Early Human Development xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Early Human Development

journal homepage: www.elsevier.com/locate/earlhumdev

Sleep: An underemphasized aspect of health and development in neurorehabilitation

ARTICLE INFO

Keywords:
Sleep
Cerebral palsy
Parents
Neurorehabilitation
Health
Development

ABSTRACT

Sleep deficiency has unique causes and implications for children with neonatal brain injury; contributing to the development or exacerbation of neurodevelopmental impairments and yet it is an underemphasized aspect of health and development. There is very little research evidence to guide the management of sleep disorders in children with cerebral palsy, a common neurodevelopmental disability of childhood. This paper is a comprehensive review and analysis of the literature regarding what is known about sleep quantity and quality in children with cerebral palsy. The specific implications for children with cerebral palsy are explored including the adverse effects of sleep deficiency on general child development, physical health and growth, and mental functioning. The consequences for the family are also discussed. Finally, the assessment and management of sleep problems are summarized to provide guidance to clinicians who work in neurodevelopmental medicine.

1. Introduction

Recent literature shows increasing recognition that sleep plays a critical role in child health and development [1]. More specifically, sleep plays an essential role in optimal general health, physical performance, and cognitive functioning of children with and without neurodevelopmental conditions [1,2]. Thus, sleep is emerging as an essential component of a triad of healthy behaviours, which also includes healthy diet and physical activity. Tremblay et al. [3] recently introduced the Canadian 24 h Movement guidelines [3] for children which, to our knowledge, are the first of its kind integrating recommendations for sleep in movement guidelines. Under the "whole day matters" philosophy, kids between the ages of five and 13 years old should sleep nine to 13 h each night, while eight to 10 h of sleep is recommended for youth aged 14- to 17-years [1].

Sleep deficiency is broadly defined as insufficient sleep or sleep patterns that interfere with physical and mental well-being. Sleep deficiency can result from inadequate amount (deprivation) or decreased quality of sleep. Chronic sleep loss and associated sleepiness and daytime impairments pose serious threats to childhood academic success and health, and are important public health issues [4]. For example, there is a growing body of research that suggests that sleep deficiency in childhood is associated with adverse outcomes including increased adiposity, challenges with emotional regulation, worse academic performance and decreased quality of life and well-being [1]. Understanding the implications of insufficient sleep during childhood is critical in developing promising strategies to optimize health and developmental outcomes.

Sleep problems, such as bedtime resistance and night waking are common among all children during their first few years [5]. While the majority of children who are typically developing outgrow their sleep problems around school age, as many as 30% of preschool children continue to experience sleep deficiency and the same proportion of adolescents may not be getting the optimal amount or quality of sleep [1]. The prevalence of sleep disorders is much higher in children with neurodevelopmental disabilities, with a reported prevalence as high as 85% [2,6]. Therefore it is critical that clinicians who work with this population understand the unique causes and implications of sleep deficiency as well as the range of possible interventions to improve sleep.

Sleep deficiency has unique causes and implications for infants who experienced neonatal brain injury and present with subsequent neurodevelopmental impairments. However, there has been little focus on sleep issues within this population. A review by Lelis et al. [7] included only 12 published papers on sleep in children with cerebral palsy (CP); three studies have been published since [8–10]. Increased awareness of the issues associated with sleep deficiency is needed to advance research and clinical practice regarding sleep assessment and management. Early recognition of sleep deficiency and use of strategies to ensure sufficient sleep can contribute to optimizing developmental potential and reducing the burden of sleep deprivation on the family.

The goal of this article is to provide an overview of what is currently known about (1) the causes of sleep deficiency in children with CP; (2) the consequences of sleep deprivation on children with CP and their family; and (3) implications for clinicians in neurodevelopmental medicine.

http://dx.doi.org/10.1016/j.earlhumdev.2017.07.006

2. The causes of sleep deficiency in children with CP

CP is a non-progressive injury to the developing brain in the pre-, *peri* or postnatal period that results in a movement or posture disorder leading to activity limitations [11]. With a prevalence varying from 2.0 to 3.6 cases per 1000 live births [12–14], CP is a common neurodevelopmental disability of childhood. Children with CP present with a range of motor abilities that can affect the ability of the child to perform motor tasks. In addition, many children have co-existing morbidities including seizure disorders, cognitive impairments, and vision and hearing impairments [11] that can also affect their abilities to perform daily functional activities.

Infants and children at risk for or diagnosed with CP are often followed by specialized professional teams such as neonatal follow-up clinics, neurodevelopmental or rehabilitation clinics for children with CP. The early focus of parents and clinicians includes medical management as well as optimizing infant development. Participation in age appropriate activities is emphasized as children enter pre-school and school programs. Over the last decade, physical activity promotion and reduction of sedentary behaviour has become an important focus of rehabilitation programs, in an effort to enhance function and long-term health. In contrast, sleep in children with CP has only recently been recognized as an important part of the formula to promote long-term health, in line with “the whole day matters” philosophy in typically developing children [5,15].

There is evidence that children with CP are seven to twelve times more likely to experience sleep disorders, when compared to their peers [6]. Difficulties with all aspects of sleep have been reported in children with CP, which may be related to common co-morbid medical conditions [16–19]. Lelis et al. [7] performed a review of the literature specific to sleep and children with CP and identified eleven reported types of sleep disorders; 1) sleep hyperhidrosis; 2) disorders of arousal; 3) difficult morning awakening; 4) sleep disordered breathing; 5) bruxism; 6) insomnia; 7) nightmares; 8) parasomnias (e.g., sleepwalking); 9) difficulties in initiating and maintaining night time sleep (night waking); 10) sleep-wake transition disorders; and 11) sleep anxiety. These sleep disorders can be caused by a number of intrinsic factors related to various medical conditions that affect the following systems/aspects of health: 1) Neurological system; 2) Mental health (including behavioural disorders and co-morbidities such as autism spectrum disorder); 3) Ophthalmological; 4) Hearing; 5) Upper airway; 6) Pulmonary; 7) Gastrointestinal; and 8) Musculoskeletal system. Extrinsic factors such as socio-familial factors and clinical, surgical and pharmacological interventions may also have an adverse effect on sleep [7]. Common examples and consequences of these issues are presented in Table 1.

Concerns about sleep of children and adolescents with CP have been reported to vary by age and gross motor function and often consist of multiple factors that impede sleep [20]. In a study of 154 children and adolescents, participants identified sleep routines, settling routines, daytime activities, and behaviour and sensory regulation as primary concerns. Concerns for children and adolescents with more significant motor involvement were mostly related to posture, movement control, breathing, reflux and digestion, and temperature and perspiration. Issues with settling routines were of more concern for children under six [20].

In summary, sleep issues are a common occurrence among children with CP. There is a range of factors (intrinsic and extrinsic) that contribute, often in combination, to the manifestation and persistence of sleep problems.

3. The consequences of sleep problems for children with CP and their families

Sleep serves a crucial restorative and protective role. Effective sleep has been associated with immune and cardiovascular function and many essential growth and restorative processes such as muscle growth, tissue repair, release of growth hormone and synthesis of proteins [21]. Various theories regarding the role of sleep in human functioning have emphasized physical and psychological restoration, energy conservation, consolidation of memories, discharge of emotions, brain growth, and other basic biological functions including immune system maintenance [22]. Consequences of sleep deficiency for children who are typically developing include adverse physical and mental health outcomes, including negative consequences for academic performance and learning [23].

This section summarizes the most important findings in the literature in combination with clinical observations and the potential relevance to

Table 1
Factors related to sleep in children with CP.

Factors	Examples	Consequences related to sleep
Intrinsic		
Neurological	Epilepsy/nocturnal seizures	Arousals and awakenings
Mental health	Behavioural issues	Failure to register daytime and night-time cues, irritability, oppositional behaviour, anxiety, low mood, over activity and poor attention span
Ophthalmological	Blindness/visual impairment	Circadian rhythm abnormalities resulting in delayed secretion of nocturnal melatonin
Hearing	Hearing impairment	Frightened, disoriented
Upper airway	Abnormal airway muscle tone	Breathing disorders, upper airway obstruction, mixed sleep apnoea, recurrent aspiration pneumonia
Pulmonary	Pulmonary aspiration	Breathing disorders and possible sleep apnoea
Gastrointestinal	Gastro-oesophageal reflux	Breathing disorders leading to arousals and wakes
Musculoskeletal	Muscle spasms or other forms of musculoskeletal pain, decreased ability to change body position	Arousals and wakes
Extrinsic		
Socio-familial variables	Bed-sharing[a]	Sleep disorders, disorders of arousal
Clinical surgical and pharmacological interventions	Use of devices (orthosis, night worn splints, postural equipment), medication, major surgery (e.g. scoliosis, corrective hip surgery).	Pain, discomfort, side effects of medication (decreased rapid eye movement in REM sleep, abnormal body movements according to the stage of sleep)

[a] The relationship between sleep deficiency and co-sleeping is complex as parents will often sleep with their child to ensure necessary medical care is provided during the night. Therefore it is important to consider that parents choose co-sleeping arrangements because their children have difficulty maintaining sleep and not to assume that co-sleeping is a cause of sleep issues [8].