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SCIENTIFIC INVESTIGATIONS

Risk of Obstructive Sleep Apnea Lower in Double Reed Wind Musicians

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Study Objectives: Obstructive sleep apnea (OSA) is caused by a collapse of the upper airway. Respiratory muscle training with a wind instrument (didgeridoo) in patients with moderate OSA has been previously shown to improve OSA symptomology. However, a survey of orchestra members did not indicate a difference in OSA risk between wind and non-wind instrumentalist. The present study examines whether playing of different wind instrument types may affect the risk of OSA.

Methods: A national sample of active musicians (n = 906) was surveyed through the internet. Participants' risk for OSA was determined by the Berlin Questionnaire. Additional survey items included questions about general health and musical experience.

Results: A binary logistic regression was conducted to determine if OSA risk was predicted by gender, age, number of years playing instrument, number of hours per week playing instrument, and instrument type. Musicians who played a double reed instrument had a lower risk of OSA (p = 0.047) than non-wind instrumentalists. Additionally, in double reed instrumentalists, the number of hours spent playing the instrument predicted lower OSA risk (p = 0.020). The risk for OSA in other wind instruments (i.e., single reed, high brass, and low brass) was not significantly different from non-wind musicians.

Conclusions: Playing a double reed musical instrument was associated with a lower risk of OSA.

Keywords: Obstructive sleep apnea, risk factors, epidemiology

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Obstructive sleep apnea (OSA) is characterized by the collapse of the upper airway during sleep. The most common treatment for OSA is the use of continuous positive airway pressure therapy (CPAP). While CPAP is an effective treatment for OSA,[1] it is poorly tolerated by some.[2,3]

During sleep, muscle tone of the upper airway is reduced, leading to snoring or blockage. In 2002, Mann and colleagues[4] demonstrated that electrical stimulation of the genioglossus muscle causes an increase in diameter of the hypopharyngeal airway. In a similar study, Randernath and associates[5] also showed that stimulation training of the tongue can be effective in reducing snoring, but they failed to find an effect for OSA. Although it would be impractical to propose a similar electrical shock-based treatment for OSA at this time, these studies do suggest that increasing muscle tone of the upper airway could be beneficial for patients with OSA.

In a related literature, oropharyngeal exercises derived from speech therapy have been shown to reduce OSA severity.[3] It has also been shown that 4 months of practice on the didgeridoo (a wind instrument from indigenous Australians) reduced OSA symptoms.[6] Studies suggest that upper airway muscle training may strengthen the muscles of the upper airway through changes in plasticity of neural respiratory control.[7]

If respiratory training is indeed important for reducing OSA risk, there may be naturally occurring groups of individuals in the population who are already receiving this type of practice. For example, professional wind instrument musicians spend years engaging in training of the respiratory muscles and upper airway, which may suggest that a lower incidence of OSA might be found among wind players.

BRIEF SUMMARY

Current Knowledge/Study Rationale: Training with the musical instrument didgeridoo demonstrated relief of obstructive sleep apnea (OSA) symptoms. However, a general survey of wind instrumentalists did not show differences in OSA risk.

Study Impact: When taking the type of wind instrument into consideration, double reed instrumentalist had a lower risk of OSA. Therefore, respiratory muscle training, accomplished by playing some wind instruments, may serve to protect against the development of OSA.

Although a recent study surveyed a large sample of orchestra members failed to find differences in OSA risk between wind musicians and non-wind musicians,[8] there are differences in the physical demands of various instrument types represented in western music. The study design may not have been adequate to fully capture differences if they exist. The present experiment surveys musicians for risk of OSA and compares categories of instruments, such as double reed and single reed woodwinds along with high and low brass.

METHODS

Participants

Participants were recruited via email solicitation from a national sample of collegiate music instructors in the United

States and local professional music organizations in the southern region of the United States. Collegiate instrumental music instructors and other professional musicians were identified as a convenient sample of individuals who were believed to be likely to spend large amounts of time playing an instrument. Selection of collegiate instrumental music instructors and local professional musicians also facilitated rapid identification of a large pool of potential participants via internet and other publicly available sources. Email addresses were obtained by public internet searches of U.S. college and university music programs. Local orchestras in the southern region of the U.S. were solicited through their music directors.

Procedure

Respondents were asked to complete either an online survey battery (n = 913), consisting of self-report questionnaires, or paper and pencil versions (n = 73) of the same survey battery. The response rate for email solicitation was approximately 10%. The response rate for direct solicitation was approximately 90%. Anonymity was maintained for the questionnaire responses by collecting no uniquely identifying information about respondents. Ethics approval was obtained from the university's Committee for the Protection of Human Subjects prior to data collection.

Measures

Participants were asked to complete a battery of questionnaires, which were designed to assess baseline demographic characteristics of the sample and risk for obstructive sleep apnea. The following measures were utilized in the current study:

Personal Health History Questionnaire

The Personal Health History Questionnaire is an 11-item self-report questionnaire, developed for use in this study and designed to assess baseline demographic, health status, sleep habits, sleep disorder history, and health behavior characteristics of the sample. Participants were asked a general question on self-assessed health.[9] They were also asked to rate their level of activity by checking 1 of 4 descriptions of increasing activity levels.[10] Participants were also presented with a list of psychiatric, neurological, cardiovascular, respiratory, and sleep disorders. They were asked to mark any diagnoses they had ever received. A list of common symptoms of OSA (e.g., dry mouth in morning, gasping for breath during sleep, tossing and turning throughout the night, excessive sweating during sleep) were presented, and participants were asked to indicate whether they had experienced these symptoms. Participants were asked how many hours they typically slept on weekdays and weekends. Participants were also asked to rate the frequency of other common health related behaviors on a scale of 1 to 5, with 1 being "Never or Almost Never" and 5 being "Always or Almost Always." These behaviors included: smoking, caffeine use, use of alcohol as a sleep aid, use of pharmacological sleep aids, taking medications to stay awake, getting adequate sleep, exercise, and feeling anxious or stressed.

Music History Questionnaire

The Music History Questionnaire is a 6-item questionnaire, developed for use in the current study and designed to obtain information about primary instrument types, musical history, and current practice routines. Participants were asked to list the instrument that they currently played along with how many years they have played the instrument and how many hours per week they typically played the instrument. Participants were divided into 5 instrumental groups: (1) double reed woodwinds (e.g., oboe, bassoon, English horn); (2) single reed and flute woodwinds (e.g., flute, clarinet, saxophone); (3) high brass (e.g., trumpet, horn); (4) low brass (e.g., trombone, euphonium, tuba); and (5) non-wind (e.g., string, percussion, keyboard). One author with an extensive music background was able to classify less common or non-western instruments.

Berlin Questionnaire

The Berlin Questionnaire is a 10-item self-report questionnaire which was used to determine the risk of OSA. The Berlin Questionnaire has previously been validated[11] and assesses 3 aspects of risk for OSA, including snoring, daytime sleepiness, and either having hypertension or having a high body mass index (BMI). High scores on ≥ 2 of 3 categories suggests "high" risk for OSA. High scores on < 2 of 3 categories are believed to reflect "lower" risk for OSA.

Epworth Sleepiness Scale

The Epworth Sleepiness Scale is an 8-item self-report questionnaire, which was used to assess daytime sleepiness.[12]

Statistical Analysis

A total of n = 986 participants completed the survey. Data were analyzed for participants who currently played a musical instrument; n = 80 participants were excluded, leaving n = 906 in the final data set. Descriptive statistics were computed for demographic characteristics of the sample and reported in **Table 1**. Means and standard deviations were obtained for all continuous variables, while percentages were obtained for categorical variables. Chi-squared procedures were used to analyze demographic difference on categorical variables, and analysis of variance (ANOVA) with a Tukey post hoc was used to test for potential group differences in continuous variables. To assess the impact of instrument type on risk for obstructive sleep apnea, data were submitted to a series of binary logistic regression analyses. Results are reported in Tables 2 and 3. Statistical significance was determined using $\alpha = 0.05$.

RESULTS

Demographic information is depicted in **Table 1**. As would be expected, participants considered at high risk for OSA according to the Berlin Questionnaire reported increased frequency of OSA symptomatology, including dry mouth in the morning ($p < 0.001$), gasping for breath during sleep ($p < 0.001$), tossing and turning during the night ($p < 0.001$), recent weight gain ($p < 0.001$), frequent nighttime urination ($p = 0.005$), and excessive sweating during sleep ($p = 0.001$). Participants considered at high risk of OSA had significantly higher scores on the Epworth Sleepiness Scale ($M = 8.3$, $SD = 4.0$) than those considered at low risk ($M = 7.3$, $SD = 3.6$, $t(904) = 3.45$, $p < 0.001$).

Participants at high risk for OSA were also more likely to report a diagnosis of an anxiety disorder ($p = 0.002$), depres-

Table 1—Demographics by instrument type

	All	Double Reed	Single Reed	High Brass	Low Brass	Non-Wind
N	906	76	204	124	122	380
Age	42.9 (13.5)	41.7 (14.5)	43.8 (13.6)	42.0 (12.8)	44.0 (14.4)	42.7 (13.3)
Gender, male / female (%)	60.6 / 39.3	35.5 / 64.5	53.9 / 46.1	75.8 / 24.2	88.5 / 10.7	55.3 / 44.7
Race (%)						
White	89.5	96.1	91.7	94.4	90.2	85.3
Asian/Pacific Is.	3.8	1.3	2.9	0	0.8	6.8
Hispanic/Latino	3.2	1.3	2.0	3.2	2.5	4.5
Black	1.4	0	1.0	1.6	3.3	1.3
Other	1.8	1.3	2.5	0.8	3.3	2.1
BMI	26.1 (5.2)	24.1 (4.6)	25.5 (4.7)	27.2 (5.1)[a]	28.8 (5.5)[a]	25.6 (5.1)
Hours Sleep						
Weekday	6.8 (1.0)	6.8 (1.0)	6.8 (1.0)	6.8 (1.0)	6.7 (0.9)	6.8 (1.0)
Weekend	7.6 (1.1)	7.6 (1.2)	7.7 (1.0)	7.6 (1.2)	7.5 (1.1)	7.6 (1.1)
Epworth	7.6 (3.7)	7.8 (3.5)	7.3 (3.7)	7.7 (3.8)	7.6 (3.7)	7.7 (3.8)
OSA Diagnosis (%)	4.0	2.6	2.5	5.6	4.1	4.5
High Risk OSA (%)[c]	28.0	15.8	25.0	33.9	33.6	28.4
Years played instrument	30.2 (13.5)	28.5 (13.5)	30.1 (13.4)	29.3 (12.4)	29.8 (14.2)	31.0 (13.6)
Hours practice/week	13.2 (10.4)	15.4 (9.7)	12.2 (9.5)	13.7 (10.2)	10.4 (8.3)[b]	14.1 (11.4)

All numbers expressed as mean (standard deviation) or percentage. [a]p < 0.05 compared to double reed, single reed, and non-wind. [b]p < 0.05 compared to double reed and non-wind. [c]p < 0.05 χ^2 comparison among instrument types.

sion (p < 0.001), diabetes (p = 0.001), hypertension (p < 0.001), insomnia (p = 0.008), nasal allergies (p = 0.009), and obesity (p < 0.001).

Of those at high risk, 9.4% were diagnosed with OSA; 1.8% of those at low risk reported an OSA diagnosis (p < 0.001). Participants who self-reported a previous diagnosis of OSA were significantly more sleepy as measured by the Epworth Sleepiness Scale ($M = 10.7$, $SD = 4.3$) than those without OSA ($M = 7.5$, $SD = 3.6$, $t(904) = 5.18$, $p < 0.001$). Additionally, participants who reported a diagnosis of OSA were more likely to report dry mouth in the morning (p = 0.027), gasping for breath during sleep (p < 0.001), and tossing and turning during the night (p = 0.002).

There was a significant difference in the frequency of participants identified as having high OSA risk among the 5 instrument types (χ^2 (4) = 10.625, p = 0.031; see **Table 1**). Double reed instrumentalist had a lower than expected frequency of high OSA risk (adjusted residual = -2.5).

There were no significant differences among instrument types in self-report of psychiatric disorders (e.g., anxiety, ADHD, bipolar, depression), neurological disorders (e.g., seizure, stroke), cardiovascular disorders (e.g., heart disease, hypertension), respiratory disorders (e.g., asthma, nasal allergies), sleep disorders (e.g., insomnia, narcolepsy), or other health problems (e.g., chronic pain, diabetes, obesity). Additionally, no significant differences were reported among instrument types in activity level, smoking, amount of caffeine, alcohol before bedtime, use of sleep or wake medications, feeling of stress or anxiety, amount of exercise, or general state of health.

A binary logistic regression was conducted to explore the role of additional variables in the prediction of a high risk of OSA (see **Table 2**). Gender, age, number of years playing instrument, number of hours per week playing instrument, and instrument type were regressed onto OSA risk as determined by the Berlin Questionnaire.

BMI was not included in the regression model due to multicollinearity. Because a third of the Berlin Questionnaire is based on an individual's BMI, there is a high correlation between the 2 scores ($r_{pb} = 0.535$, p < 0.001). When BMI was included in the regression model, BMI was the only significant predictor of OSA risk (p < 0.001).

With BMI removed from the model, playing a double reed instrument predicted a lower risk of OSA as compared to non-wind instrumentalist (p = 0.047).

Double reed instrumentalist were the only group of musicians who was primarily female (see **Table 1**). Overall, there was a significant relationship between gender and high risk of OSA (19.4% of males compared to 8.6% of females, r = 0.11, p = 0.001). However, this relationship was no longer significant after controlling for BMI (r = 0.02, p = 0.618). Additionally, when submitted to the covariate adjusted regression model, gender was not a significant predictor of OSA risk (**Table 2**).

A second binary logistic regression was conduced on only double reed instrumentalists to determine which variables were related to a low risk of OSA (**Table 3**). The number of hours per week the instrumentalist played was the only significant predictor of OSA risk (p = 0.020). Double reed instrumentalists at low risk for OSA played on average 16.5 ± 1.2 h (mean ± SEM) per week, while those at high risk played on average 9.1 ± 2.7 h per week.

DISCUSSION

In this self-report survey of musicians, double-reed woodwind musicians (e.g., oboe, bassoon, English horn) were found to have a significantly lower risk of OSA than non-wind instru-

Table 2—Binary logistic regression predicting high risk of OSA according to the Berlin Questionnaire

Predictor	B	Wald's χ^2	df	p	Odds Ratio	95% CI
Years Playing	0.001	0.010	1	0.921	1.001	0.981 – 1.022
Hours Playing / Week	-0.014	3.256	1	0.071	0.986	0.970 – 1.001
Gender	-0.313	3.355	1	0.067	0.732	0.524 – 1.022
Age	0.016	2.162	1	0.141	1.016	0.995 – 1.038
Double Reed[a]	-0.676	3.949	1	0.047*	0.508	0.261 – 0.991
Single Reed[a]	-0.195	0.912	1	0.340	0.823	0.774 – 1.904
High Brass[a]	0.194	0.711	1	0.399	1.214	0.552 – 1.227
Low Brass[a]	0.101	0.182	1	0.670	1.106	0.696 – 1.757
Test		χ^2	**df**	**p**		
Overall Model Evaluation		30.456	8	> 0.001*		
Goodness-of-Fit Test						
Hosmer & Lemeshow		7.745	8	0.459		

[a]Comparison group is non-wind instrumentalist. *p < 0.05.

Table 3—Binary logistic regression predicting high risk of OSA according to the Berlin Questionnaire in double reed instrumentalists

Predictor	B	Wald's χ^2	df	p	Odds Ratio	95% CI
Years Playing	0.151	1.754	1	0.185	1.163	0.930 – 1.453
Hours Playing / Week	-0.120	5.411	1	0.020*	0.887	0.802 – 0.981
Gender	0.282	0.145	1	0.703	1.325	0.311 – 5.648
Age	-0.114	1.138	1	0.286	0.892	0.723 – 1.100
Test		χ^2	**df**	**p**		
Overall Model Evaluation		11.088	4	0.026*		
Goodness-of-Fit Test						
Hosmer & Lemeshow		15.550	8	0.057		

p < 0.05.

mentalists (e.g., string, percussion, keyboard). There were no other significant differences in self-reported risk of OSA among musicians trained in other instrument types (i.e., single reed woodwind, high brass, low brass). The results of the present study are consistent with the theory[6] that upper airway stimulation associated with the playing of specific musical instruments may provide an effective alternative method of treatment for persons diagnosed with OSA, particularly those with mild to moderate forms of OSA, for which CPAP may be ineffective or inappropriate.

Sleep in patients with OSA is accompanied by decreases in neuromuscular activity of muscles, which dilate and stiffen the pharyngeal airway during inspiration.[13,14] Interestingly, an increase in muscle activity, presumably compensatory in nature, occurs in these patients during wakefulness. Changes in morphology and proportion of fiber type consistent with muscle injury have been observed in the upper airway dilator muscles, both in animal models of OSA[15] and in OSA patients.[16] Randerath et al.[5] found that training of the tongue muscles by electrostimulation was effective in reducing snoring in OSA patients. A significant reduction in symptoms and overall severity was demonstrated in patients with moderate OSA following an extensive oropharyngeal exercise program, derived from speech therapy.[3] Thus, both electrical and physical stimulation (via exercise) may have beneficial consequences and contribute to proper maintenance of upper airway patency.

A novel approach to the facilitation of upper airway function involves training on musical instruments which require respiratory expiration. Lessons and daily practice of the didgeridoo, a wind instrument of indigenous Australian descent, reduced both daytime sleepiness, and indices of disease severity (e.g., apnea-hypopnea index) in patients with OSA.[6] As these authors suggest, treatments are not effective unless they are practiced consistently. Compliance with a regimen that involves playing a musical instrument may be more successful (at least among musical enthusiasts) than compliance with a daily regimen of oropharyngeal exercises.[6] However, it should be noted that in the present study, double reed musicians at low risk for obstructive sleep apnea played their instruments for an average of 16.5 hours per week, which may be too large a commitment for some people with OSA. Additionally, double reed instruments are notoriously difficult to learn to play properly.

It is then reasonable to suggest that a lower incidence of OSA might be anticipated in professional wind instrumentalists, compared to non-wind instrumentalists or to non-musicians. Brown et al.[8] examined the risk of OSA in a large sample of orchestral musicians. No significant differences in the risk of OSA were found between wind and non-wind instrumentalists. Even woodwind and brass musicians were not found to be different from non-wind musicians. However, this study did not take into account the different types of woodwind instruments. In fact, double reed woodwind instrumentalists in the present study did present a significantly lower risk of OSA compared to non-wind instrumentalists.

What factor(s) could account for this selective difference? Resistive respiratory muscle strength training has been used to relieve symptoms of sleep disordered breathing in patients with paralysis.[17] Both double reed wind instruments (e.g., oboe, bassoon, English horn) and high brass (e.g., trumpet, horn) are played by blowing through a small aperture. Thus, both double reed wind and high brass instruments are associated with a relatively high air resistance,[18] yet only double reed wind instruments were associated with lower risk of OSA. Air pressures associated with playing the oboe (30-42 mm Hg) or the bassoon (15-39 mm Hg) are somewhat high relative to other instruments, but certainly not out of the range of trumpets (13-42 mm Hg) or saxophones (20-46 mm Hg).[19] These data argue against air pressure or resistance as a mechanism of interest. Puhan et al.[6] suggested that circular breathing may be a mechanism by which didgeridoo practice reduces OSA symptomology. However, in a large scale survey of musicians, circular breathing was not found to be related to either the risk of OSA or OSA diagnosis.[8]

Rather, we suggest that a critical factor may involve the different muscles (or different pattern of muscle activation) that are likely to be activated by the playing of different types of instruments. For double reed woodwind instruments, the lips are placed on a relatively small mouthpiece, and the musician makes a "buzzing" sound. For clarinet or saxophone, one forms something of an overbite over a much larger mouthpiece. For all brass instruments, the lips are brought together as if forming the sound of the letter "m." Thus, it is quite likely that separate categories of instruments activate different programmed sequences of movements (and the associated muscles). Each distinct pattern of activation may support the patency of the upper airway to a greater or lesser extent. Few empirical studies currently address the muscle physiology particular to categories of musical instruments, and this suggests one direction for future research.

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