

Article

Paediatric Sleep Questionnaire for Obstructive Sleep Apnoea Syndrome Screening: Is Sleep Quality Worthy of Note?

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Featured Application: The investigation of sleep quality can be an important parameter in order to identify potential paediatric subjects at risk of obstructive sleep apnoea syndrome (OSAS) more effectively.

Abstract: Obstructive sleep apnoea syndrome (OSAS) is the most severe condition on the spectrum of sleep-related breathing disorders (SRBDs). The Paediatric Sleep Questionnaire (PSQ) is one of the most used and validated screening tools, but it lacks the comprehensive assessment of some determinants of OSAS, specifically anamnestic assessment and sleep quality. This study aims to assess the accuracy of some specific items added to the original PSQ, particularly related to the patient's anamnestic history and to the quality of sleep, for the screening of OSAS in a paediatric population living in Sicily (Italy). Fifteen specific items, divided into "anamnestic" and "related to sleep quality" were added to the original PSQ. The whole questionnaire was administered via a digital form to the parents of children at 4 schools (age range: 3–13 years). For each item, sensitivity and specificity, positive and negative predictive values, and positive and negative likelihood ratios were calculated. The highest sensitivity (80.0, 95% CI: 28.4; 99.5), in combination with the highest specificity (61.1, 95% CI: 35.7; 82.7), was found for the Item 32 ("assumption of bizarre or abnormal positions during sleep"). This item was found statistically significant for predicting the occurrence of OSAS in children (p -value ≤ 0.003). The study demonstrates the accuracy of specific items related to sleep quality disturbance for the preliminary assessment of the disease. Although these results should be validated on a larger sample of subjects, they suggest that including the factors discriminating sleep quality could further increase the efficiency and accuracy of PSQ.

Keywords: paediatric sleep-related breathing disorders; paediatric obstructive sleep apnoea syndrome; Paediatric Sleep Questionnaire (PSQ); screening accuracy; sleep quality disturbance



Citation: Panzarella, V.; Giuliana, G.; Spinuzza, P.; La Mantia, G.; Maniscalco, L.; Pizzo, G.; Matranga, D. Paediatric Sleep Questionnaire for Obstructive Sleep Apnoea Syndrome Screening: Is Sleep Quality Worthy of Note? *Appl. Sci.* **2021**, *11*, 1440. <https://doi.org/10.3390/app11041440>

Academic Editor: Gaetano Isola
Received: 30 November 2020
Accepted: 1 February 2021
Published: 5 February 2021

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1. Introduction

Sleep-related breathing disorders (SRBDs) represent a series of disorders compromising the quality of life of patients, especially paediatric patients. They are characterised by habitual snoring and a series of daytime-related symptoms such as hyperactivity, drowsiness and poor school performance. Obstructive sleep apnoea syndrome (OSAS) is the most severe spectrum of SRBDs. It is characterised by repeated episodes of complete and/or partial and/or prolonged obstruction of the upper airways during sleep, normally associated with a reduction in blood oxygen saturation.

Patients with breathing disorders related to obstructive sleep apnoea are considered to be at high-risk for other health complications such as obesity or being overweight, hypertension, and cardiovascular and metabolic diseases [1,2].

To manage OSAS early, especially in order to reduce the psychological and functional complications related to these disorders, it is essential to adopt large-scale screening measures as effectively as possible. To this end, several paediatric screen questionnaires have been proposed. Sleep Clinical Record (SCR), OSA-18, Brouillette Score (BS), “I’m sleep”, Sleeping Sleepless Sleepy Disturbed Rest (SSSDR) and Paediatric Sleep Questionnaire (PSQ) are several examples of the most widely used paediatric screening questionnaires [3–6]. Among these, only SCR, in addition to the question-based survey, includes a fairly detailed physical examination of the child, attributing a diagnostic value to the tool [7]. For these reasons, it is considered the most complex and time-consuming diagnostic questionnaire, and it is not easy to use.

Both OSA-18 and BS, because of their low sensitivity and specificity, have been poorly classified in the current guidelines of the European Respiratory Society Task Force [3]. “I’m sleep” has a relatively high sensitivity (82%), given the simplicity of the tool, while the specificity is equal to 50% [4]. SSSDR is a new survey that promotes greater knowledge of healthy sleep and helps in the early identification of different and widely defined sleep disorders, including obstructive SRBDs [5]. Due to its recent introduction into the international scientific community, it has not yet been included in the current guidelines of the European Respiratory Society Task Force.

Finally, the Paediatric Sleep Questionnaire (PSQ) [6] has its sensitivity and specificity evaluated at 78% and 72%, respectively, with reliability at Class I and Class II, according to the classification of the American Academy of Neurology (AAN) [1]. The 22-item questionnaire can be filled in easily by the parents of subjects aged between 2 and 18 using only the answers “yes”, “no”, and “I do not know”. The questionnaire, divided into 10 sections, investigates different aspects of the quality of the sleep, from snoring to diurnal and nocturnal behavioural habits.

A very recent and helpful comparison of the questionnaires used in the screening of obstructive SRBD in children was performed by Bhurgard et al. [5] in order to help in the choice of the best tool for early identification and management of patients’ conditions. As reported by the authors, in the current guidelines of the European Respiratory Society Task Force, PSQ is defined as a “useful tool” to predict OSAS, with an apnoea–hypopnea index (AHI) of >5, detecting the neurobehavioral consequences associated with OSAS and/or evaluating their regression after adenotonsillectomy, which is considered the first choice for OSAS treatment in children [5]. For these reasons, it is one of the most used and validated screening tools, appearing at least as effective as or better than PSG (polysomnography) [1,5,6]. The inclusion of PSQ in the European guidelines and its use in many literature articles that have translated and rewritten the questions in different languages has made PSQ the most suitable questionnaire in the last twenty years, according to the literature [8–20].

To date, PSQ seems to be the questionnaire with the best diagnostic accuracy, and, thanks to cultural–linguistic validation, it can be easily used after psychometric evaluation as an additional diagnostic tool for the paediatric population [21]. However, from a comparison with other questionnaires [5], PSQ would appear to be missing the comprehensive assessment of some determinants of OSAS that are related to targeted anamnestic assessment and sleep quality [5,22]. In particular, PSQ lacks questions regarding the anamnestic aspect (e.g., ethnicity, other pathologies such as frequent high airway infections, presence or increase of adenoids or tonsils, nasal obstruction) and some crucial features related to sleep quality. Among the latter, it would seem that additional specific issues (e.g., difficulty in falling asleep, frequent nocturnal arousal, limb movements during sleep, sleep terrors, sleepwalking and abnormal sleep positions) could more efficiently highlight subjects at risk of OSAS [5,23]. Consequently, it would be important to consider investigating them for a more appropriate screening of OSAS.

Based on these suggestions, the main aim of this study is to assess the accuracy of specific items added to the original PSQ, particularly related to the patient's anamnestic history and the quality of sleep, for the screening of OSAS in a paediatric population living in Palermo (Italy).

2. Materials and Methods

2.1. Study Design

The study protocol conformed with ethical guidelines of the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards, and it was approved by the institutional review board of the University Hospital "Policlinico Paolo Giaccone" in Palermo (approval number 10/2020). The study was carried out in two stages. In the first stage, the selection and definition of specific items to be included in the original PSQ were carried out. In the second stage, the accuracy of the additional items was statistically evaluated by administering the modified PSQ on a selected sample of paediatric subjects.

2.1.1. First Stage

Using the original PSQ as the gold standard, in order to implement it using other anamnestic and sleep quality determinants of OSAS, a review of the other sleep screening questionnaires was performed. Therefore, fifteen specific items were selected. The questions were kept simple and concise and were divided by topic, namely, "anamnestic" and "sleep quality".

The "anamnestic" dimension included 7 items investigating ethnicity, whether the child was born premature or full-term, the presence of previous illnesses, familiarity with sleep breathing problems, the presence of respiratory diseases and the presence or absence of adenoids.

The "sleep quality" dimension included 8 items investigating particular behaviours of the child during the night that are considered useful for assessing the quality of sleep: the tendency to sweat and frequent arousal, the assumption of bizarre positions, confused awakenings, sleepwalking, the tendency to drool during sleep, nightmares, insomnia and, finally, grinding teeth.

All the selected items, with numbering assigned in order to be added to the original 22-question PSQ (i.e., from No. 23 to No. 37), are detailed in Table 1.

Table 1. Items added to the Paediatric Sleep Questionnaire (PSQ) and considered for paediatric obstructive sleep apnoea syndrome (OSAS) screening.

Dimension	N°	Items
ANAMNESTIC ITEMS	23	What is the ethnicity of your child? (Caucasian vs. Non-Caucasian)
	24	Was your child born premature? (Yes vs. No)
	25	Does your child have the following already diagnosed diseases or syndromes (e.g., skeletal malformations, chromosomal disorders, neuromuscular disorders, genetic disorders, storage disorders)? (Yes vs. No)
	26	Does the child's father or mother have sleep breathing problems? (Yes vs. No)
	27	Does your child suffer from seasonal allergies, asthma or nasal congestion? (Yes vs. No)
	28	Does your child suffer from frequent ear or respiratory tract infections? (Yes vs. No)
	29	Does your child still have adenoids or tonsils? (Yes vs. No)

Table 1. Cont.

Dimension	N°	Items
SLEEP QUALITY ITEMS	30	Does your child sweat at night? (Yes vs. No)
	31	Does your child tend to wake up frequently during sleep? (Yes vs. No)
	32	Is your child in bizarre or abnormal positions during sleep (e.g., hyperextending neck or sitting) or is restless during sleep? (Yes vs. No)
	33	Does your child have confused awakenings (e.g., the child looks awake but confused, disoriented and sometimes aggressive)? (Yes vs. No)
	34	Does your child sleepwalk? (Yes vs. No)
	35	Does your child tend to drool while sleeping? (Yes vs. No)
	36	Does your child often report having nightmares? (Yes vs. No)
	37	Does your child suffer from insomnia or difficulty falling asleep? (Yes vs. No)

2.1.2. Second Stage

The modified PSQ, with the 15 added items, was administered via digital form (Google form) so it could be widely and easily distributed in the COVID-19 pandemic period.

The administration of the new questionnaire was, therefore, conducted from 16 to 30 June 2020 among a population of children, aged between 3 and 13 years, from four public schools located in the province of Palermo (Sicily, Italy). Informed consent for data processing was obtained in advance from the parents of the children through the school Dean. More specifically, an information letter and the entire questionnaire was sent to the school Deans in order to obtain the consent to proceed. The Deans then sent the digital questionnaire to the parents by e-mail or mobile phone. Before filling out the questionnaire, each parent had to give consent for data processing in compliance with Italian and European Union policies on the management of sensitive data.

Male or female children not presenting syndromic disorders (i.e., achondroplasia; Beckwith–Wiedemann syndrome; Down syndrome; Ehlers–Danlos syndrome; Ellis–van Creveld syndrome; Noonan syndrome; Pierre Robin sequence/complex; Prader–Willi syndrome; sickle cell diseases) were considered eligible for inclusion. In the case of more than one eligible child within the same family unit, the parents were asked to complete the questionnaire for each of their children.

The validation of the 15 added items was conducted through the following statistical analysis. Demographic characteristics of patients were summarised through counts and percentages for categorical variables and mean \pm standard deviation (SD) for quantitative variables. For the diagnosis of OSAS, the optimal cut-off of 0.33 was used, as suggested by Chervin et al. 2000 [6]. For each item, sensitivity and specificity, positive and negative predictive values and positive and negative likelihood ratios were calculated and expressed as percentages and 95% exact confidence intervals. The difference between these measures of accuracy was judged to be statistically significant in the case of non-overlapping confidence intervals. In the first stage of the analysis, multiple correspondence analysis (MCA) was applied to find the similarity among items in terms of their profiles in a subspace of low dimensionality [24]. The aim of MCA is to reduce data dimensionality with the minimum loss of information. Both the quality of approximation and the loss of information were measured in terms of percentage of total inertia; they add up to 100% [25,26]. Internal

reliability of items was assessed through the Cronbach's alpha, and $\alpha \geq 0.7$ was considered acceptable. Finally, logistic regression was used to assess the predictive ability of the items to predict OSAS (presence or absence). Data sparseness was taken into account through Firth penalisation. Results were shown as adjusted odds ratios (ORs) and the triplet of Wald, score and gradient p -values. Statistical analysis was performed using Stata IC/SE 15.1 (Stata Corporation, College Station, TX, USA) and R software (version 4.0.2), limited to logistic regression with Firth penalisation. An alpha value of 0.05 was considered significant.

3. Results

One hundred and twenty-five modified PSQs were completed correctly. Of these, only one was excluded as the child presented neuromuscular disorders.

Of the 124 children, the average age was 5.69 ± 2.78 (SD), and the range was 3–14 years. There were 62 (50%) males with an average age of 6 ± 3.02 (SD) and 62 (50%) females with an average age of 5.38 ± 2.51 (SD).

Relating to the evaluation of the additional items, the highest sensitivity (80.0, 95% CI: 28.4; 99.5), in combination with the highest specificity (61.1, 95% CI: 35.7; 82.7), was found for Item 32 (LR+: 2.1, 95% CI: 1.0; 4.3 and LR-: 0.3, 95% CI: 0.0; 1.9). The highest specificity (97.5, 95% CI: 92.8; 99.5), in combination with the highest sensitivity (40.0, 95% CI: 5.3; 85.3), was found for Item 33 (LR+: 15.7, 95% CI: 3.3; 74.1 and LR-: 0.6, 95% CI: 0.3; 1.3) (Table 2).

Table 2. Accuracy of the additional 15 items for OSAS: sensitivity, specificity, predictive values and likelihood ratios, with 95% CIs.

Item	TP	FP	FN	TN	Se (95% CI)	Sp (95% CI)	PPV (95% CI)	NPV (95% CI)	LR+ (95% CI)	LR- (95% CI)
23	5	118	0	0	100.0 (48.8;100.0)	0.0 (0.0;3.1)	4.1 (4.1;4.1)	–	1.0 (1.0;1.0)	–
24	1	8	4	110	20.0 (0.5;71.6)	93.2 (87.1;97.0)	11.1 (1.9;44.9)	96.5 (94.7;97.7)	3.0 (0.5;19.9)	0.9 (0.6;1.3)
25	1	0	4	118	20.0 (0.5;71.6)	100.0 (96.9;100.0)	100.0 –	96.7 (95.0;97.9)	–	0.8 (0.5;1.2)
26	3	52	2	66	60.0 (14.7;94.7)	55.9 (46.5;65.1)	5.5 (2.7;10.8)	97.9 (91.8;99.0)	1.4 (0.7;2.9)	0.7 (0.2;2.1)
27	1	14	4	104	20.0 (0.5;71.6)	88.1 (80.9;93.4)	6.7 (1.1;30.6)	96.3 (94.4;97.6)	1.7 (0.3;10.4)	0.9 (0.6;1.4)
28	1	13	4	105	20.0 (0.5;71.6)	89.0 (81.9;94.0)	7.1 (1.2;32.3)	96.3 (94.4;97.6)	1.8 (0.3;11.3)	0.9 (0.6;1.4)
29	4	117	1	1	80.0 (28.4;99.5)	0.9 (0.0;4.6)	3.3 (2.2;5.0)	50.0 (6.8;96.2)	0.8 (0.5;1.3)	23.6 (1.7;235.3)
30	1	44	4	74	20.0 (0.5;71.6)	62.7 (53.3;71.4)	2.2 (0.4;11.8)	94.5 (92.1;96.7)	0.5 (0.1;3.1)	1.3 (0.8;2.0)
31	2	8	3	110	40.0 (5.3;85.3)	93.2 (87.1;97.0)	20.0 (6.6;47.0)	97.4 (94.7;98.7)	5.9 (1.7;20.9)	0.6 (0.3;1.3)
32	4	7	1	11	80.0 (28.4;99.5)	61.1 (35.7;82.7)	36.4 (21.7;54.2)	91.7 (64.7;98.5)	2.1 (1.0;4.3)	0.3 (0.0;1.9)
33	2	3	3	115	40.0 (5.3;85.3)	97.5 (92.8;99.5)	40.0 (12.4;75.8)	97.4 (94.8;98.7)	15.7 (3.3;74.1)	0.6 (0.3;1.3)
34	1	0	4	118	20.0 (0.5;71.6)	100.0 (96.9;100.0)	100.0 –	96.7 (95.0;97.9)	–	0.8 (0.5;1.2)
35	2	6	3	112	40.0 (5.3;85.3)	94.9 (89.3;98.1)	25.0 (8.1;55.7)	97.4 (94.8;98.7)	7.9 (2.1;29.7)	0.6 (0.3;1.3)

Table 2. Cont.

Item	TP	FP	FN	TN	Se (95% CI)	Sp (95% CI)	PPV (95% CI)	NPV (95% CI)	LR+ (95% CI)	LR- (95% CI)
36	0	2	5	116	0.0 (0.0;52.2)	98.3 (94.0;99.8)	0.0 –	95.9 (95.8;96.0)	0.0 –	1.0 (1.0;1.0)
37	1	8	4	110	20.0 (0.5;71.6)	93.2 (87.1;97.0)	11.1 (1.9;44.9)	96.5 (94.7;97.7)	3.0 (0.5;19.9)	0.9 (0.6;1.3)

Se = sensitivity, SP = specificity, 95% CI = 95% confidence interval, PPV = positive predicted value, NPV = negative predicted value, LR+ = positive likelihood ratio, LR- = negative likelihood ratio.

Positions of all the items are shown in the two-dimensional subspace obtained by MCA. The first dimension could be interpreted as the “sleep quality” dimension. Items 31–33 and 37 showed the highest contribution to the inertia (Table 3) and were proximal on the first axis and far away from the origin (Figure 1). The second dimension could be interpreted as the “anamnesis” dimension., Items 27–28 showed the highest contribution to the inertia (Table 3) and were proximal on the second axis and far away from the origin (Figure 1).

Table 3. Multiple correspondence analysis (MCA) results of the additional 15 items for OSAS: overall percentage of inertia and absolute contributions of categories to each dimension.

Item nr.	Category	Overall % Inertia	Absolute Contribution to Inertia	
			Sleep Disorders	Anamnesis
24	no	0.006	0.006	0.003
	yes	0.078	0.081	0.042
25	no	0.001	0.001	0.000
	yes	0.075	0.086	0.028
26	no	0.013	0.001	0.068
	yes	0.016	0.002	0.083
27	no	0.007	0.001	0.033
	yes	0.053	0.008	0.237
28	no	0.007	0.002	0.027
	yes	0.056	0.014	0.212
29	no	0.015	0.001	0.008
	yes	0.000	0.000	0.000
30	no	0.018	0.022	0.008
	yes	0.030	0.037	0.013
31	no	0.010	0.013	0.004
	yes	0.110	0.147	0.04
32	no	0.010	0.013	0.001
	yes	0.107	0.133	0.015
33	no	0.007	0.009	0.001
	yes	0.156	0.210	0.018
34	no	0.001	0.001	0.000
	yes	0.074	0.081	0.017
35	no	0.002	0.000	0.003
	yes	0.025	0.002	0.051
36	no	0.000	0.000	0.001
	yes	0.026	0.004	0.057
37	no	0.007	0.009	0.002
	yes	0.090	0.115	0.027

The highest contributions (in bold) indicate the items' categories contributing most to each dimension.

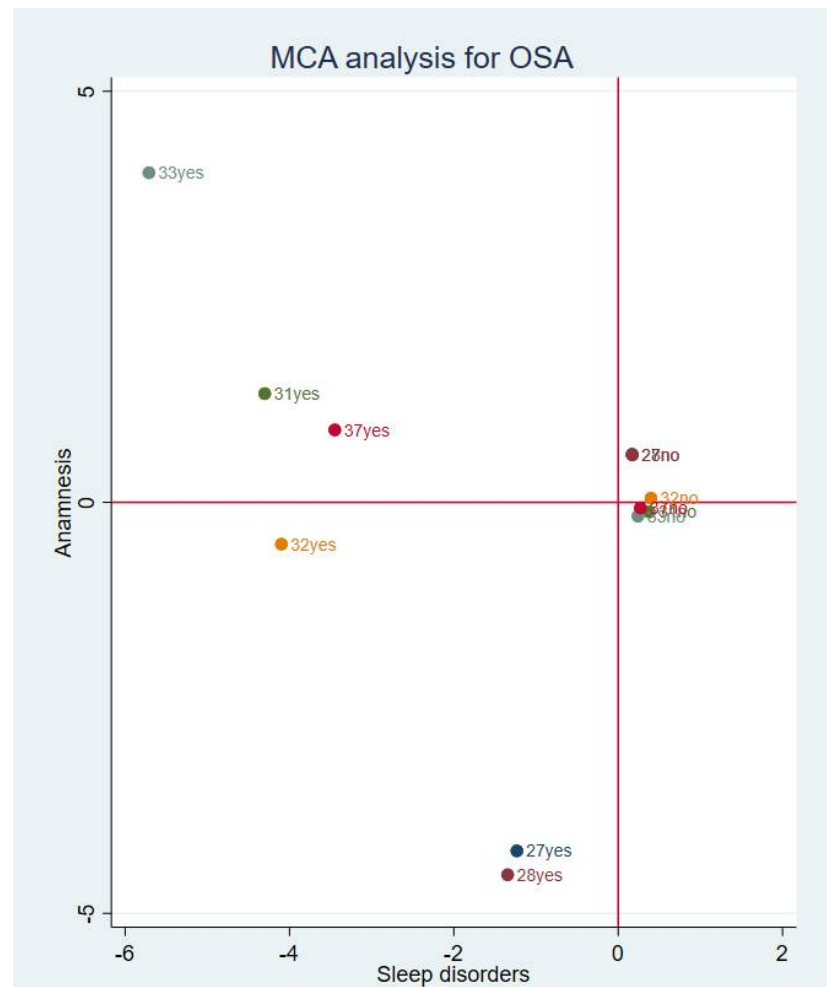


Figure 1. Two-dimensional map of MCA showing the projection of Items 27–28–31–32–33–37 on two dimensions (“sleep disorders” and “anamnesis”).

The quality of approximation of all items on the MCA plot was 65.2% of the total inertia, equal to 0.04. All items showed an internal consistency of 58%. When MCA was calculated on the subset of Items 27–28–31–32–33–37, the quality of approximation of the MCA plot (Figure 1) was raised to 76.5%, equal to 0.08.

The internal consistency of these six items as a whole was 60%, of Items 27–28 was 66%, and of Items 31–32–33–37 was 67%. Logistic regression of OSAS (presence or absence) related to the six items 27–28–31–32–33–37, confirmed that only Item 32 was important for predicting the occurrence of OSAS in a child (Table 4).

Table 4. Logistic regression of OSAS vs. Items 27–28–31–32–33–37.

Item	OR	p-Value		
		Wald	Score	Gradient
27 (yes vs. no)	4.38	0.343	0.505	0.461
28 (yes vs. no)	0.25	0.455	0.579	0.505
31 (yes vs. no)	0.17	0.274	0.251	0.231
32 (yes vs. no)	62.10	0.003	0.003	0.004
33 (yes vs. no)	7.16	0.190	0.114	0.162
37 (yes vs. no)	2.20	0.571	0.532	0.575

OR = adjusted odds ratio; p-values calculated from logistic regression with Firth penalisation; bolded p-value is statistically significant.

4. Discussion

Respiratory sleep disorders, and mainly OSAS, are frequent in subjects of developmental age. In the paediatric population, it is especially important to diagnose them early in order to reduce the impact of further related comorbidities (e.g., obesity or excess weight, hypertension, and cardiovascular and metabolic diseases [1,2]). To this end, various screening questionnaires have been discussed in the literature, such as SCR, OSA-18, BS, "I'm sleep", SSSDR and PSQ. Among these, PSQ would seem to be the best screening tool, with the highest sensitivity and specificity (equal to 78% and 72%), appearing at least as effective as or better than PSG (polysomnography) [1,5,6,11,27].

However, very recently, more attention is being paid to specific physiological and pathological determinants that are potentially related to the OSAS, involving anamnestic and sleeping aspects, which are not investigated thoroughly enough by PSQ. The race of children, for example, plays an important role: African American children are four- to six-times more likely to have OSAS than Caucasian children. Several population-based studies have also pointed out that premature birth and sleep-disordered breathing of parents are among the main risk factors for OSAS. Premature babies have three- to five-times greater risk of developing OSAS in infancy than those without this anamnestic history. Moreover, the presence of neuromuscular pathologies, skeletal disorders (mandibular hypoplasia), and/or already diagnosed genetic syndromes (e.g., Pierre Robin sequences, Treacher Collins syndrome, Nager syndrome and Stickler syndrome) lead to increased risk of development of OSAS [28]. Another poorly investigated anamnestic aspect concerns the presence of allergic rhinitis and adenotonsillar hypertrophy, which, due to related chronic/periodic upper airway lumen reduction, would appear to be strongly correlated with the potential for the onset of paediatric OSAS [29–31].

Regarding sleep quality, certain related behaviours exhibited by the child during the night or upon awakening would seem useful to intercept the presence of OSAS. Apnoea hypoxia generates frequent night-time awakening in children that can manifest as sleep-related fears or confused awakenings [32]. Excessive sweating associated with shortness of breath during sleep and the assumption of abnormal or bizarre positions by the child to reduce perceived obstruction in the upper airways are common [33]. Nocturnal oral breathing, typical of subjects with OSA, also determines an increase in the tendency to drool while sleeping, which is more evident in subjects aged 3–5 years [32].

Therefore, the purpose of our study was to investigate the accuracy of 15 specific items, decided upon after comparison/review of the literature, specifically related to the anamnestic and sleep quality dimensions that favour and/or predict paediatric OSAS. The modified PSQ, consisting of the 22 elements of the original PSQ and the 15 selected elements that were added, was thus presented in a digital form (Google form) and submitted, from 16 to 30 June 2020, to a population of children from four different schools located in the province of Palermo (Sicily, Italy).

The choice to use a Google form was mainly dictated by the convenience of this medium during the COVID-19 pandemic period. Moreover, the use of Google forms made it possible to collect the answers in real-time on a single worksheet, thus facilitating the analysis of the results.

One hundred and twenty-four responses to our questionnaire were analysed, showing that among the 15 additional items, specific pathological conditions of the upper airways and particular determinants of poor sleep quality have a marked discriminative accuracy of paediatric OSAS.

Regarding the former, the items with greater accuracy concern the spectrum of allergies, asthma, nasal congestion and ear or respiratory tract infections (Item 27 and Item 28). These results are perfectly in line with those of very recent studies by Zheng et al. (2018) and Trivedi et al. (2017) [29,34]. Specifically, allergic rhinitis and asthma, in particular, are characterised by several biological mechanisms involving immune response to microbial antigens and other inflammatory stimuli, which, leading to adenotonsillar

hypertrophy and subsequent rhino-oropharyngeal obstruction, reciprocally affect the development/exacerbation of both asthma and OSAS [29,35].

Regarding determinants of sleep quality, the items with greater accuracy were the frequent awakenings during sleep (Item 31), the assumption of bizarre or abnormal positions during sleep (Item 32), the presence of confused awakenings (Item 33) and, finally, the presence of insomnia or difficulty sleeping (Item 37).

All of these aspects are interrelated. Repeated episodes of complete and/or partial and/or prolonged obstruction of the upper airways during sleep are usually associated with a reduction in blood oxygen saturation. Consequently, there is an alteration of blood-gas balance with the activation of a series of biological mechanisms that lead to the arousal of certain areas of the brain, including those that control movement. The identification of this condition by parents could help clinicians hypothesise the possible presence of OSAS. As these children are in a critical period for brain development, the impact of OSAS can have more serious consequences than they might in older individuals [34,36]. Confirming what has been described, our data showed the highest combination of sensitivity and specificity of Item 32 (“assumption of bizarre or abnormal positions during sleep”) and hypothesised that including this question could increase the efficiency and accuracy of PSQ. Further research to test such a hypothesis is desirable.

We consider this result very important for the ease of application of this specific item to all screening tools. The assumption of bizarre or abnormal positions during sleep in children with potential OSAS is related to the need to assume positions that facilitate airflow through the upper airways. Hence, a simple but careful observation of the child during sleep by the parents could easily induce the suspicion of obstructive respiratory disease and initiate further investigations into the quality of their child’s sleep.

This study has a few limitations. First of all, the lack of clinical examination of OSAS did not allow us to assess the accuracy of the modified PSQ but only to assess the accuracy of each one of the fifteen additional questions. Further research is desirable to this aim. The second limitation is the lack of non-Caucasian children in our sample, which inhibit us from comparing the differential risk of OSAS between ethnicities.

5. Conclusions

With a limited sample size, this pilot study highlights how the investigation of sleep quality can be an important parameter in order to identify potential paediatric subjects at risk of OSAS more effectively. The assumption of bizarre or abnormal positions during sleep (e.g., hyperextending neck or sitting), especially if present with other determinants that alter sleep quality, should be considered an alarm bell for the investigation of possible obstructive sleep apnoea. Further studies on a larger population are needed to support these suggestions.

6. Patents

There are not any patents resulting from the work reported in this manuscript.

Author Contributions: Conceptualisation, V.P., G.G. and D.M.; methodology, D.M., L.M., G.L.M. and P.S.; software, G.L.M.; validation, V.P., G.P. and G.G.; formal analysis, D.M. and L.M.; investigation, G.L.M., P.S. and G.G.; resources, D.M. and L.M.; data curation, V.P. and G.P.; writing—original draft preparation, V.P., G.L.M. and P.S.; writing—review and editing, G.P.; visualisation, G.G.; supervision, V.P.; project administration, G.P. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding. The article processing charge was funded partly by the University of Palermo (FFR grants).

Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Institutional Review Board of the University Hospital “Policlinico Paolo Giaccone” in Palermo (approval number 10/2020; 25/10/2020).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Conflicts of Interest: The authors declare no conflict of interest.

References

- Kaditis, A.G.; Alvarez, M.L.A.; Boudewyns, A.; Alexopoulos, E.I.; Ersu, R.; Joosten, K.; Larramona, H.; Miano, S.; Narang, I.; Trang, H.; et al. Obstructive sleep disordered breathing in 2- to 18-year-old children: Diagnosis and management. *Eur. Respir. J.* **2016**, *47*, 69–94. [[CrossRef](#)]
- Faizal, W.M.; Ghazali, N.N.N.; Badruddin, I.A.; Zainon, M.Z.; Yazid, A.A.; Ali, M.; Khor, C.Y.; Ibrahim, N.B.; Razi, R.M. A review of fluid-structure interaction simulation for patients with sleep related breathing disorders with obstructive sleep. *Comput. Methods Programs Biomed.* **2019**, *180*, 105036. [[CrossRef](#)]
- Borgström, A.; Nerfeldt, P.; Friberg, D. Questionnaire OSA-18 has poor validity compared to polysomnography in pediatric obstructive sleep apnea. *Int. J. Pediatr. Otorhinolaryngol.* **2013**, *77*, 1864–1868. [[CrossRef](#)]
- Kadmon, G.; Chung, S.A.; Shapiro, C.M. I'M SLEEPY: A short pediatric sleep apnea questionnaire. *Int. J. Pediatr. Otorhinolaryngol.* **2014**, *78*, 2116–2120. [[CrossRef](#)] [[PubMed](#)]
- Burghard, M.; Brożek-Mądry, E.; Krzeski, A. Sleep disordered breathing in children - Diagnostic questionnaires, comparative analysis. *Int. J. Pediatr. Otorhinolaryngol.* **2019**, *120*, 108–111. [[CrossRef](#)]
- Chervin, R.D.; Hedger, K.; Dillon, J.E.; Pituch, K.J. Pediatric sleep questionnaire (PSQ): Validity and reliability of scales for sleep-disordered breathing, snoring, sleepiness, and behavioral problems. *Sleep Med.* **2000**, *1*, 21–32. [[CrossRef](#)]
- Villa, M.P.; Paolino, M.C.; Castaldo, R.; Vanacore, N.; Rizzoli, A.; Miano, S.; Del Pozzo, M.; Montesano, M. Sleep clinical record: An aid to rapid and accurate diagnosis of paediatric sleep disordered breathing. *Eur. Respir. J.* **2013**, *41*, 1355–1361. [[CrossRef](#)]
- Li, X.D.; Tai, J.; Xu, Z.F.; Peng, X.X.; Feng, G.S.; Zhang, Y.M.; Zhang, J.; Guo, Y.L.; Wu, Y.X.; Shi, J.; et al. The validity and reliability of simplified Chinese version of the pediatric sleep questionnaire for screening children with obstructive sleep apnea syndrome in Beijing. *Zhonghua Er Bi Yan Hou Tou Jing Wai Ke Za Zhi* **2016**, *51*, 812–818. [[CrossRef](#)]
- Tomás Vila, M.; Miralles Torres, A.; Beseler Soto, B. Versión española del Pediatric Sleep Questionnaire. Un instrumento útil en la investigación de los trastornos del sueño en la infancia. Análisis de su fiabilidad (Spanish version of the Pediatric Sleep Questionnaire (PSQ). A useful instrument in investigation of sleep disturbances in childhood. Reliability analysis). *An. Pediatr. (Barc)* **2007**, *66*, 121–128. [[CrossRef](#)]
- Ranieri, S.; Ballanti, F.; Cozza, P. Linguistic validation of a questionnaire for the diagnosis of sleep-related breathing disorders in children [Validazione linguistica di un questionario per la diagnosi dei disturbi respiratori del sonno nei bambini]. *Dental Cadmos.* **2016**, *84*, 576. [[CrossRef](#)]
- Hasniah, A.L.; Jamalludin, A.R.; Norrashidah, A.W.; Norzila, M.Z.; Asiah, K.; Anida, A.R.; Fadzil, A.A.; Ramli, Z.; Samsinah, H. Cross-cultural adaptation and reliability of pediatric sleep questionnaire in assessment of sleep-disordered breathing in the Malay speaking population. *World J. Pediatr.* **2012**, *8*, 38–42. [[CrossRef](#)] [[PubMed](#)]
- Certal, V.; de Lima, F.F.; Winck, J.C.; Azevedo, I.; Costa-Pereira, A. Translation and cross-cultural adaptation of the Pediatric Sleep Questionnaire into Portuguese language. *Int. J. Pediatr. Otorhinolaryngol.* **2015**, *79*, 175–178. [[CrossRef](#)]
- Shteinberg, Y.H.; Eisenbach, N.; Sela, E.; Gruber, M.; Ronen, O. Translation and cultural adaptation of the Hebrew version of the Pediatric Sleep Questionnaire: A prospective, non-randomized control trial. *Sleep Breath.* **2020**. [[CrossRef](#)]
- Jordan, L.; Beydon, N.; Razanamihaja, N.; Garrec, P.; Carra, M.C.; Fournier, B.P.; Vi-Fane, B.; Kerner, S.; Felizardo, R.; Boy-Lefèvre, M.L.; et al. Translation and cross-cultural validation of the French version of the Sleep-Related Breathing Disorder scale of the Pediatric Sleep Questionnaire. *Sleep Med.* **2019**, *58*, 123–129. [[CrossRef](#)]
- Bertran, K.; Mesa, T.; Rosso, K.; Krakowiak, M.J.; Pincheira, E.; Brockmann, P.E. Diagnostic accuracy of the Spanish version of the Pediatric Sleep Questionnaire for screening of obstructive sleep apnea in habitually snoring children. *Sleep Med.* **2015**, *16*, 631–636. [[CrossRef](#)]
- Yüksel, H.; Söğüt, A.; Yılmaz, O.; Kutluay, E. Reliability and validity of the Turkish version of the pediatric sleep questionnaire: A tool for prediction of sleep related breathing disorder. *Tuberk Toraks.* **2011**, *59*, 236–241. [[CrossRef](#)]
- Pires, P.J.S.; Mattiello, R.; Lumertz, M.S.; Morsch, T.P.; Fagondes, S.C.; Nunes, M.L.; Gozal, D.; Stein, R.T. Validation of the Brazilian version of the Pediatric Obstructive Sleep Apnea Screening Tool questionnaire. *J. Pediatr. (Rio J.)* **2019**, *95*, 231–237. [[CrossRef](#)] [[PubMed](#)]
- Gupta, R.; Ali, R.; Verma, S.; Joshi, K.; Dhyani, M.; Bhasin, K.; Bhasin, N.; Goyal, J. Study of Sleep Disorders among Young Children Using Hindi Translated and Validated Version of Pediatric Sleep Questionnaire. *J. Neurosci. Rural. Pract.* **2017**, *8*, 165–169. [[CrossRef](#)] [[PubMed](#)]
- Okada, M.; Kitamura, S.; Iwadare, Y.; Tachimori, H.; Kamei, Y.; Higuchi, S.; Mishima, K. Reliability and validity of a brief sleep questionnaire for children in Japan. *J. Physiol. Anthropol.* **2017**, *36*, 35. [[CrossRef](#)]
- Öner, P.; Barut, Y.; Öner, Ö.; Üneri, Ö.Ş.; Bodur, Ş.; Turgut, S.; Munir, K.M. Çocuklarda Uyku Ölçeği'nin Geçerlik ve Güvenirliği. Reliability and validity of Turkish translation of the pediatric sleep questionnaire [Çocuklarda uyku ölçeği'nin geçerlik ve güvenirligi]. *Klinik. Psikofarmakol. Bulteni.* **2009**, *19*, 382–395.
- Sen, T.; Spruyt, K. Pediatric Sleep Tools: An Updated Literature Review. *Front. Psychiatry* **2020**, *11*, 317. [[CrossRef](#)] [[PubMed](#)]

22. Bruni, O.; Ottaviano, S.; Guidetti, V.; Romoli, M.; Innocenzi, M.; Cortesi, F.; Giannotti, F. The Sleep Disturbance Scale for Children (SDSC). Construction and validation of an instrument to evaluate sleep disturbances in childhood and adolescence. *J. Sleep Res.* **1996**, *5*, 251–261. [[CrossRef](#)]
23. Li, Z.; Celestin, J.; Lockey, R.F. Pediatric Sleep Apnea Syndrome: An Update. *J. Allergy Clin. Immunol. Pract.* **2016**, *4*, 852–861. [[CrossRef](#)] [[PubMed](#)]
24. Matranga, D.; Di Fede, O.; Paderni, C.; Albanese, A.; Pizzo, G.; Magro, R.; Compilato, D.; Campisi, G. Demographic and behavioural profiles of patients with common oral mucosal lesions by a homogeneity analysis. *Oral Dis.* **2012**, *18*, 396–401. [[CrossRef](#)] [[PubMed](#)]
25. Benzecri, J.P. *Correspondence Analysis Handbook*; CRC Press: Boca Raton, FL, USA, 2019.
26. Greenacre, M.; Blasius, J. *Multiple Correspondence Analysis and Related Methods*; Chapman & Hall/CRC: Boca Raton, FL, USA, 2006.
27. Canto, G.D.L.; Singh, V.; Major, M.P.; Witmans, M.; El-Hakim, H.; Major, P.W.; Flores-Mir, C. Diagnostic capability of questionnaires and clinical examinations to assess sleep-disordered breathing in children: A systematic review and meta-analysis. *J. Am. Dent. Assoc.* **2014**, *145*, 165–178. [[CrossRef](#)] [[PubMed](#)]
28. Joosten, K.F.; Larramona, H.; Miano, S.; Van Waardenburg, D.; Kaditis, A.G.; Vandebussche, N.; Ersu, R. How do we recognize the child with OSAS? *Pediatr. Pulmonol.* **2017**, *52*, 260–271. [[CrossRef](#)]
29. Zheng, M.; Wang, X.; Zhang, L. Association between allergic and nonallergic rhinitis and obstructive sleep apnea. *Curr. Opin. Allergy Clin. Immunol.* **2018**, *18*, 16–25. [[CrossRef](#)]
30. Gulotta, G.; Iannella, G.; Vicini, C.; Polimeni, A.; Greco, A.; de Vincentiis, M.; Visconti, I.C.; Meccariello, G.; Cammaroto, G.; De Vito, A.; et al. Risk Factors for Obstructive Sleep Apnea Syndrome in Children: State of the Art. *Int. J. Environ. Res. Public Health* **2019**, *16*, 3235. [[CrossRef](#)]
31. Gozal, D.; Kheirandish-Gozal, L.; Capdevila, O.S.; Dayyat, E.; Kheirandish, E. Prevalence of recurrent otitis media in habitually snoring school-aged children. *Sleep Med.* **2008**, *9*, 549–554. [[CrossRef](#)]
32. Sinha, D.; Guilleminault, C. Sleep disordered breathing in children. *Indian J. Med. Res.* **2010**, *131*, 311–320.
33. De Vincentiis, G.C.; Sitzia, E.; Panatta, M.L. [OSAS in età pediatrica]. *Quaderni ACP 2014* **2014**, *21*, 244–251.
34. Ipsiroglu, O.S.; Fatemi, A.; Werner, I.; Paditz, E.; Schwarz, B. Self-reported organic and nonorganic sleep problems in schoolchildren aged 11 to 15 years in Vienna. *J. Adolesc. Health* **2002**, *31*, 436–442. [[CrossRef](#)]
35. Trivedi, M.; ElMallah, M.; Bailey, E.; Kremer, T.; Rhein, L.M. Pediatric Obstructive Sleep Apnea and Asthma: Clinical Implications. *Pediatr. Ann.* **2017**, *46*, e332–e335. [[CrossRef](#)] [[PubMed](#)]
36. Walter, L.M.; Nixon, G.M.; Davey, M.J.; O'Driscoll, D.M.; Trinder, J.; Horne, R.S. Sleep disturbance in pre-school children with obstructive sleep apnoea syndrome. *Sleep Med.* **2011**, *12*, 880–886. [[CrossRef](#)] [[PubMed](#)]