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Oculomotor Exercises, their Importance, and Effect on Postural Stability

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Abstract

Aim: Identifying the importance of oculomotor exercises and their impact on postural stability.

Methodology: To conduct this review which belongs to a narrative approach we included studies, which vary from the year 1978 to 2023. The initial search resulted in a large number of articles, which were screened based on their titles and abstracts. Full texts of selected articles were reviewed based on data to ensure relevance to our aim. The most special focus was given to articles that evidenced the role of visual training in postural stability. All studies were searched in trusted sources such as PubMed, Science Direct, MEDLINE, Web of Science, Google Scholar, Cochrane Library, PEDro, Wiley Library, and Oxford Academic. Inclusion criteria were all articles focusing on the role of oculomotor exercises in postural stability. Exclusion criteria were all articles that focused only on improving oculomotor exercises in reading.

Results: Various oculomotor exercises, including saccades, smooth pursuit eye movement exercises, and eye fixations combined or not with balance exercises, contribute to the improvement of postural control, thus indicating a positive approach to rehabilitation, reducing the risk of falls or improving sports performances.

Conclusion: Visual training through oculomotor exercises helps increase postural stability and, therefore, prevent injuries. These exercises enable a strong connection and optimal integration between the visual, vestibular, and

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proprioceptive systems.

Keywords: Oculomotor exercises, visual training, postural stability, visual system, balance

INTRODUCTION

The sense of sight is considered the most important sense that guides every individual in performing the activities of daily life, as well as in sports activity (1). The purpose of the vision is to obtain information about the surrounding environment so that we can plan appropriate actions (2). To have good coordination in daily activity, a good interaction between the eyes and the brain is needed, and further a transfer of this information to two other systems that enable optimal motor skills, such as the vestibular system and the proprioceptive system. A very important component for individuals in carrying out daily activities is balance, both in the individual and professional sports aspect. It is important to have the ability to maintain a straight posture, which depends on the vestibular, somatosensory, and visual system, as well as the ability of the motor elements (3). These systems interact to maintain cognitive spatial function and the interaction between the visual and vestibular system affects the ability of postural stability, depending on a variety of relationships of the head and surrounding objects (4). An individual cannot maintain body balance if any of the above components is missing, which makes people fear falling and predisposing them to fractures (5). To improve the function of the vestibular and proprioceptive system, various exercises are used in addressing balance (6) and the proprioceptive system itself (7), but for the visual system, exercise strategies are not used both in clinical practices and in sports training strategies, thus leaving it more in the shade compared to the two systems mentioned above. The good functioning of the visual system can be achieved through little-known and almost never-used oculomotor exercises, which are exercises performed through different eye movements and are considered physical therapy of the eyes and brain (8). Therefore, this literature review will focus on highlighting the importance of the good functioning of the visual system in postural stability through the training of the latter with oculomotor exercises.

1. Types of eye movements and their function

Eye movements are essential in gathering accurate information from the external environment enabling individual optimal control in activities of daily life. There are four basic types of eye movements: saccades, smooth pursuit movements, vergence movements, and vestibular ocular movements. According to Purves and colleagues, saccades are rapid eye movements that suddenly change the fixation point (9). They range in amplitude from the small movements made while reading to the much larger movements made while looking around an environment. These movements can be made voluntarily, but they occur reflexively whenever the eyes are open, even when they are fixed on a particular target. When people deliberately use their eyes to follow a smoothly moving object or target, this is known as smooth eye movement. To keep the target image on the fovea at all times, the smooth pursuit system attempts to match the

subject's eye movements to the target's speed (10). Another type of movement is the vergence eye movement, which makes it possible to move the point of view from near to far while simultaneously maintaining the image of the target in both foveas. Vergence movements are contralateral, which means that the eyes move in the opposite direction from each other, in contrast to other eye movement systems (11). There are also vestibular ocular movements, which are part of the oculomotor subsystem and are enabled by the vestibular ocular reflex, working to stop the movement of images on the retina when the head or body is turned (12).

2. Methodology

The present review provides an overview of studies focused on the importance of the visual system in postural stability using visual training/oculomotor exercises.

2.1. Literature search

This narrative review includes 39 studies varying from 1978 to 2023. The search was conducted in databases such as PubMed, Scopus, Science Direct, MEDLINE, Web of Science, Google Scholar, Cochrane Library, PEDro, Wiley Library, and Oxford Academic. Keywords used in the search are oculomotor exercises, visual training, visual system, postural stability, balance, and performance. Inclusion criteria were all articles focusing on the role of oculomotor exercises in balance. To conduct this literature review we mainly focused on including randomized controlled trials, case-control studies, and qualitative studies. We included all the studies that responded to our initial purpose without being limited to the age (from 14-80 years old), gender, background, or occupation of the subjects within the respective studies. Extending our exclusion focus only on articles that focused on improving oculomotor exercises in reading and/ or in improving vision problems, as well as mentally impaired subjects.

2.2. Research methodology results

The articles selected and cited in this review are in English, mainly from the last 10 years. Exceptions are some older articles, and the reason for their inclusion is the relevant scientific description of the visual system and its role in postural stability. The initial search resulted in a large number of articles, which were screened based on their titles and abstracts. Full texts of selected articles were reviewed based on data to ensure relevance to our aim. The most special focus was given to articles that evidenced the role of visual training in the vestibular system and postural stability.

3. The importance of the visual system in balance

Zhu and colleagues observed that static balance was related to visual contribution, and the best performances were evident when performed with eyes open (13). Postural balance is reduced with age in healthy individuals, as poor support and vision can negatively affect these age groups (14).

Despite age, sight is essential for balance management as it tells us where we are in space, how to reach a goal, and what limitations exist (3). The visual system is the predominant sensory system used by adults to maintain optimal postural balance (15, 16). The latter is also related to the dominance of each eye. Just as we have a dominant hand or foot, the eyes also tend to dominate each other. One study revealed that the right eye is more dominant than the left eye for most individuals (17). Regarding eye dominance, a study was conducted by Park and colleagues (18), in which the authors attempted to compare and analyze the ability of balance control between elderly and young subjects using Balance Master. Balance Master (Inc., USA, 2000) was able to determine body sway objectively, determine the location of the central pressure point, and assess the postural control ability of the elderly by measuring the dominant or non-dominant eye, respectively. According to the study results, there were no apparent differences in postural control in young individuals regarding dominant and non-dominant viewing. However, the older participants' postural control in the non-dominant gaze was significantly compromised.

4. What is the impact of oculomotor exercises on postural stability?

To perform most daily tasks, it is necessary to have good functioning of postural control, which in turn has two main functions. First, there is an antigravity mechanical function that builds posture or postural balance (19). The postural balance also depends on this antigravity function, which requires that, under static conditions, the projection of the gravity center lies within the support surface. Second, postural control acts as a frame of reference for actions and perceptions regarding the external world. The head, trunk, and arms are examples of body segments that serve as frames of reference for defining target locations in the external world and planning actions toward those targets. It is important to note that "postural control is no longer considered simply a summation of static reflexes but, rather, a complex skill based on the interaction of dynamic sensorimotor processes. The two main functional goals of postural behavior are postural orientation and postural equilibrium" (20). Making such a parenthesis on balance as a component of postural control, we can further see studies that address the role of oculomotor exercises/various eye movements in balance, knowing also the fact that postural control also depends on visual inputs. The role of oculomotor exercises has been seen with a higher priority in recent years, so this literature review mainly focuses on studies oriented in this direction.

The use of visual skills, which are a reliable measure of functional ability even in sports activities, is being observed, especially in dynamic sports. By performing oculomotor exercises for four weeks, it is observed an increase in dynamic visual acuity from 29/73 ± 4/19 to 56/20 ± 8/81 ($p < 0.001$) and in the general

stability index from 28/66 ± 7/ 23 to 51/60 ± 6/38 ($p = 0.001$) (21).

If two types of oculomotor exercises are combined (smooth pursuit eye movements, horizontal and vertical, as well as saccade movements) for four weeks, according to Fischetti and colleagues (22), significant differences were observed in all stability parameters during quiet standing in the experimental group ($p < .05$), suggesting that the postural control system and eye movements are interconnected.

Other studies support the role of oculomotor exercises in balance (18), where it was observed that performing eye exercises for 10 consecutive weeks in 30 sessions resulted in static balance and improved dynamics. These data are identified by considering the center of pressure measurements and the "*Time Up and Go*" test. Moreover, using these exercises significantly reduces the probability of falls in elderly individuals. Likewise, if a combination of eye exercises and balance exercises is performed for 6 weeks, it improves not only dynamic balance but also reduces vertigo and fatigue symptoms (23). On the other hand, if eye fixation exercises combined with balance exercises are performed, slightly greater improvements appear in the balance component compared to performing eye saccade exercises in combination with balance exercises (24). So, it may be a good idea to address the combination of different eye movements to achieve balance effectively.

The importance of neurophysiological systems has been mentioned above. But what is the form through which they contribute to postural stability? The vestibular system affects postural stability and visual stabilization through the vestibular spinal reflex, which produces muscle contraction against gravity to help maintain postural stability, and the vestibular ocular reflex, which makes eye movements to maintain clear visual acuity during head movements (25), so this reflex helps by shifting the eyes in opposition to the head to maintain the line of sight in space (26). Another reflex that interacts with the vestibular nucleus and can produce eye movements is the cervico-ocular reflex (27), which is activated by stimulation of the upper neck mechanoreceptors and has a special role as when the trunk rotates, it keeps the eyes fixed in the orbits, stabilizing the images on the retina. Therefore, as a result of oculomotor exercises and eye fixation exercises with a duration of three weeks, changes were observed in postural stability during standing with active head rotation, as well as in dynamic visual acuity ($p<0.05$) (28).

Different eye movements positively affect dynamic stability, specifically eye fixations and saccades. Still, the smooth pursuit of eye movements harms maintaining dynamic stability, as in the study of Schulmann, Godfrey, & Fisher (29), visual tracking of a moving limb during balance impairs the individual's stability. This could be related to the fact that when the smooth

pursuit system is compromised, the saccadic system kicks in because the system cannot keep up with the target motion's speed, making target saccades more frequent and noticeable (30). So, this system may impact stability because to determine body position and make the proper postural changes, the central nervous system uses motion-induced optic flow patterns on the retina (31).

Likewise, the importance of saccade eye movements in balance is emphasized in a recent study, where it was observed that the reduction in the speed of saccade movements to fast stimuli in the external environment could be a factor that reduces balance, especially in elderly individuals (32). The previous study by Stoffregen and colleagues (33) examined the relationship between eye movements and postural control and showed similar results. Participants in two trials were instructed to move their eyes to track the horizontal oscillations of the visual stimuli. Postural sway variability was lower when the target was swaying than when the object was stationary. Head rotation did not increase during target movement, and the amplitude of the target displacement was within the range that does not normally cause head rotation. Eye movements while the eyes remained closed did not reduce body instability. The target movement was matched in both amplitude and frequency against the eye movements. The findings show that there is no competition between postural control and eye movements for central processing resources, and it brings to the front how postural control and visual performance are functionally integrated. To see how the dynamics of the ocular and postural systems are interrelated, the findings lead us to hypothesize that any dynamic coupling of these systems should improve visual performance.

However, given the fact that with increasing age, the visual system's function deteriorates, and eye movements, as well (34), should be considered. While fall accidents might have an impact on an individual's quality of life, managing post-fall disability in the elderly can be extremely costly for society. Elderly people with visual impairments are more likely to fall because their vision, a crucial aspect of balance, is compromised (35). In an earlier study by Bae Y (36), performing saccade exercises in one group and quiet eye-tracking movements in another group for 5 minutes resulted in a significant reduction in the length and speed of the center of pressure in the group that made the saccade compared to the other group. However, plantar sensitivity, which is an indicator that contributes to postural balance, was significantly improved. The effectiveness of eye exercises differs due to age and the way of standing, which means when the base is narrow or when the base of the stance is wide. In young subjects, the amplitude of oscillations in the anteroposterior direction during saccade eye movements is greater on a narrow base than on a wide base. In the elderly, the amplitude of postural oscillations is reduced during saccade movements compared to eye fixation movements, but unlike young subjects,

there are no changes compared to the basics of posture (37). On the other hand, other studies emphasize that eye movements, specifically saccade exercises, do not worsen postural control, and attention can contribute to maintaining or improving postural stability during saccades (38). Some studies have observed that there is no significant relationship between saccade eye movements and posture (39). Despite the positive results of visual system training, Althomali M.M and colleagues (40) observed the ineffectiveness of the latter, where there was not found a discernible improvement in mobility or balance following visual attention training that was similar to oculomotor exercises but focused on pursuing an objective among multiple distracting elements. Unlike these results, Son C.H and colleagues (41) observed that a self-administered eye exercise program five times per week of fifteen min, for four consecutive weeks in stroke subjects who are weak in stability can improve balance and gait ability. Positive results of eye training exercises were also observed in the study of Park J.H (18) in balance improvement, especially in the elderly who have experienced a fall.

An important approach to understanding eye exercises' relationship with postural control can be found in the study of Uchida and colleagues (42), where it was observed that smoking caused an unusual imbalance, which was high in frequency and large in amplitude. Periodic saccadic eye movements were observed to greatly reduce this typical oscillation, suggesting that brainstem regions associated with the control of standing and saccadic eye movements are affected by nicotine absorbed into the bloodstream while smoking. The positive role that saccade exercises have in the control of postural balance can be evidenced in other studies (43). An exception can be counter-saccade exercises (voluntary saccade movement made in the opposite direction of the visual target), which significantly reduce postural stability (44). The duration of the oculomotor exercise protocol varied in different studies, showing positive results in balance after three weeks (28, 45) or six weeks (23, 36). However, it is important to conduct further experimental studies to demonstrate the effect of these exercises on postural stability as a crucial element in preventing falls in patients, athletes, or other individuals.

CONCLUSION

The visual system is an important system to support every individual in daily and sports activities. Moreover, its role increases the stability of the posture, increasing the importance of its training through oculomotor exercises to also prevent falls. This is achieved by having a single compactness between the visual, vestibular, and proprioceptive systems. Therefore, further studies should address the importance of eye exercises left in the shade compared to exercises that train the vestibular and proprioceptive systems.

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