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The effect of sleep position on sleep bruxism in adults with obstructive sleep apnea

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Abstract

Background: Most of the respiratory events in adults with obstructive sleep apnea (OSA) occurs in supine position. It has been reported that the contraction of masseter muscles is dependent on the occurrence of arousals rather than on the occurrence of respiratory events.

Objectives: This study had two aims: (1) to compare the rhythmic masticatory muscle activity (RMMA) index in supine position (RMMA_sup) and in non-supine positions (RMMA_nsup) in adults with OSA; and (2) to determine the associations between RMMA index in both supine position and non-supine positions on the one hand, and several demographic and polysomnographic variables on the other hand.

Methods: One hundred OSA participants (36 females and 64 males; mean age = 50.3 years (SD = 10.5)) were selected randomly from among patients with a full-night polysomnographic recording. RMMA_sup index and RMMA_nsup index were compared using Mann–Whitney *U*-test. Multivariate linear regression analyses were used to predict RMMA index both in supine and non-supine positions based on several demographic and polysomnographic variables.

Results: In patients with OSA, the RMMA_sup index was significantly higher than the RMMA_nsup index ($p < .001$). RMMA_sup index was significantly associated with the arousal index ($p = .002$) and arousal index in supine position ($p < .001$). RMMA_nsup index was only significantly associated with the arousal index in non-supine positions ($p = .004$).

Conclusion: Within the limitations of this study, RMMAs occur more frequently in supine position than in non-supine positions in patients with OSA. In both sleep positions, RMMAs are associated with arousals.

KEYWORDS
obstructive sleep apnea, sleep arousal, sleep bruxism, sleep position

All authors approved the manuscript.

1 | INTRODUCTION

Obstructive sleep apnea (OSA) is a condition characterised by repetitive complete (apnea) or partial (hypopnea) obstruction of the upper airway occurring during sleep.[1] These events often result in blood oxygen desaturation and are usually terminated by brief arousals from sleep.[1] The clinical diagnosis of OSA is based on symptoms such as excessive daytime sleepiness, loud snoring, and witnessed breathing interruption or awakenings in the presence of at least five apnea and/or hypopnea events per hour of sleep (viz., apnea/hypopnea index (AHI)).[2] Patients with untreated OSA are at increased risk of impaired quality of life, hypertension, stroke, heart failure, diabetes, and involvement in car and work-related accidents.[3,4] According to a systematic review,[5] the overall OSA prevalence rate in the general population ranges from 9% to 38%.

Cartwright was the first to suggest that there is a worsening of respiratory events in supine position in adults with OSA.[6] A recent review[7] described that the increased frequency and severity of respiratory events in supine position are likely caused by a combination of increased upper airway collapsibility, reduced lung volume, and an inability of the airway dilator muscles to adequately compensate for collapsing forces in supine position. The most commonly used definition for position-dependent OSA (POSA) is a supine AHI of more than or equal to twice the non-supine AHI.[8]

Sleep bruxism (SB) is defined as a repetitive jaw-muscle activity characterised by clenching or grinding of the teeth and/or by bracing or thrusting of the mandible.[9] The gold standard for the assessment of SB is polysomnography (PSG). According to Rompre et al.,[10] SB is diagnosed when the rhythmic masticatory muscle activity (RMMA) index is at least two events per hour of sleep. The prevalence of self-reported SB is around 12.8% in the general adult population.[11] This prevalence rate was found to be unrelated to sex; however, it decreases with increasing age.[11] SB has been reported to be associated with several sleep-related disorders, such as periodic limb movement during sleep, sleep-related gastroesophageal reflux disease, and OSA.[12]

Kato et al.[13] suggested that in adults with OSA, the contraction of masseter muscles is dependent on the occurrence of arousals rather than on the occurrence of respiratory events per se. Besides sleep arousal, many other factors, including sex, body mass index (BMI), and sleep staging have been reported to be associated with OSA, SB, or both.[5,14–16] Further, in 56% of adults with OSA, respiratory events occur mainly in their supine position.[8] Therefore, we hypothesized that the RMMA index in supine position (RMMA_sup index) is significantly higher than RMMA index in non-supine positions (RMMA_nsup index) in adults with OSA. Our second hypothesis was that RMMA index in both supine position and non-supine positions are associated with arousals. Thus, the aims of this study were: (1) to compare the RMMA index in supine position and in non-supine positions in adults with OSA; and (2) to determine the association in supine position and in non-supine positions between RMMA index, on the one hand, and different demographic and other polysomnographic variables on the other hand.

2 | MATERIALS AND METHODS

2.1 | Study design

This is a prospective cross-sectional study. The protocol was approved by the institutional Medical Ethics Committee of the OLVG West, Amsterdam (WO 16–577). This study has also been registered on https://trialsearch.who.int/ (NL8516).

2.2 | Participants

One hundred adults with OSA (36 females and 64 males; mean ± SD age = 50.3 ± 10.5 years) were selected randomly from patients who underwent a full PSG recording at the department of neurophysiology of the OLVG West in Amsterdam, The Netherlands, between June 2017 and May 2018. POSA was defined as a supine AHI of more than or equal to twice the non-supine AHI.[8] Fifty adults with POSA and 50 adults with non-POSA were selected to match the positional dependency rate among patients with OSA at this hospital.[17]

Patients who met the following criteria were included in this study: (1) age ≥18 years; and (2) diagnosed with OSA (excessive daytime sleepiness, loud snoring, and witnessed breathing interruption or awakenings in the presence of AHI ≥5). Exclusion criteria were: (1) total sleep time (TST) ≤4 h; (2) continuous artefacts or missing data on electroencephalography (EEG), electromyography (EMG), or respiratory channels (e.g. airflow and oxygen saturation) of PSG recordings; and/or (3) patients with OSA treatment in situ during PSG.

2.3 | Polysomnography

A home PSG system (SOMNOscreen Plus, SOMNOmedics GmbH, Randersacker, Germany) was used to perform a full-night sleep recording. The following channels were recorded: EEG (F4:C4, C4:O2, F3:C3, C3:O1), electrooculogram (E2:M1, E1:M2), electrocardiogram, bilateral masseter muscle EMG, anterior tibialis EMG, pressure airflow, snoring, abdominal and thoracic respiratory effort, oxygen saturation, heart rhythm, plethysmography, and sleep position.

2.4 | PSG analysis

Prior to scoring, all PSG recordings were pseudonymized by removing patients' general information (e.g. name, sex, date of birth, and identity number). Subsequently, they were renamed by a series of numbers by a sleep technologist at the Department of Clinical Neurophysiology, OLVG West, Amsterdam, the Netherlands. Finally, the PSG scoring was performed offline using DOMINO software (SOMNOmedics GmbH, Randersacker, Germany). Sleep stages and respiratory events (e.g. apnea, hypopnea) were scored manually by certified PSG technicians at the department according to the American Academy of Sleep Medicine scoring criteria.[18] Sleep arousals were analysed according to the AASM scoring manual by B.K. and D.L.

The EMG signals were filtered between 10 and 100 Hz.[18] A notch filter of 50 Hz was used to remove alternator noise. Also, the ECG elimination technique was applied to remove ECG contamination from EMG signals. RMMAs were scored by B.K. and D.L. according to published criteria.[19] Each EMG burst had a mean amplitude of at least two times higher than the baseline EMG amplitude on bilateral masseter EMG traces. EMG bursts occurring within an interval shorter than 3 s were defined as a single EMG episode. RMMAs were classified into three subtypes: phasic RMMA, tonic RMMA, and mixed RMMA (phasic RMMA: three or more continuous EMG bursts lasting 0.25–2 s; tonic RMMA: each EMG burst was longer than 2 s; and mixed RMMA: both phasic and tonic EMG patterns were observed within a single EMG episode).

2.5 | Outcome variables

The primary outcome variables of this study were: RMMA_sup index ($\text{RMMA\_sup index} = \frac{\text{number of RMMA events in supine position}}{\text{sleep time in supine position in hours}}$) and RMMA_nsup index ($\text{RMMA\_nsup index} = \frac{\text{number of RMMA events in non}-\text{supine positions}}{\text{sleep time in non}-\text{supine positions in hours}}$).

2.6 | Statistical analysis

To screen whether or not the outcome variables were normally distributed, histograms were drawn and Kolmogrov-Smirnov tests were performed. Mann–Whitney *U*-test was used to test the differences between RMMA_sup index and RMMA_nsup index.

Collinearity diagnostic tests were performed before the multiple linear regression analysis with backward stepwise elimination were carried out, by calculating the variable inflation factor (VIF). Collinearity was considered to be present with a VIF higher than 3.3.[20] Statistical power of a multiple regression analysis was calculated in the event that a particular multiple regression analysis was found to be insignificant.

Multiple linear regression analysis with backward stepwise elimination was carried out to investigate the association between RMMA_sup index and total arousal index, arousal index in supine position, arousal index in non-supine position, total AHI, AHI in supine position, AHI in non-supine position, age, sex, BMI, sleep profiles (including N1%, N2%, N3%, and REM%), TST, and sleep efficiency (SE). The same analysis was also carried out to investigate the association between RMMA_nsup index and total arousal index, arousal index in supine position, arousal index in non-supine position, total AHI, AHI in supine position, AHI in non-supine position, age, sex, BMI, sleep profiles (including N1%, N2%, N3%, and REM%, TST, and SE). The cut-off *p*-value for removal of the variables for the backward selection was .10.

Statistical analysis was performed using IBM SPSS Statistics (version 27.0, Armonk, NY, the U.S.), and differences were considered significant when the *p*-value was smaller than .05.

3 | RESULTS

The detailed demographic information as well as the sleep profiles of the 100 participants are presented in Table 1. Among the 100 participants, there were 36 females and 64 males, with a mean (SD) age of 50.3 (10.5) years and a mean (SD) BMI of 29.5 (4.9) kg/m.[2] Fifty-four participants out of the 100 participants had comorbid SB (viz., ≥2 RMMA episodes per hour of sleep).

When comparing the RMMA index in supine and non-supine positions, the RMMA_sup index (1.2|3.2|6.4) was significantly higher than the RMMA_nsup index (0.7|1.4|2.9) ($p<.001$) in adults with OSA.

Multiple linear regression with backward stepwise elimination showed that RMMA_sup index was significantly associated with sleep arousals in supine position ($p<.001$) and total arousal index ($p=.002$) (Table 2). This model has a Pearson R of .591 and an adjusted R^2 of .335, indicating that this model explained 33.5% of the variance of RMMA_sup index. There were 93 patients included in the model. Seven patients were not included due to missing information on supine sleep time. With regard to variables in non-supine positions, multiple linear regression with backward stepwise elimination showed that RMMA_nsup index was significantly associated with sleep arousal index in non-supine position ($p=.004$), while there was a tendency towards significance for the association between RMMA_nsup index and total arousal index ($p=.052$) (Table 3). This model has a Pearson R of .329 and an adjusted R^2 of .080, meaning that this model explained 8.0% of the variance of RMMA_nsup

TABLE 1 Overview of the demographic and polysomnographic data of adults with OSA ($n=100$).

Variables	Adults with OSA
Sex	36F, 64M
Age	50.3 ± 10.5
BMI	29.5 ± 4.9
TST (hr)	7.1 ± 1.1
N1 (%)	3.2|5.3|9.2
N2 (%)	53.7 ± 9.9
N3 (%)	18.8 ± 8.7
REM (%)	20.9 ± 5.7
Sleep efficiency (%)	84.5|91.8|95.4
Total Arousal index	5.9|8.1|12.4
Arousal index in supine position	8.0|12.4|25.1
Arousal index in non-supine positions	3.6|5.8|10.0
Total AHI	10.5|18.9|38.2
AHI in supine position	17.5|32.1|65.7
AHI in non-supine positions	5.3|10.9|25.6

Note: Mean and standard deviation are provided for normally distributed variables. Percentiles (25%|median|75%) are provided for not normally distributed variables.

Abbreviations: AHI, apnea/hypopnea index; BMI, body mass index; OSA, obstructive sleep apnea; TST, total sleep time.

index. There were 99 patients included in the model. One patient was not included due to missing information on non-supine sleep time. For detailed results of each step of the above two multiple regression analyses, see Data S1.

TABLE 2 Multiple linear regression model with backward stepwise elimination predicting rhythmic masticatory muscle activity (RMMA) index in supine position in adults with OSA ($n = 93$).

Included variable(s)	B	Standard error	*p*
Total arousal index	0.283	0.091	.002*
Arousal index in supine position	0.323	0.048	<.001*
Excluded variables			
Age			.271
BMI			.238
Sex[a]			.128
N1%			.265
N2%			.392
N3%			.786
REM%			.984
Total AHI			.584
AHI in supine position			.316

Note: $F_{(2,90)} = 24.189$, $p < .001$, with adjusted $R^2 = .335$. Dependent variable: RMMA index in supine position.

Abbreviations: AHI, apnea/hypopnea index; BMI, body mass index; OSA, obstructive sleep apnea.

[a]Dummy variables were used to represent sex, where female is tagged as 1, male as 0.

*p-value of <.05 is considered statistically significant.

4 | DISCUSSION

Our study is the first to investigate the difference in RMMA index between supine and non-supine sleep positions in a large number of individuals with OSA. The results show that the RMMA_sup index is significantly higher than the RMMA_nsup index among adults with OSA. Furthermore, it was found that RMMA index is only significantly associated with sleep arousals in both supine and non-supine positions when taking demographic and other polysomnographic variables into account.

To the best of our knowledge, only three studies[21–23] from the same research group compared the frequencies and durations of RMMA events between sleep in supine position and sleep in non-supine positions among individuals with OSA, all of which reported no significant difference in frequencies and durations of RMMA events between the two sleep position conditions. However, as compared to the present study, those previous studies enrolled only a small number of individuals with OSA, i.e., 24 patients in Phillips et al.,[21] 9 patients in Okeson et al.,[22] and 16 in Okeson et al.[23] Consequently, their insignificant findings could be explained by a lack of statistical power.

As demonstrated in supine position as well as in non-supine positions, the RMMA index could be predicted only by arousal index, and not by the other included variables. These findings are in line with the conclusions of the studies of Kato et al.[13] and Aarab et al.,[24] which suggested that masseter contraction is dependent on sleep arousals rather than on respiratory events in patients with OSA. However, sleep arousals in non-supine positions could only explain 8.0% of the variance in the RMMA index in non-supine positions, and sleep arousals in supine positions could only explain 33,3% of the variance in the RMMA index in supine positions. This calls for

Included variable(s)	B	Standard error	*p*-value
Arousal index in non-supine position	0.095	0.032	.004*
Total arousal index	−0.048	0.024	.052
Age	−0.029	0.017	.099
Excluded variable(s)			
BMI			.420
Sex[a]			.480
N1%			.465
N2%			.690
N3%			.979
REM%			.956
Total AHI			.582
AHI in non-supine positions			.547

Note: $F_{(3,95)} = 3.845$, $p = .012$, with adjusted $R^2 = .080$. Dependent variable: RMMA index in non-supine positions. There were 100 patients in all. Ninety-nine patients were included in the analysis. One patient was not included due to no non-supine sleep time.

Abbreviations: AHI, apnea/hypopnea index; BMI, body mass index; OSA, obstructive sleep apnea.

[a]Dummy variables were used to represent sex, where female is tagged as 1, male as 0.

*p-value of <.05 is considered statistically significant.

TABLE 3 Multiple linear regression model with backward stepwise elimination predicting rhythmic masticatory muscle activity (RMMA) index in non-supine positions in adults with OSA.

future studies to identify more predictors for the RMMA index in adults with OSA.

Sleep position trainer (SPT) is a treatment modality designed to decrease the supine sleep time and has shown good treatment results for individuals with mild and moderate OSA.[25] Our study is the first to demonstrate that RMMA index in supine position is significantly higher than RMMA index in non-supine positions among individuals with OSA. As SB is very prevalent among patients with OSA,[12] our findings could call for clinicians to explore the possibility for SPT to treat both SB and OSA at the same time for individuals with OSA, without the possible side-effects that are frequently associated with mandibular advancement devices, that is, excessive salivation, mouth dryness, and temporomandibular side-effects in the short-term and orthodontic side-effects in the long-term.[26,27]

4.1 | Strengths and limitations

To the best of our knowledge, this is the first study investigating possible associated factors of RMMA in supine and non-supine positions separately in a large sample of adults of OSA. However, no healthy controls enrolled were enrolled in our study. Thus, it is difficult to determine whether the characteristics of RMMA related to sleep positions are intrinsic to SB or influenced by the sleep dependency of OSA.

5 | CONCLUSIONS

Among the adult patients with OSA, RMMA occurs more frequently in supine position than in non-supine positions. In both sleep positions, RMMAs are associated with arousals.

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CONFLICT OF INTEREST STATEMENT

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PEER REVIEW

The peer review history for this article is available at https://www.webofscience.com/api/gateway/wos/peer-review/10.1111/joor.13696.

DATA AVAILABILITY STATEMENT

The data underlying this article cannot be shared publicly due to the privacy of individuals that participated in the study. The aggregate data will be shared on reasonable request to the corresponding author.

ETHICS STATEMENT

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The study was approved by the institutional Medical Ethics Committee of the OLVG West, Amsterdam (WO 16–577).

INFORMED CONSENT

Informed consent was obtained from all individual participants included in the study.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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