A Feedback-Controlled Mandibular Positioner Identifies Individuals With Sleep Apnea Who Will Respond to Oral Appliance Therapy

John E. Remmers, MD; Zbigniew Topor, PhD; Joshua Grosse, MMath; Nikola Vranjes, DDS; Erin V. Mosca, PhD; Rollin Brant, PhD; Sabina Bruehlmann, PhD; Shouresh Charkhandeh, DDS; Seyed Abdolali Zareian Jahromi, PhD

1University of Calgary, Calgary, Canada, 2Zephyr Sleep Technologies, Calgary, Canada, 3The Snore Centre, Calgary, Canada, 4University of British Columbia, Vancouver, Canada

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Predicitive Accuracy of an In-Home Computer Controlled Mandibular Positioner in Identifying Favourable Candidates for Oral Appliance Therapy

INTRODUCTION

Obstructive sleep apnea (OSA) is a chronic disease caused by repeated narrowing or closure of the pharynx during sleep. The disease compromises quality of life, increases risk of accidents, and is associated with increased risk of cardiovascular events and reduced survival rate. Continuous positive airway pressure (CPAP), the standard therapy for this disease, is efficacious and benign. However, long-term compliance with CPAP is low and this may contribute to its ineffectiveness in preventing adverse cardiovascular outcomes. Oral appliance therapy is an alternative therapy that protrudes the mandible, thereby opening the pharynx. Though individuals generally prefer oral appliances, their efficacy rate is less than ideal.

Prospective selection of individuals who respond to oral appliance therapy should increase the clinical utility of the therapy, and research has focused on predicting outcome with oral appliance therapy. Disease severity, body position during sleep, age, sex, weight, and other anatomical features and clinical variables have been investigated and found to correlate with outcome. Similarly, encouraging results have been reported with pharyngeal imaging and nasoendoscopy. However, none of these approaches has been shown in prospective studies to identify individuals who will experience therapeutic success with oral appliance therapy. Use of a remotely-controlled mandibular positioner (RCMP) used during sleep has been demonstrated to accurately identify such individuals. This test uses temporary dental trays and is carried out in a polysomnographic setting, where a technologist advances the mandible

BRIEF SUMMARY

Current Knowledge/Study Rationale: Oral appliances that protrude the mandible are a potentially important therapy for the treatment of obstructive sleep apnea. However, only 50% to 70% of individuals with sleep apnea experience a satisfactory therapeutic response to the therapy. Hence, we need a test that prospectively identifies therapeutic responders.

Study Impact: The current study describes a feedback-controlled mandibular positioner for use at home and demonstrates that it prospectively identifies individuals with obstructive sleep apnea who will respond to oral appliance therapy. Additionally, the feedback-controlled mandibular positioner test provides a mandibular position that is efficacious in almost all responders.
METHODS

General
This study was approved by the Conjoint Health Research Ethics Board of the University of Calgary, and informed consent was obtained from all participants. Participants were recruited from the population of patients seen by the principal investigator or other sleep physicians at the outpatient clinic of the Foothills Medical Center Sleep Disorders Center (Calgary, Alberta, Canada), and by the dental co-investigators at The Snore Centre (Calgary, Alberta, Canada). Most of the individuals referred to the recruitment sites were referred for snoring or suspected sleep-disordered breathing; all potential study participants received an in-home cardiorespiratory evaluation during sleep (Snore Sat Recorder, Sagatech Electronics, Inc., Calgary, Alberta, Canada) to document their oxygen desaturation index (ODI) and oxyhemoglobin indices. All study participants were required to meet the following eligibility criteria: ability to understand and provide informed consent, age between 21 and 80 years, OSA (ODI > 10 events/h), body mass index (BMI) < 45 kg/m², neck circumference < 50 cm, absence of severe oxyhemoglobin desaturation during sleep (indicated by a mean oxyhemoglobin saturation > 90%), mandibular range of motion > 5 mm, adequate dentition (10 upper and 10 lower teeth), ability to breathe comfortably through the nose, absence of central sleep apnea, absence of anticipated changes in medical therapy that could alter OSA severity during the study, absence of anticipated change in body weight (≥ 5%) during the study, absence of symptomatic nonrespiratory sleep disorders (eg, restless legs syndrome, chronic insomnia), absence of severe respiratory disorder(s) other than sleep-disordered breathing, and absence of loose teeth or advanced periodontal disease.

A 2-part investigation was performed involving 2 separate groups of participants. Part 1 was carried out on a first group of participants (n = 149) to develop a predictive method. Part 2 was carried out on a second, different group of participants (n = 53) to evaluate prospectively the accuracy of the predictive method. Although the participants in part 1 and part 2 were different individuals, the procedures and protocol were the same in both parts of the study. Specifically, all participants underwent a 2-night feedback-controlled mandibular positioning (FCMP) study, and all received a custom treatment appliance. All participants underwent outcome testing with the treatment appliance in the mouth for 2 nights in the home using a validated monitor that automatically calculates a 4% ODI. Therapeutic success or failure was defined as a mean ODI from the 2 outcome studies of less or greater than 10 events/h, respectively.

Feedback-Controlled Mandibular Positioner
The FCMP system received and processed nasal airflow and oxyhemoglobin saturation (O₂ Sat) signals and identified REs in real time at the participant’s bedside. Signal processing was performed by a laptop computer that formed part of the FCMP system (Figure 1). O₂ Sat was derived from a pulse oximeter (MS-2040 Masimo Corporation, Irvine, California) using a finger hood probe. Nares pressures were recorded separately from each naris using a dual catheter system, with each naris cannula leading to a separate pressure transducer. Airflow in each naris was calculated as the square root of naris pressure, with total respiratory airflow being the sum of the 2 airflows. Tidal volume was calculated as the integral of inspiratory airflow, and breath-by-breath ventilation as the ratio of tidal volume to respiratory period. REs were detected in real time and were stratified in relation to the magnitude of decrease in O₂ Sat and ventilation by the FCMP device.

The FCMP device also included a computer-controlled mandibular positioner consisting of a linear actuator attached to...
temporary dental trays (Figure 1). The mandibular positioner and temporary dental trays were identical to those used in previous studies of the RCMP device.42–45 Briefly, upper and lower trays were filled with impression material and attached by anterior brackets to a linear actuator that moved the mandible in the anterior-posterior axis. The FCMP study comprised 2 full-night sequences. At the beginning of each night, the test was initiated with the dental trays set at the participant’s habitual bite and was allowed to protrude only to the previously measured maximum voluntary protrusion for the participant. At the test start, or following interruption of operation by the participant, the mandible was held at a static position for 30 minutes before the controlling algorithms began active adjustment. The first night entailed a dynamic interaction between the controller and observed REs. The size and timing of the protrusive step depended on the number and grade of REs, and ranged from 0.2 mm of movement after a 3-minute delay to 1.4 mm of immediate movement. Successive protrusive movements were separated by at least 3 minutes with the distance moved being the sum of all singular steps associated with individual REs detected during this period. Each singular step was 0.2 mm with a minimum 5-second delay to ensure a slow rate of adjustment. If no REs were observed during a particular 3-minute interval, small perturbations were carried out in which the mandible was protruded in two 0.3-mm steps separated by a 2- to 5-second delay, then returned 0.6 mm to the prior position if the preceding protrusion did not result in a significant increase (≥ 30%) in respiratory airflow. Conversely, the mandible was retruded 0.6 mm and held at that position if the airflow did not decrease. If the retrusive step caused a decrease in airflow, the mandible was returned to the position prior to the retrusive step. Perturbation activity was abandoned upon detection of an RE. The results of this first study night were used to automatically calculate a provisional prediction of oral appliance therapy outcome and a predicted efficacious protrusive position at which to start the next night of study.

The second night was a quasi-static study involving smaller, less frequent adjustments in mandibular position in order to evaluate the efficacy of the predicted efficacious protrusive position derived from the dynamic study. The movement of the mandible was restricted at or near the provisionally predicted efficacious protrusive position derived from the dynamic study night, and a continuous ODI calculation (number of REs/elapsed time) commenced in real time. Once the predicted efficacious protrusive position was reached, the mandible was not moved unless the ODI exceeded 10 events/h for 2 hours or more. In that case, the mandible was advanced 0.6 mm and the continuous ODI calculation was reinitiated. The mandible was held in this position or advanced 0.6 mm if the ODI value exceeded 10 events/h after 1 hour, and so on. Though the FCMP test was designed to find an efficacious protrusive position, not necessarily the minimum efficacious protrusive position, the system automatically prompted a third study night at a starting protrusive value of 70% if the results from the second study night predicted an efficacious protrusive position > 80%. This was done in an attempt to find a lower efficacious protrusive position than the one tested during the second study night.

Figure 2—Classification error versus number of trees in the random forest.

Classification error is a prediction of the accuracy of the random forest when it is applied to a population other than the one it was trained on. Note that the error stabilizes at approximately 250 trees; 400 trees were used to optimize accuracy.
A random forest (RF) machine learning method was developed in part 1 of the investigation. The RF machine was trained by providing data from the FCMP study carried out on each part 1 participant, together with the binary outcome for that participant, ie, therapeutic success or failure derived from the home sleep study with the oral appliance in place. Specifically, 266 features were extracted from both nights of each FCMP study. The RF machine uses multiple decision trees, and we evaluated the dependence of classification error on the number of trees using the “out of bag” method. Figure 2 shows the relation between classification error and number of trees. A 400-tree RF system was selected as this number provided a classification error that was clearly at a minimum value. In order to predict the overall outcome, each of the 400 decision trees gave a prediction of either therapeutic success or failure. All decision trees were polled, and the majority poll determined the final prediction for that study. Therapeutic success was predicted if more than 50% of decision trees predicted success and therapeutic failure if fewer than 50% of decision trees predicted success. Prediction of therapeutic outcome was performed solely by the RF machine, without human intervention, based only on data derived from the FCMP test.

The internal predictive accuracy of the trained RF machine was assessed by three tenfold cross-validation tests applied to part 1 participants. The external predictive accuracy of the trained RF machine was evaluated by applying it to the FCMP test data from part 2 participants, none of whom had participated in part 1. The observed outcomes of part 2 participants were not supplied to the machine. Rather, using the FCMP data alone, the RF machine prospectively predicted the therapeutic outcome (success or failure) for each part 2 participant. Each prediction was then compared to the actual therapeutic outcome (success or failure) observed for that participant. A binary agreement analysis was carried out by calculating sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV).

**Research Protocol**

The research protocol is outlined in Figure 3. Participants underwent a 2-night respiratory home evaluation during sleep with a Snore Sat Recorder to determine baseline ODI and visited the dentist for fitting of the temporary trays and for determination of the habitual bite and maximal voluntary protrusive position, as described previously. These readings were used as range of motion limits during the test. Before the night 1 FCMP test, a technician visited the home and instructed the participant on the use of the bedside equipment and self-application of the nasal cannula, O2 Sat probes, and temporary dental trays. On the morning following each study night, data from the FCMP system were uploaded, analyzed, and used to set the parameters for the next night of study. Upon completion of the study, the FCMP system automatically calculated a prediction of either therapeutic success (outcome ODI < 10 events/h) or failure (outcome ODI > 10 events/h) for each participant. For those individuals predicted to experience therapeutic success, the FCMP system automatically calculated a predicted efficacious protrusive position. After completing the FCMP test, each participant received a custom treatment appliance, either a SomnoDent G2 (SomnoMed, Sydney, New South Wales, Australia) in part 1 or a Micro2 (ProSomnus Sleep Technologies, Pleasanton, California, United States) in part 2. Though the dentists were blinded to the FCMP prediction, they were provided with a target protrusive position for each participant’s custom oral appliance. The target was either the predicted efficacious protrusive position for those individuals who were predicted to experience therapeutic success, or, for individuals predicted by the FCMP test to experience therapeutic failure, a default value of 70% of the protrusive range. The custom oral appliances were set to the target protrusive position (either immediately or over a period of a few weeks if required) and a 2-night home sleep study with the custom appliance was performed. If the ODI value was < 10 events/h, the individual was considered a therapeutic responder. If the ODI value was > 10 events/h, the
appliance was advanced progressively with periodic respiratory home evaluations during sleep until therapeutic success was observed or maximum protrusion was reached.

### RESULTS

As shown in Figure 3, 202 individuals meeting the acceptance criteria were recruited for the study: 149 in part 1 and 53 in part 2. Five individuals from part 1 and two individuals from part 2 had inconclusive FCMP tests (ie, no prediction) and declined further testing. Thirteen individuals from part 1 and three individuals from part 2 were lost to follow-up and did not complete the study protocol. The final study population, therefore, consisted of 179 individuals who completed the study protocol: 131 in part 1 and 48 in part 2.

As shown in Table 1, participants were, on average, middle age, predominantly male, obese, and had moderate sleep apnea. The mean baseline physiological characteristics, including sex distribution, adjusted neck circumference, arterial oxygen saturation, or SaO2, time spent at < 90% SaO2, and sleep apnea scales (Epworth Sleepiness Scale, Sleep Apnea Quality of Life Index, and Pittsburgh Sleep Quality Index) for participants in the 2 parts were comparable except that the mean BMI and mean baseline ODI were significantly greater in part 2 than part 1. A plot of participants’ baseline ODI in relation to their BMI, shown in Figure 4, reveals an overlapping distribution of points for participants in parts 1 and 2.

The overall oral appliance success rate was 76.3% for phase 1 and 70.8% for phase 2. The difference between the 2 values was not statistically significant (P = .44; Fisher exact test). The distribution of baseline ODI in relation to BMI for therapeutic responders and nonresponders (Figure 4) reveals that therapeutic outcome cannot clearly be predicted by the ODI/BMI relationship. Of the 101 obese (BMI > 30 kg/m²) participants who completed either part of the study, 68.3% experienced therapeutic success (outcome ODI < 10 events/h). Of the 51 individuals with severe OSA (ODI > 30 events/h) who completed either part of the study, 52.5% experienced therapeutic success.

The final outcome response to custom oral appliance therapy for FCMP predicted responders and for FCMP predicted nonresponders in part 2 is shown in Figure 5. With one exception, all predicted responders experienced therapeutic success (outcome ODI < 10 events/h), and 13 of 18 predicted nonresponders experienced therapeutic failure (outcome ODI > 10 events/h). These data are summarized in Table 2, showing

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**Table 1**—Baseline data for participants in study parts 1 and 2.

<table>
<thead>
<tr>
<th>Part 1 (n = 131)</th>
<th>Part 2 (n = 48)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sex</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female: n = 21; Male: n = 110</td>
<td>Female: n = 8; Male: n = 40</td>
<td>.541†</td>
</tr>
<tr>
<td><strong>Age (y)</strong></td>
<td>49.8 (24–76)</td>
<td>48.4 (26–70)</td>
</tr>
<tr>
<td><strong>Adjusted neck circumference (cm)</strong></td>
<td>48.0 (35.5–59.5)</td>
<td>49.1 (39–63)</td>
</tr>
<tr>
<td><strong>BMI (kg/m²)</strong></td>
<td>30.3 (20.1–39.1)</td>
<td>33.3 (23.6–45.9)</td>
</tr>
<tr>
<td><strong>Baseline ODI (events/h)</strong></td>
<td>25.5 (10.5–65.1)</td>
<td>31.1 (10.3–74.6)</td>
</tr>
<tr>
<td><strong>SaO2 (%)</strong></td>
<td>92.1 (88.7–96.3)</td>
<td>91.9 (87.1–94.7)</td>
</tr>
<tr>
<td><strong>% of time at &lt; 90% SaO2</strong></td>
<td>13.0 (0.1–57.3)</td>
<td>16.5 (0.7–84.9)</td>
</tr>
<tr>
<td><strong>Epworth Sleepiness Scale score</strong></td>
<td>9.7 (0–23)</td>
<td>9.7 (0–23)</td>
</tr>
<tr>
<td><strong>Sleep Apnea Quality of Life Index</strong></td>
<td>4.6 (1.7–6.6)</td>
<td>4.3 (2.0–6.7)</td>
</tr>
<tr>
<td><strong>Pittsburgh Sleep Quality Index</strong></td>
<td>8.1 (1–19)</td>
<td>8.1 (3–19)</td>
</tr>
</tbody>
</table>

* = statistical significance. † = Fisher exact test. Independent samples t tests used for remainder of variables. Data are presented as mean (range). Individuals with inconclusive feedback-controlled mandibular positioner tests and those lost to follow-up (not included in the table) had baseline characteristics similar to individuals who completed the study. BMI = body mass index, ODI = oxygen desaturation index, SaO2 = arterial oxygen saturation.
an overall error rate of 12% and the following statistical parameters: sensitivity 85%; specificity 93%; positive predictive value 97%, and negative predictive value 72%. The machine learning system was re-trained on part 1 data using a criterion of therapeutic success of outcome ODI < 10 events/h and a 50% reduction from baseline ODI. When applied to part 2 data, the < 10 events/h and 50% predictive accuracy remained high, with the following statistical parameters: sensitivity 81%, specificity 94%, positive predictive value 96%, and negative predictive value 71%.

Figure 6 shows the relationship between predicted efficacious protrusive position and the final efficacious protrusive position at outcome for part 2 participants predicted to be a therapeutic success. The median predicted efficacious protrusive position for all predicted responders in part 2 was 63% of full protrusive range. The third night study was prompted on 15 participants (31%) and reduced the predicted efficacious protrusive position in almost all cases (13 of 15; 87%) by an average of 2.5 ± 0.8 mm. Of the 29 participants who were correctly predicted to be therapeutic successes, 1 participant was not tested at the predicted efficacious protrusive position due to a protocol discrepancy, 24 (86%) responded with an ODI < 10 events/h at the predicted efficacious protrusive position, and the remaining 4 participants required an additional 1 to 3 mm of protrusion to achieve therapeutic success. The median value for final efficacious protrusive position at outcome was 74% of full protrusive range. Efficacious protrusive position did not correlate with ODI ($r^2 = 0.11$) or BMI ($r^2 = 0.17$).

Over 500 nights of FCMP testing were completed during both parts of the current study. After each FCMP study, some participants reported having tooth and/or gum discomfort during the FCMP test. These symptoms were transient, however, and did not persist beyond a few hours. No significant safety concerns or adverse events were reported by the participants or study coordinators. All participants received a clinical evaluation by one of the study dentists within 3 weeks of completing the FCMP test. These examinations revealed no injury or damage to teeth, tongue, or mucosa, and no dental pain.

Table 2—Sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) for part 2 data.

<table>
<thead>
<tr>
<th>Predicted Success</th>
<th>Predicted Failure</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Therapeutic Success</td>
<td>29</td>
<td>5</td>
<td>85%</td>
</tr>
<tr>
<td>Therapeutic Failure</td>
<td>1</td>
<td>13</td>
<td>93%</td>
</tr>
<tr>
<td>PPV 97%</td>
<td>NPV 72%</td>
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</table>

Predictions of therapeutic success or failure were made automatically by the random forest machine using feedback-controlled mandibular positioner test data only.

DISCUSSION

The current investigation supports the feasibility of an unattended sleep study using a feedback-controlled mandibular positioner. The results indicate that analysis of test data using prospectively established decision methods predicts binary therapeutic outcome and identifies an efficacious protrusive position with reasonable accuracy.

Both part 1 and part 2 study populations displayed a broad range of baseline ODI values, with mild, moderate, and severe
OSA groups being comparably represented. Similarly, values of BMI were evenly distributed between 25 and 45 kg/m². BMI and baseline ODI were significantly lower in part 1, where the RF was trained, than in part 2, where the predictive method was validated. That the predictive accuracy of the RF was high despite this difference in the training and validation populations suggests that the method may be relatively insensitive to such population differences. The overall therapeutic success rates for the 2 populations, 71% and 76%, is somewhat greater than some published reports, but comparable to others. 

ODI was selected as the measure by which to assess OSA in all baseline and outcome studies, all of which were home sleep tests. Over the course of the study, more than 800 full-night tests were carried out (approximately 2 baseline and 2 outcome tests for each participant). This large number of tests dictated that we use automatic scoring in the interest of efficiency and reliability. The Snore Sat Recorder used in this study has been shown to correlate well with a polysomnogram-determined respiratory disturbance index \( r^2 = 0.97 \) suggesting that the recorder provides a reliable index of the full-night frequency of respiratory disturbances. Furthermore, the oxygen component used in the scoring of ODI is less prone to uncontrolled variability and noise than the ventilatory component used in the scoring of AHI. A comparison of both ODI and AHI (auto-scored by a home sleep recorder) to PSG data found oximetry to be more reliable than nasal airflow measurements.

The accuracy of the FCMP in predicting oral appliance therapy outcome in the home is comparable to that previously reported for in-laboratory, attended studies using an RCMP. Specifically, sensitivity and specificity for the 2 previous investigations of RCMP were 86% and 92%, and 82% and 93%, respectively. The values for FCMP in the current study were 85% and 93%, respectively. Compared to the previous studies, the PPV value from the current study was higher (97% versus 93% and 90%) and the NPV was lower (72% versus 83% and 87%). These differences probably reflect the higher therapeutic success rate in the current study compared to the previous studies. The Wisconsin Sleep Cohort reveals that approximately 30% of all individuals with sleep apnea are female, whereas our representation in the study was 16%. This may influence the predictive accuracy, and may or may not influence the overall oral appliance efficacy rate. A recent study by Sutherland et al. showed no correlation of sex with oral appliance outcome. We did not put a quota on the relative proportion of males and females recruited into the study; however, we acknowledge that the low number of females in our study population is a shortcoming.

RF machine learning appears to be a suitable method for predicting therapeutic outcome. This ensemble method utilizes values for a large number (n = 266) of weak predictors derived from the 2 nights of testing. These values are analyzed by a forest of 400 individual decision trees to arrive at a binary prediction of therapeutic outcome. Because the method’s elemental analysis is a single decision tree classification, RF classification would appear to be intrinsically appropriate for predicting a binary outcome. The use of many variables and many decision trees should result in a more generalizable, robust prediction method.

Individuals with mild and supine predominant OSA have been reported to be favorable candidates for oral appliance therapy. Additional individual-specific factors including younger age, female sex, and moderate obesity (characterized by lower BMI and neck circumference) may predict a successful outcome with oral appliance therapy. However, complete resolution of OSA by oral appliance therapy has been reported in individuals with severe OSA and obesity. Craniofacial features including shorter soft palate length, higher hyoid bone position, greater angle between the cranial base and mandibular plane, and retrognathic mandible have also been reported to predict favorable outcome of oral appliance therapy. Nevertheless, a recent review noted that cephalometric parameters alone are not able to reliably predict outcome of oral appliance therapy. A recent study by Edwards et al. has demonstrated the importance of control system characteristics, such as loop gain, in explaining treatment failure of oral appliance therapy, indicating that factors other than anatomical features play a role in explaining oral appliance treatment failure.

New techniques such as nasoendoscopy during drug-induced sleep or while awake, cone-beam computed tomography scans, multisensor catheters, and nasopharyngoscopy that assess anatomical and functional characteristics of upper airways may ultimately prove to provide clinical utility. Currently, however, none have been tested prospectively and none would appear to convey the predictive accuracy, convenience, and applicability documented in the current study for the FCMP test.
adjustable temporary appliance. Here the appliance is set at a fixed protrusion for 1 or more nights, and advanced in pre-selected steps between nights in response to individual and/or bed partner report. Such a method would seem to suffer from variability introduced by numerous multiniight comparisons, from placebo effects, and from the intrinsic unreliability and inconvenience of such reporting. Currently, no published reports document the predictive accuracy of the method.

Prediction of an efficacious mandibular position is an aspect of a feedback-controlled mandibular positioning test that may contribute to clinical utility. Our results support the notion that the predicted protrusive position provided by the FCMP test is efficacious in most cases. In addition to improving efficiency of delivering oral appliance therapy, provision of an effective protrusive position derived from the FCMP test may reduce the long treatment time associated with self-titration. Further, for a substantial number of participants, the test identified an effective therapeutic position at protrusive distances less than 70% of full protrusion. This implies that use of the efficacious protrusive position may lessen the final protrusive distance compared to traditional approaches, many of which begin protrusive adjustment of the custom treatment appliance at 70% of full protrusion. Thus, information derived the FCMP study may improve tolerance and reduce side effects associated with unnecessarily high protrusions.

In conclusion, the results of the current investigation demonstrate feasibility and reasonable predictive accuracy of an in-home sleep test performed with a feedback-controlled mandibular positioner. The test appears to have the capability to predict a binary outcome of oral appliance therapy as well as an efficacious mandibular position. The only other test, to our knowledge, shown prospectively to accurately make these predictions is the antecedent test, the RCMP in the polysomnographic setting. Although the antecedent test requires identification of sleep stages and body position to predict outcome of oral appliance therapy, the feedback-controlled system achieves comparable predictive accuracy using only information related to respiratory status and mandibular position. This likely reflects the design of the 2-night, dynamic FCMP test where all variables, including sleep stage and body position, are appropriately and automatically taken into account by the machine learning method. The feasibility and predictive accuracy of the feedback-controlled mandibular positioner home sleep test described in the current report suggest that such a test may usefully contribute to clinical management of OSA.

REFERENCES


ABBREVIATIONS

BMI, body mass index
CPAP, continuous positive airway pressure
FCMP, feedback-controlled mandibular positioner
NPV, negative predictive value
O2 Sat, oxyhemoglobin saturation
ODI, oxygen desaturation index
OSA, obstructive sleep apnea
PPV, positive predictive value
RCMP, remotely-controlled mandibular positioner
REs, respiratory events
RF, random forest
SaO2, arterial oxygen saturation


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SUBMISSION & CORRESPONDENCE INFORMATION

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DISCLOSURE STATEMENT

Work for this study was completed at Zephyr Sleep Technologies and The Snore Centre, located in Calgary, Alberta, Canada. The study involved an investigational medical device. All authors have reviewed and approved the manuscript. J.E. Remmers, Z. Topor, J. Grosse, E.V. Mosca, S. Bruehlmann, S. Charkhandeh, and S.A. Zareian Jahromi are employees of Zephyr Sleep Technologies. R. Brant previously received warrants for work done for Zephyr Sleep Technologies. N. Vranjes has no conflicts of interest to report. Financial support was provided by Alberta Innovates Technology Futures, Zephyr Sleep Technologies, and the NRC-IRAP Industrial Assistance Fund. Equipment was provided by SomnoMed Ltd., ProSomnus Sleep Technologies, and Zephyr Sleep Technologies.

Address correspondence to: Dr. Sabina Bruehlmann, Director, Technology, Zephyr Sleep Technologies Inc., 610A 70th Ave SE, Calgary, AB, Canada; Tel: (587) 332-0285; Fax: (587) 332-0208, Email: sbruehlmann@zephyrsleep.com