in mining workers of the state of Minas Gerais", a screening study carried out by the Universidade Federal de Ouro Preto (Ouro Preto Federal University), aimed at identifying the prevalence of cardiovascular risk factors in this population. The considered cardiovascular risk factors were: high blood pressure (systolic blood pressure ≥ 130 mmHg or diastolic blood pressure ≥ 85 mmHg)[20], hyperglycaemia (≥ 100 mg/dL)[21], high total cholesterol (≥ 200 mg/dL)[22], high triglycerides (≥ 150 mg/dL)[22], high low-density lipoprotein (LDL) cholesterol (≥ 160 mg/dL)[22], low high-density lipoprotein (HDL) cholesterol (men < 40 mg/dL)[22], large WC (≥ 90 cm[20]), tobacco use, and low level of physical activity (International Physical Activity Questionnaire -IPAQ)[23]. The 524 individuals who had at least one cardiovascular risk factor were invited to perform polysomnography, After exclusions due to refusals, vacations, absences and resignations, 118 workers were included.

Sleep evaluation

PSG was carried out at the regional Santa Casa de Misericórdia hospital by a professional team trained by the research coordinator. The examinations were held at night, starting at 10 p.m. and ending at 6 a.m. They were performed using an Alice 5 PSG system (Philips Respironics, Inc., Murrysville, PA, USA). The surface electrodes were fixed using conventional techniques to obtain an electrooculogram, electromyogram, and electroencephalogram. The resting heart rate was measured after a rest period of at least 5 minutes, by the electrocardiogram sensor of the PSG system. The arterial oxygen saturation was monitored continuously with a pulse oximeter.

The apnoea-hypopnoea index (AHI) corresponded to the sum of the number of apnoea and hypopnoea events divided by the total hours of sleep. The presence of apnoea was registered when AHI was ≥ 5 events/ hour, and the absence of apnoea was registered when AHI was < 5 events/hour. The severity of OSA was defined based on the AHI index as follows: normal < 5 events/hour; mild ≥ 5 and < 15 events/hour; moderate ≥ 15 and < 30 events/hour; and severe ≥ 30 events/hour[24].

Body adiposity indices

Anthropometric and body composition data were collected. All procedures were carried out according to the Lohman *et al.* protocol[25]. The stature was measured using a digital stadiometer (Charder® brand, model HM-210D) calibrated and coupled to the wall, and the weight was measured using a Tanita® model BC-558 body composition monitor (Biospace Co., Ltd., Factory, Korea)[25]. BMI was calculated using the formula weight/height^2, and individuals with BMI values ≥ 25 kg/m^2 were considered overweight[26].

WC and hip circumference (HC) were measured in triplicate during expiration using a simple inelastic metric tape, with the individual in an upright position, with a relaxed abdomen, arms laterally to the body, feet together, and the weight evenly distributed on the two lower limbs. For the WC measurement, individuals were asked to breathe normally during the procedure to prevent muscle contractions by facilitating breathing to accomplish the anthropometric measurement[25]. WC was measured at the midpoint between the iliac crest and the lowest rib[25]. The subjects were considered to have central obesity when WC was ≥ 90 cm[20]. HC was measured in the largest part of the gluteal region[26]. The waist-to-hip ratio (WHR) was calculated by dividing WC (cm) by HC (cm) and was classified as abnormal when the value was ≥ 0.9[26].

The waist-to-height ratio (WHtR) was calculated by dividing WC (cm) by the height (cm) and was considered abnormal at values ≥ 0.50[27]. NC was measured at the level of the thyroid cartilage, just above the laryngeal prominence, with the participants with an upright spine and the head in horizontal plane of Frankfurt[28]. For the definition of the risk of OSA, NC ≥ 40 cm was adopted as a cut-off point[15]. The neck-to-height ratio (NHtR) was calculated by dividing NC (cm) by the height (cm), and the 75th percentile of the sample studied (≥ 0.24) was used as the NHtR threshold.

The body composition was estimated using a Tanita® model BC-558. The individuals were evaluated in an upright anatomical position with a fixed point in front of them, barefoot, and with their feet correctly positioned in the centre of the platform, according to the manufacturer's manual. Participants had to fast for 4 hours and an empty bladder They should wear minimal clothes, and no metallic embellishments for bioimpedance. The orientations were provided on the day before the evaluation.

The percentage of total body fat (TBF) was classified as abnormal when the value was ≥ 20% for men aged 20 to 39 years and ≥ 22% for men aged 40 to 59 years[29]. Based on the classification criteria from the Tanita® manual, visceral fat (VF) was classified on a scale from 0 to 59 and was considered abnormal in the range from 13 to 59.

According to the Tanita® manufacturer's manual, tetrapolar bioimpedance is a highly reproducible and easy-to-use method compared to the dual-energy X-ray absorptiometry (DXA) gold standard. Because the method is tetrapolar, it can estimate the body composition of the upper and lower body with greater precision. Some other body composition evaluation methods, such as DXA, computed tomography, hydrostatic weighing, and magnetic resonance imaging, are costly compared to bioimpedance. The Tanita® approach provides a lower cost, easier handling, and high reproducibility, although the precision of bioimpedance is influenced by water intake, menstrual cycle, physical activity, and individual posture.

Statistical analysis

The results of descriptive analysis are presented as absolute and relative frequencies, and the median was calculated according to the Shapiro-Wilk normality test. To analyze the discriminatory potential of the body fat indicators for the AOS screening, receiver operating characteristic curves (ROC) were constructed. And sensitivity, specificity and positive and negative predictive values (PPV and NPV, respectively) and their respective confidence intervals were calculated for the indicators of body fat in the presence of OSA. The area under the curve (AUC) was used to evaluate the best method, isolate or combined, of body fat indicators in the detection of OSA. These AUC were statistically compared using the Hanley & McNeil test[30]. The McNemar test was used to determine the presence of an association between the proposed screening tests (adiposity indicators) and OSA. For all tests, the level of significance was 5%. Statistical analyses were performed using the Statistical Package for Social Sciences, version 22.0 (SPSS, Chicago, IL, USA), MedCalc Statistical Software version 18.11.6 (MedCalc, Ostend, Belgium) and OpenEpi version 3.01 (OpenEpi, Atlanta, GA, USA).

Multiple tests

Combination of tests is useful for increasing the sensitivity and/or specificity of the tests, decreasing the number of false results and improving the quality of the diagnosis. The simplest ways to form a multiple test, from the results of two tests, are combinations in parallel (simultaneous) and serial (sequential)[31]. For parallel testing, two or more tests are used at the same time to evaluate presence of disease or not. Thus, the presence of the disease is considered when there is a positive result in any of the tests or in the two tests[31]. The series tests are applied consecutively, the second being applied only if the first one presents a positive result, that is, a new test is requested in result of the previous one[31].

In the present study combinations in parallel and in series of different anthropometric indicators were used in order to increase the sensitivity and specificity of the screening tests for OSA from the values generated by the ROC curve[31].

Research Ethics Committee

The study protocol was approved by the Human Research Ethics Committee of the Federal University of Ouro Preto (Opinion no. 074/2011). All participants signed the informed consent form.

Results

We evaluated 118 individuals. The median age was 35 years, with a minimum of 18 and a maximum of 57 years.

The proportion of individuals identified with OSA after diagnosis realized by PSG was 84.7% (n = 100). Of these, 41.5% (n = 49) had mild OSA, 28.8% (n = 34) moderate OSA and 14.4% (n = 17) severe OSA.

The indicators of adiposity, including BMI, WC, WHtR, and TBF, showed sensitivity higher than 70% for the OSA prediction (AHI ≥ 5 events/hour). PPVs were greater than 85% for all adiposity indicators evaluated, demonstrating a high probability of positive results for workers with OSA. VF, NC and NHtR presented specificity, with values of more than 70% (i.e. they were most effective in correctly identifying workers without OSA). All NPVs were less than 45%, demonstrating a low probability of a negative test when identifying individuals without OSA (**Table 1**).

Assessing parallel combinations of the adiposity indicators for OSA predicting , we observed that groups with sensitivity greater than 80% had an abnormal WC or NHtR (abnormal WC or NC; **Table 2**).

PPVs higher than 97% for the adiposity indicators in serial combinations were also observed for abnormal WC and NHtR (abnormal NHtR and WHR; **Table 3**). Thus, the use of the WC and NHtR indicators in parallel or serial combinations were the best to predict OSA.

Figure 1 shows the relationship between sensitivity and specificity for the WC (**Figure 1A**) and NHtR (**Figure 1B**) indicators. Both indicators had area under the curve (AUC) values greater than 0.7, demonstrating the effectiveness of the test for discriminating individuals with OSA.

Table 1 Sensitivity, specificity, and positive/negative predictive values of adiposity indicators for obstructive sleep apnoea (OSA) screening (AHI ≥ 5/hour) in shift workers (n=118). Inconfidentes Region, MG, Brazil

Indicators of Adiposity	*TP*	*FP*	*TN*	*FN*	*Sensitivy (95% CI)*	*Specificity (95% CI)*	*PPV (95% CI)*	*NPV (95% CI)*	*p-value**
BMI (≥ 25 kg/m^2)	83	8	10	13	86.5 (78.2-91.9)	55.6 (33.7-75.4)	91.2 (83.6-95.5)	43.5(25.6-63.2)	0.383 (NS)
WC (≥ 90 cm)	77	7	11	23	77.0 (67.9-84.2)	61.1 (38.6-79.7)	91.7 (83.8-95.9)	32.4 (19.1-46.2)	0.005
WHtR (≥ 0.24)	82	9	9	14	85.4 (77.0-91.1)	50.0 (29.0-71.0)	90.1 (82.3- 94.7)	39.1 (22.2-59.2)	0.405 (NS)
NC (≥ 40 cm)	59	4	14	41	59.0 (49.2-68.1)	77.8 (54.8-91.0)	93.7 (84.8-97.5)	25.5 (15.8-38.3)	≤ 0.001
NHtR (≥ 0.58)	44	1	17	52	45.8 (36.2-55.8)	94.4 (74.2- 99.0)	97.8 (88.4-99.6)	24.6 (16.0-36.0)	≤ 0.001
WHR (≥ 0.90)	63	6	12	37	63.0 (53.2-71.8)	66.7 (43.8-83.7)	91.3 (82.3-96.0)	24.5 (14.6-38.1)	≤ 0.001
TBF high	80	10	7	19	80.8 (72.0-87.4)	41.2 (21.6-64.0)	88.9 (80.7-93.9)	26.9 (13.7-46.1)	0.136 (NS)
VF (13 a 59)	21	1	17	78	21.2 (14.3-30.3)	94.4 (74.2-99.0)	95.5 (78.2-99.2)	17.9 (11.5-26.8)	≤ 0.001

BMI: body mass index; WC: waist circumference; WHtR: waist-to-height ratio; NC: neck circumference; NHtR: neck-to-height ratio; WHR: waist-hip ratio; TBF: total body fat; VF: visceral fat; TP: true positive; FP: false positive; TN: true negative; FN: false negative; 95% CI: 95% confidence interval; PPV: positive predictive value; NPV: negative predictive value; NS: non-significant; *McNemar Test - significant results at p ≤ 0.05.

Table 2 Sensitivity, specificity, and positive/negative predictive values of parallel combination of adiposity indicators for obstructive sleep apnoea (OSA) screening (AHI ≥ 5/hour) in shift workers (n=118), Inconfidentes Region, MG, Brazil

Indicators of Adiposity	*TP*	*FP*	*TN*	*FN*	*Sensitivy (95% CI)*	*Specificity (95% CI)*	*PPV (95% CI)*	*NPV (95% CI)*	*p-value**
WC (≥ 90 cm) ou NC (≥ 40 cm)	81	7	11	19	81.0 (72.2-87.5)	61.1 (38.6-79.7)	92.1 (84.5-96.1)	36.7 (21.9-54.5)	0.029
WC (≥ 90 cm) ou NHtR (≥ 0.58)	78	7	11	18	81.3 (72.3-87.8)	61.1 (38.6-79.7)	91.8 (84.0-96.0)	37.9 (22.7-56.0)	0.043
WC (≥ 90 cm) ou VF (13 a 59)	77	7	11	23	77.0 (67.9-84.2)	61.1 (38.6-79.7)	91.7 (83.8-95.9)	32.4 (19.1-49.2)	0.005
NC (≥ 40 cm) ou WHR (≥ 0.90)	76	6	12	24	76.0 (66.8-83.3)	66.7 (43.8-83.7)	92.7 (84.9-96.6)	33.3 (20.2-49.7)	0.001
NC (≥ 40 cm) ou VF (13 a 59)	64	4	14	36	64.0 (54.2-72.7)	77.8 (54.8-91.0)	94.1 (85.8-97.7)	28.0 (17.5-41.7)	≤ 0.001
NHtR (≥ 0.58) ou WHR (≥ 0.90)	69	6	12	27	71.9 (62.2-79.9)	66.7 (43.8-83.7)	92.0 (83.6-96.3)	30.8 (18.6-46.4)	≤ 0.001
NHtR (≥ 0.58) ou VF (13 a 59)	49	1	17	47	51.0 (41.2-60.8)	94.4 (74.2-99.0)	98.0 (89.5-99.7)	26.6 (17.3-38.5)	≤ 0.001
WHR (≥ 0.90) ou VF (13 a 59)	64	6	12	36	64.0 (54.2-72.7)	66.7 (43.8-83.7)	91.4 (82.5-96.0)	25.0 (14.9-38.8)	≤ 0.001

WC: waist circumference, NC: neck circumference; NHtR: neck-to-height ratio; VF: visceral fat; WHR: waist-hip ratio; TP: true positive; FP: false positive; TN: true negative; FN: false negative; PPV: positive predictive value; NPV: negative predictive value; 95% CI: 95% confidence interval; *McNemar test - significant results at p ≤ 0.05.

Table 3 Sensitivity, specificity, and positive/negative predictive values of the serial combination of adiposity indicators for obstructive sleep apnoea (OSA) screening (AHI ≥ 5/hour) in shift workers (n=118), Inconfidentes Region, MG, Brazil

Indicators of Adiposity	*TP*	*FP*	*TN*	*FN*	*Sensitivy (95% CI)*	*Specificity (95% CI)*	*PPV (95% CI)*	*NPV (95% CI)*	*p-value**
WC (≥ 90 cm) e NC (≥ 40 cm)	55	4	14	45	55 (45.2-64.4)	77.8 (54.8- 91.0)	93.2 (83.8- 97.3)	23.7 (14.7-36.0)	≤ 0.001
WC (≥ 90 cm) e NHtR (≥ 0.58)	40	1	17	56	41.7 (32.3-51.7)	94.4 (74.2-99.0)	97.6 (87.4-99.6)	23.3 (15.1-34.2)	≤ 0.001
WC (≥ 90 cm) e VF (13 a 59)	21	1	17	79	21.0 (14.2-30.0)	94.4 (74.2-99.0)	95.5 (78.2-99.2)	17.7 (11.4-26.5)	≤ 0.001
NC (≥ 40 cm) e WHR (≥ 0.90)	46	4	14	54	46.0 (36.6-55.7)	77.8 (54.8-91.0)	92.0 (81.2-96.9)	20.6 (12.7-31.6)	≤ 0.001
NC (≥ 40 cm) e VF (13 a 59)	16	1	17	84	16.0 (10.1-24.4)	94.4 (74.2-99.0)	94.1 (73.0-99.0)	16.8 (10.8-25.3)	≤ 0.001
NHtR (≥ 0.58) e WHR (≥ 0.90)	35	1	17	61	36.5 (76.5-46.4)	94.4 (74.2-99.0)	97.2 (85.8-99.5)	21.8 (14.1-32.2)	≤ 0.001
NHtR (≥ 0.58) e VF (13 a 59)	15	1	17	81	15.6 (9.7-24.2)	94.4 (74.2-99.0)	93.8 (71.7-98.9)	17.4 (11.1-26.0)	≤ 0.001
WHR (≥ 0.90) e VF (13 a 59)	20	1	17	80	20.0 (13.3-28.9)	94.4 (74.2-99.0)	95.2 (77.3-99.2)	17.5 (11.2-26.3)	≤ 0.001

WC: waist circumference, NC: neck circumference; NHtR: neck-to-height ratio; VF: visceral fat; WHR: waist-hip ratio; TP: true positive; FP: false positive; TN: true negative; FN: false negative; PPV: positive predictive value; NPV: negative predictive value; 95% CI: 95% confidence interval. *McNemar test – significant results at p ≤ 0.05.

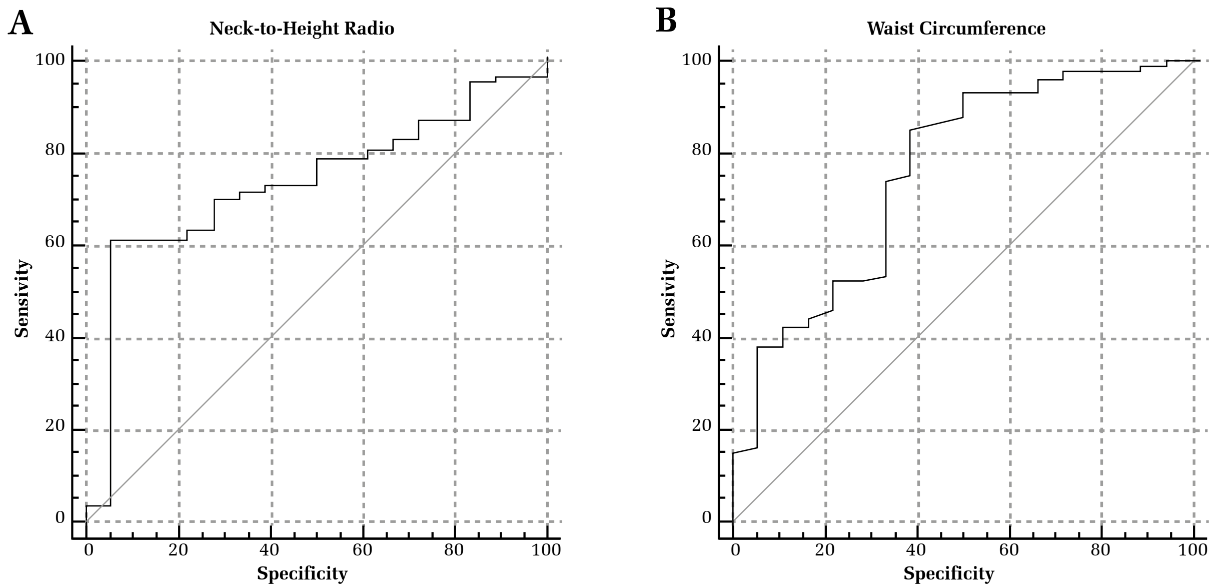

Figure 1 Discriminatory power of the adiposity indicators for obstructive sleep apnoea (OSA) screening in shift workers. **A** AUC of neck-to-height ratio (0.74; p=0.001). **B** AUC of waist circumference (0.76; p=0.001). Inconfidentes Region, MG, Brazil

Discussion

In the present study, WC and NHtR showed the highest sensitivity and specificity for OSA screening, both separately and in combination, as well as higher AUC values.

WC and NHtR showed 77.5% sensitivity and 94.4% specificity, respectively. Similarly, Davies *et al.*[19] found a significant relationship between OSA and the WC and NHtR indicators and observed 87% sensitivity and 79% specificity for OSA prediction using WC. Dancey *et al.*[32] observed that NHtR was the most significant indicator for OSA prediction. However, NC and WHtR were not considered good OSA predictors because of sensitivity of less than 70% and a non-significant relationship with OSA, as also observed by Ip *et al.*[33] The accuracy of the WC and NHtR measurements observed in the present study corroborated the explanatory hypotheses of the anatomical risk factors for this disease, including compromised upper airway passages and the reduction of diaphragm activity with the accumulation of fat in neck and abdomen[1].

Using combinations of indicators, in parallel or in series, we observed that all combinations were significant. The combination of WC and NHtR showed the highest sensitivity (81.3%) in parallel and the highest specificity (94.4%) in series. The choice of indicators for OSA should be based on the balance between sensitivity and specificity. The use of multiple tests (i.e. combining different indicators) is suggested to increase the sensitivity and specificity of a diagnostic test, especially when the recommended gold standard, such as PSG, has a high cost[31]. The sensitivity is important for disease screening since this measure selects individuals who are likely to have the disease, but false positives may occur. Therefore, the specificity should also be considered to exclude truly healthy individuals[31].

The indicators of adiposity that showed a significant relation with OSA were WC, NC, WHR, NHtR, and VF. Soylu *et al.*[15] have suggested the use of WC and NC as indicators of body adiposity because these indicators are easy to measure and they correlate with the development of OSA. Other studies in adult populations have shown that the accumulation of abdominal fat, measured by WHR, is a similar or better predictor of OSA than BMI is[34], and WHR was also associated with sleep-disordered breathing in both sexes[35].

In the current study, BMI and TBF did not show significant associations with OSA in shift workers. However, Peppard *et al.*[34] demonstrated that excess weight increased the risk of the disorder 10-fold in officials in Wisconsin, USA. A sectional study conducted in Italy by Di Lorenzo *et al.*[35] has revealed a higher prevalence of excess weight in 718 shift workers from a chemical industry in Apulia, compared with that in day-shift workers. Several mechanisms have been suggested to explain the relationship between OSA and risk factors such as weight gain, anthropometric parameters, and metabolic disorders. Shift work is believed to strongly influence weight gain because of circadian rhythm alterations, sleep deprivation, and alterations in food intake[36]. BMI and TBF are indicators of the total body adiposity but do not reflect the adiposity in specific body anatomic regions, thus being different from the other anthropometric indicators evaluated in this study. The indicators that demonstrated a significant relationship with OSA are those that represent accumulation of fat in the abdominal region and the neck.

The reduced sample size for the polysomnography can be explained by the method execution procedures (sleeping one night in the hospital) and it was done during an individual day off, which may be an inconvenience or impossibility for personal reasons. Although sample size and body composition assessment by the technique employed (Tanita®) be considered limitations of this study, its results show the usefulness of body fat indicators for OSA screening. Thus, the use of adiposity indicators in the abdominal (WC) and neck (NHtR) regions seems to be a low-cost method for OSA screening in shift workers with pre-existing cardiovascular risk factors.

Authors contribution

All authors contributed equally to the design and implementation of the research, to the analysis of the results and to the writing of the manuscript.

References

1. Lam JCM, Sharma SK, Lam B. Obstructive sleep apnea: definitions, epidemiology & natural history. Indian J Med Res. 2010;131:165-70.
2. Tufik S, Santos-Silva R, Taddei JA, Bittencourt LR. Obstructive Sleep Apnea Syndrome in the Sao Paulo epidemiologic sleep study. Sleep Med. 2010;11(5):441-6.
3. Koyama RG, Esteves AM, Oliveira e Silva L, Lira FS, Bittencourt LR, Tufik S, et al. Prevalence of and risk factors for obstructive sleep apnea syndrome in Brazilian railroad workers. Sleep Med. 2012;13(8):1028-32.
4. World Health Organization. Internation Agency for Research on Cancer. Painting, Firefighting and Shiftwork. Vol. 98, IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. Lyon: IARC Library Cataloguing in Publication; 2010.
5. Knutsson A. Health disorders of shift workers. Occup Med. 2003;53:103-8.
6. Farooqi IS, O'Rahilly S. 20 years of leptina human disorders of leptina action. J Endocrinol. 2014;223(1):T63-70.
7. Grundy A, Cotterchio M, Kirsh VA, Nadalin V, Lightfoot N, Kreiger N. Rotating shift work associated with obesity in men from northeastern Ontario. Health Promot Chronic Dis Prev Can. 2017;37(8):238-47.
8. Mazzuca E, Battaglia S, Marrone O, Marotta AM, CastroGiovanni A, Esquinas C, et al. Gender-specific anthropometric markers of adiposity, metabolic syndrome and visceral adiposity index (VAI) in patients with obstructive sleep apnea. J Sleep Res. 2014;23(1):13-21.
9. Morris LG, Kleinberger A, Lee KC, Liberatore LA, Burschtin O. Rapid risk stratification for Obstructive Sleep Apnea, based on snoring severity and body mass index. Otolaryngol Head Neck Sug. 2008;139(5):615-8.
10. Borges PTM, Ferreira Filho ES, Araújo TME, Moita Neto JM, Borges NES, Melo Neto B, et al. Correlation of cephalometric and anthropometric measures with obstructive sleep apnea severity. Int Arch Otorhinolaryngol. 2013;17(3):321-8.
11. Campostrini DDA, Prado LBF, Prado GF. Síndrome da Apneia Obstrutiva do Sono e Doenças Cardiovasculares. Rev Neurocienc. 2014;22(1):102-12.
12. Gondim LMA, Matumoto LM, Melo Júnior MAC, Bittencourt S, Ribeiro UJ. Estudo comparativo da história clínica e da polissonografia na síndrome da apneia/hipopneia obstrutiva do sono. Rev Bras Otorrinolaringol. 2007;73(6):733-7.
13. Leger D, Bayon V, Laaban JP, Philip P. Impact of sleep apnea on economics. Sleep Med Rev. 2012;16(5):455-62.
14. Musman S, Passos VMA, Silva IBR, Barreto SM. Avaliação de um modelo de predição para apneia do sono em pacientes submetidos a polissonografia. J Bras Pneumol. 2011;37(1):75-84.
15. Soylu AC, Levent E, Sariman N, Yurtlu S, Alparslan S, Saygi A. Obstructive Sleep Apnea Syndrome and anthropometric obesity index. Sleep Breath. 2012;16(4):1151-8.
16. Sá RTO, França IML, Catão CDS, Cruz JB. Análise dos fatores de risco para síndrome da apnéia obstrutiva do sono em motoristas de caminhão. Rev Cienc Med Biol. 2018;17(1):27-32.
17. Zancanella E, Haddad FM, Oliveira LAMP, Nakasato A, Duarte BB, Soares CFP, et al. Apneia obstrutiva do sono e ronco primário: diagnóstico.

Braz J Otorhinolaryngol. 2014;80(1 Suppl 1): S1-S16.

18. Pinto JA, Godoy LBM, Marquis VWPB, Sonego TB, Leal CFA, Ártico MS. Anthropometric data as predictors of obstructive sleep apnea severity. Braz J Otorhinolaryngol. 2011;77(4):516-21.
19. Davies RJ, Ali NJ, Stradling JR. Neck circumference and other clinical features in the diagnosis of the Obstructive Sleep Apnea Syndrome. Thorax. 1992;47(2):101-5.
20. International Diabetes Federation. The IDF consensus worldwide definition of the metabolic syndrome. Brussels: IDF; 2006.
21. American Diabetes Association. Diagnosis and classification of diabetes Mellitus. Diabetes Care. 2008;31(Suppl 1):55-60.
22. Sociedade Brasileira de Cardiologia. IV Diretriz Brasileira sobre dislipidemias e prevenção da aterosclerose. Arq Bras Cardiol. 2007;88(Suppl 1):1-19.
23. International Physical Activity Questionnaire. Guideline for Data Processing and Analysis of the International Physical Activity Questionnaire (IPAQ): short and long forms [Internet]. Geneva: IPAQ; 2005 [acesso em 10 abr 2019]. Available from: https://www.researchgate.net/file.PostFileLoader.html?id=5641f4c36143250eac8b45b7&assetKey=AS%3A294237418606593%401447163075131
24. Iber C, Ancoli-Israel S, Chesson JRA, Quan S. The American Academy of Sleep Medicine manual for the scoring of sleep and associated events: rules terminology and technical specifications. Westchester: American Academy of Sleep Medicine; 2007.
25. Lohman TG, Roche AF, Martorell R. Anthropometric standardization reference manual. Champaign: Human Kinetics Books; 1998.
26. World Health Organization. Obesity: preventing and managing the global epidemic: report of a WHO Consultation. Vol. 894, WHO Technical Report Series. Geneva: WHO; 2000.
27. Browning LM, Hsieh SD, Ashwell MA. Systematic review of waist-to-height ratio as screening tool for the prediction of cardiovascular disease and diabetes: 0.5 could be a suitable global boundary value. Nutr Res Rev. 2010;23(2):247-69.
28. Preis ST, Massaro JM, Hoffmann U, D'Agostino RB Sr, Levy D, Robins SJ, et al. Neck circumference as a novel measure of cardiometabolic risk: the Framingham Heart Study. J Clin Endocrinol Metab. 2010;95(8):3701-10.
29. Gallagher D, Heymsfield SB, Heo M, Jebb SA, Murgatroyd PR, Sakamoto Y. Healthy percentage body fat ranges: an approach for developing guidelines based on body mass index. Am J Clin Nutr. 2000;72(3):694-701.
30. Hanley JA, McNeil BJ. A method of comparing the areas under receiver operating characteristic curves derived from the same cases. Radiology. 1983;148(3):839-43.
31. Fletcher RH, Fletcher SW, Wagner EH. Epidemiologia clínica: elementos essenciais. Porto Alegre: Artes Médicas; 2006.
32. Dancey DR, Hanly PJ, Soong C, Lee B, Shepard JJ, Hoffstein V. Gender differences in sleep apnea: the role of neck circumference. Chest. 2003;123(5):1544-50.
33. Ip MSM, Lam KS, Ho C, Tsang KW, Lam W. Serum leptin and vascular risk factors in Obstructive Sleep Apnea. Chest. 2000;118(3):580-6.
34. Peppard PE, Young T, Palta M, Dempsey J, Skatrud J. Longitudinal study of moderate weight change and sleep-disordered breathing. JAMA. 2000;284(23):3015-21.
35. Di Lorenzo L, De Pergola G, Zocchetti C, L'Abbate N, Basso A, Pannacciulli N, et al. Effect of shift work on body mass index: results of a study performed in 319 glucose-tolerant men working in a southern italian industry. Int J Obes Relat Metab Disord. 2003;27(11):1353-8.
36. Pillar G, Shehadeh N. Abdominal fat and sleep apnea: the chicken or the egg? Diabetes Care. 2008;31(Suppl 2):303-9.