The feasibility of a mandibular movement test as a screening tool for polysomnography candidates

To the Editor:

Sleep apnoea syndrome (SAS) is a common sleep disorder with a prevalence ranging from 5.9% to 79.2% in the European general population over 40 years of age, depending on the clinical symptoms and apnoea hypopnoea scoring criteria used [1]. Despite its frequency, the fact that it is a significant risk factor for many common diseases, and a recent meta-analysis demonstrating that available treatments are effective [2], SAS remains underdiagnosed.

Indeed, patients with sleep apnoea presenting with concomitant cardiovascular diseases often have no typical presentation pointing towards obstructive SAS [3]. In various locations around the world, suspected SAS patients may find that accessing diagnostic examinations can be challenging. The average waiting time for a sleep study can vary from 2 to 48 months in industrialised countries [4]. Nevertheless, in-lab full-night polysomnography (PSG) remains the 'gold-standard' for the diagnosis of SAS, despite the fact that it is time consuming, expensive and often not widely available [5]. In certain countries, PSG is obligatory in the diagnostic work-up for SAS. Thus, targeting the patient population that is most likely to benefit from PSG would help to optimise the limited resources at hand.

Recent studies have suggested that mandibular movements (MM) can be considered a surrogate for the measurement of respiratory effort during sleep and can estimate total sleep time (eTST), as well as sleep fragmentation. Thus, MM can be used to identify sleep-disordered breathing [6, 7]. In their study, Martinot *et al.* [7] compared the respiratory disturbance index measured by MM (MM-RDI) and the usual respiratory disturbance index measured by PSG (PSG-RDI). They reported that the MM-RDI is highly concordant with the PSG-RDI: in patients with a moderate-to-high pre-test probability for obstructive SAS, a MM-RDI >13.5 per h has a false positive rate of 4.72–18.49% (95% CI) when detecting a PSG-RDI $\geqslant$15 per h, and a false negative rate of 0.0–16.82% (95% CI).

Our objective was therefore to assess the feasibility of use of the MM-RDI as a screening tool in an ambulatory setting for PSG candidates. In order to address this question, we report herein the results of a preliminary study based on the retrospective analysis of a large, anonymous patient database in Belgium (clinicaltrials.gov identifier number NCT03129984).

From 2015–2016, data were collected for 4231 Belgian patients (figure 1), on whom automated MM tracking was performed (as prescribed by their practitioner), by the attachment of a type IV sleep monitor that included a MM magnetic sensor (Brizzy, Nomics, Liege, Belgium), under ambulatory conditions. In order to determine whether or not a given patient required PSG, we used the previously reported MM-RDI cut-off at >13.5 per h and a minimal eTST of over 4 h, if MM-RDI $\leqslant$13.5 per h [7].

The prescriber was a cardiologist in 80.9% of the cases (the cardiologist prescribers (CP) group in figure 1), and in 19.1% of the cases (the non-cardiologist prescribers (NCP) group), the prescribers comprised other types of practitioners (a general practitioner in 6.59%, an otorhinolaryngologist in 4.62%, a pulmonologist in 3.89%, an orthodontist in 3.59%, or another type of practitioner in 0.52% of cases). Out of 4231 tests, 165 (3.9%) were unusable because of a major technical failure (damaged sensor, incorrectly positioned sensor, battery not recharged, too-short monitoring time or other technical/electronic problems). Of the 4066 remaining patients, only 9.4% of the analysable population had an estimated total sleep time below 4 h.

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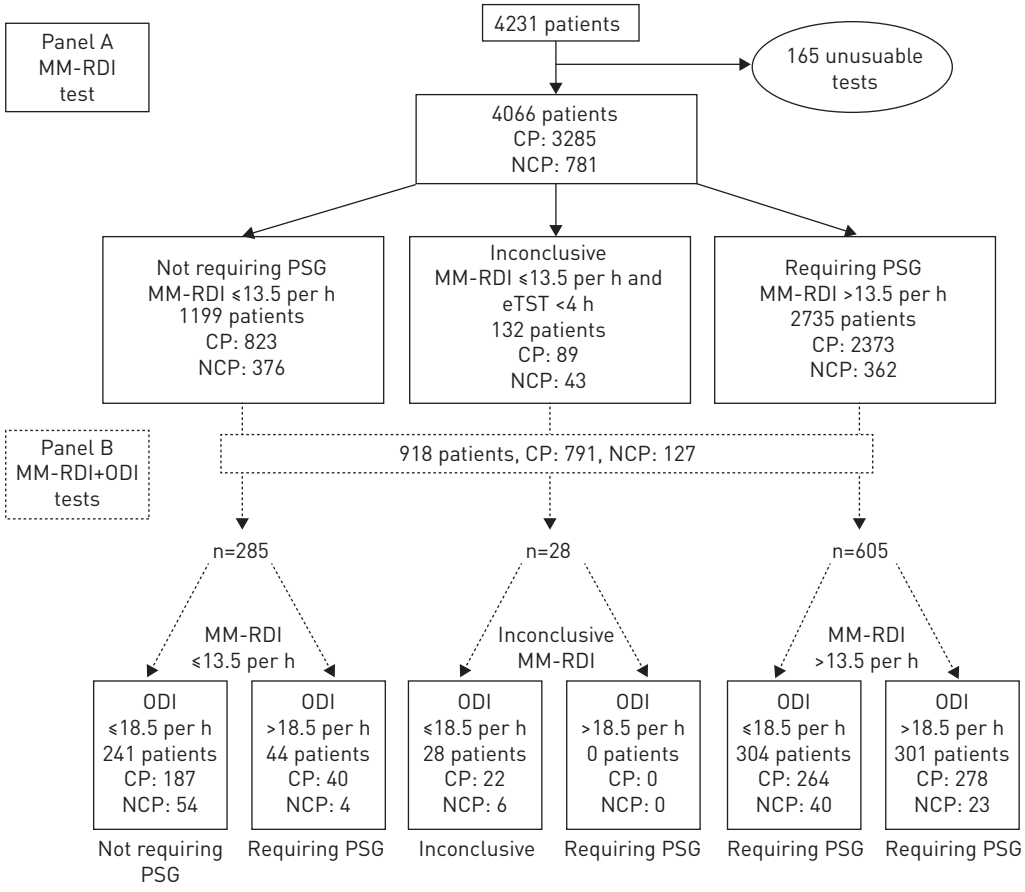

FIGURE 1 Flow chart demonstrating (in panel A) the total number of patients who performed a mandibular movement respiratory disturbance index (MM-RDI) test, the number of unusable tests and the final number of patients entering analysis. The latter were classified into three groups: patients classified as "not requiring polysomnography (PSG)" (left) with an MM-RDI ⩽13.5 per h and an estimated total sleep time (eTST) of at least 4 h; patients classified as having "inconclusive" tests (centre) with an MM-RDI ⩽13.5 per h and an eTST <4 h; and patients classified as "requiring PSG" (right) with an MM-RDI >13.5 per h. Inconclusive MM-RDI tests should be repeated. A significantly higher percentage of patients "requiring PSG" was found among those who had cardiologist prescribers (CP) *versus* those who had non-cardiologist prescribers (NCP) (Chi-squared test, p<0.001). Panel B extends the flow chart to the 918 patients in panel A who had simultaneous oximetry in addition to mandibular movement tracking. The three groups in panel A are thus further subdivided, according to a 3% oxygen desaturation index (ODI) > or ⩽18.5 per h (requiring and not requiring PSG, respectively). In this panel, the final classification "requiring PSG" is conditioned by a MM-RDI >13.5 per h and/or an ODI >18.5 per h. Oximetry provided additive diagnostic value in favour of the need for PSG among patients with an initially negative MM-RDI in 17.6% and 6.9% of CP and NCP patients, respectively (Chi-squared test, p=0.069).

Among the 4066 usable patient data-points, 67.3% and 29.5% were classified as 'requiring' and 'not requiring' PSG, respectively. Only a small percentage (3.25%) of cases were classified as 'inconclusive' because of a MM-RDI ⩽13.5 per h, combined with less than 4 h of eTST (figure 1, panel A). These preliminary results differed further, according to the type of prescriber; 25% of those patients whose prescribing practitioner was a cardiologist (panel A) were classified as 'not requiring' PSG *versus* 48.14% (Chi-squared test, p<0.001) of patients under the care of other types of prescribers (panel A).

We performed a complementary analysis in the subgroup of 918 patients who had a MM-RDI test with simultaneous oximetry incorporated into the MM magnetic sensor device. We used an oxygen desaturation index (ODI) cut-off at >18.5 per h (oxygen desaturation >3%), a threshold demonstrated to be associated with a PSG apnoea hypopnoea index (AHI) >15 per h, with a sensibility of 85.1% and specificity of 85.3% in a patient population from a previous sleep heart health study [8]. Oximetry provided additive diagnostic value in favour of the need for PSG among initially negative MM-RDI patients for 17.6% and 6.9% of the CP and NCP groups, respectively (Chi-squared test, p=0.069). On the other hand, 48.7% of CP patients and 63.4% of NCP patients with a positive MM-RDI test had a negative ODI (Chi-squared test, p=0.026; see figure 1, panel B). Furthermore, 53%, 55% and 40% of the whole,

CP and non-CP populations, respectively, who had an ODI ⩽18.5 per h (that was not in favour of the need for PSG), had a value of MM-RDI >13.5 per h, in favour of PSG.

In order to fully compare the results of MM-RDI and ODI, and in particular, the manner in which the addition of the MM test to oximetry, or oximetry to the MM test enhances the need for PSG, we generated receiver operating curves (ROC) for the whole, CP and non-CP populations. Concerning the latter populations, the areas under the ROC for MM-RDI with a need for PSG, with the ODI pre-specified cut-off >18.5 per h, were 0.78 (95% CI 0.75–0.81), 0.77 (95% CI 0.74–0.81) and 0.79 (95% CI 0.68–0.9), respectively. The areas under the ROC for the ODI with a need for PSG with the MM-RDI pre-specified cut-off >13.5 per h were 0.77 (95% CI 0.74–0.80), 0.77 (95% CI 0.74–0.8) and 0.77 (95% CI 0.69–0.85), respectively. These ROC analyses support the coupling of MM-RDI and oximetry data when screening for PSG candidates.

When considering the feasibility and design of future studies, a screening test for SAS needs to be associated with a low rate of unusable test results. In the model developed by Pietzsch *et al.* [5], a technical failure rate of 9% (range 7–12%) was used. In this preliminary evaluation of MM-RDI as a screening test, we observed a technical failure rate of 3.9% and an inconclusive test rate of 3.2%, suggesting that this parameter does not pre-empt future MM-RDI studies. In addition, Martinot *et al.* [7] reported that MM-RDI is associated with a positive likelihood ratio of 8.46 and a sensitivity of 89% for an RDI of 15 per h, demonstrating concordance with evaluation criteria for obstructive sleep apnoea devices, as reviewed by Collop *et al.* [9].

The question of whether or not to perform systematic patient screening is an unresolved issue, particularly in cardiac patients, even if they have no sleep-related symptoms [10–13]. Of course, the cost of diagnosis is one of the key points of the debate and cost-sparing procedures need to be developed. In this regard, the estimated cost of SAS diagnosis in 2016 was reportedly $229 million in the US [14]. In 2012, the Haute Autorité de la Santé reported that the reimbursed cost for sleep disorder diagnosis in France was €31.8 million [15]. Considering our preliminary data, the economic gain would be around 25% of these diagnostic costs for cardiac patients and around 48.1% for non-cardiac patients. In contrast, the cost of the MM test for each patient is less than €2.20 ($2.61), corresponding to the price of the magnetic sensor and its renewal, after every 50 patients. Coupled with oximetry, the cost is raised to €0.3 ($0.36), corresponding to the utilisation of the same sensor during the associated warranty period. Given ambulatory conditions and automation, only material deployment and final interpretations represent further costs in addition to the €2.5 for necessary material.

This preliminary study has several limitations, the main one being that further clinical data and PSG results were unavailable, making it impossible to study other factors that might help to select PSG candidates. Although this study is preliminary in nature, it confirms that MM-RDI has potential as a simple screening tool for PSG candidates. Our results further suggest the synergy between oximetry and the MM-RDI test. The utility of MM-RDI, in addition to screening questionnaires and portable polygraphy, also requires further investigation. Even more important, by increasing the pre-test probability of SAS through the incorporation of MM-RDI tests, empirical continuous positive airway pressure (CPAP) treatment could become a more cost-effective strategy than the actual gold-standard of a full-night PSG with CPAP titration [5].

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