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Sleeping disorders in children

A functional neuroanatomical approach

Introduction

Children of all ages experience difficulties initiating and maintaining sleep, which is known as childhood insomnia. Insomnia is a symptom that may be caused by a primary sleep disorder or is associated with other sleep, medical and psychiatric disorders [12]. Insomnia among children and adolescents is ubiquitous and takes a great toll on youth and their families, impacting academic achievement, mood, social functioning, and a variety of developmental outcomes. Unfortunately, however, pediatric insomnia mostly remains unidentified and untreated [2]. Therapeutic possibilities so far include bedtime routine, sleeping hygiene, consistent sleep schedule, avoiding stimulating activities, limiting caffeine intake before bed, and engaging in daily physical activity [29]. Medications are frequently prescribed but there is a lack of data regarding controlled studies to support the use of pharmacologic agents in the management of childhood insomnia. From a psychological point of view the fears of children need to be addressed [19], for example, looking under the bed together to rule out a population of slimy, frightening, nightmare-inducing somethings with tentacles and claws (■ Fig. 1).

This article intends to highlight the so-called behavioral sleeping disorders characterized by bedtime problems, e.g. problems falling asleep or problems sleeping through the night. Between 15–30% of children 2–5 years old and 11–15% of school-age children (6–12 years) experience these difficulties. Children with behavioral problems more frequently show a difficulty with self-regulation, such as attention deficit hyperactivity disorder (ADHD) or autism

spectrum disorder (ASD) present with behavioral sleep problems [27].

In this patient collective these problems are also observed in children with sensorimotor dysfunction (SMD), especially problems falling asleep. Children say that they need light or at least an open door. Often, they need a parent or a lot of soft toys in bed. When asked what happens when they are alone in the dark, they mention anxiety, feeling or even seeing of ghosts, thieves and monsters, or just a presence. Interestingly, these symptoms soon disappear after initiating manual therapy to treat segmental dysfunctions especially in the key sensory regions [6].

Segmental dysfunction—a functional problem

Each “segmental blockage” is the source of altered proprioception and leads to a disorder of sensorimotor control in infancy [6]. A segmental blockage or, better, a segmental dysfunction is defined as a contraction of the short, autochthonous, deep muscles and the sur-

rounding tissue caused by a motor system activation and an activation of the sympathetic system. This activation is a result of a nociceptive signal transmitted via the A δ or the C-fibers [4]. Possible nociceptors are located in every tissue associated with the specific segment. These afferents converge to the wide dynamic range neuron (WDR), this leads via axon collaterals to the described activation reaction of the motor and sympathetic system. It induces a segmental or metamer effect via alpha and gamma motoneurons [4, 15]. The activation of the gamma motor system comes along with a tonic contraction of muscle spindles, which subsequently are no longer able to provide adequate proprioceptive information. It is obvious that in this cascade the proprioceptive system is not merely altered, but rather the exteroceptive system and the segmental innervated viscera are influenced [6].

Fig. 1 ◀ Anxiety at night (with kind permission © Laura Sammer, all rights reserved)

Table 1 Duration of sleep during lifetime [17]

Age group	Recommendation
Newborns (0–3 months)	14–17 h
Infants (4–11 months)	12–15 h
Toddlers (1–2 years)	11–14 h
Preschool children (3–5 years)	10–13 h
Children (6–13 years)	9–11 h
Teenagers (14–17 years)	8–10 h
Young adults (18–15 years)	7–9 h
Adults (26–64 years)	7–9 h
Older adults (over 65 years)	7–8 h

Sensorimotor dysfunction—symptoms and treatment

Persisting segmental dysfunctions, especially in the upper cervical spine, can cause sensorimotor dysfunction (SMD) in preschool and school age children with an impairment of movement quality and the ability to classify the spatial relationship of things to one another. This results in a disturbance of basal cognitive function and may lead to certain behavioral problems as well as cognitive deficits. The resulting symptoms can present as attention deficit hyperactivity disorder (ADHD) or also autism spectrum disorder (ASD), which have to be ruled out as an important differential diagnosis [6].

The main symptom in SMD and indications for manual treatment are the disturbance of body control and movement quality, which can be demonstrated with the motocybernetic test (MKT) [7]. Other symptoms in school children are reading and spelling disabilities, concentration disorders or reduced fine motor skills [7]. These children often describe difficulties initiating or maintaining sleep as previously described.

The modified atlas therapy according to Arlen is the therapy of choice [6], moreover the full armamentarium of manual and osteopathic techniques can additionally be used. The main therapeutic aim must be the precise examination of the key sensory regions for segmental dysfunctions. These key sensory regions are the cervico-occipital junction, the cervicothoracic junction combined with the first rib and the upper thoracic

spine, the thoracolumbar junction and the lumbosacral junction combined with the sacroiliac joint [6].

The atlas therapy according to Arlen is a very gentle and highly effective treatment. From the neutral position of the head a very fast, ultrashort push with the middle fingertip is performed on the transverse process of the atlas in an individually defined direction. The push may be made transversally or diagonally.

To provide a correct and effective atlas therapy according to Arlen, an exact determination of the therapeutic impulse direction is necessary [8]. An effective therapy results in an improvement of body control and spatial orientation. This usually correlates with improved cognitive skills and mood and the sleeping modality. The improvement of the sleeping modality, which is not a classical indication for manual medicine in children, is regularly seen as a fortunate side effect. An explanation why children feel that monsters are under the bed cannot be given. This observation led to a literature search about the topic to find possible explanations for this phenomenon. To define problematic, insufficient or abnormal sleep, it is important to have an understanding of what constitutes normal sleep in children.

Sleep—a common feature but not simple

Sleep is a period of physical inactivity during which an individual of a particular species avoids movement within an environment to which it is poorly adapted, whilst using this time to undertake a range of essential biological activities that allow optimum performance during the period of activity [11]. From the 10th week of gestational age the fetus shows 2 types of quiescence. The first short phase of inactivity is when the fetus interrupts every activity being done for about 1 min and the second is when the fetus remains motionless for about 3 min. These resting periods increase with gestational age [9]. Sleep and sleep cycles involving rapid eye movement (REM) and non-rapid eye movement (NREM) begin around 26–28 weeks of pregnancy [13].

A newly born child shows a sleep cycle of about 50 min, which lengthens over the first years of life to a cycle length of 90–120 min like a grown-up person. In the first weeks of life infants wake up after every cycle for a short period. After 3–4 cycles they stay awake for a longer period of time. Up to the 3rd month of life the cycles differentiate and become more regular. After the 3rd month the sleep-awake rhythm adjusts more and more to the cycle of adults. Also, the duration of sleep itself varies in every human being and changes during a lifetime ([21]; **Table 1**).

Sleeping disorder—a common problem in children

High quality of sleep is very important because sleeping disorders may interfere with physical, cognitive, emotional and social development. The clinical manifestation of sleep problems can be different by age as well as developmental level and may show many different manifestations in adults. Children with excessive sleepiness may, for example, exhibit motor overactivity, inattentiveness, irritability, or oppositional behavior rather than daytime sleepiness [28]. Especially in children with ADHD or ASD and other developmental delays (DD) and disorders with ASD (w/ASD) sleeping disorders are very common. An improvement of sleep leads to an improvement of the symptoms and higher quality of life for children and parents [16, 24]. Hiscock et al. demonstrated that with only approximately 10 min more of sleep, children with ADHD showed an improvement of their symptoms [16]. There are many different types of sleeping disorders (International Classification of Sleep Disorders 2, ICSD 2, sleep disorder categories and individual sleep disorders) but the chief sleep complaints of children are [28]:

- Difficulties initiating or maintaining sleep
- Excessive daytime sleepiness
- Snoring or other breathing problems during sleep
- Abnormal movement or behavior during sleep.

The different kinds of sleep disorders that children can develop also vary at different ages. They are often behavioral or psychological but medical factors must always be excluded. Preschool children often show anxiety about being separated from parents at night, have too much stimulating activities before bedtime, inadequate limit-setting on uncooperative bedtime or night-time behavior as well as negative associations with being in bed. Inappropriate patterns of daytime napping, putting the child to bed too early or night-time fears can be contributory factors [26]. During this age (2–5 years toddler to preschool children) children develop a strong imagination that is combined with strong feelings. They start to enjoy fantasy play, which is not always only positive. Also, dragons, witches and monsters can be seen or sensed, especially in the darkness, when they hear a sound they cannot interpret or things they cannot see clearly in the dark are misinterpreted. Things they saw or heard during the day can become monstrosities during the night [14, 21]. In schoolchildren night-time fears might intensify. Worry and anxiety may cause difficulty in falling asleep or staying asleep. Even if the original source of concern may no longer exist, the difficulty in falling asleep may persist because the child has developed the habit of lying awake in bed in an agitated state (conditioned insomnia). Also, the restless legs syndrome can be a reason for sleeping disorders in that age. In older children and later, early morning awakening may be part of an anxiety or depressive disorder. Otherwise, the child may have been woken too early by environmental factors which intrude into sleep [26].

In adolescence worries, anxiety and depression can be the reason for not being able to sleep at this age. Nicotine, alcohol, and caffeine-containing drinks, as well as illicit drug use, are additional possible influences. Also the delayed sleep phase syndrome can be found in this age. (delayed sleep by 2h or more beyond what is considered to be an acceptable bedtime causes difficulties in getting up for school the next morning) [26]. Optimizing sleep is very important. The therapeutic ap-

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Abstract

In children with sensorimotor dysfunction (SMD), a history of sleeping disorder can be regularly recorded. Many children describe the following sleeping disorders: they need light or at least an open door. Additionally, a parent is needed. They often use soft toys, which are built around them like a wall in order to have close physical contact. In the dark they are afraid because they feel ghosts, a presence or simply a monster under the bed or in the room. Sensorimotor dysfunction (SMD) is a functional disorder of the movement system caused by reversible segmental dysfunctions, mostly in several sensory regions. The SMD is manifested not only through gross and fine motor weaknesses but also through behavioral problems. The SMD is diagnosed using the

motocytbernetic test (MCT). The symptom of behavioral sleeping disorder is highlighted, especially since it is a general problem both in healthy children and in children with behavioral problems, such as SMD, attention deficit hyperactivity disorder (ADHD) or autism spectrum disorders (ASD). As a therapeutic alternative, the possibilities of manual medicine are emphasized, especially atlas therapy according to Arlen, since the complaints will disappear completely after just a few treatment sessions.

Keywords

Manual medicine · Sensorimotor dysfunction · Sleep-wake disorder · Attention deficit hyperactivity disorder · Autism spectrum disorders

Schlafstörungen bei Kindern. Ein funktioneller neuroanatomischer Ansatz

Zusammenfassung

Bei Kindern mit sensomotorischen Dysfunktionen (SMD) lassen sich regelmäßig anamnestisch Einschlafstörungen erfassen. Viele Kinder beschreiben Einschlafprobleme folgender Art: Sie benötigen Licht oder zumindest eine teilweise geöffnete Tür und die Gesellschaft eines Elternteils. Zusätzlich verwenden sie oft Stofftiere, welche wie eine Mauer um sich aufgebaut werden, um dichten Körperkontakt zu haben. In Dunkelheit fürchten sie sich, weil sie Geister, eine Präsenz oder schlichtweg ein Monster unterm Bett oder im Raum spüren. Die SMD ist eine funktionelle Störung des Bewegungssystems, verursacht durch reversible segmentale Dysfunktionen meist in mehreren sensorischen Schlüsselregionen. Die SMD äußert sich nicht nur durch Grob- und feinmotorischen Schwächen, sondern auch durch Verhaltensauffälligkeiten. Die

SMD wird mittels des motokybernetischen Tests (MKT) diagnostiziert. Wir wollen auf das Symptom der Einschlafstörung hinweisen, im Speziellen da es sich um ein generelles Problem sowohl bei gesunden Kindern aber auch bei Kindern mit Verhaltensauffälligkeiten wie beispielsweise SMD, Aufmerksamkeitsdefizit-/Hyperaktivitätsstörung (ADHS) oder Autismus Spektrum Störungen (ASD) handelt. Als therapeutische Alternative wollen wir auf die Möglichkeiten der manuellen Medizin hinweisen, im Speziellen auf die Atlastherapie nach Arlen, da sich dadurch die Beschwerden bereits nach wenigen Behandlungen gänzlich legen.

Schlüsselwörter

Manuelle Medizin · Sensomotorische Dysfunktion · Schlaf-Wach-Störung · Aufmerksamkeitsdefizit-/Hyperaktivitätsstörung · Autismus-Spektrum-Störung

proach must include sleep hygiene and behavioral techniques (sleep education, environmental changes, behavioral interventions) and, in individual cases, pharmacological treatment. [22, 25].

The monster under the bed—feeling of presence

Sleep is critical for typical synaptic development and brain maturation. Poor sleep can have detrimental effects on children's cognition in the domains of

Fig. 2 ▲ Sensorimotor control always starts in the sensory system. The information gained at receptors is transmitted via afferent system to the central nervous system. The processing and planning of the movement process takes place in the “inner model”. After this process is completed, the motor command is sent to the periphery. An efference copy is created and immediately compared with the new sensory input. If there is a mismatch, a correction is initiated immediately, even before higher centers are used. (with kind permission, © Andreas Sammer, all rights reserved)

attention, memory, mood regulation and behavior [25]. There are many hypotheses of insomnia ranging from maturation differences, circadian-relevant gene anomalies, abnormal melatonin rhythms, arousal and sensory dysregulations. In all hypotheses there is one question missing. Why is there a monster under the bed? Strange sensations, like somebody is nearby when no one is actually present and cannot be seen (feeling of a presence, FoP) are often described as ghosts, wraiths and other apparitions. That this is a common phenomenon is shown by the existence of stories about ghosts in nearly all cultures [3]. The FoP is also often observed in patients with neurological lesions, such as epilepsy, ischemic stroke or after intracerebral hematoma. These lesions can be located for example in the frontoparietal lobe, the temporal lobe, the insula or the thalamocapsular-caudate region. Patients with such lesions describe the following: presence of a person, black shadow or presence of a man in peripersonal space, leading to anxiety. Such phenomena are also described in people suffering from Parkinson's disease [10] or in psychiatric patients. But the sensation of FoP is not only a result of brain damage or a neurodegenerative or neurological disease. It can also appear during periods of physical exhaustion. There is anecdotal evidence for a high incidence of anomalous perceptual ex-

periences during mountain climbing at high altitudes [5].

Neuroanatomical approach

The neural origin of this sensation that somebody or something is nearby is still unclear. One case report described that stimulation in the temporoparietal cortex induces the FoP, suggesting that disturbed sensorimotor processing (tactile, proprioceptive, and motor cues) is important [1]. As is well-known the brain has distinct functional regions. The cognitive abilities occur primarily in the cerebral cortex which covers the two cerebral hemispheres. Each hemisphere is divided into the frontal, parietal, occipital and temporal lobes. The frontal lobe is concerned with planning future actions, control of movement and short-term memory. The parietal lobe is responsible for somatic perception, with forming a body image and relating it to the extrapersonal space. The occipital lobe processes the visual inputs, the temporal lobe the acoustic ones. Furthermore, it is involved with learning, memory and emotion through its deep structures [20]. The exact interaction between these lobes is still under investigation. What is known is that perceptual transformation takes place in temporoparietal regions. Perception consist of extrinsic information about the state of the world as well as intrinsic information about the body. Extrinsic information

can be provided by auditory and visual inputs. Intrinsic information includes both kinematic and kinetic information about the body. This information is used to plan a motor command in so-called internal models of external space. Inaccuracy on the input side limits the accuracy to estimate the location of a target [20]. It can lead to a mismatch between the observed and the expected sensory signals. This is understood by reading the article by von Holst “Das Reafferenzprinzip” [18]. The central nervous system keeps an internal copy, the so-called efference copy of the efferent motor command. This copy is an anticipation of the upcoming sensory input. This makes it possible to compare the reafferent sensory input with the planned, or better, desired one. Differences in it can lead to rapid movement corrections without involvement of higher brain functions. This principal is called feed forward control, the brain plans the whole movement in advance, anticipating the upcoming sensory input and also plans eventual correction movements. The advantage of this system is the quick movement control because it compensates for the neural delay, which a classical feedback system would have. The main disadvantage is that it depends on an exact perception and it's unimpaired processing in the somatosensory cortex (■ Fig. 2).

What happens when there is a conflict in perceived and expected perception was shown in an experiment conducted

Fig. 3 ▲ Feeling a presence while writing this article during night, as a result of tiredness, diffuse light and exhaustion, since the author is the father of two small children. *Right* the simplified three main afferents, 1. proprioception (e.g. muscles, ligaments, joints), 2. exteroception, 3. visual control (especially the upper extremities are always under visual control). *Left* “perceptive shadow” if there is a mismatch between these afferents or the central processing

by Blanke et al. [3]. In this experiment a blindfolded participant moved a master device with his arm (actually via the inserted right index finger). These movements were reproduced as tactile stimuli in real time via a robotic arm on the participants back. During synchronous stimulation the participants had the imagination that they were touching themselves. In a next step the system started to reproduce the movements asynchronously. A delay of 500 ms was enough to induce a feeling of presence. The participants described it as a presence of a person or shadow behind them. Afterwards some participants reported that they felt fear or something threatening. Blanke et al. concluded in comparison of these findings and their lesion analysis that three brain regions could be responsible for the FoP phenomenon: the temporal and parietal cortex and the insula. These regions have been associated with bodily self-consciousness and are areas that integrate sensorimotor or multisensory bodily signals [23]. Of course, further studies were recommended to understand the underlying mechanisms in detail.

In comparison with clinical findings in manual medicine a fourth responsible part for the FoP phenomenon is suspected: the sensory system. Inaccuracy

in afferent signals may lead to a similar conflict in sensorimotor processing and an FoP phenomenon. Simplified, the brain has to process three main afferents, the proprioceptive, the exteroceptive and the visual system. These multisensory bodily signals have to be integrated to finally achieve a body self-consciousness. A segmental dysfunction can alter the afferent system. This results in inaccurate information from various body structures and tissues and can possibly create a feeling of a presence: a perceptive shadow (■ Fig. 3).

The developing nervous system in particular can reach its limits in this unexpected situation. In darkness this unexpected sensation will be misinterpreted as fearful imaginations, e.g. a monster, ghost, wraith. Moreover, and this does not just apply to young nervous systems, the unknown and unexpected causes anxiety: and this is where the chain starts, where the CNS has to process these “unexpected” afferents, which leads to additional effort. Compensation strategies are needed to get a better temporospatial orientation while falling asleep. One strategy is light to have continuous visual control of surrounding spaces and more importantly the own body. Next is an increased physical contact to get a better afferent signal. Children seek close

contact to a parent or a wall of soft toys around them.

Conclusion

Although this explanation is just a hypothesis it seems logical and more importantly, it fits to the clinical experience. Most studies about feeling the presence phenomenon focus on the brain and it's processing of sensorimotor data. Explanations are mainly neurological defects, brain lesions or a situation of physical exhaustion.

In articles no investigations about the peripheral component were found. Clinical experience shows how important it is, as manual therapy can immediately improve the situation. As a result of this we want to offer a supplementary therapy to treat children with behavioral sleeping disorders; however, we would like to emphasize that treatment in severe cases should always be interdisciplinary with pediatricians and psychologists. Anxiety in children is a severe problem, which has to be taken seriously. We want to end with an unscientific but fitting citation of a famous character of modern pop culture:

“Fear leads to anger, anger leads to hate, hate leads to suffering (Master Yoda, Star Wars Episode I – The Phantom Menace (1999)).”

Take home message

- This article has tried to give a logical explanation for the correlation between behavioral sleeping disorder and segmental dysfunctions.
- An improvement concerning sleeping problems in children with sensorimotor dysfunction is seen in daily practice but studies are missing.
- The importance of a better sleep is obvious—manual medicine can be a good alternative treatment to medication.
- The common occurrence of insomnia in SMD, ADHD and ASD suggests a correlating pathomechanism of this symptom, therefore a manual treatment is recommended.
- There are hardly any negative side effects in manual medicine in children, especially in atlas therapy accord-

ing to Arlen. The positive effects outweigh the negative ones.

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Compliance with ethical guidelines

Conflict of interest. A. Sammer and F. Sammer declare that they have no competing interests.

For this article no studies with human participants or animals were performed by any of the authors. All studies performed were in accordance with the ethical standards indicated in each case.

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