

Investigating the Association between Sleep Problems and Physical Activity in Children with Cerebral Palsy: A Cross-Sectional Study

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ABSTRACT

Objectives: Given the significance of sleep and physical activity (PA) as modifiable factors influencing overall health and development in childhood, this study aims to examine the association between sleep problems and PA levels in children with cerebral palsy (CP) and to compare these findings with typically developing (TD) children.

Materials & Methods: This cross-sectional observational study included 40 children aged 6–12 years. The participant group comprised 20 children diagnosed with CP, exhibiting Gross Motor Function Classification System (GMFCS) levels I–II, and 20 age- and sex-matched TD peers. PA was measured using MOX accelerometers worn continuously for 24 hours on weekdays. Sleep habits were assessed using the Children's Sleep Habits Questionnaire (CSHQ) and the Epworth Sleepiness Scale (ESS), both completed by parents.

Results: Children with CP demonstrated significantly lower levels of light, moderate, and vigorous PA compared to children with TD ($p < 0.05$). No significant difference was observed in total sleep habit scores between the groups ($p = 0.423$). A significant positive correlation was found between moderate PA and sleep habit in the CP group ($r = 0.49$, $p = 0.03$). Among children with TD, those with sleep problems engaged in significantly less vigorous PA than those without ($p = 0.044$).

Conclusion: Children with CP exhibit lower PA levels than their TD peers. In this population, moderate-intensity PA appears to have a positive effect on sleep problems. Promoting moderate PA may contribute to improved sleep and overall health in children with CP. These findings highlight the importance of integrated PA and sleep health strategies in pediatric rehabilitation.

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Introduction

Cerebral palsy (CP) is a non-progressive, permanent disorder of the immature brain, characterized by difficulties in movement and postural control (1). CP is the most common diagnosis among conditions that cause physical activity (PA) limitations

(2). PA is essential for the optimal physical, emotional, and psychosocial development of all children (3).

Sustained PA in childhood and adolescence mitigates the risk of future chronic diseases and improves overall health outcomes (4). Children with CP tend to lead more sedentary lifestyles compared to

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their typically developing (TD) peers, due to factors such as muscle weakness, balance impairments, and reduced postural control (5). Moreover, reportedly, children with CP in the 0–6 age group exhibit more sedentary behaviors than older individuals with CP (6). A sedentary lifestyle is currently considered a significant risk factor for health problems such as obesity, insulin resistance, and hypertension (7). Additionally, sedentary behavior has been shown to negatively impact sleep quality and increase the risk of insomnia and other sleep disorders (8).

Sleep is a periodic and regulatory process in which the organism temporarily and reversibly loses consciousness in response to environmental stimuli. Sleep deprivation can lead to various health problems, including cognitive dysfunctions (e.g., reduced fine motor skills, impaired decision-making), emotional imbalances, immune system suppression, and metabolic disorders (9). CP is a neurological condition frequently associated with sleep disturbances. According to the reliable literature, 23–46% of children with CP experience clinically significant sleep problems. Muscle spasms, pain, difficulties with nighttime positioning, and mobility restrictions are among the primary factors negatively affecting sleep quality in this population (10).

Given the gap in understanding the relationship between sleep and PA in children with CP, this cross-sectional study aimed to examine the association between parent-reported sleep problems and objectively measured levels of physical activity in these children and to compare these variables with a TD peer group.

Materials & Methods

Participants

This multicenter, cross-sectional observational study was conducted in special education and rehabilitation centers. Ethical approval was obtained from the Marmara University Non-Interventional Clinical Research Ethics Committee (approval number: 09.2017.418). The study was carried out in accordance with the principles of the Declaration of Helsinki. Written informed consent was obtained from the parents of all participating children. The inclusion criteria for the CP group were having a diagnosis of CP, being classified as Level I or II according to the Gross Motor Function Classification System (GMFCS), being between 3 and 12 years of age, and not having a diagnosis of intellectual disability. For the control group, inclusion criteria included being between 3 and 12 years of age, being cooperative, and having no behavioral problems. Exclusion criteria for both groups

included the presence of additional musculoskeletal or neuromuscular disorders, severe visual impairment, a history of selective dorsal rhizotomy, intrathecal baclofen treatment, or botulinum toxin injection within the past six months, as well as the presence of diabetes, malignancy, severe cardiac or pulmonary disease, or a habitual intake of caffeine-containing beverages.

Randomization

Participants were recruited from three different institutions. In each institution, individuals who met the pre-established inclusion and exclusion criteria were identified. Among all eligible individuals, 60 children (30 with CP and 30 with TD) were selected using a simple random sampling method via the platform www.randomizer.org. During the later stages of the study, some participants were excluded for various reasons (e.g., technical issues, non-compliance). Hence, the final analyses were completed with a total of 40 children—20 with CP and 20 healthy controls.

The sample size was calculated based on a minimal clinically significant difference of 0.5% in accelerometer-measured PA, resulting in a required sample of 19 children per group to achieve 80% power at an alpha level of 0.05. The study flow diagram is presented in Figure 1.

Study design

The demographic data form was completed through face-to-face interviews with the parents. The Children's Sleep Habits Questionnaire (CSHQ) (11) and the Epworth Sleepiness Scale (ESS) (12) were used to assess sleep habits. PA levels were measured using the MOX activity monitor (accelerometer). A blinding protocol was implemented among the research team during both data collection and analysis to ensure impartiality during the measurement and evaluation processes. The measurement of PA was conducted by a designated researcher responsible solely for administering the MOX device and collecting raw data. Similarly, the administration of the sleep-related questionnaires (CSHQ and ESS) was carried out by a different researcher.

Outcome measurement

PA assessment

The MOX accelerometer was worn for 24 hours on weekdays to measure PA levels. The device was positioned vertically, either in the participant's pocket or attached to the collar. The data recorded by the MOX device were analyzed using IDEEQ Data Acquisition and Analysis Software, displaying the collected information in graphical format. This software provides three types of graphs: a 3-axis graph (X, Y, Z), an oscillation intensity graph, and a functional

activity (FA) graph. Among these, the PA graph was used for analysis in the present study (13).

Sleep assessment

In this study, the CSHQ was used to assess children's sleep patterns and behavioral characteristics related to sleep. This 33-item parent-reported questionnaire evaluates various dimensions such as bedtime routines, night wakings, and daytime behaviors in children aged 2–10. The items are based on a Likert-type scale and measure the frequency of sleep-related problems. The validity and reliability study of the Turkish version was conducted by Perdahlı et.al., with the internal consistency coefficient (Cronbach's alpha) reported as above 0.80 (11). For the

total score evaluation, a widely accepted cut-off point of ≥ 41 was used, with scores above this threshold indicating the presence of sleep problems. In addition, the ESS was used to assess excessive daytime sleepiness. This self-reported scale evaluates the likelihood of falling asleep in eight common daily situations. The total score ranges from 0 to 24, with scores above 10 interpreted as indicative of increased daytime sleepiness. The validity and reliability of the Turkish version were established by Ağargün et al. (1999), with a reported internal consistency coefficient of 0.75 (12). Both questionnaires were administered directly to the children's families, and the responses were recorded for analysis.

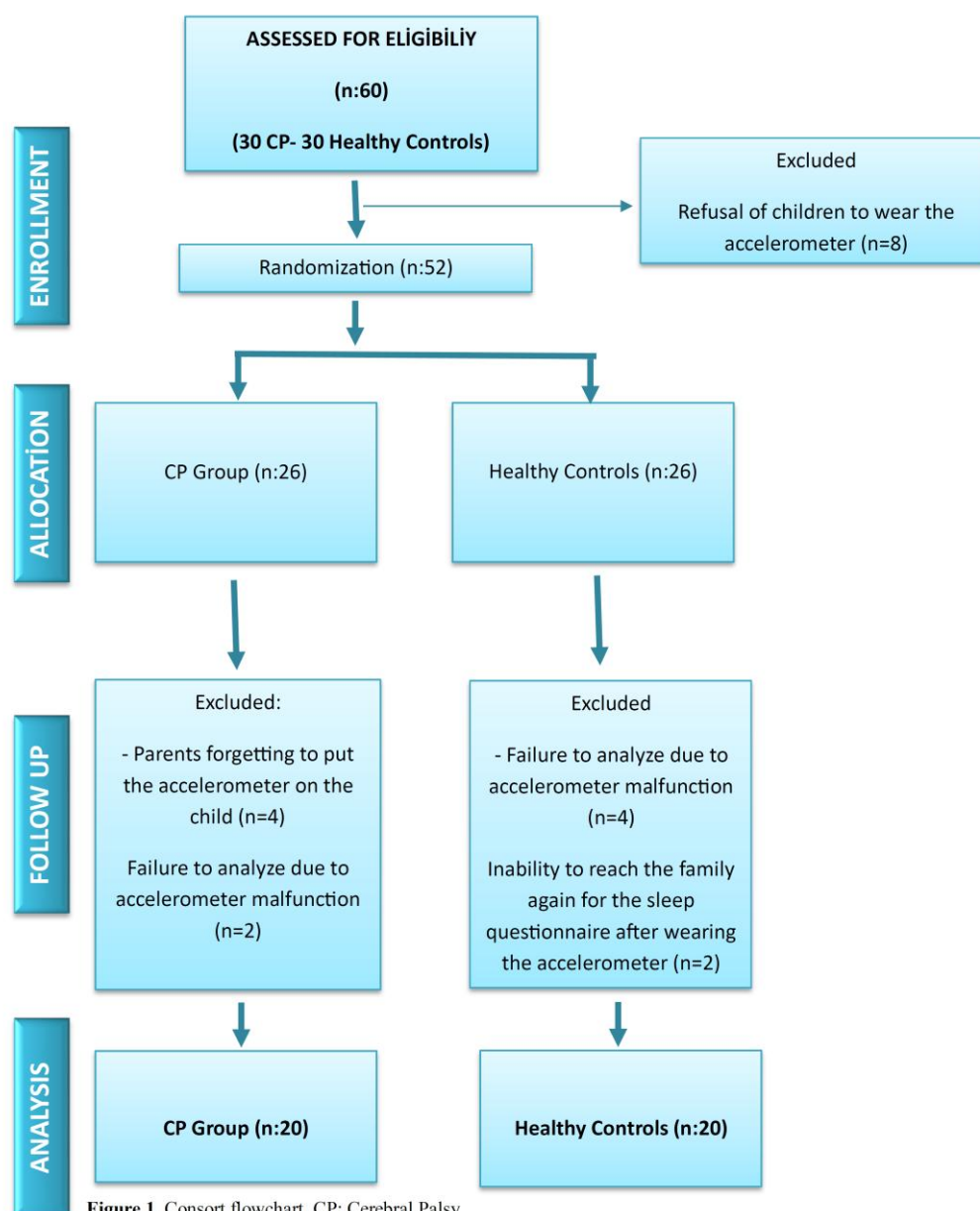


Figure 1. Consort flowchart. CP: Cerebral Palsy

Statistical analysis

The distribution of the data was assessed with the Kolmogorov-Smirnov test, indicating a non-normal distribution. Consequently, comparisons between the Cp group and the TD group were conducted using the Mann-Whitney U test. For the relationship between the groups, Spearman correlation was used. For all tests, the statistical level was set at $p=0.05$. Statistical analysis was conducted using SPSS 11.0.

Results

The present study included 20 children with CP (6 males, 14 females; age: 9.75 ± 2.31 years; BMI: 19.39 ± 3.84) and 20 healthy children (11 males, 9 females; age: 9.4 ± 2.37 years; BMI: 21.07 ± 2.46). Comparison of the demographic characteristics of the two groups revealed no significant differences (Table 1).

Table 1: Comparison of demographic characteristics

	CP (n=20)		Typical Development (n=20)		p*
	Mean $\pm$ SD	Min - Max	Mean $\pm$ SD	Min - Max	
Age (years)	9.75 ± 2.31	6-12	9.4 ± 2.37	6-12	0.639
Height (cm)	130.3 ± 15.51	108-160	136.2 ± 15.97	1.12-1.60	0.243
Weight (kg)	28.8 ± 19.00	17-59	40.15 ± 10.99	24- 56	0.069
BMI (kg/m ²)	33.6 ± 11.1	13.9-28.4	21.07 ± 2.46	16.6-27.8	0.107
Sleep Quality	19.39 ± 3.84	34 - 68	43.5 ± 8.59	35- 58	0.423

BMI: Body Mass Index, *Mann-Whitney U test was used for comparison.

Table 2: Descriptive information and comparison of pa and sleep quality in cp and typical development group

	CP (n=20)				Typical Development (n=20)				p*
	Mean $\pm$ SD	Min - Max	Median	IQR	Mean $\pm$ SD	Min - Max	Median	IQR	
Standing	323.2 ± 166.14	51 - 603	274	212.25	234 ± 94.34	96 - 447	227	105.5	0.126
Lpa	8.3 ± 5.81	2 - 23	5	7	24.85 ± 9.11	2 - 34	28.5	11.25	0.000
Mpa	28.8 ± 19.00	8 - 66	19	33.5	93.25 ± 42.88	8 - 150	101.5	65.25	0.000
Vpa	4.65 ± 5.02	1 - 15	2	4.75	18.9 ± 15.83	2 - 50	13	17.75	0.000
Sleep Quality	44 ± 8.39	34 - 68	40.5	9.75	43.5 ± 8.59	35 - 58	38	15.5	0.423

Lpa: Low-intensity physical activity; Mpa: Moderate-intensity physical activity; Vpa: Vigorous-intensity physical activity

* Mann-Whitney U test was used for comparison.

Table 3: Comparison of the relationship between sleep quality and physical activity levels

	CP (n=20)		Typical Development (n=20)	
	Spearman Correlation	p	Spearman Correlation	p
Standing	-0.11	0.64	0.03	0.89
Lpa	0.37	0.11	-0.34	0.14
Mpa	0.49	0.03	-0.43	0.06
Vpa	0.30	0.19	-0.31	0.19

Lpa: Low-intensity physical activity; Mpa: Moderate-intensity physical activity; Vpa: Vigorous-intensity physical activity

Among the CP group, 17 children were diagnosed with the spastic type (9 hemiparetic, 8 diparetic), 2 with the dyskinetic type, and 1 with the ataxic type.

While no significant difference was found in standing time between the CP and healthy groups ($p=0.126$), significant differences were observed in low-, moderate-, and high-intensity PA durations ($p<0.05$) (Table 2). No significant difference was observed in sleep problems between the CP and healthy groups ($p=0.423$). Additionally, all participants completed the ESS, and all scores were below the cut-off value of 10 (Table 2), indicating no excessive daytime sleepiness in either group.

The relationship between sleep problems and PA levels is presented in Table 3. A significant positive correlation was found between moderate-intensity PA duration and sleep problems in children with CP ($p=0.03$). However, no significant relationship was found between sleep problems and PA levels in children with TD.

When individuals with and without sleep problems were compared in both the CP and TD groups, a significant difference in sleep problem scores was observed (CP group: $p=0.001$; TD group: $p=0.001$). Among children with TD, a significant difference was also found in high-intensity PA between those with and

without sleep problems ($p = 0.044$). However, no significant differences were found in other PA parameters when comparing children with and without sleep problems in either group (Table 4).

Discussion

PA and sleep are modifiable lifestyle factors significantly influencing children's overall health and well-being. According to current literature, moderate-to-vigorous physical activity (MVPA) is essential for achieving adequate sleep quality in children (14,15). This study aimed to assess the sleep quality and PA levels of children with CP and their TD peers, and to explore the bidirectional relationship between PA and sleep quality in children with CP.

According to the Turkish Physical Activity Guide and the World Health Organization (WHO), children aged 5–11 years should engage in at least 60 minutes of MVPA daily. In this study, significant differences were found between CP and TD groups in all PA intensity durations (low, moderate, and high), with the exception of standing time. Healthy children were significantly more active than those with CP. Specifically, the average daily low-intensity PA duration for children with CP was 8 minutes, and moderate-intensity PA was 28 minutes—substantially lower than TD children, who averaged 24 and 93 minutes, respectively. These findings align with recent studies showing that healthy children exceed PA recommendations, while children with CP fall well below them (16–18). A notable trend of pronounced sedentariness among ambulatory pediatric individuals with CP is evident from the data, particularly concerning in light of the critical importance of regular PA for optimal physical, emotional, and psychosocial development (19). Numerous studies have demonstrated that PA during childhood can mitigate risk factors for obesity and chronic conditions, playing a critical role in reducing sedentary behavior (3,17).

Children with CP often do not meet recommended PA levels, which may negatively affect not only their physical fitness but also sleep quality, metabolic health, and overall quality of life. Promoting PA and reducing sedentary time are vital for their long-term health. Additionally, a growing body of evidence highlights the importance of sleep for child development (20,21). While CP-related sleep disturbances commonly include difficulties falling asleep, frequent nocturnal awakenings, pain, and poor positioning, children with TD typically experience sleep issues such as sleep-onset difficulties (22.3%) and early morning awakenings (19.7%) (21). In this study, a total score of 41 on the CSHQ was used as the clinical cut-off to identify children at risk for sleep problems, consistent

with previously validated thresholds. Despite applying this criterion, no significant difference was found in the overall prevalence of sleep problems between the CP and TD groups. Furthermore, although the CSHQ includes subscales that assess specific domains such as bedtime resistance, sleep onset delay, sleep duration, night wakings, and parasomnias, this study did not include a detailed analysis of subscale-level differences. Future research with a larger sample size and stratified analysis may provide more insight into which specific sleep domains are more affected in children with CP compared to their TD peers. In the present sample, the prevalence of sleep problems was 40% in both CP and TD groups, and no significant difference was observed in sleep habits. However, previous studies report that sleep problems affect up to 85% of children with CP compared to 25% in children with TD (22). Furthermore, abnormal sleep scores have been associated with higher GMFCS levels. Poor sleep during childhood increases the risk of long-term physical and psychological health issues (23,24). The absence of significant differences in sleep habits between the groups in this study may be attributed to the inclusion of only GMFCS levels I and II and the exclusion of children with intellectual disabilities. Nevertheless, the broader literature emphasizes the higher prevalence and severity of sleep problems in the population of children with CP. Thus, early identification and intervention for sleep disturbances remain critical for preserving long-term health in children with CP and TD.

One of this study's key findings was the significant positive correlation between moderate-intensity PA and sleep problems in children with CP. This suggests a regulatory effect of PA on sleep and highlights the potential of moderate activity to enhance sleep quality, even in children with motor limitations. Similar results have been reported by Gerritsen et al., who found that moderate-intensity PA is positively associated with sleep duration and quality (25), and by Hulst et al., who emphasized the sleep-enhancing effects of moderate activity in children with CP (19). A Brazilian study also reported that low PA levels negatively impact sleep habits in children with CP (26).

Among children with TD, vigorous PA differed significantly according to sleep quality, indicating that sleep disturbances may hinder participation in high-intensity exercise. This finding aligns with a meta-analysis reporting a significant relationship between high-intensity PA and sleep duration in healthy children aged 3–13 years. Additionally, Smit et al. demonstrated that low PA is associated with poorer sleep duration and quality in children with CP and TD (27). These results collectively support the beneficial effects of

moderate-to-high PA on sleep habits in pediatric populations, regardless of neurodevelopmental status.

Undeniably, even moderate activity improves sleep in children with CP, suggesting that PA should be an integral component of rehabilitation and support programs. Moreover, the obtained findings reinforce the bidirectional nature of the sleep–PA relationship. Literature shows that PA regulates circadian rhythms, improves sleep architecture, and enhances sleep, particularly through the non-rapid eye movement sleep phase (28). Conversely, poor sleep can impair motivation and reduce physical performance. Thus, promoting moderate-intensity PA in daily routines for children with CP may help improve their sleep patterns. PA has also been shown to regulate circadian rhythms and metabolism, improve sleep quality, and reduce adiposity and obesity risk (29). The current literature supports the view that a combination of high PA levels, specifically MVPA, low sedentary behavior, and sufficient quality sleep provides the most comprehensive health benefits for children (15,30).

Study limitations

Several limitations of this study should be acknowledged: first, sleep habits were assessed using subjective questionnaires rather than objective measures such as actigraphy or polysomnography. Second, the statistical power was limited due to the small sample size. Only five participants in the CP group were at GMFCS level II, limiting between-level comparisons. Third, although the CP group included various subtypes (spastic hemiparesis, diparesis, dyskinetic, ataxic), the sample size was insufficient for subtype-specific analyses. The fourth limitation is the use of the ESS, which was originally developed for adults and may not fully capture or accurately reflect daytime sleepiness in children. Finally, the cross-sectional design prevents conclusions about causality in the sleep–PA relationship. Future longitudinal and interventional studies are needed to understand these dynamics better.

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In Conclusion

The obtained findings suggest that moderate-intensity PA is associated with fewer sleep problems in children with CP. This relationship should be considered in both public health policy and individualized rehabilitation planning. Importantly, the present results highlight the reciprocal influence of sleep habits on PA. The observation that children with sleep problems exhibited reduced PA levels in both CP and TD groups highlights the need to approach rehabilitation from a bidirectional perspective. Poor sleep can lead to fatigue, attention deficits, and reduced physical performance—further limiting daily activity. Accordingly, improving sleep may enhance not only nighttime rest but also daytime function and PA participation. Rehabilitation programs for children with CP should integrate both PA and sleep interventions to maximize developmental outcomes.

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Author Contributions

Buse Sert: Conceptualization, methodology, investigation, data collection, data curation, formal analysis, interpretation of the results, visualization, project administration, writing – original draft, and writing – review & editing.

Orhan Öztürk: Methodology, formal analysis, interpretation of the results, and writing – review & editing.

Yeliz Çirak: Conceptualization, methodology, supervision, interpretation of the results, and writing – review & editing.

İlksen Demirbüken: Supervision and writing – review & editing

Conflict of Interest

The authors declare no conflict of interest.

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