Efficacy of Roncolab mobile application for diagnosing the primary sign of sleep-disordered breathing (snoring) in children

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ABSTRACT

*Sleep-disordered breathing (SDB) is a group of disorders associated with breathing anomalies during sleep. Easily detectable by sound, snoring is one of the most common manifestations and the main sign of SDB. Snoring is characteristic of breathing sound during sleep, without apnea, hypoventilation, or interrupted sleep. It may reduce the percentage of sleep and increase microarousals due to breathing effort or gas exchange. A range of questionnaires have been validated and adapted to the pediatric population to screen for patients who require laboratory testing. The Pediatric Sleep Questionnaire (PSQ) screens for SDB and identifies primary signs such as snoring. RoncoLab is a mobile application that records and measures snoring intensity and frequency. **Aim:** To compare the RoncoLab app and the PSQ regarding how efficiently they diagnose snoring. **Materials and Method:** This was an observational, analytical study of 31 children aged 7 to 11 years who visited the pediatric dental clinic at Benemérita Universidad Autónoma de Puebla, Mexico (BUAP). The PSQ was applied to diagnose SDB. Guardians were then instructed on how to download and use the mobile application to record data while the child was sleeping at home. Agreement between RoncoLab and the PSQ was analyzed statistically by Cohen's Kappa index at 95% confidence level. **Results:** The Kappa index for identification of primary snoring was 0.743 (p<0.05). App sensitivity was 0.92, and specificity 0.82. **Conclusion:** There is good agreement between PSQ and RoncoLab for diagnosing primary snoring, with acceptable sensitivity and specificity.*

Keywords: sleep disorders - children - snoring - validity of results - mobile applications.

Eficacia de la aplicación móvil Roncolab para el diagnóstico de signo primario de trastorno respiratorio del sueño (ronquido) en niños.

RESUMEN

*Los trastornos respiratorios del sueño (TRS) son un grupo de padecimientos asociados con anormalidades respiratorias del sueño. Una de las manifestaciones más comunes es el ronquido; signo fácil de detectar por el ruido que emite y se considera como el signo principal. Este trastorno es característico del ruido respiratorio durante el sueño, sin apneas, hipoventilación, ni interrupciones del sueño. Este puede ocasionar disminución del porcentaje del sueño y aumentar los microdespertares, esto debido al esfuerzo respiratorio o al intercambio de gases. En la actualidad existen cuestionarios validados y adaptados para la población pediátrica útiles como herramienta clínica para el tamizaje y selección de pacientes que requieran pruebas de laboratorio. El Pediatric Sleep Questionnaire (PSQ) permite el cribado de TRS e identificación de signos primarios como el ronquido. RoncoLab es una aplicación móvil que registra y mide la intensidad y frecuencia del ronquido. **Objetivo:** Comparar la eficacia del diagnóstico del ronquido por medio del RoncoLab contrastado con el PSQ. **Materiales y Método:** Estudio observacional, analítico, en el cual se incluyeron 31 niños de 7 a 11 años, que acudieron a la clínica de odontopediatría de la Benemérita Universidad Autónoma de Puebla, México (BUAP) Se aplicó el PSQ a los 31 niños para el diagnóstico de TRS, después se le instruyó al tutor como descargar y utilizar la aplicación móvil para registrar los datos obtenidos en las horas de sueño en casa. El análisis estadístico de concordancia entre los instrumentos diagnósticos se realizó con el Índice Kappa de Cohen a un nivel de confianza del 95%. **Resultados:** El Índice de Kappa para la identificación de los ronquidos primarios fue de 0.743 (p<0.05). La sensibilidad de la aplicación fue de 0.92, mientras la especificidad fue de 0.82. **Conclusión:** Existe buena concordancia entre el PSQ y el RoncoLab en el diagnóstico de ronquido primario, con sensibilidad y especificidad aceptable.*

Palabras clave: trastornos del sueño - niños - validación de resultados - aplicación móvil.

INTRODUCTION

Sleep is a complex physiological and behavioral process that enables people to disconnect from the external environment[1]. Healthy people usually fall asleep 20 minutes after lying down. It has been reported that 20% to 30% of people have sleeping difficulties[2]. Normal sleep is important to development at all stages of life. On average, a person spends one third of their life sleeping, reflecting the fact that sleep is essential to performing and completing important physiological functions that ensure complete physical and mental equilibrium throughout the day. Sleeping is key to physical and psychological development in childhood and adolescence[3,4].

Sleep-disordered breathing (SDB) is a group of different disorders involving breathing anomalies during sleep. Obstructive type SDBs are not a specific disease, but an upper airway dysfunction syndrome. In some cases, the breathing anomaly occurs while the patient is awake[4,5].

Lack of sleep is harmful to cognition, decision making, psychomotor function, mood and immune function. Poor sleep is a risk factor for cardiovascular disease, dementia, obesity, diabetes, depression, pain and mortality, among other disorders.

Snoring, the main sign of sleep-disordered breathing, is one of its most common manifestations. SDB comprises a variety of disorders, ranging from the simplest, which is habitual or primary snoring, all the way to sleep apnea-hypopnea syndrome (SAHS), including intermediate disorders such as upper airway resistance syndrome (UARS) and central hypoventilation syndrome[6].

Primary snoring is a characteristic disorder of breathing sound during sleep, without apneas, hypoventilation or interrupting sleep, although it does reduce sleep percentage and increase microarousals due to breathing effort or gas exchange effort. Snoring is a hoarse sound caused by obstruction of the air flow through the nose and pharynx. Structures with soft tissues (tongue, soft palate, uvula, tonsils, adenoids and pharynx wall) are highly collapsible, which places them in contact with each other and causes them to vibrate when someone breathes during sleep[7].

SDB and sleep apnea are well known in adults. However, they also occur in the pediatric population, with prevalence ranging from 7% to 17%, depending on how they are defined, and the instruments used in each study. In Mexico, the prevalence of child obesity has recently increased to the highest rate in the world, leading to higher prevalence of SDB, including disorders such as obstructive sleep apnea and primary snoring related to obesity. Timely diagnosis and management of SDB in children can prevent associated comorbidities[8-10].

Among the range of sleep-disordered breathing symptoms, primary snoring is the least harmful. Primary snoring is sometimes not considered either for diagnosis or for the possibility of providing treatment. It has been reported that more than one third of children with primary snoring develop sleep apnea-hypopnea within four years, and 7% develop a moderate to severe disease such as central hypoventilation syndrome. The most significant risk factor for progression of the disease is child obesity, for which prevalence is reported as 8% to 12%[11].

Among 3- to 6-year-olds, the main cause of snoring is physiological hypertrophy of adenoids and tonsils, which at these ages are larger in relation to airway diameter. Most snoring incidents during sleep are therefore expected at these ages[12].

The gold standard for diagnosing SDB and sleep apnea is assisted polysomnography (PSG) in the lab. However, it is expensive, time consuming, technically complex, and requires patients to sleep in the laboratory. In Mexico, there may be significant delays in the diagnosis and treatment of STB due to the limited availability of PSG. Nevertheless, simpler tools such as validated sleep questionnaires can also be used to detect SDB and have gained considerable clinical relevance for recording initial symptoms in epidemiological studies[13-15].

Sleep questionnaires are used as a subclinical tool to describe psychometric qualities in the field of sleep medicine to screen for signs, symptoms and factors that foster the development of SDB. Pediatric sleep questionnaires are mainly directed to parents. Most of these questionnaires for SDB screening, such as the *Pediatric Sleep Questionnaire* (PSQ), are long and tedious, so various mobile applications, such as *RoncoLab,* have been proposed for diagnosing SDB signs and symptoms.

The *RoncoLab* app is attractive, innovative and easy for parents to use[16-18]. It shows whether, how much and how long a patient snores; analyzes snoring; can be programmed to activate after a given number of minutes and can play background sound to help the patient fall asleep. It shows the different sleep analyses performed during the night and provides a list of possible remedies to snoring and a list of different factors that may foster the onset of snoring.

By default, *RoncoLab* record samples of the patient's snoring, as well as other sounds occurring during the night. Once the recording has been made, the app provides a graph showing silent and snoring times. It also records total sleep time and how long the patient has been in bed and assigns a score to patient snoring. It can play back the recorded snoring. The main aim of the application is to ascertain rest quality and snoring intensity.

The aim of this study was to compare the efficacy of the *RoncoLab* mobile app to that of the *Pediatric Sleep Questionnaire* for diagnosing the primary sign (snoring) of SDB in the pediatric population.

MATERIALS AND METHOD

This was an observational analytical study. Children aged 7 to 11 years, who had been referred to the postgraduate Pediatric Dentistry clinic at the School of Stomatology at Benemérita Universidad Autónoma de Puebla for a sleep study, were invited to participate. Prior to registration, the Ethics and Research Committee (2021160) obtained informed consent from the parents and oral and written assent from the children. Exclusion criteria were patients (1) under

respiratory treatment, (2) under maxillary orthopedic treatment (maxillary expansion), (3) with intellectual disability, (4) under psychiatric treatment, or (5) with craniofacial anomalies. The PSQ for SDB diagnosis, validated and adapted to the pediatric population, was applied to the 31 children. The 22 questions were answered by a parent or legal guardian.

A snorer was defined as any child whose guardian provided affirmative answers to at least one of the 2 following questions in the questionnaire: 'Does your child snore more than half the time?' 'Does your child snore all the time?' Probable sleep-disordered breathing was identified when 8 or more questions were answered affirmatively (score <0.33) (Table 1). Any questions answered "No" o "Don't know" were not counted.

Table 1. Short version of the *Pediatric Sleep Questionnaire*

A. Behavior during the night and while sleeping:

When your child is sleeping, does he/she…				Do not fill in this column
… snore more than half the time?	Yes	No	D.K.	A2
… snore all the time?	Yes	No	D.K.	A3
… snore noisily?	Yes	No	D.K.	A4
… breathe noisily or deeply?	Yes	No	D.K.	A5
… have problems or difficulty breathing?	Yes	No	D.K.	A6
Have you ever…				
… noticed that your child stops breathing during the night?	Yes	No	D.K.	A7
Does your child…				
… tend to breathe with his/her mouth open during the day?	Yes	No	D.K.	A24
… have a dry mouth when he/she wakes up in the morning?	Yes	No	D.K.	A25
… occasionally wet the bed?	Yes	No	D.K.	A32

B. Behavior during the day and other possible problems:

Does your child…				
… wake up in the morning feeling tired?	Yes	No	D.K.	B1
… fall asleep during the day?	Yes	No	D.K.	B2
Has your child's teacher or any other carer ever mentioned that your child seems to be sleepy during the day?	Yes	No	D.K.	B4
Does your child find it difficult to wake up in the morning?	Yes	No	D.K.	B6
Does your child complain of headache in the morning upon waking up?	Yes	No	D.K.	B7
Has your child ever, since birth, had a "stop" in growth?	Yes	No	D.K.	B9
Is your child overweight (weigh more than normal for his/her age)?	Yes	No	D.K.	B22

C. Please mark the relevant box with an X → Your child…	Never	Some-times	Often	Nearly always	Do not complete this box
…does not seem to hear what people say to him/her.					C3
…has difficulty organizing his/her activities.					C5
…is easily distracted by irrelevant stimuli.					C8
…fidgets, moving hands and feet while seated.					C10
…is constantly on the go, as if drive by a motor.					C14
…interrupts the conversations or games of others.					C18

Table back-translated from *Tomas M. et al. 2007. Versión española del Pediatric Sleep Questionnaire. Un instrumento útil en la investigación de los trastornos del sueño en la infancia*. (Version in Spanish of the Pediatric Sleep Questionnaire. A useful instrument for researching childhood sleep disorders)

Then the parent or guardian was instructed on how to download and use the mobile application to record information while the child was sleeping at home.

The parent or guardian was instructed to use *RoncoLab* for two nights at home in the patient's bedroom, beginning on the day that the PSQ sleep questionnaire was answered. The mobile application was switched on when the patient went to bed and began to rest in a quiet environment isolated from any other area or object that emitted sounds that could alter the records. *RoncoLab* was programmed to activate after the first 20 minutes, corresponding to the beginning of the deep sleep phase. Snoring was recorded throughout all the patient's sleeping hours.

RoncoLab defined as a snorer any child who snored for more than 15 minutes. (Figs. 1 a-b).

Cross tabulation was used to calculate *RoncoLab* sensitivity and specificity.

Statistical analysis was performed on IBM SPSS version 22. Agreement between diagnostic instruments was analyzed using Cohen's Kappa index at 95% confidence interval, and considered insignificant if the result was 0.0 to 0.2, low for 0.2 to 0.4, moderate for 0.4 to 0.6, good for 0.6 to 0.8 and very good for 0.8 to 1.0.

RESULTS

A total 31 children and their parents signed consents and assents, respectively, and joined the study, answered the questionnaire and used the mobile application between August 2022 and December 2022. There were 20 boys (64.5%) and 11 girls. (35.5%). Mean age was 8.8 years.

Screening prevalence for sleep-disordered breathing among Mexican children was 42% according to the Pediatric Sleep Questionnaire (PSQ) validated and adapted for SDB screening in the pediatric population. The *RoncoLab* application identified 51.6% of the patients as snorers, while the PSQ identified 45.2%.

RoncoLab sensitivity was .92, and specificity was .82. Data were recorded on the presence of the primary sign of SDB (Table 2). The Kappa index for identification of primary snoring between the PSQ
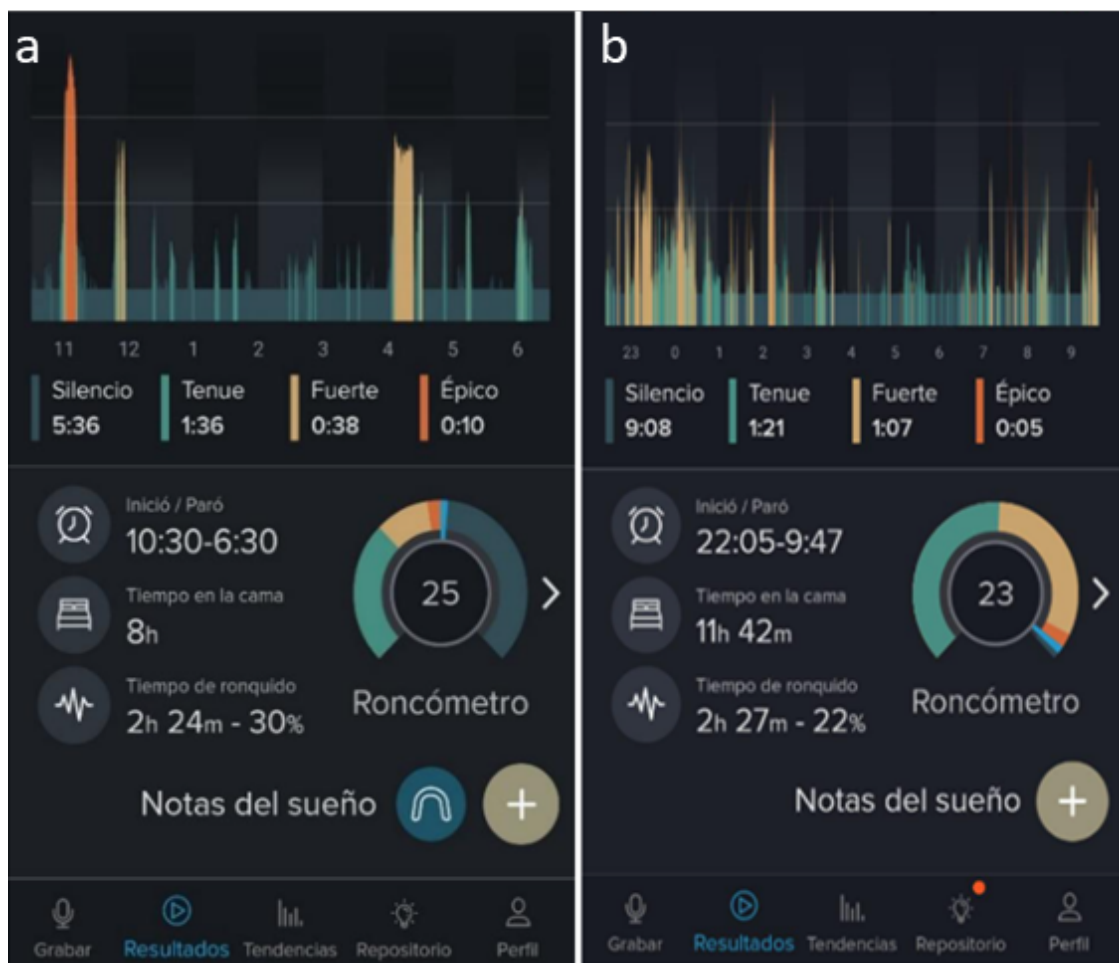

Fig. 1a-b: Screenshots of the RoncoLab application provided by parents.

Table 2. Screening for primary sign with RoncoLab. Snoring.

Snores		Frequency	Percentage (%)
	Yes	16	51.6
	No	15	48.4
	Total	31	100

Table 3. Agreement in diagnosis of primary snoring. *Pediatric Sleep Questionnaire vs. RoncoLab*

		PSQ		Total	Kappa Value	P Value
		YES	NO			
RoncoLab	YES	13	3	16	.743	<.000
	NO	1	14	15		
Total		14	17	31		

and the *RoncoLab* mobile application was 0.743 with p<0.05 (Table 3).

DISCUSSION

Although validation is required, the *RoncoLab* mobile application may be implemented in diagnosis and screening for Sleep-Disordered Breathing, since it has been found to be efficient, useful and practical for diagnosing snorers.

Among Mexican children, there is a high percentage of possible cases of sleep-disordered breathing compared to reports in the worldwide literature. In Argentina, Frairea A. et al.[10] used the PSQ to study a pediatric population

and reported 7% SDB prevalence and 9.7% snorers.

It is therefore important to raise awareness and conduct further studies on SDB in the Mexican pediatric population using validated, adapted instruments to standardize figures. It is suggested to consider other factors such as body mass index, high blood pressure, place of origin, and ethnicity, among others, to help decipher the high percentage of probable SDB in Mexican children.

To conclude, agreement between PSQ and the *RoncoLab* application for diagnosing primary snoring in the pediatric population was good, displaying acceptable sensitivity and specificity.

CONFLICT OF INTEREST
The authors declare no potential conflicts of interest regarding the research, authorship, and/or publication of this article.

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