Official Journal of the European Paediatric Neurology Society

Review article

Long-term sleep disturbances in children: A cause of neuronal loss

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ARTICLE INFO

Article history:
Received 25 July 2009
Received in revised form
1 May 2010
Accepted 5 May 2010

Keywords:
Children
Sleep deprivation
Cellular stress
Intellectual loss
Melatonin

ABSTRACT

Short-term sleep loss is known to cause temporary difficulties in cognition, behaviour and health but the effects of persistent sleep deprivation on brain development have received little or no attention. Yet, severe sleep disorders that last for years are common in children especially when they have neurodevelopmental disabilities. There is increasing evidence that chronic sleep loss can lead to neuronal and cognitive loss in children although this is generally unrecognized by the medical profession and the public. Without the restorative functions of sleep due to total sleep deprivation, death is inevitable within a few weeks. Chronic sleep disturbances at any age deprive children of healthy environmental exposure which is a prerequisite for cognitive growth more so during critical developmental periods. Sleep loss adversely effects pineal melatonin production which causes disturbance of circadian physiology of cells, organs, neurochemicals, neuroprotective and other metabolic functions. Through various mechanisms sleep loss causes widespread deterioration of neuronal functions, memory and learning, gene expression, neurogenesis and numerous other changes which cause decline in cognition, behaviour and health. When these changes are long-standing, excessive cellular stress develops which may result in widespread neuronal loss. In this review, for the first time, recent research advances obtained from various fields of sleep medicine

Abbreviations: fMRI, functional magnetic resonance imaging; MEG, magnetoencephalography; NDD, neurodevelopmental disabilities; NREM, non-rapid eye movement; REM, rapid eye movement.

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doi:10.1016/j.ejpn.2010.05.001

are integrated in order to show that untreated chronic sleep disorders may lead to impaired brain development, neuronal damage and permanent loss of developmental potentials. Further research is urgently needed because these findings have major implications for the treatment of sleep disorders.

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1. Introduction

Recent research activities in various fields of sleep medicine force us to view the wake–sleep states as an interrelated and orchestrated change in behavioural, cognitive, genetic, anatomical, electrical, molecular, cellular, biochemical, and endocrine functions in which the pineal melatonin plays an important role.[1] Viewing sleep as a complex, neurological process rather than an independent state promotes better understanding of sleep disorders and their adverse effects on cognition, behaviour and health. The purpose of this review is to discuss the neuronal, metabolic and other mechanisms of sleep, based on recent scientific advances; then to summarise and integrate the evidence which supports the hypothesis that in childhood chronic sleep deprivation can lead to permanent neurological damage especially during early critical developmental periods. Sleep deprivation is generally defined in sleep medicine as sufficient loss of sleep during a period of time which results in impairment of neurological and physical functions. Sleep deprivation not only depends on the quantity but also on the restorative quality and timing of sleep. Children require more sleep than adults with individual variations. Sleep deprivation can be short or long-term, partial or total. Short-term sleep deprivation could be caused by loss of a few hours of sleep. It is more difficult to define chronic or long-term partial sleep loss but in clinical practice children with neurodevelopmental disabilities frequently exhibit persistent sleep disturbances with inadequate hours of sleep for years or even lifetime. Partial and also total short-term sleep loss has been studied mainly in animals, less frequently in healthy adults but only on rare occasions in children.[2–4] Research on the permanent adverse effects of sleep loss on neurodevelopment is still minimal.[5] There are no controlled studies in children, which is not surprising as such experiments are unethical to perform, due to adverse psychological and medical consequences.

One of the anecdotal total long-term sleep deprivation experiments involved a top radio personality, Peter Tripp, who in 1959 wanted to break the world record for staying awake for the longest period of time. He succeeded in breaking the record by staying awake for 201 h but became psychotic towards the end of his ordeal. Following this event, those close to him felt that his personality had permanently changed. He lost his job, had difficulties settling and his wife divorced him.[6] Since then others have broken the world record for staying awake but all of them had serious cognitive and behavioural changes during their attempts. The long-term neurological and psychological consequences were not studied. The experiment of Peter Tripp illustrates the critical importance of sleep for survival. Indeed, complete lack of sleep in animal experiments leads to death within 3 weeks.[7,8]

In typically developing children, with exceptions, the sleep difficulties tend to be partial, short term and respond favourably to appropriate management.[9] In contrast, in children with neurodevelopmental disabilities (NDD) the prevalence rates of sleep difficulties may be as high as 75–80% and the sleep disturbances tend to last for years or even for a lifetime. While they can be helped by therapies or environmental changes they may respond less readily than typical children.[10–12] Sleep disturbances are associated with many neurological conditions, alone or in combinations, such as intellectual disability,[13] epilepsy,[14] cerebral palsy,[15] visual impairment,[16] autism,[17] attention deficit hyperactivity disorder,[18] fetal alcohol spectrum disorders[19] and brain maldevelopment.[20] Not infrequently such children only sleep for 3–4 h a night for years or for their entire lives. The number of coexisting neurological disorders and their severity proportionately predispose to disturbed sleep.[21] Untreated sleep deprivation may lead to deterioration of the already impaired brain functions as evidenced by increased difficulties in learning, memory, verbal creativity, attention, abstract reasoning and many other perceptual, cognitive and