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Sleep and learning in school children

Sono e aprendizagem em crianças escolares

Sueño y aprendizaje en escolares

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Abstract

Objectives: To discuss physiological factors that affect learning in school children and the harmful effects of major sleep disturbances on that age. Methodology: Articles were analysed between 2020 and 2015 in LILACS, PUBMED, SciELO and MEDLINE databases with the keywords: Sleep and Child; Sleep and Learning; GH and Learning; Memory and Learning; Blood Flow and Learning; Oxygenation and Learning; Immunity and Cognition. Additionally, we also referred to the books "Sleep and Sleep Medicine" and "Insomnia from Diagnosis to Treatment". Results and discussion: We found evidence in the literature that sleep influences brain plasticity, spatial learning, motor training, long-term memory, Growth Hormone (GH) release, synapses remodelling and acts on the Hypothalamic-pituitary-adrenal (HPA) axis. Furthermore, clinical and practical findings also show that immunity is affected and children with sleep problems present significant disturbances in learning. Conclusion: The relationships between sleep reduction/ sleep disorders and daytime /nocturnal brain function, influence learning of school children.

Keywords: Sleep; Learning; School; Child; Teaching.

Resumo

Objetivos: Discutir os fatores fisiológicos que afetam a aprendizagem nas crianças escolares e os efeitos prejudiciais dos maiores distúrbios de sono nesta idade. Metodologia: Foram analisados artigos entre 2020 e 2013 nas bases de dados LILACS, PUBMED, SciELO e MEDLINE com os descritores: Sono e Criança; Sono e Aprendizagem; GH e Aprendizagem; Memória e Aprendizagem; Fluxo Sanguíneo e Aprendizagem; Oxigenação e Aprendizagem; Imunidade e Cognição. Ademais, nós também utilizamos os livros “Sono e a Medicina do Sono” e “Insônia do Diagnóstico ao Tratamento”. Resultados e discussão: Foram encontradas evidências na literature sobre como o sono influencia na plasticidade cerebral, aprendizagem espacial, treino motor, memória de longa duração, liberação do hormônio do crescimento (GH), remodelação sináptica e a atuação no eixo Hipotálamo-hipófise-adrenal (HHA). Outrossim, achados clínicos e práticos também indicam como a imunidade é afetada e crianças com problemas de sono apresentam distúrbios significativos na aprendizagem. Conclusão: A relação entre a redução do sono/distúrbios de sono e funcionamento cerebral durante o dia/noite, influencia na aprendizagem de crianças escolares.

Palavras-chave: Sono; Aprendizagem; Escola; Criança; Ensino.

Resumen

Objetivos: discutir los factores fisiológicos que afectan el aprendizaje en los niños escolares y los efectos nocivos de los principales trastornos del sueño en esta edad. Metodología: Se analizaron artículos entre 2020 y 2015 en las bases de datos LILACS, PUBMED, SciELO y MEDLINE con los descriptores: Sueño e Niños; Sueño y aprendizaje; GH y aprendizaje; Memoria y Aprendizaje; Flujo sanguíneo y aprendizaje; Oxigenación y Aprendizaje; Inmunidad y cognición. Además, también utilizamos los libros "Sueño y Medicina del sueño" e "Insomnio del diagnóstico al tratamiento". Resultados y discusión: Se encontró evidencia en la literatura sobre cómo el sueño influye en la plasticidad cerebral, el aprendizaje espacial, el entrenamiento motor, la memoria a largo plazo, la liberación de la hormona del crecimiento (GH), la remodelación sináptica y el desempeño en el eje hipotálamo-pituitaria-adrenal. (HPA). Además, los hallazgos clínicos y prácticos también indican cómo se ve afectada la inmunidad y los niños con problemas de sueño tienen importantes discapacidades de aprendizaje. Conclusión: La relación entre la reducción del sueño / trastornos del sueño y el funcionamiento del cerebro durante el día / noche influye en el aprendizaje de los escolares.

Palabras clave: Sueño; Aprendizaje; Escola; Niño; Ensenãnza.

1. Introduction

Sleep is a universal phenomenon in the animal kingdom assuring survival. The most widely accepted hypothesis about the function of sleep over brain functions it is the promotions of brain plasticity of the, enhancing several mechanisms which culminate in the formation and consolidation of memory. Furthermore, sleep has a strong influence on cognition, learning, memory and mood, and sleep deprivation slows down working memory, reduces cognitive efficiency and induces a depressed mood (Silva, 2014).

Insomnia is the most common sleep disorder, being present at any age range. It is defined by a difficulty regarding the initiation, maintenance, consolidation or overall quality of sleep, hence leading to a daytime impairment. It can emerge from a stressful event or other clinical conditions, manifesting itself as a symptom or disorder (Bacelar, 2019).

Chronic insomnia occurs in 9-13% of children and adolescents and the risk factors are errors in sleep hygiene; errors in sleep knowledge and perceptions; personality traits; medical diseases; health perception and somatic problems; psychiatric or psychological problems; female gender after puberty; family history of insomnia; tobacco and alcohol; TV in the bedroom; insufficient communication with parents as well as low socio-economic status (Paiva, 2017; Reis, 2013).

Sleep deprivation (or insufficient sleep) involves voluntary sleep reduction. Its prevalence ranges from 1.1 to 13.6% in children aged 6 to 10 years (Ranum, 2020), but increases with age reaching 18.9% of adolescents between the 8th and 10th grades (Paiva, Gaspar, & Matos, 2016). Risk factors are the so-called sleep thieves (mobile phones, social networks, internet and multimedia games), the excess of curricular and extracurricular activities, family pressures for success (Li et al, 2013), family disorganization; parents' late working hours or habits; sedentarism (Paiva et al, 2016; Matos, Gaspar, & Paiva, 2017) and early classes starting times (Hale & Troxel, 2018).

The effects of sleep deprivation are already well documented both in physical and cognitive performance, which impairs work memory and reaction time without detriment to cognitive abilities (Patrick et al, 2017), thus having direct consequences of a decrease in school academic success (Beebe, Field, Miller, Miller, & LeBlond, 2017). There are, however, other consequences such as increased accidents; health problems (type 2 diabetes, obesity, headaches, hypertension); sleepiness and risk behaviours (Matos et al, 2017; Paiva,

2015).

This review intends to discuss the physiological factors that affect learning in school children; as well as the harmful effects of the main sleep disorders in this particular age range.

2. Methodology

The present qualitative study is a integrative review of the literature and the methodology adopted was proposed by Pereira A.S et al.(2018). We analysed all articles between 2020 and 2013 in the LILACS and MEDLINE database with the key words: Sleep and Child; Sleep and Learning; GH and Learning; Memory and Learning; Blood Flow and Learning; Oxygenation and Learning; Immunity and Cognition. After that process we then elaborated a literature review article on "Sleep of Schoolchildren and its relationship on Learning". Additionally, the books "Sleep and Sleep Medicine" and "Insomnia; from diagnosis to treatment" have been used; as well as articles on the subject present in other databases, such as PUBMED and SciELO. In addition, due to the difficulty in finding recent literature on the amount of GH released during sleep, Van Cauter & Plat's (1996, 1998) articles were used as reference, which discuss the subject.

The integrative literature review determines the knowledge of themes and aims to identify, collect, analyze and synthesize results of research and studies on the same subject, independent. This can help providing an up-to-date general and clinical context on the subject.

3. Results

Sleep deprivation induces a deterioration of spatial memory and an imbalance of inflammatory cytokines in rats, in the plasma and in the hippocampus with an activation of glial cells (Wadhwa et al, 2017).

Sleep deprivation and sleep restriction have effects on the hippocampus serotonergic system for spatial learning, with an increase in serotonin and thus a decrease in 5-HT2A receptors, by negative feedback, which act indirectly on glutamate signals, involved in sleep and memory regulation (Saygin et al, 2017).

Slow-wave sleep has been shown to be essential for the brain to maintain its ability to respond efficiently to motor training and then adapt to the environment. The capacity for synaptic potentiation is greater in the morning after a sleep night than in the afternoon,

indicating that deep sleep is related to its normalization (Fattinger et al, 2017).

A study of zebra fish (Danio rerio) has shown that growth hormone (GH) promotes an increase in glutamate receptor expression, mainly AMPA (α-amino-3hydroxy-5-methylisoxazole-4propionic) and NMDA (N-methyl-d-aspartate), promoting an increase in long-term memory and learning (Studzinski, Barros, & Marins, 2015). It has also been demonstrated in rats that low dose GH administration protects against degeneration of cognitive performance and causes significant improvement in memory, attention, motivation and working capacity (Barcelo et al, 2016).

Studies also demonstrate that the secretion of growth hormone (GH) has its plasma concentration increased at the beginning of sleep, reaching its peak 24 hours after and then decreasing (Halal & Nunes, 2019). In adult men, approximately 70% of GH pulses occur during slow-wave sleep (Van Cauter & Plat, 1996, 1998).

In a study of rats, it was shown that during sleep, synapses of glutamate receptors undergo changes in composition and signalling from the Homer1a gene, which accumulates in neurons during the waking state and are removed by the action of noradrenaline. There is a fall in noradrenaline during the onset of sleep, allowing Homer1a to act in synapses and weaken them, thus participating in the remodelling of synapses and further consolidation of contextual memory (Diering et al, 2017).

The hypothalamic-pituitary-adrenal axis (HPA) is affected and affects stress levels when there is a loss in sleep quality (Van Dalfsen & Markus, 2018). In a study using rats on sleep restriction, it was shown that there is a higher expression of regulatory genes of the HPA axis, such as pro-opiomelanocortin and corticotrophin release factor. Only in males there was an increase of the adrenal expression of mRNA 11β-hydroxylase and melanocortin receptor (Buban, Shupe, Rothwell, & Wu, 2020).

In children born small for gestational age (SGA), the incidence of chronic diseases is more common and GH is usually prescribed as a therapy (Dunger et al, 2020). IGF-1 is decreased both in the placenta and blood of SGA neonates, indicating a disorder in the GH-IGF axis (Renes, Doorn, & Hokken-Koelega, 2019).

4. Discussion

With sleep deprivation and its consequential decrease in the quantity or quality of sleep, the body adapts through compensatory mechanisms so that losses can be lessened (Diaz et al, 2017); however the short and long term negative impacts persist (Medic, Wille, &

Hemels, 2017; Agorastos, Pervanidou, Chrousos, & Baker, 2019).

In individuals with sleep deprivation, there are immunity losses, with increased cytokine activity, such as interleukin-1-beta (IL-1-beta), tumour necrosis factor (TNF) and interferon (IFN). There is also an increase in inflammatory markers, such as C-reactive protein (Ruiz & Tufik, 2014). This change in autoimmune regulation may be one of the mechanisms underlying the increase in health complaints (Paiva, 2015).

In a study following children from one to four years of age, it was found that those with one year of age who had a better sleep report by their parents, had better formation capacity for concepts, abstract thinking and problem solving skills at four years of age (Bernier, Beauchamp, Bouvette-Turcot, Carlson, & Carrier, 2013). In addition, children reported by their relatives to have sleep problems at preschool, had difficulty in tests that evaluated work memory, underwent kindergarten retention and had worse grades in first grade tests in English and mathematics. However, these findings are only significant in children with low effortful control, such as focus, inhibition of dominant responses, and detection errors (Diaz et al, 2017).

A study regarding adolescents who underwent short sleep (6.5 hours), demonstrated that they performed worse in terms of learning and behaviour than those who had a healthy 10-hour sleep11. Sleep disorders are more prevalent in children with learning disabilities (Aishworiya, Chan, Kiing, Chong, & Tay, 2016). Children with obstructive sleep apnea have microvascular changes, such as decreased average diffusibility of dendate gyrus and other parts of the brain, making verbal memory capacity smaller, also correlated with a decrease in the volume of gray matter from surrounding areas of dendate gyrus (Cha et al, 2017).

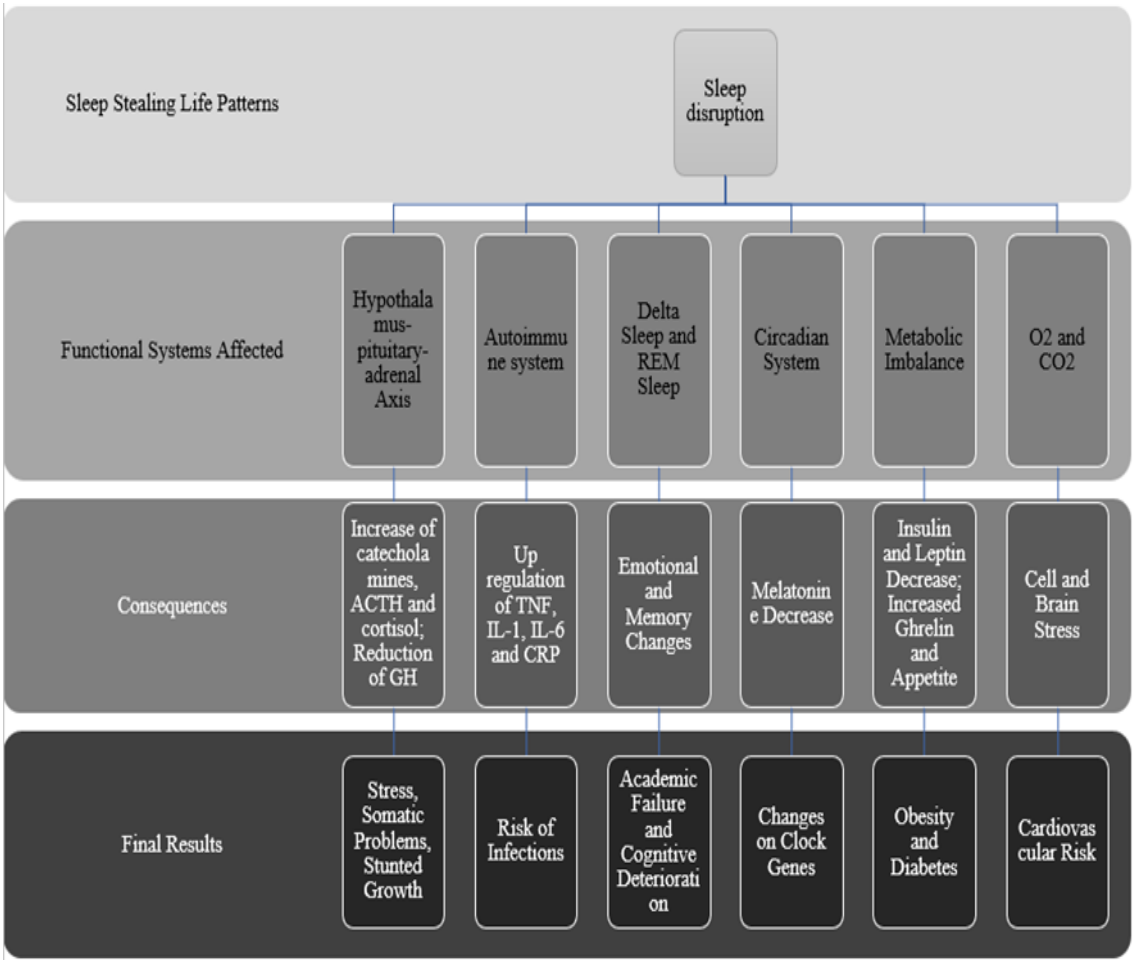
In young adults, brain oxygenation during slow-wave sleep is higher than in older adults. When older adults present levels of brain oxygenation during sleep, similar to that of young adults, they demonstrated a preserved performance of episodic memory (Scullin & Bliwise, 2015).

Children with obstructive sleep apnea were linked to worse grades in school subjects, sleepiness, hyperactivity, and mood dysregulation. In addition, patients with restless leg syndrome and periodic limb movement disorder were related to dysfunctions such as hyperactivity and inattention (Beebe, 2011). The growth hormone axis (GH) and insulin-like growth factor type 1 (IGF-1) are involved in learning, memory, neuroprotection, communicating with the immune system and sleep (Chennaoui, Leger, & Gomez-Merino, 2020); being involved in normal ovarian and testicular regulation (Ipsa, Cruzat, Kagize, Yovich, & Keane, 2019); growth in stature, affecting the Z score (Liu, Wang, & Chen, 2019).

5. Conclusion

As summarized in Figure 1, it is concluded that reduced sleep and detrimental habits of school children directly interfere with their day and night brain functioning and their health, negatively influencing learning and growth. Sleep disorders at these ages are also responsible for several of the many learning problems and should therefore, be treated.

Figure 1. Flow chart on sleep disruption and its subsequent effects.



Source: Recovered from the authors' personal file.

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