Proceedings of the 3rd International Conference on Biological Engineering and Medical Science
DOI: 10.54254/2753-8818/20/20230767

Muscle twitching during REM sleep contributes to the development of the body

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Abstract. Animals must cultivate, refine, and sustain precise sensorimotor maps as their body progresses and alters during early growth and throughout their life. Many studies have proposed the possibility that spontaneous muscle twitching occurs only during REM (or active) sleep to help animals draw sensorimotor maps and improve spinal self-organization by activating skeletal muscle, which will be elaborated and discussed in this paper. First of all, this article explains the characteristics of muscle twitching, which make their function possible. Secondly, this paper expounds the effects of muscle twitching on the cerebellum and spine respectively, which provides strong evidence for the hypothesis that muscle twitching helps to improve the sensorimotor map. To conclude, REM sleep's spontaneous muscle twitching is indispensable for neurodevelopment. Further research could aid in comprehending neurodevelopmental disorders and even offer chances for early detection and treatment.

Keywords: REM slumber, myoclonic twitching, cerebellum, spinal self-organization, activity-dependent growth.

1. Introduction

Muscle twitching in puppies is a common occurrence during sleep, as is seen in infants' rapid eye movement (REM) sleep. Studies of today have shown that muscle twitching is not a result of REM sleep paralysis, which is traditionally assumed to be a random movement event caused by a short-term mistake. Instead, it is involved in the process of sensorimotor mapping and memory-muscle cortex shaping. Sensorimotor mapping's advancement and upkeep is essential for the body's initial growth and evolution throughout its life cycle. It helps humans to move from 'basic' movements of babies and fetuses to coordinated, flexible, and adaptive movements of adults, which further demonstrates that muscle twitching during REM sleep is linked to neonatal brain development.

The purpose and significance of muscle twitching for human learning and sensorimotor development will be covered in this article. To a certain extent, understanding the mechanism of muscle twitching can aid in our understanding of the etiology of neurodevelopmental diseases and may even open up possibilities for early detection and treatment.

2. Overview of muscle twitching

Uncovering research has revealed that, in contrast to the widely accepted idea of the body in a "sleep paralysis" state during REM sleep, the entire skeletal muscles of the body frequently twitch. This is only

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true when the body is in active sleep, where all skeletal muscles are relaxed [1]. Skeletal muscle is triggered when limb movement and muscle twitching occur during REM sleep, and tactile and proprioceptive receptors send information to the brain.

Narayanan et al. the 1971 study [2]uncovered that the most common limb muscle twitches in rats are seen in the late gestation stage, especially in the initial fortnight after birth. Rats' muscles still twitch as they age, but less often, which is compatible with their fast development and the advent of adult-like motor abilities. Muscular twitching is seen in all skeletal muscles that have been studied up to this point, including those responsible for limbs, fingers, and eyes. Additionally, it was discovered in the study that muscle twitching only happens during REM sleep, when all skeletal muscles loosen up [1].

3. Characteristics of muscle twitching

Discreteness is one of the characteristics of muscular twitching during REM sleep. They seldom happen at the same moment, although they might happen swiftly and continuously. Wake-up exercises, on the other hand, often include continuous and synchronous muscular stimulation. Discrete events appear to be particularly well suited for these processes [3, 4]if the purpose of twitching is to convey information about the body for the development, improvement, and maintenance of sensorimotor maps. It is far simpler to concentrate on a single occurrence when there is silence than when it is overtaken by a great deal of unrelated activity.

Twitching's abruptness and small amplitude are its second defining features. When it does, it frequently happens rapidly and abruptly, and since the amplitude is so little, it seems to the unaided eye that they are imperceptible random movements. Three-dimensional motion tracking in conjunction with high-speed photography has shown to be an effective method for exposing the intricate kinematics of twitches and how they alter during early development [3].At first sight, a seizure of the forelimb at 250 frames per second appears to be a mere twitching, yet it is merely one part of a more intricate, perpetual twitching activation of multiple joints, both within and between limbs. Indeed, mice exhibited this coordinated twitching pattern as early as two days of age [5].

Twitching also has the ability to be influenced by developmental experiences, suggesting possible modifications to the spinal and brainstem mechanisms that regulate them more generally. Twitching is thought to help fine-tune the entire sensorimotor system, influencing the expression of movement upon awakening.

The aforementioned qualities of muscle twitching demonstrate that it is an independent system that gives animals valuable experience understanding their bodies as they mature. Additionally, as animal sensory movements mature, the order and structure of this experience might shift from day to day. The brain must comprehend and process the data that muscle twitching provides for organisms to reap the rewards of it [5].

4. Functions of muscle twitching

Generally speaking, REM sleep paralysis transitory mistakes are thought to be the source of muscle twitches during REM sleep. Twitches are not a byproduct of REM sleep, according to recent study, which claims that they are a self-generated event that assist motor learning and development [6].

Research has shown that muscular twitching, though of a low intensity, can be a potent stimulant of the brain, comparable to the neural activity that is activated in the brainstem, thalamus, hippocampus, and primary somatosensory and motor cortex [3].The structure of muscle twitching can be modified by developmental experience, implying possible alterations in the spinal and brainstem processes that govern them.It is believed that convulsions aid in the fine-tuning of the entire sensorimotor system, thus impacting the emergence and articulation of movement during the waking period.

5. The function of muscle twitching for cerebellar development

The cerebellum, a major contributor to sensorimotor integration, has been the focus of researchers in an effort to gain a more profound understanding of muscle twitching's part in sensorimotor growth. This is in line with the fact that muscle twitching is essential for the sensory and motor growth of the body, as previously noted. Postnatal cerebellar tissue and synaptic connections are thought to be activity-dependent, with newborns developing brain networks via activity-dependent processes. As a result, if muscle twitching stimulates cells in the cerebellar circuit, it can deliver precise sensorimotor information, increasing postnatal growth and improving this sensorimotor.

The cerebellar cortex is the source of Purkinje cells, which are known to discharge in two distinct patterns: intricate and uncomplicated. These patterns are caused by either ascending fibers or mossy fibers. Despite the fact that peripheral stimulation in young rats can produce both complex and simple spikes [6], the majority of Purkinje cells in the developing cerebellum are believed to be spontaneous and random in their activity. Researchers discovered that 60% of Purkinje cells in the cerebellum of one-week-old rats were contingent upon their state of being; of these, 65% were more active in sleep than when awake.

The study revealed a direct link between the start of muscle twitches and the start of both intricate and straightforward spikes, with muscle twitches taking precedence. Observations of the correlation between muscle twitching and cerebellar activity are anticipated to augment our knowledge of the cerebellum's part in the formation of motor synergy [7], as well as its role in cerebellar growth and its intricate ties to other structures, like the neocortex.

6. Muscle twitching for spinal self-organization function

Spontaneous muscle twitching during sleep not only aids in the development of cerebellar function but also directs the process of spinal self-organization. The spinal retraction reflex system, according to Petersson et al.'s hypothesis, has a modular structure and works on the muscle by withholding the reflex module after correction. The skin's sensory input is reflected in the module for hindlimb reflexes, which is a representation of the muscle's capacity to withdraw when the limb is in a standing position and the foot is in contact with the ground. This imprint is imprinted on the reflex pathways as a result of substantial postnatal changes; erroneous connections are either removed or reduced, and the strength of appropriate connections becomes proportional to withdrawal efficiency. In the rat, this process takes about a week and happens throughout the first three postnatal weeks, depending on the body component [8]. Any neonatal-induced alteration or motor pattern of peripheral nerve innervation can be accommodated by this sensorimotor transition.

The following observations serve as the foundation for the spinal cord self-organization theory. At the outset, tactile input is essential for growth adaptation, not nociceptive input. Additionally, during early development, spontaneous twitching during sleep is characterized by brief contractions of atonic muscles, which often leads to a shift in tactile input due to variations in skin-to-skin contact. Third, the presence of spontaneous muscle twitching activity is innate; neither introduction nor spinal transection will modify it or eradicate it. In the initial weeks following birth, the rat brain and its connection to the spinal cord were not fully developed. As a result, it is unlikely that the spinal system will play a direct directing role in spinal motor learning. As a result, spontaneous muscle twitching during sleep may store information about the body's three-dimensional shape and mechanical properties in the sensorimotor system's synaptic connections via unknown adaptation mechanisms, allowing complex sensory information to be quickly converted into appropriate movement correction in the spinal reflex system. Petersson et al. by utilizing simulations of computers, it was demonstrated that a correlation-based learning process, unsupervised, could exploit spontaneous muscle twitching, thus essentially elucidating the role of spontaneous motion in the functional adaptation of the spinal sensorimotor system and the functional adaptation of the withdrawal reflex system [8].

7. Conclusion

The goal of this research is to explain the function and significance of muscle twitching in human learning and sensorimotor development, as well as to better understand the genesis of neurodevelopmental diseases via the study of muscle twitching mechanisms. It is possible to infer that autonomic muscle twitching during REM sleep appears to be an excellent way for the brain to direct the growth of the body. In terms of movement, muscle twitching can activate cells in the cerebellar circuit, which can offer precise sensorimotor information, boosting postnatal growth and sensorimotor improvement. Throughout development, they are formed in a non-random, ordered way and selectively increase or erase complicated convulsion patterns.

The arrangement and configuration of muscle twitching are ordered yet malleable. Furthermore, unlike continuous movements that occur when awake, muscle twitches are distinct in the situation of inadequate muscular tension, ensuring their quality. Muscular twitching is the prime stimulus for the entire neural network of the central nervous system during its early stages. Because there is no discharge mechanism during muscle twitches, sensory information from the periphery can be passed on with exceptionally high fidelity.

The tactile feedback generated by spontaneous muscle twitching during sleep changes the sensorimotor transformation of young rats in a predictable way, elucidating the role of spontaneous movement in the functional adaptation of the spinal sensorimotor system and providing a key explanation for understanding how these basic circuits integrate information about the individual's body structure to perform the extremely complex calculations required for accurate motility. This common technique may be shared by several sensorimotor systems.

Only a few of the mechanisms and functions of muscle twitching during REM sleep are described in this paper, but there are many more possibilities to investigate in this field, such as how the effects of muscle twitching on different tissue structures coordinate to regulate our growth and development. The resulting findings give strong evidence that active sleep and its accompanying convulsions are chosen during early development because they provide an excellent framework for animals to comprehend their bodies. It may be stated that destroying the mechanism of muscle twitching in the early developing stage would result in sensorimotor function impairments in newborns, which may lead to subsequent cognitive and emotional issues. As a result, we might speculate that a complete understanding of early developmental sleep and muscle twitching may aid in the early diagnosis and treatment of mental disease.

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