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Vestibular modulation of postural stability: An update.

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Abstract

Postural stability is defined as the dynamic postural response to applied perturbations. Postural stability is an important topic of discussion especially for older people. Because as there is increase in the age the integration between different body systems will decrease and this may contribute for balance difficulties. Balance difficulties were one of the major factors that decrease the quality of life in elderly people. Physical activity was reported to increase the strength of the muscles and limit the fall and faints due to postural disturbances. The vestibular stimulation regulates postural control through influencing integration in all levels that is cortical, midbrain, medulla and spinal cord levels. The present article provides an understanding of vestibular modulation of postural stability through influencing the integration of neural signals at different levels. This understanding helps to plan the management techniques accordingly and it is the need of time to conduct more studies in this area to recommend vestibular stimulation as an adjunctive therapy for management of postural instabilities.

Keywords: Postural stability, Vestibular stimulation, Physical activity.

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Introduction

Postural stability is defined as the dynamic postural response to applied perturbations [1]. Postural stability is an important topic of discussion especially for older people. Because as there is increase in the age the integration between different body systems will decrease and this may contribute for balance difficulties. Balance difficulties were one of the major factors that decrease the quality of life in elderly people [2-4]. Physical activity was reported to increase the strength of the muscles and limit the fall and faints due to postural disturbances [5]. Vestibular system is the part of inner ear. It plays a major role in the maintenance of posture and equilibrium through statokinetic reflexes [6]. It has two vestibular organs called otolithic organs and semicircular canals. Linear acceleration and deceleration was detected by otolithic organs whereas angular acceleration and deceleration was detected by semicircular canals. Earlier studies reported that stimulating the vestibular system has positive impact in the elderly population suffering with postural difficulties [7,8]. In fact most of the exercise designed for improving the postural stability stimulates vestibular system. Postural instability was commonly observed in patients with vestibular damage [9]. Galvanic vestibular stimulation was reported to be beneficial to modulate postural instability in individuals with altered vestibular input [9]. Rocking is a simple way to stimulate vestibular system especially for elderly population [10]. The vestibular stimulation regulates postural control through influencing integration in all levels that is cortical, midbrain, medulla and spinal cord levels. The present article reviews the possible mechanisms of vestibular modulation of postural stability.

Methods

Review of the articles published from http://www.google.com,http://www.pubmed.com, Medline, http://www.frontiersin.org and other online journals was performed and analyzed.

Role of Vestibular Stimulation in Cortical Integration

There a number of studies where vestibular influences on the postural control was explained with experimental evidences in both healthy and disease conditions. The vestibular information will be integrated with the information from other sensory systems in the central nervous system [11,12]. Alteration in the integration of vestibular signals leads to the postural difficulties such as loss of coordination, vertigo etc. [13]. However, there are compensatory mechanisms in the central nervous system which balances any changes in the vestibular inputs. This is very important especially for sportsmen and pilots [14]. Vestibulo-ocular reflex plays a major role in this adaptation process [15-23]. Chronic stimulation of vestibular stimulation leads to the mechanism called vestibular habituation. Hence, the individuals can develop the ability to suppress the vestibular illusions. This was evident as trained pilots and trained sportsmen have better postural control than control group individuals [24].

Role of Vestibular Stimulation in Midbrain Integration

The structures of the midbrain include tectum which is made up of superior and inferior colliculus, tegmentum which consists of red nucleus, periaquiductal gray matter and substansianigra. Midbrain also comprises of crus cerebri and portion of reticular formation. The nuclear complex present in the midbrain are occulo motor nerve and trochlear nerve [25]. The superior collicus consists of seven layers of fibrous and cellular lamine. The superficial layers respond to visual stimuli whereas the deeper layers respond to sensory stimuli. Hence, the superior colliculs plays an important role in sensori motor transformations [26-29]. Spike potentials are recorded in the superior colliculus followed by stimulation of vestibular nerve [26]. Red nucleus is having projections to the cerebellum and spinal cord and plays a major role in the regulation of the motor control of the limbs along with the primary motor cortex [30]. It was reported that the superior vestibular nucleus can modify the activity of the cerebellorubral and corticorubral pathways, exerting inhibitory action on the neurons of the red nucleus [31].Periaqueductal gray matter plays an important role in the regulation of the movements of neck, back and hindlimbs [32]. Vestibular projections are identified in the midbrain structures like inferior colliculus, red nucleus and periaqueductal gray matter and interstitial nucleus of Cajal. These structures are reported to receive maximum number of projections from the vestibular system [33]. Vestibular stimulation results in activation of brain with higher amplitude which was reported to be essential for postural control [34].

Role of Vestibular Stimulation in Medullary Integration

The medullary pyramids consist of the corticobulbar and cortico spinal tracts. The cortico spinal tract plays an important role in the maintenance of posture. The cortico spinal pathway is longest axonal pathway and mediates the impulses from the cerebellum, basal ganglia and thalamus [35,36]. Vestibular system modulates the activity of cortico spinal tract through its connections with cerebellum, basal ganglia and thalamus. Earlier studies testified the presence of vestibulocerebellar and cerebellovestibular pathways [37]. It was reported that vestibular stimulation causes activation of the neurons in the cerebellum [38]. Stochastic vestibular stimulation was reported to correct the postural difficulties in the patients with Parkinson's disease (PD) [39]. Further, vestibular dysfunction was reported to cause postural difficulties in the patients with PD and stimulation of vestibular afferents was reported to be an effective therapy for management of postural difficulties [40]. It was reported that, impaired integration of pedunculopontine nucleus cholinergic neurons and their thalamic efferent fibers play a role in postural control [41]. Vestibular connections to thalamus were well known and stimulation of vestibular system evokes thalamic potentials [41].

Role of Vestibular Stimulation in Spinal Cord Integration

Vestibulo spinal pathways supplies to intercostal and back muscles, as well as the extensors of the limbs and maintain the posture. There are two reflexes that are medial and lateral vestibule spinal pathways. The lateral and medial vestibule spinal pathways originate from lateral and medial vestibular nucleus respectively [42]. The peculiarity of vestibular outputs is its wider distribution than any other sensory system. The lateral vestibule spinal pathway influences the primary motor neurons of the spinal cord whereas the medical pathway travels through medial fasciculus and reticulo-spinal pathways [43].

Conclusion

The present article provides an understanding of vestibular modulation of postural stability through influencing the integration of neural signals at different levels. This understanding helps to plan the management techniques accordingly and it is the need of time to conduct more studies in this area to recommend vestibular stimulation as an adjunctive therapy for management of postural instabilities.

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