Sleep Science and Practice

BRIEF REPORT

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Didge you sleep: a feasibility study of didgeridoo training for obstructive sleep apnea

Varun Badami[1,2], Nawaf Abaalkhail[1,2], Alex Petro[1], Cathy Alessi[1,2], Jennifer L. Martin[1,2], Maria Cristina Sanchez[1,2], Joseph M. Dzierzewski[3], Alex Suarez[4] and Constance H. Fung[1,2*]

Abstract

Intolerance of positive airway pressure therapy for obstructive sleep apnea is common. Upper airway muscle therapies show promise as alternative treatments. The didgeridoo, which is a musical instrument, can be used for upper airway muscle training. Our goal was to develop a group-based didgeridoo training program for obstructive sleep apnea. We conducted a proof-of-concept single-arm study consisting of a structured didgeridoo training regimen. We surveyed patients at a large medical facility about their interest in the program. We developed and tested a manual of procedures for conducting a 4-session group program conducted over 8 weeks that instructed participants on use of the Medical Didgeridoo. We also refined procedures for baseline and 4-month follow-up assessments, which included measures of daytime sleepiness and apnea–hypopnea index. Interviews were conducted at follow-up to obtain feedback about the program. Of the 56 survey respondents, 67% reported difficulty with positive airway pressure, expressed interest in participating in a structured upper airway muscle training program, and indicated that they would be willing to practice exercises for 30 min per day. After in-depth screening of 15 patients, we recruited five patients to participate in the structured training program; all five completed the program and were able to learn to play basic sounds on the provided instrument, and four stated they would continue to play the Medical Didgeridoo after completion of the program. Given the significant level of interest and excellent participation in the didgeridoo training program, it may be feasible to conduct a large-scale study to assess treatment response.

Keywords Therapy, Instrument, Oropharyngeal, Non-pharmacological, Exercise, Feasibility

Introduction

Obstructive sleep apnea (OSA), which is characterized by repetitive episodes of airflow reduction or cessation despite ongoing effort to breathe, causes blood oxygen desaturation and arousals and has wide-ranging consequences, including increased risk of hypertension and heart disease.(Marin et al. 2005) Upper airway collapse results when decreased dilator muscle tone occurs in the setting of either a highly compliant or narrow airway. (McNicholas 2022; McNicholas & Pevernagie 2022) At sleep onset in normal individuals, there is an initial fall in muscle activity. However, this fall in muscle activity is transient in the phasic muscles; subsequently, during

*Correspondence:
Constance H. Fung
cfung@mednet.ucla.edu
[1] Geriatric Research Education and Clinical Center, VA Greater Los Angeles Healthcare System, 16111 Plummer Street 11E, North Hills, CA 91343, USA
[2] Department of Medicine, David Geffen School of Medicine at University of California, Los Angeles, 16111 Plummer Street 11E, North Hills 91343, CA, USA
[3] National Sleep Foundation, 2001 Massachusetts Ave NW, Washington, DC 20036, USA
[4] Asate AG, Hämmerli 6, 8855 Wangen, Switzerland

non-REM (NREM) sleep, phasic genioglossus activity is increased, but tonic tensor palatini activity continues to fall. In contrast, patients with OSA have a greater reduction in genioglossus activity, predisposing patients to airway collapse.(Cori et al. 2018; Oliven et al. 2020).

Continuous positive airway pressure (CPAP) remains the gold standard treatment of OSA. However, CPAP adherence is problematic, with some studies citing 30–40% long-term compliance.(Rotenberg et al. 2016) Therefore, several novel and non-CPAP treatment modalities have been developed including neuromuscular stimulation.(Fleury Curado et al. 2018; Strollo et al. 2014) In congruence with the hypothesis that less invasive muscle training may directly address the pathophysiology of airway collapse, myofunctional therapy may result in improvement of subjective measures of sleepiness and objective measures of OSA severity.(O'Connor-Reina et al. 2020; Rueda et al. 2020).

Playing a musical instrument is one method of training the upper airway muscles. One such instrument which has shown promise in improving OSA is the didgeridoo, which is a long cylindrical musical instrument belonging to the "wind family". One study found practicing the didgeridoo resulted in reduction in daytime sleepiness in patients with OSA.(Puhan et al. 2006) The authors hypothesized that producing sustained sounds from the instrument for prolonged periods may lead to strengthened upper airway muscles, and that group-based learning could be beneficial to new learners by providing opportunities to overcome barriers to learning.

Our study aimed to explore the feasibility of recruiting and retaining participants for a larger trial that would use the didgeridoo as a method to train upper airway muscles as a treatment for OSA, taught in a group-based format.

Methods

Overview

This single arm study assessed the feasibility of a structured, group-based upper airway muscle training program using the didgeridoo instrument. Because this work is in an early investigative phase, we were most interested in recruitment methods, program delivery/program implementation, adherence to the program and protocol, and retention, rather than definitive estimates of program efficacy. We chose a muscle-training program length of 8 weeks with a 4-month follow-up, based on a prior study that tested a similar program taught in private individual sessions.(Puhan et al. 2006) The study protocol was approved by our institutional review board (Fig. 1).

Participants and screening

Figure 1 summarizes participant recruitment and screening. Patients at a Department of Veterans Affairs (VA) facility in Los Angeles were recruited from February 2016 to November 2016. Recruitment flyers were posted within the facility. In addition, a brief postal survey was mailed to patients who were nonadherent to prescribed sleep apnea therapy (based on medical record review), assessing interest in completing a 4-session program on "breathing exercises" for OSA and attitudes towards OSA, CPAP, and alternative therapy for OSA. The survey also included the Epworth Sleepiness Scale (ESS) to assess daytime sleepiness, a common symptom of OSA.(Johns 1991) Telephone screening was attempted for 52 individuals (we did not contact all individuals who returned a survey, because some respondents did not express interest in our program). Individuals who screened eligible and expressed interest in the program ($n=15$) were invited for an in-person consent appointment followed by an in-person structured interview, home sleep apnea testing, and medical record review to determine eligibility for the study. Of the 15 individuals, 5 were deemed eligible to participate in the group program. This was also our target number, which was a balance of the group being large enough to provide the opportunity for participants to share their experience with other veterans yet small enough to receive sufficient attention from program staff.

Study inclusion criteria were 1) age 21 years or older, 2) diagnosis of OSA (apnea–hypopnea index $>=15$ on WatchPAT), 3) current prescription for therapy for OSA, and 4) non-adherent to positive airway pressure or oral appliance therapy. Exclusion criteria were 1) history of chronic lung disease, 2) serious medical or mental health condition, 3) use of sedative-hypnotics, 4) self-assessed inability to breathe through nose, or 5) institutionalized.

Intervention/training program

The program included four weekly in-person group sessions (Table 1). On the first day, participants were introduced to program goals and were given an acrylic instrument, the Medical Didgeridoo (Asate AG, Zurich, Switzerland). Each Medical Didgeridoo was fitted with a vibration counter to objectively measure the length of time the instrument was played; however, the counter was subsequently not found to be reliable, so these data were not included in the analyses. Then, participants viewed a live, instructional video led by a trained didgeridoo instructor (AS), who introduced the fundamentals of playing the didgeridoo with an emphasis on specific techniques (e.g., making vowel sounds while blowing into the didgeridoo) that may impact muscles involved in OSA. The session included basics of lip technique to produce and hold the keynote for 20–30 s. The research team provided hands-on technical assistance to the participants such as demonstrating how to hold the didgeridoo.

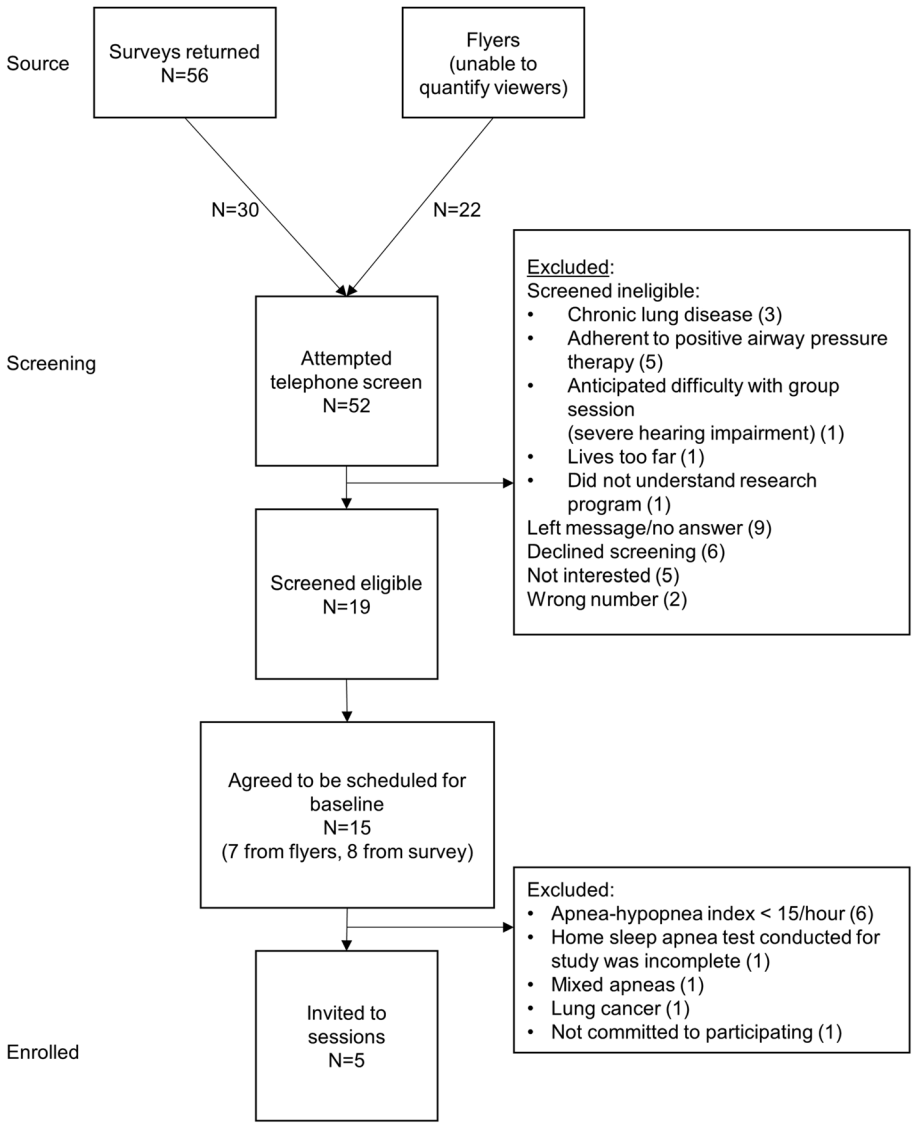

Fig. 1 Participant recruitment and screening are summarized in the figure

Table 1 Description of muscle training sessions

Session	Description
1 (week 1)	How to produce basic sound with Medical Didgeridoo. Cheek exercises such as "bullfrog technique" and blow continuously. Tongue exercises with playing "A" and "E" sounds
2 (week 2)	Throat exercises with playing "O" and "E" sounds. Abdominal exercises with playing "E" sound with "bear down technique" which is pushing belly button out. Then practice vowels from this, and previous, session
3 (week 4)	Review and troubleshoot previous exercises and vowels
4 (week 8)	Review, troubleshoot and share previous exercises and vowels techniques

At Week 2, the participants attended a second group session and watched another online class that emphasized technique for producing sounds. At Week 4, the live video stream focused on optimization of producing didgeridoo sound. At Week 8, the live video content focused on refinement of didgeridoo skills.

At the end of the first session, participants were given a practice log and instructions about the types of techniques to practice for the week. They were advised to practice for at least 30 min daily and maintain a practice log. This was reinforced in each group session.

Measures and statistical analysis

We collected baseline demographics (age, gender, years of education, employment status, race, ethnicity) as well as previous history of playing a musical instrument. ESS was used to quantify burden of daytime sleepiness. (Johns 1991) OSA severity was measured by home sleep apnea testing via WatchPat (Zoll Itamar Ltd, Caesaria, Israel). All assessments including home sleep apnea testing were conducted prior to initiation of training and 4 months after completion of Medical Didgeridoo training. Descriptive statistics were used to summarize postal survey participant characteristics and measures.

Results

Survey results (interest in program)

We mailed 344 surveys, and 56 veterans returned a completed survey (16% response rate). Of 56 respondents (97% male), two-thirds (67%) expressed interest in a didgeridoo program comprised of 4 classes where they would learn breathing exercises, and 68% indicated they would practice the exercises 30 min daily. Fifteen (27%) respondents indicated that they were currently dissatisfied with their OSA treatment, 67% reported difficulty using CPAP, and 77% believed that treating OSA is important to their health. Mean survey ESS score was 10.9 (SD: 4.7).

Participant characteristics and clinical outcomes

Table 2 shows baseline demographics as well as objective measures of daytime sleepiness and OSA severity. One of the participants had played a musical instrument previously. All participants at the 4-month follow-up had apnea–hypopnea index (AHI) $\geq$ 15. ESS decreased in 3 participants but increased in 2 participants.

Acceptability and feasibility of protocol

All 5 participants completed the 4-session training program and learned how to play a basic sound, and 4 out of 5 were able to perform specific didgeridoo skills. However, there was varying adherence with practicing the Medical Didgeridoo at home and with completing the daily practice log. We also found that the vibration/sound monitor that was attached to the didgeridoo to count minutes of practice was not reliable. This monitor (not a native part of the Medical Didgeridoo) was secured to the Medical Didgeridoo with a clamp, but clamp could not be tightened sufficiently to capture the vibrations consistently. All 5 participants completed the follow-up assessment, including the repeated home sleep apnea test. In addition, impressions and suggestions from each participant were documented following intervention sessions (summarized in Table 3). Four patients stated they would continue to practice the didgeridoo.

Discussion

These findings suggest that upper airway muscle training using the Medical Didgeridoo is a feasible and potentially promising alternative therapy to be explored further for OSA. We successfully created and tested a structured program for teaching patients exercises to train upper airway musculature using the Medical Didgeridoo. We also developed and tested a manual of procedures for identifying patients who have interest in a training program and recruited and retained participants for the duration of the program. Results of this study provide a

Table 2 Participant characteristics and sleep measures

Participant Age, Gender	Years of Education	Employed	Race & Ethnicity	Epworth Sleepiness Scale		Apnea Hypopnea Index	
				Pre	Post	Pre	Post
#1–64 M	16	Yes	Caucasian, Non-Hispanic	17	11	17	20
#2–71 M	14	No	Caucasian, Hispanic	7	9	16	36
#3–68 M	16	No	Asian, Non-Hispanic	4	8	34	45
#4–53 M	19	No	Caucasian, Non-Hispanic	11	8	64	79
#5–68 M	16	No	African American, Non-Hispanic	16	12	32	50

M Male

Table 3 Participant experience

Participant	Impression	What did you like least about sessions?	Experience practicing between sessions?	Future plans?
#1	"Adventurous"	"No fun in it. Would like it to be more creative to continue using it. Teach music aspect of it to be interesting"	"Boring, need a goal"	"Plan to play it, continue to use it"
#2	"Very good"	"Long drive to get here"	"No trouble, no problems. Practiced in living-room, and granddaughter didn't like it"	"I see playing it once in a while"
#3	"Tempered by guilt for not playing the didgeridoo enough"	"The sound quality [of video session]"	"Inspiring. I felt I was doing something for my health. I would practice when I thought of the consequence of not treating sleep apnea"	"At home, alone. I'm just going to have it near me. I enjoy playing it. My only concern is that it will wake people up"
#4	"I really enjoyed the sessions. I enjoyed them a great deal."	"None"	"I enjoyed it but I have to say that a lot of the time I had to practice in the car or outside due to interference from my wife"	"I have put it aside. You can't play a tune with it. I use it once in a while"
#5	"Fun, adventure, a good thing. The concept is great"	"Sound quality and accent of speaker [on video]"	"Relaxing and therapeutic. Even my wife got used to it and wouldn't mind if she heard it while watching tv"	"I will continue to play. I really enjoy it. I actually tried to make a shorter, travel size didgeridoo"

foundation for building and testing a full-scale program testing use of the didgeridoo in OSA.

Our survey results indicate a high level of interest in non-CPAP modalities for OSA therapy. Survey respondents had significant daytime sleepiness, and two-thirds of survey respondents were interested specifically in a breathing exercise program. The structured didgeridoo training program was offered to 5 patients in this initial study; all participants completed the training program, which consisted of a series of four in-person sessions, multiple surveys over a four-month follow-up, and a post-training program home sleep study. Participants had a positive impression of the training program, with plans to continue use of the provided didgeridoo instrument. The only other published didgeridoo training program study, to our knowledge, was conducted in a private practice setting in Europe with non-obese patients.(Puhan et al. 2006) Our study conducted in a US VA healthcare system in a group instructional setting provides new insight into the use of the Medical Didgeridoo as an alternative OSA therapy.

Treating OSA by specifically addressing upper airway anatomy and the airway dilator muscles has gained increased focus. Oropharyngeal exercises alone have been previously found to be effective mechanisms in reducing upper airway collapsibility during sleep, showing reductions in both symptoms of sleepiness and snoring as well as objective findings of OSA with significantly reduced AHI. In meta-analyses, oropharyngeal exercises have shown some improvement in oxygen saturation nadir, sleepiness and AHI in both children and adults. (Rueda et al. 2020) One specific population of patients who regularly perform upper airway exercises are musicians who play wind instruments. A meta-analysis evaluating sleep in wind instrument musicians showed that both singing and double-reed instrument playing had positive self-reported effects on sleeping and snoring, though there was no objective change in ESS or OSA diagnosis.(van der Weijden et al. 2020) It is important to note that the only prospective trial included in the analysis was Puhan and colleague's didgeridoo study of 25 patients who underwent individual training, which did in fact show improvements in ESS and AHI after a structured training program.(Puhan et al. 2006).

A few challenges and potential avenues of improvement were noted in creating and administering the training program. Our mailed survey had a modest response rate, which limits generalizability of the survey results; however, the survey was helpful for identifying patients with interest in the program. Including a follow-up survey for non-responders would likely increase the response rate in a future study. One consistent feedback was difficulty in using the Medical Didgeridoo, which is distinct from playing a classical wind instrument. Measuring adherence to practicing the didgeridoo was also a challenge in this feasibility study; one potential solution for a future program is the integration of an electronic device with the didgeridoo to objectively monitor the instrument. Furthermore, consistently providing in-person sessions for training can be logistically complicated; a potential solution could be a virtual training montage. Additional sessions (especially virtual) scheduled weekly for 8 weeks or longer instead of 4 sessions may be one method of improving program success rate. Weekly sessions would be more consistent with the frequency of musical instrument lessons. Selecting participants who have experience regularly practicing a musical instrument may yield more success in a future program. The participants indicated that a barrier to practicing was the loud sound associated with practicing. Selecting participants who have a location where they could practice regularly would be an important step for a future program. Participants of a future program might practice more if they could mute the sound of the instrument or if a quieter instrument were available. Similarly, a smaller version of the instrument would reduce the barriers to practicing. Selecting individuals who are not planning to travel during the study intervention period would be important for a future study. Finally, this study was not powered to assess for specific changes in sleepiness or objective measures of OSA severity, but rather to assess interest in conducting a larger program in the future. Since practicing is a key step in producing clinical outcomes, reducing the barriers to practicing would likely increase the likelihood of a clinical response (e.g., reduction in hypersomnolence) to the program. Previous studies in both pharyngeal training and didgeridoo specifically have shown improvement in these outcome measures.

Conclusion

We created a structured program of in-person, group training to assess if Medical Didgeridoo use could be a feasible alternative to train the upper airway musculature and treat sleep apnea, and we found that patients were motivated but moderately adherent to daytime practice regimens. Given the level of interest, further work is needed to address whether medical didgeridoo training should be considered for individuals considering alternative treatment for OSA.

Abbreviations

OSA	Obstructive sleep apnea
CPAP	Continuous positive airways pressure
VA	Veterans affairs
AHI	Apnea hypopnea index
ESS	Epworth sleepiness scale

Acknowledgements
We are appreciative of the support of Karen Josephson and Stella Jouldjian, who provided feedback on the program materials and advice on the project.

Authors' contributions
CHF, CA, JLM, and JMD were responsible for the overall design of the study. AS provided the live, instructional video and the didgeridoo instructional material. AP, MCS, and CHF collected the data. CHF, VB, NA, CA, and JLM analyzed the data. VB, NA, CA, JLM, AS, JMD, and CHF prepared the manuscript. All authors reviewed the manuscript.

Funding
This project was funded by UCLA Department of Medicine Start Up fund (to CHF) and supported by the VA Greater Los Angeles Geriatric Research, Education and Clinical Center. Only the authors were involved in the design of the study and collection, analysis, and interpretation of data and in writing the manuscript.

Availability of data and materials
The datasets used and/or analyzed during the study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
The study protocol was approved by our institutional review board, VA Greater Los Angeles Healthcare System. Written informed consent was obtained by participants of the group didgeridoo sessions. A waiver of documentation of informed consent was granted for the survey.

Consent for publication
Not applicable.

Competing interests
Alex Suarez is President of Asate AG, which is the manufacturer of the Medical Didgeridoo used in the study. All Medical Didgeridoo instruments used in the study were purchased by the project team.

Received: 21 May 2023 Accepted: 13 December 2023
Published online: 25 January 2024

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