Review Article

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A Critical Review on the Normal Postural Control

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Abstract

Postural control evolves from an interaction of the individual with the environment and the task. It emerges from a complex interaction of neural and musculoskeletal system, together referred as the system of postural control. Research into balance and postural control has shifted and broadened over the past few decades. To date, only few reviews were performed with reference to balance. However, with regard to postural control, no such review has been done. Here, we present a critical review on normal postural control. Relevant literature search was performed through the electronic databases of PubMed, Cochrane, CINAHL, Google Scholar, Web of Science, EMBASE, OvidSP and ScienceDirect until December 2010. Literatures available about postural control are limited and about basic its concepts in line with the current knowledge of literature is inconclusive.

Keywords: Balance; Critical Review; Control; Postural Sway; Stability.

Introduction

Postural control involves controlling the body's position in space for dual purposes of stability and orientation. The stability underlying standing quietly (quiet stance) is called static balance. Quiet stance is characterized by small amounts of postural sway. In a perfectly aligned posture, the vertical line of gravity falls in the midline between the mastoid process, a point in front of the shoulder joints, the hip joints, a point in front of the ankle joints [1]. The ideal alignment in stance allows the body to be maintained in equilibrium. Here, the normal postural control is critically reviewed.

Reflex and postural control

Nashner reported the role of reflexes in controlling posture. He studied on 12 subjects task specific differences of reflex function were investigated by experiments in which the role of stretch reflex to stabilize sway during stance could altered. He reported 5 out of 12 subjects in his study used long-latency (120msec) stretch reflexes to help reduce postural sway. Following an unexpected change in the usefulness of stretch reflexes, the 5 subjects progressively altered reflex again during the succeeding 3-5 trails. Comparing subjects using the reflex with those not doing so, stretch reflex control resulted in less swaying. The 5 subjects using reflex controls oftentimes swayed more [2]. Several previous studies by similar task have postulated that the stabilizing responses are primarily of vestibular rather than of proprioceptive origin [3].

Postural tone

A certain level of muscle tone is present in a normal, conscious, and relaxed person to maintain body in balance. In relaxed state no electrical activity is recorded in normal human skeletal muscle using electromyography (EMG). This has led researchers to argue that non-neural contributions to muscle tone

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are the result of small amounts of free calcium in the muscle fiber, which cause a low level of continuous recycling of cross-bridges [4]. When we stand upright, activity increases in antigravity postural muscles to counteract the force of gravity. This is referred to as postural tone [5].

Quiet Stance

Researchers have found that some of the muscles tonically active during quiet stance are the soleus and gastrocnemius, because the line of gravity falls slightly in front of the knee and ankle, the tibialis anterior, when the body sways in the backward direction, the gluteus medius and tensor fasciae latae but not the gluteus maximus, the iliopsoas, which prevents hyperextension of the hips, but not the hamstrings and quadriceps and the thoracic erector spinae in the trunk, because the line of gravity falls in front of the spinal column [6]. From the laboratory experiment, the researchers have shown that no one stands absolutely still. The body sways in small amounts, mostly in the forward and backward direction [7]. Recent years, they have begun to focus on mechanisms underlying stability in other directions as well [8].

Early days of postural control research

Early postural control research by Nashner and colleagues explored muscle patterns that underlie movement strategies for balance [7, 9, 10]. Results from postural control research in neurologically intact young adults suggest that the nervous system combines independent, though related, muscles into units called muscle synergy [5]. A synergy is defined as the functional coupling of group of muscles such that they are constrained to act together as a unit. Traditionally, ankle strategy and its related muscle synergy were among the first patterns for controlling upright sway. Nashner reported motion of the platform in the backward direction causes the subject to sway forward [7]. Muscle activity begins at about 90 to 100msec after perturbation onset in the gastrocnemius, followed by activation of hamstrings 20 to 30msec and finally by the activation of the paraspinal muscles [11].

Horak and Nashner suggested that the hip strategy is used to restore equilibrium in response to larger, faster perturbations or when the support surface is complaint or smaller [9]. In contrast to AP postural control, ML control of balance occurs primarily at the hip and trunk, rather than at the ankle [12-15]. AP muscle response patterns are organized in a distal to proximal manner while ML muscle patterns are organized in a proximal to distal direction, with hip muscles being activated before ankle muscles [16]. They noted that primary ML motion of the body is lateral movement at the pelvis, which requires adduction of one leg and abduction of the other leg. If width between feet is greater than 8 cm, then motion at the ankle diminishes. Hip abductor and adductor muscle groups are activated in control of the loading and unloading of two legs with ML sway [15-17].

Brain and its connections

The brainstem has important centers for controlling the facilitation through raphe-spinal and coerulospinal tracts and inhibition of muscle tone through the mesopontine tegmentum and the reticulospinal tract important for control of posture. The muscle-tone facilitatiory and inhibitory systems are present within the brain stem [18]. From this we can say that CNS must activate synergistic muscles at mechanically related joints for balance control. CNS organizes sensory information from visual, somato-sensory and vestibular systems for postural control. Muscle response latencies to visual cues signaling perturbations to balance are quite slow (200msc) when compared to somatosensory responses (80 to 100msec) [19].

The upright equilibrium of the freely standing human is maintained by using three independent sensory sources from (Figure 1) somatosensory, vestibular inputs, and vision [20]. In their study normal young children ranging in age from 1½ to 10 years were assessed to find the strategy of control to altered support surface and visual conditions. The experimental protocol used a movable platform and visual surround, and the analytic techniques, using EMGs and measures of reaction forces and body motions. They reported young children below the age of 7½ years were unable to suppress systematically the influence of inputs derived from the support surface or from vision when these provided inappropriate orientation information due to the motion of these surfaces. From this they emphasizes that the automatic postural adjustments and the context-dependent reweighting of support surface, vestibular, and visual inputs are organizationally separate

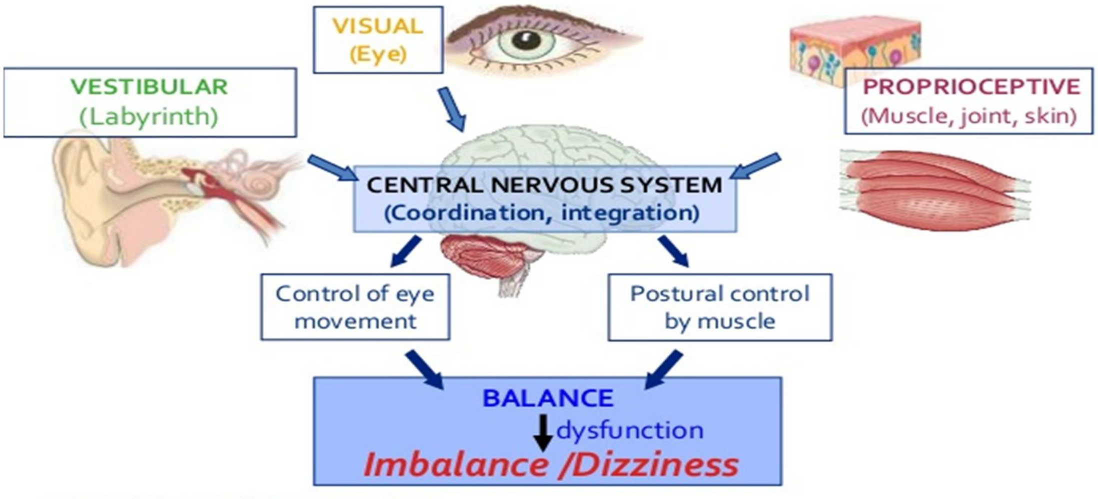

Fig. 1: Somatosensory, vestibular, and visual sensory system interaction

processes and that the hierarchically lower level automatic process matures before the higher level adaptive processes.

Intermodal theory of sensory organization

According to intermodal theory of sensory organization by Stoffregen and Riccio there is no conflict rather all the senses provide information that increases specificity in postural control [21]. There is no relative weighting of sensory information rather orientation emerges from an interaction of all three senses. Intermodal information provides CNS with essential information for postural control. Body sway across the six sensory conditions within a large group of neurologically intact adults reports that the adults sway least in the conditions in which support surface orientation inputs are accurately reporting the body's position in space relative to the surface regardless of the availability and accuracy of visual inputs [22].

Postural sway

A study was done to investigate how postural sway was affected by provocation of vision, by the position of the vestibular organ, and by provocation of proprioception postural sway. Mediolateral (ML) sway does not seem to be influenced by the position of the vestibular organ. Postural sway was measured by using a force plate. Tests were performed with eyes open and eyes closed, with head in neutral position and rotated to the right and to the left and with head maximally extended, both standing on firm surface and on foam. Measures of ML speed (mm/s); anterior-posterior (AP), speed (mm/s), and velocity moment (VM) (mm^2/s) were analyzed using a multilevel approach. The multilevel analysis revealed how postural sway was significantly affected by closed eyes and standing on foam, and by the position of the vestibular organ. Closed eyes and standing on foam both significantly prolonged the dependent measurement, irrespective of whether it was ML, AP or VM. However, only AP and VM were significantly affected by vestibular position [23].

Recent Research

Recent researchers have suggested that there are significant attentional requirements for postural control. These requirements vary depending on the postural task, on the age of the individual, and on the individual's balance abilities [24]. Attention is defined as the information-processing capacity of an individual. Neumann suggested that if two tasks are performed together and require more than the total processing capacity, the performance on either or both will deteriorate [25]. According to systems theory of motor control, a number of different neural and musculoskeletal systems contribute to the emergence of normal balance function in children [26]. These include neural subsystems such as sensory, motor and higher integrative functions and musculoskeletal contributions such as muscle strength, joint range of motion, skeletal alignment and upright posture [27].

Conclusion

Postural control depends upon the superfluous inputs from somatosensory, visual and vestibular systems. Future studies should focus more on assessment of different aspects of postural control and examine its effects on functional balance.

Conflicts of interest: None declared.

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