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Gentle Motion, Deep Sleep and Enhanced Rehabilitation: Investigating the Impact of Rocking Movements on Sleep – A Narative Review

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Abstract: Abstract: Sleep plays a crucial role in physical and mental well-being, being a fundamental component of the body's natural rehabilitation and recovery process. Adequate sleep not only facilitates tissue repair but also enhances cognitive function and mood. For those undergoing physical rehabilitation or recovering from injuries, prioritizing restorative sleep is indispensable, as it accelerates healing processes. Recent studies explore innovative technologies like rocking movements to enhance sleep quality. While anecdotal evidence suggests benefits, scientific literature on rocking movements remains limited. This narrative review examines the impact of rocking movements on sleep quality and memory processes. Studies suggest potential benefits, such as such as a shorter duration of N1, increased spindle density in the N2, and longer time spent in N3, indicating enhanced sleep quality. The potential relevance of these findings lies in advancing non-pharmacological treatments for individuals with insomnia or mood disorders, and they may also have implications for foraging populations dealing with reduced deep sleep and memory impairments. Further research in clinical settings is imperative to explore the impact of sleep quality on rehabilitation training, determining if the positive influences of sleep consolidation translate into substantial clinical outcomes in rehabilitative care.

Keywords: Sleep Quality, Rocking Movements, Rehabilitation, Sleep Environment

1. Introduction

Sleep is an essential component of the body's natural rehabilitation and recovery process. During sleep, the brain and body undergoes a series of complex physiological and psychological changes that are crucial for physical and mental well-being [1]. Not only does sleep play a pivotal role in repairing and restoring the body's tissues, but it also aids in consolidating memories and promoting cognitive function [2]. Furthermore, a good night's sleep can significantly impact mood, reduce stress, and enhance overall emotional well-being. For those engaged in physical rehabilitation or recovering from injuries, a equate and restorative sleep is indispensable, as it accelerates the body's healing processes

and ensures that rehabilitation efforts are more effective [3]. Thus, prioritizing sleep as an integral part of any rehabilitation plan is essential to maximize recovery and achieve an optimal health status [4].

Sleep is a complex and dynamic process, and the normal hypnogram is organized in distinct stages, each characterized by unique physiological and neurological (electroencephalographic) patterns. The sleep cycle consists of four main stages: N1 (non-REM stage 1), N2 (non-REM stage 2), N3 (non-REM stage 3), and REM (rapid eye movement) [5]. N1 marks the transition from wakefulness to sleep, lasting only a few minutes and involving light sleep. N2 follows, representing a deeper state with reduced responsiveness to the external environment [6]. N3, also known as slow-wave sleep, is the deepest non-REM stage, crucial for physical restoration and growth. REM sleep, in contrast, is marked by heightened brain activity, vivid dreams, and rapid eye movements [7]. Each stage plays a crucial role in the overall sleep cycle, contributing to cognitive functions, memory consolidation, and emotional well-being. The cycle repeats multiple times throughout the night, with REM stages becoming longer in later cycles [8] . This intricate interplay of sleep stages ensures a comprehensive and restorative sleep experience.

The recent studies aimed to develop innovative technologies and new concepts of sleep environments to improve sleep experience. One such innovation, which has gained attention in recent years, is the concept of sleeping on a rocking bed [9–12]. Relaxing babies using rocking beds or rocking movements in the arms of the parents is a well-known practice worldwide, a natural behaviour, that apparently has relaxing effects and has shown benefits upon sleep induction and deep sleep prolongation [13,14].

This unconventional approach to sleeping environment departs from the conventional, static sleep room and introduces new instruments to enforce the depth of sleep. Inspired by age-old practices of rocking infants to sleep, the rocking bed has gained interest for its potential to improve sleep quality and overall sleep-related health in the adult population [15].

In the landscape of sleep research, particularly the impact of environmental factors on sleep quality, a noteworthy gap persists in the scientific literature concerning the effects of rocking movements on sleep architecture and overall sleep quality in adults. While there is anecdotal evidence and historical practices supporting the potential benefits of rocking movements, empirical studies comparing various sleep parameters in adults with and without rocking movements are scarce. This narrative review addresses this gap by systematically examining existing research and shedding light on the potential implications of adopting a rocking sleep environment, thereby contributing to a deeper understanding of sleep mechanics and optimization techniques.

2. Results

The focal point of this article is a meticulous examination of pivotal research works pertaining to rocking movements, elucidating the critical insights that have emerged from these studies. As far as our knowledge this is the first narrative review that follows the studies concerning sleep quality and sleep architecture parameters compared between a control nights' sleep in a normal bed to a nights' sleep in a rocking bed.

Rocking Movements Effect - Pros

Sluijis et al in his article quantified the effect of rocking movements at different intensities (low, moderate and high) during naps. The following parameters were included: sleep onset, wake time and the number/duration of wake bouts. They used polysomnographic measurements for 45 minutes to record the nap. It was observed without statistically significance a higher percentage of time spent in N2 or N3 sleep stages during movement naps compared to control naps. Moreover, a shorter latency to stage N3 ($p=0.005$) was noted and a shorter latency to deep sleep in those with low intensity and moderate intensity movements compared to controls.

They also obtained an increased number of slow oscillations in movements naps (low-intensity group) than in controls, more sleep spindles (in medium-intensity group) than in controls, results explained by a higher time spent in NREM sleep, concluding that rocking promotes sleep (probably more in those with a low and medium intensity)[12].

Baek et al in his paper, studied the influence of rocking movements upon naps (three hours of sleep) using a recliner chair and showed a higher length of N3 stage, a decrease in the time spent during N1 stage in those napping with rocking movements compared to the controls. Also, they observed a shorter period of latency to enter the deep sleep, accompanied by a higher frequency of sleep spindles. The reinforced beneficial sleep's longer duration is positively associated with a higher frequency of sleep spindles (waves that have a frequency of 11-16 Hz, marking the transition from the incipient sleep phase N1 to N2). This characteristic improves neuropsychological processes such as long-term memory consolidation, sensory higher threshold, which is useful for reducing wake ups, improved motor reflexes, summing a dozen of enhancement of the well-being[11].

Perault et al. showed in their study that the length of N3 sleep stage increases in the rocking night compared to baseline. A reduced number of arousals was also noted, so that sleep disruptions are rarely encountered, and deep sleep can take place in that period [16]. After a night's sleep using the device, it has been shown that the stages of deep sleep, particularly N3 increased in the group which has previously been classified as bad sleeper compared to the increase in the group of good sleepers. The subjects which were more likely to have a sleep breathing disorder are prone to suffer from depressive disorder or even disabling neurological disorders as dementia. Using the device could be an effective measure on long term.

Bayer et al in his study including good sleepers with no sleep-disorders non-habitual showed that reclining on a gently oscillating bed at a frequency of 0.25 Hz aids in the shift from wakefulness to sleep and extends the duration of N2 sleep stages with an increased spindle density per an epoch of 30 seconds, with a shorter duration of stage N1, and of the latency to enter N2 [17].

Rocking Movements Effect - Cons

Slujis et al in his article regarding the assessment of rocking movements in the old generation (>60 years of age) showed no benefic effects of rocking movements upon sleep onset, duration of deep sleep phases and no increase in the sleep spindles number [10].

Omlin et al analysed the effect of the rocking bed upon respiration and he observed an increase in respiratory rate in the rocking group (lateral translation of the whole body) versus control. Lateral translational rocking motions induced a vestibulo-respiratory adjustment, resulting in an elevated respiratory rate. This increase was not contingent on the specific frequencies or amplitudes of the applied movements, yet it was not observed when the movements matched the subjects' resting respiration frequency[14].

3.Discussion

While numerous studies have suggested positive effects of rocking movements on sleep quality, it is imperative to acknowledge the existing body of research that presents contrasting perspectives, indicating a complex landscape in understanding the influence of these mechanical interventions on sleep patterns.

One of the primary factors contributing to the contradictory results could be individual differences, especially in age groups. Slujis et al. specifically focused on the older generation (>60 years of age), and it's possible that the effects of rocking movements on sleep may vary with age. Aging is associated with changes in sleep architecture and neurophysiological

processes, which could influence how individuals respond to interventions like rocking motions [10], while the subjects included in the study of Perrault are younger (mean±SD,23.39±1.61years old) [16]

Discrepancies in study design and methodology could also contribute to the varying outcomes. For instance, the type and duration of rocking movements, the equipment used (bed vs. recliner chair), and the specific sleep parameters measured can all impact results. Baek et al used a recliner chair in order to promote sleep [11] while Slujis et al used a bed [10]

Contextual factors, such as the sleep environment, participant characteristics, and even cultural aspects, could contribute to different outcomes. Cultural perceptions of rocking or individual preferences for certain sleep environments might influence the efficacy of rocking motions

The Role of Rocking Movements: Theories Behind Accelerating Wake-Sleep Transition and Enhancing Sleep Consolidation

While our review has provided a comprehensive exploration of the influence of rocking motions on sleep quality, it is crucial to consider how these findings can be translated into meaningful clinical applications. The potential clinical implications are manifold, with specific attention to non-pharmacological interventions for sleep-related challenges.

Vestibular and sensory receptors have a neuronal linking with structures from the cortex involved in emotions, for example the amygdala. This structure affects the sleeping processes, including sleep onset, depth, and the emotional effects related to sleep [18,19]. Most of the participants in the study of Bayer et al found a 'relaxing' feeling associated with the new sleeping environment and summarize the night as a pleasant experience [17]. Inputs of the vestibular or somatosensory systems given by the rocking movements may influence sleep control centres in hypothalamus or brainstem. Both the inputs send projections to thalamic nuclei, further leading impulses to the corticothalamic networks [20–22].

Ximena Omlin et al in their study showed that memory performance can increase over a night of sleep using a device with lateral rocking movements in subjects with a baseline poor night's sleep but vestibular stimulation caused by these movements showed no effect on the performances of good sleepers, which already have a quality sleep on the baseline [23] .

Bayer et al. demonstrated that using a rocking bed not only shortens the onset of sleep but also increases the occurrence of two key sleep patterns observed through EEG: slow oscillations and sleep spindles. These two electrophysiological phenomena not only characterize NREM sleep but recent research has linked them to one of the most fascinating behavioural outcomes of sleep—memory consolidation [17]. Almost a hundred years ago, it was first shown that sleeping after learning enhances memory performance compared to being awake for the same duration. Recent neuroimaging studies have attributed a direct role to slow oscillations and spindles in facilitating this effect [24,25]. The results of Bayer et al are confirmed by Perrault et al which revealed that rocking augmented spindle activity, and the rise in fast spindles showed a correlation with a decrease in arousals during N3, indicating a potential role of spindles in maintaining sleep stability and quality[16]. Therefore, rocking may not only aid in initiating and sustaining sleep but, by reinforcing slow oscillations and spindles, could also positively influence memory consolidation [26]. As we navigate the potential therapeutic applications of rocking beds, a broader consideration is the integration of sleep as a fundamental component of clinical assessments and rehabilitation programs. Acknowledging the role of sleep quality in overall health outcomes may pave the way for more holistic and successful rehabilitation practices.Regarding the clinical part, conditions like stroke-related brain damage have been linked to various sleep-wake disorders, potentially impacting both short- and long-term recovery. Consequently, incorporating routine sleep assessments into rehabilitative care is likely to bear considerable significance for stroke recovery and the mitigation of long-term

disability. Within the realm of physical rehabilitation training, experimental findings indicate that motor learning and retention can be influenced by specific training structures, including variable and massed practice[27]. In this context, sleep might play a role in the interim stabilization of newly acquired knowledge, safeguarding against retroactive interference. Moreover, it may actively contribute to consolidation by incorporating concepts of selectivity or cued reactivation during both training and sleep.

Understanding the impact of sleep quality on rehabilitation training is pivotal for designing effective programs. Incorporating rocking beds into rehabilitation facilities could be explored as a means to optimize the sleep environment for individuals undergoing rehabilitation. Further research in clinical environments is needed to assess the direct impact on rehabilitation outcomes.

4. Materials and Methods

This narrative review aimed to comprehensively assess the existing literature regarding the impact of rocking movements on sleep quality. The process of selecting studies was conducted systematically to ensure a robust and comprehensive overview of the available evidence. The following detailed criteria were employed for study inclusion:

4.1. Inclusion Criteria:

- **Population Criteria:**
  - Studies involving adults aged 18 years and above.
  - No restrictions based on gender.
- **Intervention Criteria:**
  - Studies examining the impact of rocking movements on sleep quality.
  - Inclusion of interventions involving rocking beds, recliner chairs, or other devices inducing rocking motions during sleep.
- **Outcome Measures:**
  - Studies reporting quantitative data on sleep architecture, including but not limited to sleep stages (N1, N2, N3, and REM).
  - Studies reporting qualitative data on perceived sleep quality through participant surveys or subjective assessments.
- **Study Design:**
  - Both experimental and observational studies were considered.
  - No restrictions on the type of study design, including randomized controlled trials, cross-sectional studies, and longitudinal studies.

4.2. Exclusion Criteria:

- **Population Criteria:**
  - Studies involving children or adolescents (below 18 years) or involving subjects with neurological disorders
- **Intervention Criteria:**
  - Studies assessing interventions not related to rocking movements during sleep.

Outcome Measures:

- Studies lacking clear and relevant sleep quality outcome measures.
- **Study Design:**
  - Case reports, case series, and studies with insufficient data on sleep quality outcomes were excluded.

4.3. Search Strategy:

The electronic search for relevant articles was conducted in the Medline database (PubMed, PubMed Central). The search terms included combinations of "sleep," "rocking movements," and "rehabilitation." The search strategy aimed to identify articles exploring the influence of

rocking movements on sleep quality. The search was not restricted by publication date to ensure a comprehensive overview of the existing literature.

4.4. Data Extraction:

Data extraction was performed independently by two reviewers using a predefined data extraction form. Discrepancies were resolved through discussion and consensus. The extracted data included study characteristics, participant demographics, intervention details, outcome measures, and key findings related to sleep quality.

5.Limitations

Acknowledging the limitations of this review is paramount for a holistic understanding of its scope. Firstly, the heterogeneity across the reviewed studies in terms of methodologies, participant demographics, and rocking protocols introduces variability that should be recognized. This diversity, while enriching the review's breadth, also poses challenges in drawing uniform conclusions.

Additionally, the lack of standardized metrics for evaluating the efficacy of rocking beds on sleep outcomes hinders a more precise comparison across studies. Future research efforts could benefit from establishing common parameters to facilitate more robust meta-analyses.

6. Conclusions

Optimizing sleep is integral to lifestyle medicine, contributing to enhanced physical and mental well-being. In this narrative review, we explored the impact of a simple mechanical intervention, rocking motions, on sleep quality. Our observations indicate that rocking movements enhance sleep quality by increasing time in the N3 stage (deep sleep) and maximizing spindle frequency.

These findings hold promise for advancing non-pharmacological treatments for individuals with insomnia or mood disorders. Moreover, they may offer insights for populations, particularly foraging communities, facing challenges related to reduced deep sleep and memory impairments. Further research in clinical settings is imperative to assess the impact of sleep quality on rehabilitation training.

Future investigations should extend into the long-term effects of rocking movements across diverse demographics. Exploring psychological dimensions related to the vestibular impact, coupled with neuroimaging techniques like fMRI or EEG, can deepen our understanding of the neural mechanisms during rocking-induced sleep. Additionally, exploring the therapeutic potential of rocking movements in managing sleep disorders through well-designed clinical trials with standardized protocols is a promising avenue for advancement in this field.

While the translation of improved sleep consolidation into significant clinical outcomes in rehabilitative care awaits further exploration, integrating sleep as a fundamental component of clinical assessments and rehabilitation programs is likely to have profound implications for overall rehabilitation success.

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