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Epidemiology and risk factors for sleep disturbances in children and youth with cerebral palsy: An ICF-based approach

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ABSTRACT

Objectives and background: Children with cerebral palsy are at risk for sleep disorders, and there is a complex relationship between sleep and physical, environmental and functional factors in such children. The WHO International Classification of Functioning, Disability and Health model serves as a universal framework for describing and organizing functioning and disability. This study aimed to describe sleep disturbances in Singaporean children and youth with cerebral palsy, and develop a holistic framework for evaluating risk factors and potential management strategies for poor sleep.
Methods: A cross-sectional analysis was conducted on 151 children and youth in a nationwide registry for cerebral palsy. The WHO International Classification of Functioning, Disability and Health for Cerebral Palsy Questionnaire was used to identify sleep disturbances. Risk factors analyzed were age, gender, ethnic background, financial assistance, the dominant motor feature of cerebral palsy, functional status, and comorbidities such as active epilepsy, hearing and visual impairments, generalized pain, muscle tone and involuntary contractions.
Results: 46% had difficulty with sleep, with similar proportions having difficulty with amount, onset, maintenance and quality of sleep. On multivariate regression analysis, higher functional gross motor impairment as indicated by a GMFCS level of V (adjusted OR 4.24; 95% CI 1.09–19.0) and difficulty with involuntary contractions (aOR 2.80; 1.20–6.71) were significant factors for sleep difficulties.
Conclusion: An ICF-based framework was useful in identifying possible contributory factors and strategies for managing poor sleep. Further studies with objective sleep measures would allow for better characterization of sleep disturbances in children and youth with cerebral palsy, and guide management.

1. Introduction

Cerebral Palsy (CP) is one of the most common causes of physical impairment in childhood. It describes a group of permanent disorders of movement and posture causing activity limitation, that are attributed to non-progressive disturbances in the developing brain. The motor disorders are often accompanied by disturbances of sensation, perception, cognition, communication and behavior, by epilepsy, and by secondary musculoskeletal disorders [1]. These comorbidities put children with CP at increased risk of sleep disorders, with each potentially contributing towards poor sleep. For example, the presence of epilepsy [2,3] and pain [4] were each independently associated with poor sleep in children with CP. The prevalence of a sleep disorder in children with CP, as measured by abnormal total score on the Sleep Disturbance Scale for Children, was estimated to be 23.4% in a meta-analysis by Horwood et al. [5], with higher risk in children with more severe degrees of CP [3].

Sleep is important for children's growth and development, and affects behavioral and cognitive function. Sleep disorders were found to be an independent predictor of quality of life in children with CP [6], and for behavioral difficulties, after adjusting for nighttime pain, age, and non-ambulatory status [7]. This can also negatively impact children with CP and their families, with poor sleep also affecting caregivers' sleep quality and mental health [8].

The relationship between sleep and neurodevelopmental disorders like CP is complex and multidirectional with interconnecting factors, on top of significant underlying heterogeneity in health and

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Abbreviations:

CP	Cerebral Palsy
ICF	International Classification of Functioning, Disability and Health
ICF-CY	International Classification of Functioning, Disability and Health for Children and Youth
ADLs	Activities of Daily Living
GMFCS	Gross Motor Function Classification System
MACS	Manual Ability Classification System
CFCS	Communication Function Classification System

function in children with CP. The WHO International Classification of Functioning, Disability and Health for Children and Youth (ICF-CY) was set up as a universal guideline for assessment, intervention and follow-up of children with disabilities, and provides a holistic framework for examining health, functioning, environmental factors and personal factors. Specific core sets [9] and multiple-item measures [10] have been developed for children and youth with CP, and have been used internationally in research and clinical applications [11]. In this study, we aim to describe sleep disturbances in our local population of children with CP, and to use an ICF-based approach to determine risk factors for poor sleep.

2. Methods

2.1. Data collection

The CP Registry in Singapore (SingCPR) [12] was set up by the only two tertiary pediatric hospitals in Singapore (KK Women's and Children's Hospital and National University Hospital) and Cerebral Palsy Alliance Singapore (CPAS), a social service agency that provides educational and therapy services for persons with CP. Participation was voluntary. Cases were identified from the two tertiary hospitals, CPAS, and community providers such as private pediatricians, early intervention centers and special schools. The inclusion criteria was children and youth diagnosed with CP, born 1994 and later. We reviewed data from all 151 individuals recruited from September 2017 to May 2020.

The study was approved by the SingHealth Institution Review Board, with informed written consent obtained from all subjects or caregivers.

Recruited individuals and parents completed a standardized questionnaire including socioeconomic demographics, and ratings of sleep, other body functions and activities of daily living (ADLs) based on the ICF-CY Core Sets for CP. The ICF-CY has been validated for assessing areas of functioning and disability for children and youth [13]. Items assessed included difficulty with amount, onset, maintenance and quality of sleep, along with other body functions including difficulty with maintaining sitting position, ease of transfer, toileting, muscle tone, involuntary contractions, and the presence of generalized pain. Caregivers and participants ranked their difficulty with each item on a 5-point Likert-type scale, with qualifiers defined as no difficulty, mild difficulty (present <25% of time), moderate difficulty (25–50% of time), severe difficulty (50–95% of time), or complete difficulty (>95% of time) (Supplementary Table 1).

Clinical data, obtained from doctors or medical records, included the dominant motor feature, comorbidities including epilepsy or hearing or visual difficulties, and interventions including anti-epileptic medications and tone management such as oral medications and Botulinum toxin injections. Active epilepsy was defined as having a seizure within the last 2 years, or being on anti-epileptic medication.

Functional status was assessed by trained physiotherapists and occupational therapists, using validated classification systems for people with CP. Gross motor function was assessed using the Gross Motor Function Classification System (GMFCS) [14], fine motor with the Manual Ability Classification System (MACS) [15] or mini-MACS for participants less than 4 years old [16], and communication with the Communication Function Classification System (CFCS) [17].

2.2. Statistical analysis

Data was presented as median (interquartile range [IQR]) for continuous variables, and number (percentage) for categorical variables. We performed univariate logistic regression analyses for the presence of sleep difficulties, as defined by any difficulties (i.e. score of 2 or more) on the ICF-based questionnaire with amount, onset, maintenance or quality of sleep. Risk factors analyzed were age, gender, ethnic background, financial assistance, the dominant motor feature of CP, functional status as assessed by GMFCS, MACS and CFCS, comorbidities such as active epilepsy, hearing and visual impairments, and difficulties with generalized pain, muscle tone and involuntary contractions. Variables significant on the univariable analysis were considered for inclusion in the multivariate model.

Statistical significance was indicated by a p-value of less than 0.05. Statistical analysis was conducted with R V4.0 (R Core Team, Vienna, Austria).

3. Results

151 individuals were included in our study. Table 1 reports the demographic and clinical characteristics of our study population. Participants ranged from 1 to 24 years old, with a median age of 6.18 years (IQR 3.66–10.8 years). In terms of the predominant motor type, 109 (72%) had a spastic motor type, while 42 (28%) had dyskinesia. None had ataxic motor types. The ethnic group distribution in the study was representative of the national census. The distribution of severity and motor type of CP was similar to that stated in other Registries and countries.

48 (32%) participants had difficulty with amount of sleep, 56 (37%) with onset of sleep, 51 (34%) with maintenance of sleep and 48 (32%) with sleep quality (Table 2). Overall, 69 (46%) had difficulty with one or more aspects of sleep.

On univariate analysis (Table 3), level V on GMFCS, MACS, or CFCS, the presence of active epilepsy, being on anti-epileptic medications, difficulties with generalized pain, muscle tone, having received interventions for tone management, involuntary contractions and visual impairment were associated with sleep difficulties. On multivariate analysis, GMFCS level of V and difficulty with involuntary contractions remained significant factors for sleep difficulties.

4. Discussion

In our study of Singaporean children and youth with CP, almost half had difficulties with sleep. The presence of a higher degree of gross motor impairment and involuntary muscular contractions were associated with an increased risk of poor sleep.

4.1. Frequency of sleep difficulty

Our findings confirmed that sleep disturbances are common in children with CP, with 46% of children and youth in our study finding difficulty with sleep. This is in keeping with other studies

Table 1
Demographic and clinical characteristics of study population.

n	151
Age (median [IQR])	6.18 [3.66, 10.8]
Gender = male (%)	106 (70.2)
Ethnic background (%)	
Chinese	91 (60.3)
Malay	31 (20.5)
Indian	17 (11.3)
Other	12 (7.9)
Mother's occupation (%)	
Homemaker	68 (46.3)
Part-time	9 (6.1)
Full-time	70 (47.6)
Receiving financial support (%)	42 (27.8)
Dominant motor feature (%)	
Spastic	109 (72.2)
Dyskinetic	42 (27.8)
GMFCS (%)	
I	16 (10.6)
II	34 (22.5)
III	33 (21.9)
IV	29 (19.2)
V	39 (25.8)
MACS (%)	
I	30 (19.9)
II	39 (25.8)
III	29 (19.2)
IV	19 (12.6)
V	34 (22.5)
CFCS (%)	
I	49 (32.7)
II	21 (14.0)
III	19 (12.7)
IV	30 (20.0)
V	31 (20.7)
Active epilepsy (%)	38 (25.2)
Visual impairment (%)	70 (46.4)
Hearing impairment (%)	26 (17.2)

internationally [2–4], which identified sleep disorders in 32–46% of pre-school and schooling children with CP as evaluated using the Sleep Disturbance Scale for Children. There were similar proportions of individuals with difficulties with sleep onset, maintenance, amount and quality.

4.2. Risk factors for sleep problems

The presence of involuntary muscular contractions was an independent risk factor for poor sleep. These may represent dystonia, which is characterized by involuntary sustained muscle contractions that cause repetitive twisting movements and abnormal posturing. This may trigger arousal from sleep and difficulties with sleep positioning. Children may also have hyperarousability and sleep-wake transition disorders, including restless leg syndrome and periodic leg movement disorder. Further evaluation of reported involuntary muscle contractions would be warranted, including blood investigations for iron deficiency and polysomnography to further characterize these movements and associated arousals. As iron deficiency is closely linked to restless leg syndrome and other hypermotor sleep disorders [18], assessment of iron status and correction of functional iron deficiency should be considered. Treatment of dystonia, such as with gabapentin [19], has also been found to significantly improve quality and amount of sleep in children. In children with dyskinetic CP, intrathecal baclofen also improved dystonia and sleep [20]. Other measures targeting dystonia such as botulinum injections or deep brain stimulation may be considered.

Such involuntary movements may also constitute seizures, which cause nocturnal arousals that disturb sleep [21], in turn worsening epilepsy control. Even though active epilepsy was not found to be a statistically significant risk factor in our study, having frequent or regular seizures would likely interfere with sleep. This may require further clinical evaluation to differentiate, utilizing sleep/wake behavior assessments and/or combined polysomnography electroencephalogram studies. Treatment of sleep disorders such as obstructive sleep apnea (OSA) in adults has improved epilepsy control [22]; and non-pharmacological and pharmacological management of epilepsy may in turn improve sleep. This needs to be balanced with the risk of somnolence or difficulties with sleep initiation with antiepileptics.

In keeping with previous studies [3,5], a higher degree of functional gross motor impairment, as indicated by a GMFCS level of V, was an independent risk factor for poor sleep. Other contributory factors in previous studies, such as pain or visual impairment, were not significant in our study.

4.3. ICF-based model of sleep in children with CP

The ICF model serves as a universal framework for describing and organizing functioning and disability, and is the recommended model of care in chronic conditions such as CP. There is a multitude of potential causes for poor sleep in children with CP as reviewed by Simard-Tremblay et al. [23], ranging from anatomical factors to medical conditions and social backgrounds. Given this complexity, the ICF model served as a useful framework in evaluating such risk factors and potential areas for intervention, as well as to assess the effect of poor sleep on functioning and disability. A sample model is illustrated in Fig. 1. While our analysis focused on risk factors related to the domains of health condition, body function and structure and activities, the inclusion of other personal and environmental factors such as sleep environment and assistive equipment in future studies would allow for a more holistic and complete evaluation of factors both affecting and affected by sleep. This model may also be extended to evaluate the consequences of poor sleep for children with CP and their families.

Our study is, to our knowledge, the first to make use of the ICF-CY questionnaire to assess sleep disturbances in children and youth with CP. Previous studies utilized questionnaires specifically designed for the diagnosis and assessment of sleep disorders, including the Children's Sleep Habits Questionnaire (CSHQ) [24], Sleep Disturbance Scale for Children [25], and Sleep Questionnaire for Children with Severe Psychomotor Impairment (SNAKE) [26]. These questionnaires evaluate different domains of sleep (Supplementary Table 2) and are validated for typically developing children, with only the SNAKE questionnaire validated for children with life-limiting conditions and severe psychomotor impairment [27]. The ICF-CY Core Sets for CP cannot diagnose sleep disorders or

Table 2
Results of the ICF-CF questionnaire: number and proportion of children and youth with difficulty with sleep amount, onset, maintenance, and sleep quality.

	No difficulty	Mild difficulty	Moderate difficulty	Severe difficulty	Complete difficulty	Any difficulty
Sleep amount	103 (68.2%)	22 (14.6%)	21 (13.9%)	3 (2.0%)	2 (1.3%)	48 (31.8%)
Sleep onset	95 (62.9%)	28 (18.5%)	19 (12.6%)	5 (3.3%)	4 (2.6%)	56 (37.1%)
Sleep maintenance	100 (66.2%)	26 (17.2%)	17 (11.3%)	7 (4.6%)	1 (0.7%)	51 (34.0%)
Sleep quality	103 (68.2%)	26 (17.2%)	9 (6.0%)	10 (6.6%)	3 (2.0%)	48 (31.8%)

Table 3
Univariate and multivariate analysis of factors associated with sleep difficulty.

	Unadjusted Analysis		Adjusted Analysis	
	OR (95% CI)	p-value	aOR (95% CI)	p-value
Age	1.01 (0.95–1.07)	0.694		
Gender (male)	0.07 (0.53–2.18)	0.841		
Ethnic background Chinese	1			
Malay	0.56 (0.24–1.29)	0.180		
Indian	0.91 (0.32–2.58)	0.856		
Others	0.73 (0.20–2.45)	0.613		
Mother occupation				
Homemaker	1			
Part-time	1.14 (0.26–4.69)	0.852		
Full-time	1.35 (0.69–2.66)	0.383		
Financial assistance	0.65 (0.31–1.34)	0.246		
Spastic cerebral palsy	0.69 (0.34–1.41)	0.307		
GMFCS Level V	3.75 (1.75–8.43)	**<0.001**	4.24 (1.09–19.0)	**0.043**
MACS Level V	2.73 (1.25–6.20)	**0.013**	0.25 (0.05–1.11)	0.082
CFCS Level V	3.22 (1.42–7.70)	**0.006**	1.19 (0.30–4.65)	0.803
Active epilepsy	3.02 (1.42–6.67)	**0.005**	0.27 (0.01–2.59)	0.308
On antiepileptic medications	4.33 (1.90–10.6)	**<0.001**	11.0 (1.03–273)	0.070
Generalized pain	4.05 (1.71–10.4)	**0.002**	1.88 (0.66–5.66)	0.243
Difficulty with muscle tone	3.34 (1.24–10.7)	**0.025**	1.25 (0.38–4.58)	0.718
Received intervention for tone management	2.01 (1.01–4.08)	**0.492**	1.25 (0.55–2.87)	0.590
Involuntary contractions of muscles	4.32 (2.17–8.89)	**<0.001**	2.80 (1.20–6.71)	**0.019**
Any visual difficulties	2.39 (1.25–4.65)	**0.009**	2.07 (0.96–4.55)	0.065
Any hearing difficulties	1.79 (0.76–4.30)	0.181		

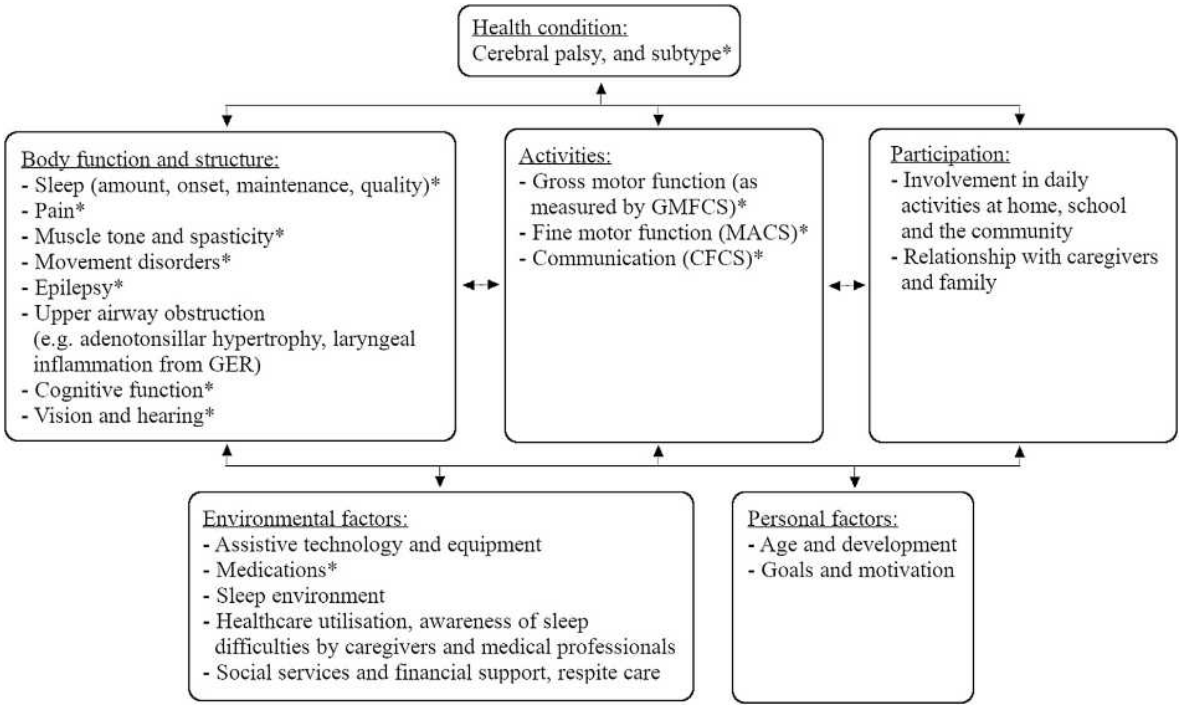

Fig. 1. Sample ICF model, adapted for sleep in children and youth with cerebral palsy
*Factors assessed in current analysis.

provide as extensive an evaluation, but are instead validated to assess function and disabilities. Sleep is a complex function with numerous biological, psychosocial and environmental variables, and especially so in children with CP. The ICF serves as a useful framework for identifying sleep disturbances and possible contributory factors, and can also be expanded to assess the wide-ranging impact of sleep disturbances. Having a common broad conceptual framework can also allow for comparison and increased transparency between patients and centers, and for review of the effects of interventions. The ICF-CY questionnaire is easy to administer, and is already part of the standardized functional assessment of children with CP. As it allows for the highlighting of the interconnections of sleep with functioning, its application is beneficial for both the individual/family and involved health care professionals.

4.4. Limitations

Our study had several limitations. We did not assess for symptoms or existing diagnosis of OSA, which may contribute

significantly to poor sleep, and for which children at CP are at higher risk due to altered upper airway tone. While interventions aimed at improving seizure control and tone were included, others such as analgesia, positive pressure airway devices, and iron replacement for hypermotor sleep disorders were not assessed, and are likely to also affect sleep.

Sleep was assessed based on subjective caregiver or personal reports. Other questionnaires such as the CSHQ correlate poorly with polysomnography [28]. Sleep studies such as polysomnography or actigraphy would provide objective measurements of sleep amount and quality, and also provide further insights into the nature of sleep disturbances. Conversely, such studies also have their limitations — polysomnography is conducted in an artificial environment in which children, particularly those with neurodisabilities, may have difficulties adapting to and sleeping in. Actigraphy or pulse oximetry may be done in the home environment; however these are not adequately validated in children with CP, and are affected by involuntary movements such as spasticity or seizures. A review of sleep assessments for children with severe CP [29] noted that current instruments including questionnaires, sleep diaries, actigraphy and polysomnography could not fully capture sleep outcomes. Both subjective and objective measures, as guided by the individual's sleep symptoms, medical and functional background, are likely required to provide a comprehensive picture of sleep. Correlation of sleep disturbances found on the ICF-CY with existing standardized sleep questionnaires, along with objective measures, would be important in future research.

As this is a national study, it may not be generalizable to the larger Asian or international community. The racial group distribution was otherwise reflective of contemporary multi-racial Singapore census data. Study participants were also recruited through healthcare providers or social services, and may not capture persons who are high-functioning and do not require regular medical or specialized services.

5. Conclusions

Sleep difficulties are common in children and youth with cerebral palsy. A higher GMFCS level and the presence of involuntary muscle contractions were significant risk factors for poor sleep. Effort should be made to recognize and manage sleep problems, and an ICF-based framework is useful in identifying possible contributory factors and strategies for managing poor sleep. Further studies with objective sleep measures will allow for better characterization of sleep disturbances in children with CP and guide potential management.

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CRediT authorship contribution statement

Aletheia ZH Chia: Conceptualization, Methodology, Formal analysis, Writing – original draft, preparation. **Yi Hua Tan:** Writing – review & editing, Resources. **Tong Hong Yeo:** Writing – review & editing, Resources. **Oon Hoe Teoh:** Writing – review & editing, Resources. **Zhi Min Ng:** Conceptualization, Methodology, Resources, Writing – review & editing, Supervision.

Declaration of competing interest

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.sleep.2022.04.021.

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