Sleep disturbances in children with cystic fibrosis, primary ciliary dyskinesia and typically developing children during COVID-19 pandemic

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Aim: We aimed to investigate sleep disturbances in children with cystic fibrosis (CF) and primary ciliary dyskinesia (PCD) and typically developing (TD) children during the COVID-19 pandemic.

Methods: Primary care givers of children with CF and PCD aged 3–16 years were asked to enrol in the study. Primary care givers of TD children were included as control group. The Sleep Disturbance Scale for Children (SDSC) was used, and questions related to sleep habits during the pandemic were asked. Results of the three groups were compared.

Results: Primary care givers of 33 children with CF, 16 children with PCD and 66 TD children were included in the study. There were no differences in terms of age and gender between the three groups. Changes in sleep patterns during the pandemic were more common among TD children and their families, with 75% of the children and 80% of their families sleeping later than before. The sleep initiation and maintenance disorder scores were higher in TD children (P = 0.001), whereas the sleep breathing disorder scores were higher in children with PCD (P = 0.001), and the sleep hyperhidrosis scores were higher in children with CF and PCD (P = 0.011). No relationships were found between sleep parameters and clinical findings of children with lung disease.

Conclusions: Children’s sleep habits have changed during the pandemic. Children with chronic lung diseases and even TD children may experience sleep disturbances during this period.

Key words: children; COVID-19; cystic fibrosis; primary ciliary dyskinesia; sleep.

The coronavirus disease 2019 (COVID-19) pandemic is a public health emergency of international concern and is psychologically affecting people all over the world. Fear of infection and uncertainty about the disease cause anxiety and mental stress. Moreover, measures taken to contain the disease, such as stay-at-home orders, social distancing and restrictions on outdoor physical activity have led to life-style changes, which can result in sleep difficulties.1,2

Cystic fibrosis (CF) and primary ciliary dyskinesia (PCD) are chronic lung diseases that may be accompanied by sleep disorders. Recurrent sinusitis, nasal polyposis and lower respiratory tract infections in both diseases may cause sleep-disordered breathing.3,4 In turn, sleep-disordered breathing, as well as medications that interfere with sleep, may cause sleep disturbances. Sleep may also be directly affected by disease-related symptoms, such as cough and pain.5 It was shown that children with CF, even when they are clinically stable, got less sleep than their peers due to more frequent nightly awakenings. In addition, disease severity was related to sleep disturbance and daytime sleepiness.5 Low baseline SpO2, FEV1 < 80%, CF-related diabetes, Percutaneous endoscopic gastrostomy (PEG) feeding and comorbidity behaviour disorder were found to be associated with lower sleep quantity in children with CF. Moreover, family characteristics such as paternal smoking and family member with a mood...
disorder and poor sleep hygiene were shown to be associated with sleep disturbances. During this pandemic, as all children, children with CF and PCD may be psychologically affected by lifestyle changes, such as not going to school, home isolation and limited peer relationships. It is also known that anxiety and depression are common in children with CF and PCD. As lung involvement is prominent in COVID-19, these children may experience even higher levels of anxiety during this period. These factors combined can lead to sleep disorders in these children.

Sleep is essential for optimal physical and mental health, immune function and cognition. Sleep disorders may interfere with the physical, cognitive, emotional and social development, especially of children. Impaired sleep quality and excessive daytime sleepiness were found to be related to lowered mood and health-related quality of life in children and adolescents with CF. As this is the most severe pandemic in generations, the effects of this situation on children’s sleep and their consequences are unknown. This study aimed to investigate the impact of the COVID-19 pandemic on sleep disturbances in children with CF and PCD and typically developing (TD) children, and compare the three groups.

Materials and Methods

All primary care givers of children with CF and PCD aged 3–16 years regularly followed up in the paediatric pulmonology department in a university hospital were asked to enrol in the study. Primary care givers of TD children of the same age range were recruited using snowball sampling and served as a control group. Because of the risk of COVID-19, the study conducted interviews via teleconference between 6 July 2020 and 10 July 2020. Curfew restriction for children was started in the beginning of April 2020 and schools were closed in March 2020. Curfew restrictions were applied to people under 20 years both in weekdays and weekend between April to mid-June. The interviews were conducted by the doctors who were regularly following up the children in the paediatric pulmonology department. Caregivers who did not wish to participate were excluded.

Data collected for all groups included the children’s age, gender, weight and height. Body mass index (BMI) was calculated. Weight and height of children were noted which were measured by their parents at home. The Sleep Disturbance Scale for Children (SDSC) was used to assess sleep disturbances. Questions about sleep habits during the COVID-19 pandemic were asked.

For the CF and PCD groups, clinical data were obtained from the children’s hospital files. The number of hospitalizations in the past year, number of sputum cultures positive for any bacteria in the past year, presence of chronic Pseudomonas aeruginosa infection and mean follow-up duration were noted. Chronic Pseudomonas aeruginosa infection was defined as P. aeruginosa positivity in more than 50% of the samples collected over a period of 12 months. Results of pulmonary function tests (PFTs) were recorded for patients who could perform spirometry in the last follow-up, and forced vital capacity (FVC), forced expiratory volume (FEV), FEV in 1 s (FEV1) and forced expiratory flow at 25–75% of the pulmonary volume (FEF25–75) spirometry tests were recorded as predicted percentages. The FEV1/FVC ratio was recorded and assessed based on age, gender and height.

The SDSC, developed for children aged 6–16 years, evaluates disorders of initiating and maintaining sleep (DIMS), sleep breathing disorders, disorders of arousal (DA), sleep–wake transition disorders (SWTD), disorders of excessive somnolence (DOES) and sleep hyperhidrosis (SHY) during the previous 6 months. The six subscales are scored on a 5-point Likert scale. The sum of scores provides a total score ranging from 26 to 130. Higher scores indicate more severe disturbances. This tool has been translated into many languages with satisfactory results in terms of validity and reliability. A Turkish version was validated by Akçay et al., and used in the study. Romeo et al. applied the SDSC to pre-school children (3–6 years). In this study, the questionnaire was administered to the primary care givers.

An additional 21 questions were prepared by the authors to investigate changes in children’s sleep habits during the COVID-19 pandemic. The questions regarded changes in the sleep patterns of the child or family members, changes in the child’s temperament and commitment to mother, daily activity changes, changes in and total duration of screen time, weight changes during the pandemic, daytime sleep, activities with the parents at home that were not related to education, playing with friends, whether the child preferred playing with friends or the parents, whether the child slept late, whether the child slept with the parents, whether the child had nightmares, whether the house had a garden and whether there were smokers at home. These questions were shown in Table 1.

Comparisons between the results of the three groups were performed. For the CF and PCD groups, relationships between sleep-related results and the patients’ clinical data were investigated.

Statistical analyses were performed using IBM SPSS Statistics version 22.0 (IBM Corp., Armonk, NY, USA) for Windows. Descriptive statistics were expressed as numbers and percentages for categorical variables and means ± standard deviations and medians and interquartile ranges for continuous variables. The normality of distribution of continuous variables was assessed with visual (histograms and probability graphs) and analytic methods (Kolmogorov-Smirnov and Shapiro-Wilk test). For comparisons between two groups, the Mann-Whitney U test was used for data that did not fit the normal distribution, and the independent samples t-test was used for data that fit the normal distribution. For comparisons between three groups, one-way analysis of variance (ANOVA) was performed where the parametric test conditions were satisfied, and the Kruskal-Wallis H test was performed where the parametric test conditions were not satisfied. For significant ANOVA results, binary comparisons between groups were performed with the Bonferroni multiple comparison test. For significant Kruskal-Wallis H test results, binary comparisons between groups were performed with the Dunnett’s multiple comparison test. Comparisons of categorical variables between independent groups were performed with the χ² test. Relationships between data that did not fit the normal distribution were evaluated with Spearman’s correlation test, and relationships between data that fit the normal distribution were evaluated with Pearson’s correlation test. A value of P < 0.05 was considered statistically significant.

Results

A total of 33 primary care givers of children with CF, 16 primary care givers of children with PCD and 66 primary care givers of
TD children were included in the study. All primary care givers were their mothers. Comparisons of age, gender and BMI z-scores between the children in the three groups are presented in Table 2. The mean age of the children with CF was 9.5 years (7–12 years), the mean age of the children with PCD was 10.5 years (8.1–12.7 years) and the mean age of the TD children was 8 years (5.3–11.2 years). There were no statistically significant differences in terms of age and gender between the three groups.

Table 2. The mean follow-up duration was 96.45 ± 35.6 months for children with CF and 43.0 ± 26.7 months for children with PCD (P = 0.001). Seven (21%) children with CF and 6 (37%) children with PCD had been hospitalised in the past year (P = 0.163). Twenty-one (63%) children with CF and 3 (23%) children with PCD had tested positive for bacteria (P = 0.008). Chronic infections had been detected in 12 children with CF, five of whom were infected with
Table 2  Comparisons of demographic features and body mass index z-scores of the children in the three groups

|                                | Children with CF (n = 33) | Children with PCD (n = 16) | TD children (n = 66) | P value  
|--------------------------------|---------------------------|-----------------------------|----------------------|---------- 
| Age (years), median (range)    | 9.5 (7–12)                | 10.5 (8.1–12.7)             | 8 (5.3–11.2)         | 0.112†  
| Gender, male/female           | 19/14                     | 8/8                         | 34/32                | 0.821‡  
| BMI z-score, mean ± SD        | –0.81 ± 1.03              | 0.03 ± 1.22                 | 0.48 ± 1.17          | 0.001** 
| Mean follow-up duration, mean ± SD | 96.45 ± 35.6             | 43.0 ± 26.7                 |                      | 0.001§  
| Number of hospitalised patients in the past year, n (%) | 7 (21)                    | 6 (37)                      |                      | 0.163†  
| Number of patients with positive sputum cultures in the past year, n (%) | 21 (63)                   | 3 (18)                      |                      | 0.008†  
| Patients with chronic infections, n (%) | 12 (36)                  | 0 (0)                       |                      |         
| FEV1%, mean ± SD              | 75.8 ± 25.6               | 93.6 ± 14.6                 |                      | 0.017†  
| FVC %, mean ± SD              | 75 ± 24.6                 | 96.6 ± 15.5                 |                      | 0.005†  
| FEF25–75%, mean ± SD          | 73.9 ± 31.7               | 96.2 ± 22.9                 |                      | 0.035†  
| FEV1/FVC, median (range)      | 101 (96.5–104)            | 99 (96.5–104)               |                      | 0.701†† 

*Level of significance: Typically developing children > Children with CF.
†Kruskal-Wallis H test.
‡Chi-square test.
§One-way analysis of variance (ANOVA).
¶Independent samples t-test.
‖Mann-Whitney U test.
BMI, body mass index; CF, cystic fibrosis; FEF25–75%, forced expiratory flow at 25–75% of the pulmonary volume; FEV1, forced expiratory volume in 1 s; FVC, forced vital capacity; PCD, primary ciliary dyskinesia; SD, standard deviation; TD, typically developing.
Bold number indicates statistically significant value.

Table 3  Comparisons of the Sleep Disturbance Scale for Children scores between the three groups

|                                | Children with CF (n = 33) | Children with PCD (n = 16) | TD children (n = 66) | P value  
|--------------------------------|---------------------------|-----------------------------|----------------------|---------- 
| Disorders of initiating and maintaining sleep, mean ± SD | 11.6 ± 2.9               | 11.9 ± 3.2                  | 14.0 ± 4.0              | 0.001**  
| Sleep breathing disorders, median (range) | 4 (3–4.5)                | 5 (3–7)                     | 3 (3–4)                | 0.001††  
| Disorders of arousing, median (range) | 3 (3–4)                  | 3 (3–4)                     | 3 (3–4)                | 0.910‡  
| Sleep–wake transition disorders, median (range) | 9 (7–11)                 | 8.5 (6–10)                  | 8 (6–10)               | 0.219§  
| Disorders of excessive somnolence, median (range) | 6 (5–9)                  | 6 (5–8.7)                   | 5 (5–7)                | 0.347†  
| Sleep hyperhidrosis, median (range) | 3 (2–5)                  | 3 (2–4)                     | 2 (2–3)                | 0.011‖   
| Total SDSC score, median (range) | 39 (33–47)                | 39.5 (35.5–44)              | 38 (33–42)             | 0.649§  
| T score, median (range)        | 53 (46–62)                | 53.5 (48.5–58.5)            | 51 (46–56)             | 0.754‡  

*Level of significance: TD children > Children with CF.
†Level of significance: Children with PCD > TD children.
‡Level of significance: Children with PCD > TD children. Children with CF > TD children.
§One-way analysis of variance (ANOVA).
‖Kruskal-Wallis H test.
CF, cystic fibrosis; PCD, primary ciliary dyskinesia; SDSC, Sleep Disturbance Scale for Children; TD, typically developing.
Bold number indicates statistically significant value.

Pseudomonas aeruginosa, six with Staphylococcus aureus and one with Haemophilus influenzae. Only nine patients with PCD and 27 patients with CF could perform PFTs. The mean FEV1 was 75.8 ± 25.6 in children with CF and 93.6 ± 14.6 in children with PCD (P = 0.017). The mean FVC was 75 ± 24.6 in children with CF and 96.6 ± 15.5 in children with PCD (P = 0.005). The FEF25–75% results were significantly lower in children with CF (73.9 ± 31.7) than in children with PCD (96.2 ± 22.9; P = 0.035). There was no significant difference in terms of FEV1/FVC results between children with CF (101 [96.5–104]) and children with PCD (99 [96.5–104]; P = 0.701).

Comparisons of the SDSC scores between the three groups are shown in Table 3. There were no differences in terms of sleep

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duration and time to fall asleep after going to bed between the three groups (P = 0.659 and P = 0.284, respectively). The DIMS score was higher in TD children (P = 0.001), the SDB score was higher in children with PCD (P = 0.001) and the SHY score was higher in children with PCD and CF (P = 0.011). No statistically significant differences were observed in DA, SWTD and DOES scores between the three groups. Four children with CF, 1 child with PCD and 21 TD children scored in the clinically significant range for the DIMS; 3 children with CF, 6 children with PCD and 1 TD child scored in the clinically significant range for the SDB; 4 children with CF, 2 children with PCD and 11 TD children scored in the clinically significant range for the SWTD; 3 children with CF scored in the clinically significant range for DOES; 4 children with CF, 3 children with PCD and 6 TD children scored in the clinically significant range for SHY. Three children with CF, one child with PCD and five TD children scored in the clinically significant range for overall.

The analysis of the responses to the questions regarding the children’s and their families’ sleep and daily habits during the COVID-19 pandemic are shown in Table 1 and revealed that changes in sleep patterns were more common in children with PCD and higher SHY score in children with PCD and CF. No statistically significant differences were observed in DA, SWTD and DOES scores between the three groups. Four children with CF, 1 child with PCD and 21 TD children scored in the clinically significant range for the DIMS; 3 children with CF, 6 children with PCD and 1 TD child scored in the clinically significant range for the SDB; 4 children with CF, 2 children with PCD and 11 TD children scored in the clinically significant range for the SWTD; 3 children with CF scored in the clinically significant range for DOES; 4 children with CF, 3 children with PCD and 6 TD children scored in the clinically significant range for SHY. Three children with CF, one child with PCD and five TD children scored in the clinically significant range for overall.

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Night sweats impair sleep quality and contribute to sleeplessness. They can be observed in a wide variety of differential diagnoses, from infectious diseases to neuroendocrine disorders. They are also common in respiratory disorders, such as allergic rhinitis, and tonsillitis. Children with CF and PCD had higher SHY scores than TD children, which could be related to their diseases.

Although some studies have associated SDB with pulmonary function parameters in children with CF, no such correlation has yet been established for patients with PCD. Likewise, we did not find any associations between sleep disorders and clinical parameters of children with lung disease. This may be due to our small sample size and the low rate of patients who were able to perform a PFT.

Certain limitations of this study should be noted. The study was conducted entirely via teleconference to avoid the risk of COVID-19. Therefore, objective measurements of sleep parameters using polysomnography were not possible due to risk of transmission of COVID-19. Sample size was small and this was an observational study. Longitudinal studies with larger sample sizes should be conducted. Future studies should include objective measurements.

Conclusions

In conclusion, this study shows that the sleep habits of children and their families have changed during this pandemic. Children with chronic lung diseases may suffer from sleep disorders during this period. Changes in sleep patterns of children and their families and also DIMS were found more frequently in TD children which could be attributed to less awareness of good sleep practices. All these sleep disorders may adversely affect children’s development. As the possible long-term consequences are not known at this time, children with lung disease and also TD children should be closely monitored.

Ethical Approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. This study was approved by the Ethics Committee of the Faculty of Medicine (Date: July 6, 2020, No. 414). Written permission to use the validated Turkish version of the SDSC was obtained from Dr Duygu Akçay.

References

1 Chokroverty S. The many faces and fangs of COVID-19: An editorial by Sudhansu Chokroverty. Sleep Med. 2020; 72: 164–6.
2 Becker SP, Gregory AM. Editorial perspective: Perils and promise for child and adolescent sleep and associated psychopathology during the COVID-19 pandemic. J. Child Psychol. Psychiatry 2020; 61: 757–9.
3 Shakkottai A, O’Brien LM, Nasr SZ, Chervin RD. Sleep disturbances and their impact in pediatric cystic fibrosis. Sleep Med. Rev. 2018; 42: 100–10.
4 Şanmanlı Eyüboğlu T, Aslan AT, Ceylan A et al. Neurocognitive disorders and sleep in children with primary ciliary dyskinesia. Pediatr. Pulmonol. 2018; 53: 1436–41.
5 Cohen-Cymberknoh M, Atia O, Gilleles-Hillel A, Kerem E, Reiter J. Sleep disorders in patients with primary ciliary dyskinesia, cystic fibrosis, and with and without pancreatic insufficiency. Respir. Med. 2019; 151: 96–101.
6 Vandeleur M, Walter LM, Armstrong DS, Robinson P, Nixon GM, Horne RSC. How well do children with cystic fibrosis sleep? An actigraphic and questionnaire-based study. J. Pediatr. 2017; 182: 170–6.
7 Vandeleur M, Walter LM, Armstrong DS, Robinson P, Nixon GM, Horne RSC. What keeps children with cystic fibrosis awake at night? J. Cyst. Fibros. 2017; 16: 719–26.
8 Abbott J, Elborn JS, Georgiopoulou AM et al. Cystic Fibrosis Foundation and European Cystic Fibrosis Society Survey of cystic fibrosis mental health care delivery. J. Cyst. Fibros. 2015; 14: S33–9.
9 Quitnter AL, Goldbeck L, Abbott J et al. Prevalence of depression and anxiety in patients with cystic fibrosis and parent caregivers: Results of the International Depression Epidemiological Study across nine countries. Thorax 2014; 69: 1090–7.
10 Behan L, Rubbo B, Lucas JS, Galvin AD. The patient’s experience of primary ciliary dyskinesia: A systematic review. Qual. Life Res. 2017; 26: 2265–85.
11 Wise MZ, Glaze DG. Assessment of Sleep Disorders in Children. Uptodate. Available from: https://www.uptodate.com/contents/assessment-of-sleep-disorders-in-children?search=sleep%20children&source=search_result&selectedTitle=2–150&usage_type=default&display_rank=2 [Accessed 1 July 2020].
12 Vandeleur M, Walter LM, Armstrong DS, Robinson P, Nixon GM, Horne RSC. Quality of life and mood in children with cystic fibrosis: Associations with sleep quality. J. Cyst. Fibros. 2018; 17: 811–20.
13 Lee TW, Brownlie KG, Conway SP, Denton M, Littlewood JM. Evaluation of a new definition for chronic Pseudomonas aeruginosa infection in cystic fibrosis patients. J. Cyst. Fibros. 2003; 2: 29–34.
14 Bruni O, Ottaviano S, Guidetti V et al. 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: 251–61.
15 Santamaría F, Esposito M, Montella S et al. Sleep disordered breathing and airway disease in primary ciliary dyskinesia. Respiriology 2014; 19: 570–5.
16 Akçay B, Akçay BD, Hekim BO. Reliability and validity of Turkish sleep disturbance scale for children. Anatolian J. Psychiatry 2020; 21 (Suppl.1): 70–7.
17 Romeo DM, Bruni O, Broagna C et al. Application of the sleep disturbance scale for children (SDSC) in preschool age. Eur. J. Paediatr. Neurol. 2013; 17: 374–82.
18 Johnson DA, Billings ME, Hale L. Environmental determinants of insufficient sleep and sleep disorders: Implications for population health. Curr. Epidemioil. Rep. 2018; 5: 61–9.
19 Horaker SM, Meltzer LJ. Bedtime problems and night wakings in young children: An update of the evidence. Paediatr. Resp. Rev. 2014; 15: 333–9.
20 Crew EC, Baron KG, Grandner MA et al. The Society of Behavioral Sleep Medicine (SBM) COVID-19 Task Force: Objectives and summary recommendations for managing sleep during a pandemic. Behav. Sleep Med. 2020; 18: 570–2.
21 Dresp-Langle B. Children’s health in the digital age. Int. J. Environ. Res. Public Health 2020; 17: 3240.
22 Galland B, Spruyt K, Dawes P, McDowall PS, Elder D, Schaughency E. Sleep disordered breathing and academic performance: A meta-analysis. Pediatrics 2015; 135: e934–46.
23 Bruni O, Sette S, Fontanesi L, Baiocco R, Laghi F, Baumgartner E. Technology use and sleep quality in preadolescence and adolescence. J. Clin. Sleep Med. 2015; 11: 1433–41.
24 Dewald JF, Meijer AM, Oort FJ, Kerkhof GA, Bögels SM. The influence of sleep quality, sleep duration and sleepiness on school performance in children and adolescents: A meta-analytic review. Sleep Med. Rev. 2010; 14: 179–89.
25 Takeuchi H, Taki Y, Asano K et al. Impact of frequency of internet use on development of brain structures and verbal intelligence: Longitudinal analyses. *Hum. Brain Mapp.* 2018; 39: 4471–9.

26 Di Renzo L, Gualtieri P, Pivari F et al. Eating habits and lifestyle changes during COVID-19 lockdown: An Italian survey. Version 2. *J. Transl. Med.* 2020; 18: 229.

27 Hargens TA, Kaleth AS, Edwards ES, Butner KL. Association between sleep disorders, obesity, and exercise: A review. *Not. Sci. Sleep* 2013; 5: 27–35.

28 So HK, Li AM, Au CT et al. Night sweats in children: Prevalence and associated factors. *Arch. Dis. Child.* 2012; 97: 470–3.

29 Amin R, Bean J, Burklow K, Jeffries J. The relationship between sleep disturbance and pulmonary function in stable pediatric cystic fibrosis patients. *Chest* 2005; 128: 1357–63.

30 Lumertz MS, Pinto LA. Sleep-disordered breathing in cystic fibrosis pediatric subjects. *Sleep Sci.* 2019; 12: 165–70.

31 Oktem S, Karadag B, Erdem E et al. Sleep disordered breathing in patients with primary ciliary dyskinesia. *Pediatr. Pulmonol.* 2013; 48: 897–903.

32 Barbosa RRB, Liberato FMG, de Freitas Coelho P, Vidal PDR, de Carvalho RBCO, Donadio MVF. Sleep-disordered breathing and markers of morbidity in children and adolescents with cystic fibrosis. *Pediatr. Pulmonol.* 2020; 55: 1974–83.