



Article

# SPHYNCS: The Use of the Swiss Narcolepsy Scale in a New Cohort of Patients with Narcolepsy and Its Borderland and Review of the Literature

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**Abstract:** Introduction and aims: Narcolepsy type 1 (NT1) is a central disorder of hypersomnolence (CDH) characterized by excessive daytime sleepiness and cataplexy. The Swiss Narcolepsy Scale (SNS), which includes the updated and short (sSNS) versions, has recently been introduced as a reliable diagnostic tool for identifying NT1. This study aims to assess the validity of the SNS scales in a new cohort of patients with CDH, while also introducing the French and Italian versions of the SNS and providing a summary of the existing literature on SNS. Materials and methods: The current study is based on the international Swiss Primary Hypersomnolence and Narcolepsy Cohort Study (iSPHYNCS) which aims to identify new biomarkers for CDH. Diagnostic accuracy of the SNS was assessed by calculating sensitivity, specificity, positive predictive value, and negative predictive value. Results: In our population, 108 participants with suspected CDH (including 28 NT1 patients) and 14 healthy controls completed the scale. Original SNS, updated SNS and sSNS scores showed a high sensitivity (86%, 89% and 79%, respectively) and high specificity (96%, 90% and 95%, respectively) for diagnosing NT1 compared to other CDH. The French version was completed by 5 participants, and the Italian version by 8 participants. Regarding previous studies, the SNS has now been assessed in six different populations, involving a total of 1247 subjects (including 326 with narcolepsy with cataplexy/NT1), suggesting high sensitivity (85–100%) and specificity (86–100%) of the SNS for the diagnosis of NT1. Conclusion: The SNS is a simple screening tool validated in seven languages (German, English, French, Italian, Dutch, Turkish and Japanese), demonstrating high sensitivity and specificity for the diagnosis of NT1.

**Keywords:** Swiss Narcolepsy Scale; excessive daytime sleepiness; questionnaires; validation

## 1. Introduction

Narcolepsy type 1 (NT1) is a rare sleep disorder, manifesting in profound excessive daytime sleepiness (EDS) with irresistible sleep attacks, sudden loss of muscle tone triggered by emotions (cataplexy), and disturbed nocturnal sleep [1]. The symptoms of narcolepsy are not pathognomonic for the disease, with the exception of definite (typical) cataplexy [2–4]. A lack of awareness about specific signs and symptoms of NT1, as well as other central disorders of hypersomnolence (CDH), or so-called narcoleptic borderland (NBL), leads to a delayed referral of patients to a specialized center and, respectively, delayed diagnosis.

In young individuals suffering from EDS, differential diagnosis is further challenged by the need to distinguish between normal physiology and potential pathology. The presenting symptoms often involve a combination of medical and psychosocial factors requiring the examination of complex behavioral patterns in young adults [5]. The lack of healthcare awareness regarding narcolepsy hinders both general practitioners and patients from effectively utilizing diagnostic tests to facilitate accurate diagnosis. Consequently, this leads to a significant reduction in the quality of life of affected individuals, secondary psychopathological disturbances, motor vehicle accidents, and financial losses [6,7].

The diagnosis of NT1 is primarily based on described clinical features and objective measures, including the results of electrophysiological tests and hypocretin-1 (Hcrt-1) measurements in cerebrospinal fluid (CSF) [8–11]. NT1 is strongly associated with positivity for the HLA-DQB1\*06:02 allele [4,10]. For the standardized qualitative assessment of the clinical symptoms, specific questionnaires have been established. The Epworth Sleepiness Scale (ESS) is most commonly used to assess propensity to fall asleep in individuals complaining of sleepiness [12,13]. However, the ESS was shown to have a low capability of distinguishing between different causes of EDS and thus in discriminating NT1 from other conditions associated with EDS/hypersomnia [3,12]. The Ullanlinna Narcolepsy Scale (UNS) is another simple questionnaire-based method used to screen for NT1 [14]. The UNS was previously demonstrated to have a high sensitivity, however a low specificity for the diagnosis of narcolepsy type 1 against EDS of another origin [15].

A novel five-item questionnaire, the Swiss Narcolepsy Scale (SNS), has been recently introduced as a screening tool for NT1 (Table 1). The scale was designed based on a prospective analysis of the frequency and characteristics of sleep–wake symptoms in patients with narcolepsy with cataplexy and their correlation with the results of ancillary tests. The SNS was found to have high sensitivity (96%) and specificity (98%) in discriminating NT1 from other disorders with EDS. The study demonstrated that the characteristics and frequency of cataplexy best predict the presence or absence of biological and electrophysiological markers of narcolepsy [1].

A more recent study on SNS by Sturzenegger et al. [15] evaluated the validity of the SNS on a larger sample size, confirming the high sensitivity and specificity of the scale in distinguishing NT1 among the other conditions associated with EDS. In another study on the SNS by Bargiotas et al. [16], the original SNS was updated by recalculating the model coefficients for scoring SNS and defining an optimal cut-off score for the scale to further increase diagnostic capacity of the scale for discriminating NT1 against narcoleptic borderland. Additionally, a simplified short form of SNS (sSNS) was introduced as an easy-to-use and easy-to-calculate questionnaire to identify NT1 patients. The sSNS includes only two questions and was shown to be a simple and reliable diagnostic tool, particularly for use in primary care as a screening tool for narcolepsy in patients with hypersomnolence. The sSNS correlated with the full SNS ( $p < 0.001$ ) and demonstrated comparable validity with the SNS. The calculations and cut-offs of the SNS and sSNS scales are presented in Table 1.

**Table 1.** (a) The questions forming the SNS (the English version) and (b) formulas for the calculation of the SNS, updated SNS and sSNS scores as well interpretation of the results.

<b>(a) Questions</b>	
Q1	How often are you unable to fall asleep? [1] never, [2] rarely (less than once a month), [3] sometimes (1–3 times a month), [4] often (1–2 times a week), and [5] almost always
Q2	How often do you feel bad or not well rested in the morning? [1] never, [2] rarely (less than once a month), [3] sometimes (1–3 times a month), [4] often (1–2 times a week), and [5] almost always
Q3	How often do you take a nap during the day? [1] never, [2] I would like, but cannot, [3] 1–2 times a week, [4] 3–5 times a week, and [5] almost daily
Q4	How often have you experienced weak knees/buckling of the knees during emotions like laughing, happiness, or anger? [1] never, [2] rarely (less than once a month), [3] sometimes (1–3 times a month), [4] often (1–2 times a week), and [5] almost always
Q5	How often have you experienced sagging of the jaw during emotions like laughing, happiness, or anger? [1] never, [2] rarely (less than once a month), [3] sometimes (1–3 times a month), [4] often (1–2 times a week), and [5] almost always
<b>(b) Formulas for calculation of scores and cut-off values for predicting NT1:</b>	
SNS score: $6 \times Q1 + 9 \times Q2 - 5 \times Q3 - 11 \times Q4 - 13 \times Q5 + 20 < 0$	
Updated SNS score: $Q1 \times (-0.47) + Q2 \times (-0.83) + Q3 \times 0.58 + Q4 \times 0.56 + Q5 \times 1.45 - 2.75 \geq -1.83$	
sSNS: $Q2 \times -0.82 + Q5 \times 1.70 - 0.74 \geq -0.68$	

Demir et al. [17] have recently assessed the validity and reliability of the Turkish version of the SNS (SNS-TR). The overall sensitivity and specificity of the SNS-TR in diagnosing NT1 are 90.5% and 100%, respectively. The SNS-TR scale showed a very reliable level of internal consistency, based on the standardized items, demonstrating that the Turkish version of the SNS, the SNS-TR, had a high discriminative power for diagnosing NT1 and distinguishing NT1 from other CDH. The most recent study on the SNS was conducted by Tanioka et al. [18], which assessed the validity of the Japanese versions of the Ullanlinna Narcolepsy Scale (J-UNS) and Swiss Narcolepsy Scale (J-SNS) for screening narcolepsy in the Japanese population. In this study, the J-SNS displayed 86% sensitivity and 86% specificity, while the J-UNS showed 96% sensitivity and 58% specificity.

Further validation of the SNS and sSNS on new population cohorts is needed. As described above, previous studies on the scales have so far been applied to German-, Dutch-, Turkish- and Japanese-speaking populations [1,15–18]. The questionnaires have not been validated or tested in other languages.

Therefore, the objectives of this study are to: (1) assess the sensitivity, specificity, positive predictive value and negative predictive value of the SNS as well as the updated SNS and sSNS scores on a new cohort of CDH patients; (2) calculate the delay in the diagnosis of narcolepsy and NBL; (3) compare the sensitivity and specificity of SNS, sSNS and ESS, (4) introduce the French and Italian versions of the SNS; and (5) provide an overview of the existing literature on SNS.

## 2. Materials and Methods

### 2.1. Cohort of the Study

The current study is based on the international Swiss Primary Hypersomnolence and Narcolepsy Cohort Study (iSPHYNCS, BASEC-ID 2019-00788). The iSPHYNCS study is a consortium of expert clinicians and researchers from various disciplines. The study is designed as an interdisciplinary, multi-omics, prospective cohort study to address the knowledge gap about CDH and identify novel biomarkers for the subgroups of CDH through multidimensional patient phenotyping [19].

We prospectively studied the clinical data of 156 enrolled participants in the ongoing iSPHYNCS study. The data, including questionnaires, clinical, and polysomnographic and biological information, were collected electronically in a REDCap database (set up at the Clinical Trials Unit (CTU), Bern). In particular, results of the SNS and ESS (raw data) were evaluated. We also calculated the delay in diagnosis in years, as measured by the time interval between the first manifestation and the diagnosis.

German-, French- and Italian-speaking patients are included in the study. Forward and reverse translations of the SNS into French and Italian were prepared by professional translators and reviewed by clinical narcolepsy specialists. The German version of the questionnaires was filled out by 109 participants ( $n = 25$  patients with NT1); the French version by 5 participants ( $n = 2$  patients with NT1) and the Italian version by 8 participants ( $n = 1$  patients with NT1). The ESS has been validated previously [20–22] and has been used under license.

### 2.2. Procedures and Statistical Analysis

The original SNS, updated SNS scores, and the scores for sSNS were calculated according to the previously suggested formulas and cut-offs (Table 1). Excessive daytime sleepiness is defined by an ESS value  $> 10$  [12]. To assess diagnostic accuracy of the questionnaires for identifying the diagnosis of NT1, sensitivity, specificity, positive predictive value, and the negative predictive value were calculated. The sensitivity and specificity of the scales were also evaluated using receiver operating characteristic (ROC) analysis, including the assessment of the area under the ROC curve. The correlation of the scales was determined using the Pearson correlation test.

Statistical significance was set at  $p < 0.05$ . Analyses were performed in R 4.2.2.

## 3. Results

### 3.1. Characteristics of the Study Population

We analyzed data from the first 156 participants included in the iSPHYNCS study. Among them, we identified 122 participants who filled out the SNS and ESS scales at enrolment, including 108 patients with a suspected diagnosis of central hypersomnia (the diagnoses were made according to the *International Classification of Sleep Disorders (ICSD)*, 3rd edition) and 14 healthy (non-sleepy) controls. Among the patients, 28 individuals met the criteria for NT1 according to the ICSD 3rd edition, and 80 suffered from a subcategory of NBL, including NT2, idiopathic hypersomnia, insufficient sleep syndrome, hypersomnia associated with a psychiatric disorder and excessive daytime sleepiness not otherwise specified (Figure 1).

Notably, the NBL diagnoses were set as preliminary ones due to overlap of signs and symptoms and will be reevaluated during the iSPHYNCS study. The delay in diagnosis varied between the diagnoses. For patients with NT1, the diagnosis was made with a delay of up to 26 years, and the median delay in all patients was approximately 7 years.

Characteristic	N = 122 <sup>1</sup>
<b>Gender</b>	
Female	90 (74%)
Male	32 (26%)
<b>Age</b>	26 (21, 34)
<b>BMI</b>	23.0 (20.9, 26.8)
<b>Diagnosis ICSD III</b>	
Narcolepsy Type 1	28 (23%)
Narcolepsy Type 2	4 (3.3%)
Hypersomnia associated with a Psychiatric disorder	9 (7.4%)
Idiopathic hypersomnia	43 (35%)
Insufficient sleep syndrome	12 (9.8%)
Hypersomnia due to a medication or substance	1 (0.8%)
Excessive daytime sleepiness not otherwise specified	11 (9.0%)
Healthy controls	14 (11%)
<sup>1</sup> n (%); Median (IQR)	

**Figure 1.** Demographic data of the iSPHYNCS study population.

All participants underwent electrophysiological examinations, including full-night polysomnography, multiple sleep latency testing and vigilance tests. Among the NT1 patients, the results of CSF Hcrt-1 measurements were available in 20 out of 28 subjects (71% of all NT1 patients). In 19 NT1 patients (95% of those who underwent measurement), Hcrt-1 was below 110 pg/mL, a level that is strongly associated with the diagnosis of NT1 [23]. In one individual meeting the criteria for NT1, the Hcrt-1 level was measured as 115 pg/mL; in this individual, genetic analysis revealed the presence of the HLA DQB1\*0602 allele. Among narcoleptic borderland individuals, the Hcrt-1 level was greater than 110 pg/mL in all participants who underwent CSF measurement.

Among the NT1 patients, the HLA analysis was performed in 22 out of 28 NT1 patients (79% of all NT1 patients); the HLA DQB1\*0602 allele was identified in 21 patients. Among narcoleptic borderland, genetic analysis was conducted in 45 out of 80 patients, revealing the HLA DQB1\*0602 allele in 7 participants.

### 3.2. Diagnostic Accuracy of the SNS

The calculated sensitivities, specificities, as well as positive and negative predictive values of the SNS, sSNS, and ESS for the diagnosis of NT1 in the iSPHYNCS cohort are summarized in Figure 2. The original SNS score, updated SNS score, and sSNS score showed high sensitivity (86%, 89% and 79%, respectively) and high specificity (96%, 90% and 95%, respectively) for the diagnosis of NT1 compared to the NBL (Figure 2a). ESS had high sensitivity (85%), but low specificity (22%) for discriminating NT1 among the other CDH. All the scales showed a high discriminative capability for NT1 against healthy controls (Figure 2b), with the specificity of the original and updated SNS score reaching

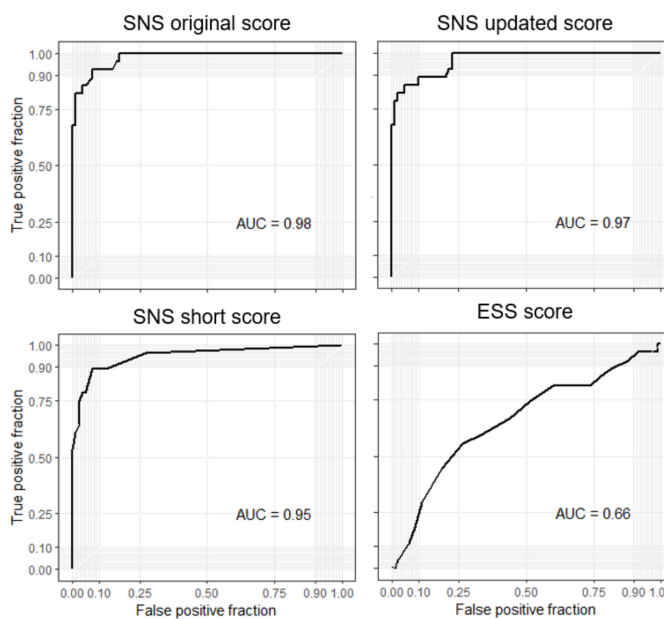
100%. The overall accuracy, as assessed in a ROC curve analysis, was best for the original SNS score (AUC of 0.98 as compared to 0.97 and 0.95 for the updated and short score, respectively). In comparison, the ESS showed high sensitivity (85%), but low specificity (22%) and low overall accuracy (AUC of 0.66 in the ROC curve analysis) (Figure 2c).

Values	Original SNS score	Updated SNS score	Short SNS score	ESS score
Sensitivity	86	89	79	85
Specificity	96	90	95	22
PPV	89	76	85	27
NPV	95	96	93	82

(a)

Values	Original SNS score	Updated SNS score	Short SNS score	ESS score
Sensitivity	86	89	79	85
Specificity	100	100	64	74
PPV	100	100	81	82
NPV	78	82	60	78

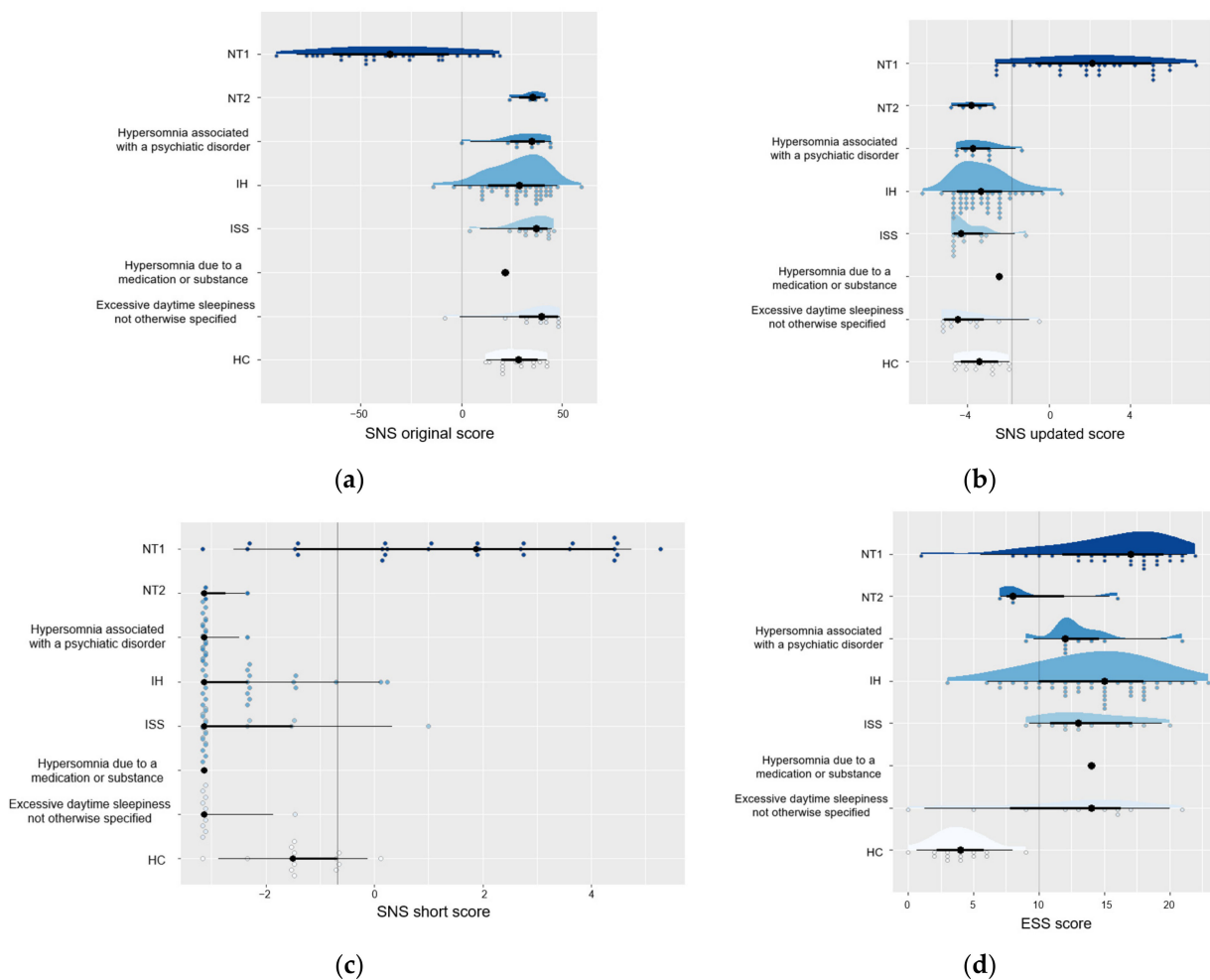
(b)



(c)

**Figure 2.** Sensitivity and specificity of SNS and ESS scores for discriminating between NT1: (a) and other central disorders of hypersomnolence (narcoleptic borderland, NBL) %; (b) healthy controls %; and (c) the area under ROC curve analyses for SNS and ESS scores. PPV—positive predictive value; NPV—negative predictive value; AUC—area under curve.

The rate of false-positive results in SNS and sSNS scores was substantially lower than in the ESS score. False-positive results across all the SNS scores were most commonly observed in patients with idiopathic hypersomnia (Figure 3).



**Figure 3.** Distribution of the results of the scores. The accentuated vertical line on each graph demonstrates the cut-off value of the score: (a) original SNS score; (b) updated SNS score; (c) short SNS score; and (d) ESS score.

#### 4. Discussion

Our report demonstrates the high discriminative capacity of the Swiss narcolepsy scale for the diagnosis of narcolepsy type 1 against other central disorders of hypersomnolence. The obtained data from a new study cohort confirmed the previously shown high diagnostic accuracy of the SNS and sSNS scales for NT1 against other CDH. Although the sample size of our iSPHYNCS population did not exceed the number of patients included in previous studies, this is the first assessment of diagnostic accuracy of the SNS in a population of patients covering the entire spectrum of the central disorders of hypersomnolence. A comparative table on the available studies on the SNS, including the current study, is shown in the Table 2.

Among the scores, the original and updated SNS scores showed the highest values of specificity and sensitivity in our cohort (above 85% for sensitivities and above 90% for specificities). In addition, the area under the ROC curve analyses demonstrated the high accuracy of the SNS scores, whereas ESS showed poor results. The SNS scores also showed a high positive predictive value (PPV) and negative predictive value (NPV). A high PPV implies that the given cut-off has a high probability of correctly distinguishing between narcoleptic and non-narcoleptic patients or healthy controls. High values of NPV indicate that the scale can identify the patients who are most likely not to have NT1. The original SNS score had the highest percentage for PPV and NPV (89% and 95%, respectively), together with high values of sensitivity and specificity, confirming the highest diagnostic accuracy for the original SNS score among all the presented scales.

**Table 2.** Overview of the results of performed studies on the SNS.

	Study Population	Epworth Sleepiness Scale	Swiss Narcolepsy Scale (Original Score)
<b>Sturzenegger &amp; Bassetti, 2004 [1]</b>	<ul style="list-style-type: none"> <li>■ N = 153</li> <li>■ n = 57 narcolepsy with cataplexy</li> <li>■ n = 56 EDS of another origin</li> <li>■ n = 40 HC</li> </ul>	Significantly higher scores in narcolepsy with cataplexy ( $17 \pm 5$ ) than non-narcoleptics ( $15 \pm 4$ , $p = 0.003$ )	Sensitivity: 96% Specificity: 98% for detecting narcolepsy with cataplexy against EDS of another origin
<b>Sturzenegger et al., 2018 [15]</b>	<ul style="list-style-type: none"> <li>■ N = 191</li> <li>■ n = 80 narcolepsy with cataplexy</li> <li>■ n = 111 EDS of another origin</li> </ul>	Sensitivity: 91% Specificity: 54% for detecting narcolepsy with cataplexy against EDS of another origin	Sensitivity: 89% and 93% Specificity: 88% and 88% for detecting narcolepsy with cataplexy against EDS of another origin
<b>Bargiotas et al., 2019 [16]</b>	<ul style="list-style-type: none"> <li>■ N = 299</li> <li>■ n = 69 NT1</li> <li>■ n = 230 EDS of another origin</li> </ul>	Sensitivity: 56% Specificity: 68% for detecting NT1 against EDS of another origin	Sensitivity 86% Specificity: 88% for detecting NT1 against EDS of another origin
<b>Demir et al., 2023 [17]</b>	<ul style="list-style-type: none"> <li>■ N = 74</li> <li>■ n = 21 NT1</li> <li>■ n = 6 NT2</li> <li>■ n = 26 IH</li> <li>■ n = 21 HC</li> </ul>	Higher scores in patients with narcolepsy (NT1 ( $18.2 \pm 3.5$ ) and NT2 ( $15.5 \pm 5.6$ )) against IH ( $p = 0.033$ )	Sensitivity: 90.5% Specificity: 100% for detecting NT1 against EDS of another origin
<b>Tanioka et al., 2023 [18]</b>	<ul style="list-style-type: none"> <li>■ N = 408</li> <li>■ n = 71 NT1</li> <li>■ n = 23 NT2</li> <li>■ n = 314 EDS of another origin</li> </ul>	Higher scores in patients with narcolepsy (NT1 ( $19.2 \pm 3.6$ ) and NT2 ( $19.4 \pm 3.5$ )) against EDS of another origin ( $p < 0.05$ )	Sensitivity: 86% Specificity: 86% for detecting NT1 against EDS of another origin
<b>Zub et al., 2023 current study</b>	<ul style="list-style-type: none"> <li>■ N = 122</li> <li>■ n = 28 NT1</li> <li>■ n = 4 NT2</li> <li>■ n = 76 patients with other CDH</li> <li>■ n = 14 HC</li> </ul>	Sensitivity: 85% Specificity: 22% for detecting NT1 against patients with other CDH	Sensitivity: 86% Specificity: 96% for detecting NT1 against patients with other CDH

HC—healthy (non-sleepy) controls; EDS—excessive daytime sleepiness; NT1—narcolepsy type 1; NT2—narcolepsy type 2; IH—idiopathic hypersomnia, CDH—central disorders of hypersomnolence.

The original SNS score was the most accurate, showing the smallest number of false positive results (Figure 3). The group with excessive daytime sleepiness not otherwise specified is of particular interest. Patients in this subcategory did not fulfill the criteria of any of the ICSD-III subcategories of CDH. In addition, the group of patients diagnosed with idiopathic hypersomnia (IH) demonstrated the highest number of false-positive results among all entities of NBL. These diagnoses will be reevaluated depending on the course and evolution of the symptoms throughout the study duration. This means that the one NBL patient who currently has a false-positive result on the SNS scale may still have the potential to be reevaluated as NT1 at a later stage. Further investigations on a larger cohort of patients with suspected NBL disorders is needed.

The sSNS, containing only two questions, correlated with the full SNS and demonstrated comparable validity with the SNS in detecting NT1 against other types of hypersomnolence. However, the specificity of the sSNS for NT1 against healthy controls was relatively low in our study cohort (64%), which is even lower than that for the ESS score (74%). This is not surprising, as the question of the sSNS on the restorative quality of night sleep implicates similarity between healthy controls and NT1. Thus, both patients with narcolepsy and healthy controls mostly feel well-rested in the morning. The study by Bargiotas et al. [16] introduced sSNS scale as a tool for distinguishing NT1 from patients with EDS of another origin. The study did not involve healthy participants. Comparatively, original, and updated SNS scores showed the highest specificity in distinguishing NT1 from healthy controls (both reaching 100%).



Unlike the SNS, the ESS score showed a substantial number of false-positive results across all diagnoses. This confirms the limited applicability of the ESS to distinguish between different disorders associated with excessive daytime sleepiness. Indeed, Sturzenegger et al. [15] previously showed that the specificity of the ESS for distinguishing NT1 among the other conditions associated with EDS is quite low (54%), while the sensitivity remains high (91%). Similar results were demonstrated by Bargiotas et al. [16], with relatively low sensitivity (56%) as well as specificity (68%). Demir et al. [17] showed, however, that the ESS scores were significantly higher ( $p = 0.033$ ) in patients with narcolepsy (NT1 or NT2) compared to IH. There were no significant differences in the ESS scores between NT1 and NT2. The study by Tanioka et al. [18] demonstrated comparable results, indicating significantly higher ESS scores in patients diagnosed with NT1 and NT2 compared to those with EDS of another origin ( $p < 0.05$ ).

In our study population, the diagnosis of NT1 was given with a significant delay of 7 years on average after the symptoms began. Among NBL individuals, the suspected diagnosis was given with a delay of more than 5 years. The greatest diagnostic delay was seen in individuals with suspected idiopathic hypersomnia (up to 32 years). This confirms previous evidence for delayed diagnosis of CDH and, in particular, narcolepsy, commonly due to physician and patient unawareness of the symptoms characteristic of the disorder [6]. The high sensitivity and specificity of SNS and sSNS scales could significantly prevent delays in the diagnosis of NT1. A wide distribution of the scale among general practitioners could thus lead to early diagnosis of NT1 and a reduction in disease burden due to the early initiation of proper treatment. Moreover, due to the simplicity of the scale, it may also be applied to the general public so that individuals suffering from excessive daytime sleepiness and seeking medical advice could be pre-screened before being referred to a specialist.

Narcolepsy, closely linked to the HLA-DQB1\*06:02 genotype, is considered an immune-mediated disease. The AS03 adjuvanted H1N1 influenza A (Pandemrix) 2009 vaccination campaign in Europe correlated with increased NT1 incidence, especially in children and young adults, supporting the immune-mediated pathogenesis [24]. These findings suggest that other infections or vaccinations, like COVID-19, have the potential to also trigger narcolepsy. A case report by Roya et al. [25] describes NT1 onset following COVID-19 recovery. Pandemrix-related narcolepsy has been associated with a diagnostic delay of up to a decade, with previous misdiagnoses including anemia, asthma, psychosocial problems, depression, and unspecified tiredness [26]. These scenarios emphasize the crucial role of readily available diagnostic tools in general practice and pediatrics to decrease the risk of delayed diagnoses.

In our study, we firstly introduced French and Italian versions of the scales. Due to the small number of participants, no further analyses to compare the validity of the scales in different languages have been performed. However, our correlation analysis showed a similar trend of less represented French and Italian versions of the scores compared with the German version. Further validation on a larger cohort of patients is needed.

The present study provides a preliminary analysis of the data gathered within iSPHYNCS. The study will be further expanded with a target sample size of 500 participants by the end of 2026. The small sample size and uncertainty for some diagnoses are some limitations to these preliminary analyses, which we will overcome in the next step by increasing the sample size and by revisiting the clinical diagnoses depending on the disease course. With the inclusion of several international sites, we will contribute to the further validation of Dutch and Italian versions of the scale.

In the current study, we assessed the accuracy of the scales in an adult population. We also plan to compare the validity of the SNS and sSNS in children (under the age of 16 years old). The latter have not been evaluated previously and this will become possible in the expected iSPHYNCS cohort. Pediatric age at narcolepsy onset is a strong predictor of diagnostic delay due to a variety of manifestations of the disorder [27]. Thus, it is important

to establish better diagnostic algorithms to make a diagnosis of NT1 in children. These data suggest that the SNS may become one of them.

Furthermore, we plan to assess and compare the accuracy of the SNS scales during the very first consultation, at enrolment, as well as at further follow-up visits with the purpose of evaluating the scales as a diagnostic tool but also possibly as a measure of treatment efficiency and monitoring. As extensively shown, ESS is evidently insufficient as a monitoring tool.

## 5. Conclusions

In summary, our study confirms the superior diagnostic accuracy of the Swiss Narcolepsy Scale for narcolepsy type 1. The diagnostic delay in NT1, averaging 7 years, underscores the urgent need for effective screening tools. The high sensitivity and specificity of the SNS scales offer promise in facilitating early diagnosis and reducing the overall disease burden. Future research should explore the use of the SNS scales during initial consultations and follow-up visits, potentially positioning it as both a diagnostic tool and a measure of treatment efficacy. In addition, further investigations should focus on evaluating the scales in young adults and children.

The SNS is a simple screening tool available in seven languages (German, English, French, Italian, Dutch, Turkish and Japanese), demonstrating high sensitivity and specificity for the diagnosis of NT1.

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