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Vision rehabilitation for visual-vestibular dysfunction: The role of the neuro-optometrist

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Abstract.
INTRODUCTION: This article discusses, in a clinically relevant format, the importance of including a neuro-optometrist as a member of the management team for patients with balance disorders.
PURPOSE: To review the importance of vision and visual processing for maintaining a sense of balance and equilibrium and the role of the neuro-optometrist in the overall rehabilitation of patients with balance disorders
SUMMARY: Dizziness, balance problems and the sensation that the space world is moving (vertigo) are one of the most commonly reported problems in general medical practice. Persons with a central nervous system injury or other idiopathic causes of visual processing problems or who have functional vision problems that are not adequately managed, often experience extreme difficulty with balance and movement, as well as with their perception of space. Consequently, the patient often experiences difficulty functioning in an environment with excessive visual stimulation such as a grocery store or shopping mall. Symptoms of disequilibrium, vestibular and balance problems are commonly a result of VOR disturbance secondary to an inner ear problem and an unstable binocularity.
CONCLUSION: The combination of neuro-optomertic rehabilitative therapy and balance therapy will result in a is an effective treatment for reducing or resolving these symptoms.

Keywords: Neuro-optometric rehabilitation therapy, vestibular ocular reflex, VOR, disequilibrium, visual-vestibular disorder, dorsal stream and ventral stream

1. Introduction

Dizziness and symptoms of disequilibrium, vertigo, and the effect they have on one's sense of balance, are among the most common complaints by patients seeking medical attention. This is especially true for patients who have acquired brain injury and concussion. Recent advances in the understanding of how the brain processes central and peripheral visual information and its relationship to central and peripheral vestibular function has added to the overall understanding and treatment of this patient population and the importance of the integration of visual and vestibular therapies to restore balance function. This article will discuss, in a clinically relevant format, the importance of including an optometrist who specializes in vision rehabilitation (neuro-optometrist), as a member of the management team for patients with balance and vestibular disorders.

2. Overview of the neurophysiology of balance

To fully appreciate how these complex systems integrate to create an efficient balance system and understand how different disease processes can disrupt

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this system, a basic understanding of the anatomy and physiology of the balance system is important. Although a more in-depth discussion of the vestibular system is presented in other chapters in this journal, I would like to summarize the areas which are important for understanding the role of vision to balance.

The human balance system has three afferent systems: vestibular, visual, and somatosensory, while the efferent system consists of multiple neurological pathways that to some degree overlap and are redundant. In order to maintain balance during changing situations, all of these pathways must ultimately play a role in coordinating motor responses of the limbs, trunk, and eyes to the incoming sensory stimuli.

2.1. *Overview of the vestibular system*

2.1.1. *Peripheral component*

The vestibular apparatus makes up the peripheral component of the vestibular system (the inner ear) that forwards information to the central vestibular system located within the CNS. The vestibular apparatus is located bilaterally within the petrous portion of the temporal bone, comprised of the bony labyrinth and otoliths and is part of the vestibulocochlear complex The labyrinth has two main subdivisions, which are sensitive to different types of head movements:

a) The semi-circular canals are ring shaped structures that are geometrically configured to be sensitive to rotational acceleration in all directions of space. There are three semi-circular canals in each ear: one horizontal semi-circular canal, one anterior semicircular canal, and one posterior semi-circular canal. The bilateral representation of each direction of movement allows for the identification of the yaw, pitch, and roll of a head movement as well as specific direction (i.e., head turn right versus head turn left). It is interesting to note that the exact position of the semi-circular canals within the skull geometrically mirrors the functional actions of the extra-ocular muscles as a result of their insertion on the eyeballs. In effect, the CNS recalibrates the neural input from the vestibular system of the inner ears to the motor output of the extra ocular muscles.

b) The second subdivision of the vestibular apparatus is the otoliths. The otoliths include the utricle and saccule which are plate-like structures comprised of calcium carbonate crystals, called otoconia, which impart mass to the otolith. Consequently, unlike the semi-circular canals, otoliths are sensitive to gravitational and linear acceleration forces in the vertical, lateral and fore-aft directions. The vestibular receptor hair cells are located within the maculae of the utricle and saccule and within the crista ampullaris of the semi-circular canals. Hair cells have bundles of cilia, which project outwards and neural activity is enhanced or suppressed by the bending of these cilia as a consequence of an accelerating motion.

2.1.2. *Central component*

Vestibular Pathways make up the central component of the vestibular system. Vestibular afferent information from receptor hair cells is transmitted via the Vestibulocochlear or VIII Cranial Nerve and arrives at the brainstem and vestibular nuclei. Central axons bifurcate into an ascending branch which extends to the superior vestibular nucleus and the cerebellum and a descending branch which reaches the medial, inferior and lateral vestibular nuclei. Most axons concerned with eye movement terminate in the rostral part of the medial nucleus and the superior nucleus (Baloh and Michael, 1996). It is in the central component of the vestibular system that integration with the visual system begins. Within the vestibular nuclei some second order afferents are sensitive purely to head movement, however, most are affected by eye movement as well. Also, Scudder and Fuchs described eye velocity-head velocity neurons as being part of the pathways which allow vision to override or enhance vestibular information (Scudder and Fuchs, 1992).

Each semicircular canal has major neural connections to one ipsilateral and one contralateral extra ocular muscle. This three-neuron pathway is the basis of the Vestibulo-Ocular Reflex (VOR) and several major tracts carry neural input between the corresponding agonist muscles of the two eyes. For example, the Medial Longitudinal Fasciculus (MLF) and the Ascending Tract of Dieter's (ATD) complete the three neuron pathway that sub serves horizontal conjugate eye movement by connecting the corresponding ipsilateral vestibular nuclei with the contra lateral abducens nucleus and lateral rectus to the ipsilateral oculomotor nucleus and medial rectus. The VOR adds to and is affected by the maintenance of stable foveal fixation during head movement. Since the three pairs of semicircular canals represent all rotational movements in three-dimensional space, vision will be maintained for all directions of head movement. Lastly, in addition to the excitatory pathway described above, second order inhibitory neurons will innervate the corresponding antagonist eye muscles. Vestibular signals that are produced as a consequence of reflex head movements (i.e. VOR) are suppressed when appropriate, allowing for the generation of appropriate saccade or pursuit eye movements. It can be appreciated that otherwise, the mismatching of visual information with other elements of the sensory motor feedback system could cause one to perceive an image as jumping and moving with the shifting of our eyes.

2.1.3. Cerebral component

At the cerebral level, animal studies (Pandya, 1973; Walzl and Mountcastle, 1949; Mickle and Ades, 1952) have identified several regions within the parietal and temporal lobes, which receive afferent vestibular information. In humans, unlike other sensory modalities such as vision and somatosensation, there is no primary vestibular cortex. Vestibular afferent information appears to be transmitted to association cortex regions, which also receive afferent input from primary and secondary visual, and to lesser degree, somatosensory centers.

The parietoinsular cortex is now considered to be a major site of vestibular projections, with half of the neurons in this region responding to vestibular information. However, in keeping with the concept of a multisensory cortex, neurons in this region also respond to visual optokinetic and somatosensory stimulation (Guldin and Grusser, 1996). Thus, the parietoinsular cortical region appears to be involved in the processing and integration of visual, vestibular, and somatosensory information.

Vestbulospinal pathways also arise from the vestibular nuclei in the brainstem. The vestibulospinal reflexes are directly responsible for postural control under static and dynamic conditions. The vestibulocerebllar pathways provides a bi-directional conduit between the flocculonodulus of the cerebellum and the lateral vestibular nuclei serving as a modulating function of motor output and as integrators of motor activity.

This integration of multisensory information utilizes an inhibitory-reciprocal process in which activation of vestibular pathways results in inhibition of visual information and vice-versa. The functional significance of this inhibitory-reciprocal sensory interaction is immediately clear in traumatic brain injury or medical issues which effects the ability of the brain to facilitate the filtering of multi-sensory inputs. It is logical that the traumatized brain, which has lost this capacity, will be unable to reconcile visual, vestibular, and somatosensory conflict resulting in balance instability, symptoms of disequilibrium, and dizziness. As discussed previously, the vestibular nucleus receives visual, somatosensory and auditory input, and in association with the VOR, is important for maintaining a stable visual spatial world when head and body movements are involved. Therefore the visual system is another major component of the afferent-efferent model relating to balance.

2.2. Overview of the visual system

Similar to the vestibular system, the visual system has peripheral, central and cerebral components.

2.2.1. Peripheral component

a) The peripheral component is comprised of the eye itself, along with the extra ocular muscles, the accommodative system, the optical media, and the retinal complex. It essentially gathers photoptic information and converts this information to electrical energy. The purity of the inputted visual information including: clarity, equality, and the blending of the input from the two eyes begins here. This provides the initialization of the central process of visual information processing and integrated visual vestibular function.

2.2.2. Central component

The central aspect of this process is organized through two main and separate systems: Parvocellular (P) and Magnocellular (M) respectively.

a) The P system transmits central foveal vision and is important for clear and precise vision. These nerve fibers start at the retina and travel via the optic nerve, the optic chiasm, optic tract and ultimately synapse at the lateral geniculate and then proceed to the optic radiations, to the primary visual cortex in the occipital lobes, then projecting to the temporal brain region as the Ventral Stream.
b) The M system is primarily involved with the processing of aspects of spatial orientation and information about where one is in space. Some of these fibers from the peripheral retina are directed primarily to the midbrain and synapse at the lateral geniculate body and then the superior colliculus, which is important for integrating posture, movement, and orientation to positional space. Other fibers continue to the occipital cortex,

2.2.3. Cerebral component

Fibers from the occipital cortex project to the inferior temporal area as the Ventral Stream and the superior

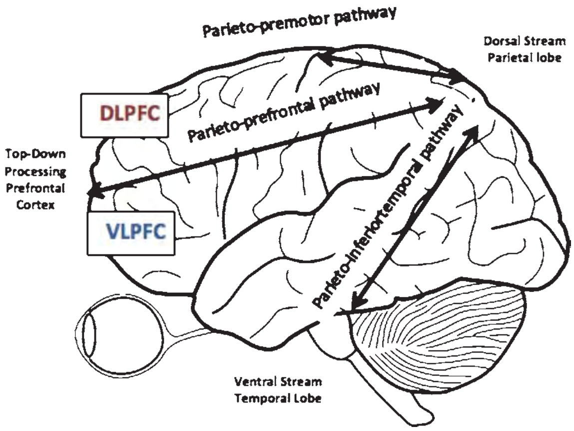

Fig. 1. Representation of the Extended Dorsal Stream.

temporal and parietal brain areas as the Dorsal Stream. In 2011, Kravitz and colleagues (Kravitz, 2011), suggested that after reaching the posterior parietal cortex, the dorsal stream trifurcates into distinct pathways: the parieto-prefrontal pathway, the parieto-premotor pathway, and the parieto-medial temporal pathway (Fig. 1).

a) The parieto-prefrontal pathway is involved in two main functions: the initiation and control of eye movements, which is important in reading eye movements, and spatial working memory, which is important in determining where to look next. This pathway also provides input to the prefrontal cortex necessary for top-down executive control of visuospatial processing.
b) The parieto-premotor pathway has two parallel projections: one to the dorsal and one to the ventral premotor cortex, receiving vestibular input from the cerebellum. The parieto-premotor pathway is responsible for visually guided reaching and grasping and also provides coordinated maps of body position [18] and integration of body movement with vision which is important for navigation: Deficits in this pathway would result in difficulties with activities such as accurate reaching and grasping as well as walking down staircases.
c) The parietal-medial temporal pathway, with connections to the limbic areas, is specialized for processing distant space and is sensitive to the speed of optic flow that is used in updating one's position during navigation. Damage to the parietal lobe can lead to impairments of many visual tasks, such as navigating through a crowded supermarket, reaching for and grasping objects, and learning from past visual experiences.[18] Thus, the Dorsal Stream is important in providing information about where one is in space and where one is looking, while the Ventral Stream provides information about the details of the object of regard. Finally, appropriate coordinated head and body postural reflexes are generated as information flows across the vestibulocerebellar and vestibulospinal tracts.

2.3. *Overview of the somatosensory system*

2.3.1. *Peripheral component*

The somatosensory system is the third and final component of the afferent-efferent model of balance. Detection of position sense begins with mechanoreceptors located within the skin, joints and muscles. Primary afferent somatosensory information is then transmitted within the peripheral nervous system along large myelinated fibers whose neuronal bodies reside within the dorsal root ganglia of the spinal cord.

2.3.2. *Central component*

Proximal transmission continues via the posterior or dorsal columns of the spinal cord with second order neurons then crossing contra laterally via the medial lemniscus to the thalamus. Processing and integration of somatosensory information takes place at this level.

2.3.3. *Cerebral component*

Processed information is then further transmitted to the primary somatosensory cortex within the parietal lobe as well as the cerebellum. It is at this level that there is integration between association areas within the parietal, frontal and temporal lobes and integrated motor responses from the cerebellum.

3. Neuro-optometric contribution to the management of patients with vestibular and balance disorders

There are three major systems contributing to the perception of a stable space world and the sense of balance. At the most basic level is the reception of sensory information. The process of integration occurs at several levels of the neurosensory pathways and it is most likely that at the level of the thalamus and cerebellum the first integration and processing of parallel information from the visual, vestibular, and somatosensory systems occurs. Finally, the primary visual cortex and the primary somatosensory cortex process information, which is then integrated with information from Secondary and Association cortical regions. Sensory conflict or mismatch, which may take place at any stage along the sensory pathway, is perceived only when all information has been processed and integrated within these cortical regions. The inability to reconcile any conflict may and often does result in the vertigo, dizziness and imbalance.

The maintenance of a stable space world, which influences balance, is significantly influenced by how visual information is processed and integrated with the vestibular and somatosensory systems. The most dominant connection between the visual and vestibular systems is the vestibular ocular reflex, also referred to as gaze stabilization. This reflex is the fastest reflex of the body, with the principal purpose to maintain a steady image on the retina during head movement and therefore the VOR is important for maintaining a stable visual spatial world when head and body movements are involved. For example, the VOR is dependent on a stable, bifoveal retinal image. Thus, uncompensated binocular deviations such as fixation disparity, heterophorias, convergence insufficiency and accommodative convergence dysfunctions are commonly associated with symptoms of vestibular dysfunction. In a broad sense, any mismatch of visual information could potentially exacerbate a vestibular problem. Many patients have moderate vertical and horizontal heterophorias that may have been well compensated for most of their lives. However, an illness or other stress factors can result in a breakdown of fusional control, and a decompensation of binocularity adding to the mismatching of afferent information affecting the VOR and ultimately balance.

Oculomotor deficits and binocular dysfunction may have a negative effect on the of the vestibular ocular reflex resulting or exacerbating symptoms of disequilibrium and discomfort in multiply-visually stimulating environments with or without motion.

Patients with vestibular and balance problems would benefit from a comprehensive neuro-optometric evaluation which encompasses the management and treatment of ocular disease to optical strategies and neuro-optometric rehabilitative therapy. While it is beyond the scope of this article to completely detail the diagnostic and management procedures that neuro-optometrists perform, the sections that follow will outline and discuss many diagnostic and treatment procedures that I have utilized over 30 years of working with this patient population.

Table 1
Optical problems associated with vestibular and disequilibrium symptoms

• Anisometropia: may cause a VOR gain triggering vestibular symptoms
• Uncorrected astigmatism: is often associated with symptoms of disequilibrium
• Uncorrected hyperopia even low amounts: often increases the symptoms associated with balance disorders
• Progressive Add lenses (PAL): Often the peripheral distortions created by the optical design of these lenses may trigger symptoms of disequilibrium
• Glare, flickering light and reflections: often exacerbate symptoms of disequilibirum

Table 2
Functional visual problems associated with vestibular and disequilibrium symptoms

• Ocular motor and fixation anomalies. One of the most common fixation problems is intrusion nystagmus and unsteady fixation patterns. The quality of foveal fixation affects the VOR often causing excessive VOR gain
• Sluggish Accommodative facility
• Poorly compensated vertical phoria
• Poorly compensated esophoria at distance
• Intermittent convergence or divergence deviations
• Unstable binocular vision
• Convergence insufficiency
• Fixation disparity

Table 3
Visual processing problems associated with vestibular and disequilibrium symptoms

• Visual sequencing difficulty
• Figure ground difficulty
• Visual closure difficulty
• Visual spatial relations difficulty
• Visual agnosia
• Visual perceptual processing deficits associated with Dorsal and Ventral stream information processing

4. The neuro-optometric evaluation

4.1. History

One of the commonly accepted concepts is that symptoms of disequilibrium and balance difficulties are a result of the inability of the brain processing system to adjust to a mismatch of information between the auditory, visual and proprioceptive processing system. Over the years I have observed and documented many problems and characteristics that seem to be common with patients who experience balance difficulties. (Tables 1–4) summarize these observations.

Table 4
Symptoms associated with visual-vestibular problems

Vision symptoms	Postural changes	Disequilibrium	Reading problems	Visual concentration	Balance
Blurred vision, Distance viewing	Face or head turn	Disorientation in an environment with multi-sensory stimuli	Discomfort while reading	Easily distracted	Loss of balance
Blurred vision, Near viewing	Head tilt	Bothered by movement in one's spatial world	Unable to sustain near work	Decreased attention span	Feeling of not being grounded
Slow to shift focus, near to far to near	Covering, closing one eye	Bothered by noises in the environment	General fatigue while reading	Reduced concentration ability	Dizziness
Difficulty taking notes	Postural skews	And sense of being overwhelmed by too much sensory information	Loss of place while reading	Difficulty recalling what has been read	Veering off to one side when walking
Pulling or tugging sensation around eyes			Double vision or moving words when reading		A feeling that the ground is tilted or soft
			Eyes get tired while reading	Easily distracted	Poor posture

The awareness of these characteristics will add to how your examination is modified. It is my experience that a large percentage of patients who I have treated have binocular vision problems, refractive anomalies, and other ocular and visual disturbances which affect the integrity of the visual input. Often the patient is not aware of these problems or they have learned to compensate for them until an additional problem occurs. The combination of vestibular deficits and an unstable visual system often results in symptoms of disequilibrium. A careful review of social, medical and eye histories including the following areas is important:

1. Medications: especially stress reduction medications. Many of these medications affect the facility of the accommodation system (Han, 2008)
2. History of virus infection or severe bacterial infection. Certain antibiotics have a toxic effect on the vestibular system depending on the dosage
3. History of recent emotional and stressful situations. Often increased levels of stress is associated with vestibular and disequilibrium symptoms
4. History of acquired brain injury, and more importantly, even mild episodes of decelerated injuries such as concussions as a result of sports and motor vehicle accidents
5. Eye history. Inquire about any history of binocular vision problems or focusing problems. Discuss in detail any reported visual symptoms
6. History of other health care treatment especially therapy for balance problems

4.2. Visual acuity assessment

Distance visual acuity is customarily measured, however, it is also important to measure near visual acuity at the individual's usual reading distance. Accurate visual acuity measurement requires observing for subtle ocular motor deficits (such as micro-nystagmus, (saccadic intrusions, drift) and signs of distortions and scotomas since these may impact the VOR as well as perception of space.

4.3. Refractive analysis

The refractive analysis is critical because adequate vision, including clarity and equality, is the initial sensory input into the integrated process of perception of space and the VOR. Often lenses are not routinely prescribed for low degrees of hyperopia and astigmatism unless distance visual acuity is compromised or if visual symptoms are experienced, However, for patients who are experiencing symptoms of balance and disequilibrium, it is important to prescribe lenses in order to optimize clear and equal vision for each eye. In terms of near vision performance, lag of accommodation and relative accommodation are important functions to measure in order to provide for efficient accommodative and convergence functioning when reading or working with a computer monitor.

4.4. Assess the level of sensory motor processing

1. When evaluating ocular motor control, (pursuit, saccades, and fixation), the examiner should inquire whether there is dizziness, vertigo, or disequilibrium experienced by the patient while following the target. Special attention should be made to evaluating saccadic speed, accuracy, and the presence of saccadic intrusions and nystagmus in addition to any restrictions of the range of ocular motility.
2. Ocular alignment is assessed using the cover test, observing the quality of fixation and the speed of sensory motor recovery. Any ocular misalignment should be evaluated in all positions of gaze at distance, as well as near, and noted as comitant or non-comitant. After assessing the quality of sensory motor fusion while fixating straight ahead at a target, it is useful to evaluate fusion stability while the patient shakes his or her head for 5 rotations. Symptoms of dizziness or disequilibrium as well as and observed nystagmus and or diplopia should be recorded.
3. Accommodative convergence facility is measured with relative fusional vergence testing.
4. Facility of sensory motor fusion including near point of convergence and fusion recovery, fixation disparity and stereopsis are evaluated using specialized auxiliary testing procedures.

4.5. Assessment of visual perceptual processing

Visual perceptual processing should be assessed with respect to visual figure ground analysis, visual sequential memory processing, speed of visual closure processing, speed and span of visual perception, and the ability to process both simultaneous and sequential visual information.

4.6. *Ocular health evaluation*

The standard protocol for a comprehensive primary care eye examination is performed including confrontation visual field testing, color vision testing, pupil testing, tonometry, and evaluation of the anterior and posterior segments with a dilated fundus examination. Special attention should be made to pupil function, corneal integrity due to the high occurrence of dry eye in this population, and gross functional visual field awareness using confrontation visual fields as a good screening procedure.

5. Summary of the evaluation sequence

Patients who experience dizziness, disequilibrium and other symptoms of vestibular dysfunction often have visual and optical problems, visual sensory motor dysfunction, visual perceptual and speed of information processing deficits. Small refractive errors, fixation anomalies, unstable binocularity and other conditions which may affect the visual input as well as the VOR, could significantly exacerbate symptoms of disequilibrium. The neuro-optometrist will customize the examination as described above in order to assess the quality of the visual input and its integration with the vestibular processing system.

6. Neuro-optometric treatment goals for balance and vestibular problems

The management of this patient population ranges from managing eye health problems to optical applications, and neuro-optometric rehabilitation therapy.

6.1. *Optical treatment modalities*

Providing the best quality and most stable visual input is achieved by prescribing an appropriate optical correction. It is important to reduce the effect of anisometropia (unequal refractive error between the two eyes) which causes magnification differences and could affect the VOR resulting in vestibular symptoms. Substituting separate distance vision and separate near vision corrections rather than a progressive multi-focal lens, avoids the peripheral distortions inherent in that lens design, which would otherwise trigger symptoms of disequilibrium. Prescribing tints and anti-reflective coatings may be beneficial to reduce symptoms of photosensitivity and glare. Often the addition of a light blue tint may enhance magnocellular processing and allow the patient to feel more "grounded" in their space world. Judicious prescribing of fusional prism lenses for large magnitude ocular misalignments and vertical deviations. Yoked prism systems may provide beneficial results for gaze restrictions, visual field defects, and certain visual perceptual processing deficits.

7. Overview of treatment goals of neuro-optometric rehabilitative therapy for balance and vestibular problems

7.1. *Enhance the stability of the visual input system*

Developing and enhancing accurate saccades involves Top Down motor planning. To improve motor planning, therapy procedures involving stimulus-generated saccades associated with high level visual processing tasks such as figure ground and visual closure skills are beneficial. Once this level is achieved, integrating the central saccadic fixation performance (parvocellular), with balance, motor control, and peripheral awareness (magnocellular), can occur. In addition to stabilizing fixation and saccades, accommodation must be maximized.

7.2. *Develop a stable binocular vision system*

The ultimate outcome of a stabilized binocular vision system are accommodative and vergence flexibility, rapid recovery of fusion, central fusional vergence stability, and stable fusional vergence associated with head and body movement.

7.3. *Facilitate and enhance a coordinated output system*

Developing balanced peripheral and central fusional vergence facility associated with high level visual–motor planning is desirable, especially in conjunction with enhanced speed of fusion recovery with rapid changes of relative divergence and convergence. Finally, the goal of stabilizing fusional vergence under dynamic intermodal conditions is achieved by providing therapy procedures which entail the processing of multi-stimuli such as auditory, visual, and proprioceptive inputs including balance while matching this input with coordinated visuomotor respnses. Specialized equipment which utilize "neurological alerts" is important during this phase of therapy in order to affect sensory motor recalibration.

7.4. Enhance the speed and facility of visual perceptual processing

The goal is to enhance or optimize the speed and span of perception, the accuracy and level of figure-ground analysis, the level and speed of visual closure, and the speed and accuracy of visual sequencing.

7.5. Visual field deficits

Visual field loss and visual distortion are special problems often associated with and/or exacerbating vestibular problems. Conditions such as hemianopia and scotomas can be addressed with yoked prism systems, visual rehabilitation, and low vision rehabilitation therapy and other optical devices (Cohen, 2003).

8. Summary

The brain is a mediator between information from the visual system, vestibular system and proprioceptive system. In a sense, the joints, eyes and ears make up the "keyboard" to the "computer", the brain. As with a computer, the efficiency and accuracy of the brain's performance is only as good as the information it receives. The visual problems discussed earlier in this article can add to neurological conflict thereby exacerbating symptoms associated with vestibular and balance problems. The very nature of vestibular treatment modalities often is dependent on stable visual information. Thus, in many cases, eliminating the visual problem is often the key to significant progress in vestibular rehabilitation, while other times treating the vestibular dysfunction enhances gains in visual therapy.

9. Conclusion

Dizziness, balance problems and the sensation that the space world is moving (vertigo) are one of the most commonly reported problems in general medical practice. Vestibular function is important for the maintenance of balance and a stable visual environment. Often, after a neurological event such as acquired brain injury, including whiplash, concussion, multiple sclerosis, cerebral vascular accident, or even the normal aging process, the peripheral and central visual systems are compromised including the accommodative convergence facility and ocular motor control resulting in a VOR disturbance. Consequently, the patient often experiences difficulty functioning in an environment with excessive visual stimulation such as a grocery store or shopping mall or movement in a crowded environment becomes quite disturbing and causes vertiginous symptoms. Often balance therapy cannot be completed until binocularity is stabilized. The combination of neuro-optometric rehabilitative therapy and balance therapy will result in a is an effective treatment for reducing or resolving these symptoms.

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