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Postural Control and Balance Issues in Individuals with Visual Disorders: A Review

REVIEW
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ABSTRACT

Balance is a complex process involving the integration of multisensory inputs, motor coordination, and biomechanical factors. It primarily depends on the harmonious interaction of the visual, vestibular, and somatosensory systems. Visual disorders can disrupt this integration and increase the risk of balance impairments. Neuroplastic changes occur in individuals with vision loss, resulting in increased reliance on other sensory systems. However, these adaptations do not necessarily lead to improved postural control. Visual disorders such as cataracts, refractive errors, glaucoma, diabetic retinopathy, and age-related macular degeneration can impair balance and mobility. Additionally, strabismus can further disrupt postural stability and negatively impact motor and social development in children. Recognizing the impact of visual disorders on balance is crucial for comprehensive clinical assessment and fall prevention. Future research should aim to clarify underlying mechanisms and guide the development of targeted, age-appropriate interventions to support postural stability in visually impaired individuals.

Keywords: Balance, postural control, vision, visual disorders

Introduction

Balance is a complex process involving the integration of multisensory inputs, motor skills, and biomechanical factors. The body activates balance mechanisms to adapt to changing conditions and maintain postural stability, requiring the coordinated functioning of various systems to ensure stability and proper posture.[1,2]

Balance is maintained by 3 main systems that work in harmony: the visual, somatosensory, and vestibular systems.[3] The visual system regulates eye movements and body posture by processing environmental information. The somatosensory system enhances body position awareness by processing signals from muscles and joints. The vestibular system detects head movements and its position relative to gravity through structures in the inner ear. The information obtained from these systems is integrated with cognitive and motor functions to ensure postural stability.[4,5]

The visual system enables organisms to see by processing information from visible light, which is received by the eye and interpreted by the brain to create a representation of the environment. It generates visual perceptions and spatial awareness, guiding movements accordingly. For normal vision, the structure and function of the ocular regions must be free of pathological conditions. Light rays must be properly focused, the neurological pathways from the retina to the visual cortex via the optic nerve must be intact, and the brain must be able to accurately interpret the received information. Any abnormalities in structure, development, or function can lead to vision loss.[6,7] Additionally, dysfunctions in the visual system can contribute to balance problems.[8]

Visual disorders that affect balance and postural control can emerge at various stages of life, either congenitally or acquired through disease or aging.[9-12] Therefore, this review does

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not restrict itself exclusively to congenital or acquired disorders, but rather addresses the common visual disorders known to significantly influence balance, regardless of their origin.

This review aims to underline the importance of recognizing visual disorders as critical factors influencing balance and mobility.

Methods

A literature search was performed in PubMed, Scopus, and Web of Science databases covering publications from 1990 to September 2025. Search terms included combinations of "visual disorder," "vision loss," "balance," "postural control," "falls," "cataract," "refractive error," "age-related macular degeneration," "glaucoma," "diabetic retinopathy," "strabismus," and "amblyopia." Inclusion criteria were (1) peer-reviewed articles or systematic reviews involving human participants; (2) studies examining the relationship between visual impairment and balance or gait; and (3) articles written in English. Studies solely involving animal models or case reports were excluded. Titles and abstracts were screened independently by 2 reviewers, with disagreements resolved by consensus. Additional references were identified through manual searching of cited works. The selected articles informed the narrative synthesis presented in this review.

Effects of Visual Disorders on Balance

Visual loss negatively affects postural control, leading to difficulties in performing motor activities.[8,13] Importantly, most studies assessing balance in individuals with visual impairments employ both static measures (e.g., posturography under eyes-open/eyes-closed conditions) and dynamic tasks (e.g., functional gait tests). Findings consistently show that static balance deteriorates more severely when visual input is restricted, highlighting a stronger reliance on proprioceptive and vestibular cues. Lower levels of postural stability in individuals with vision loss are associated with an increased risk of falls. Additionally, individuals with vision loss who are at high risk of falls exhibit lower stability limits compared to those at lower risk.[14] This indicates that vision loss affects more than just visual information; it significantly impacts balance and mobility.[8] For instance, comparisons between visually impaired and normally sighted individuals under eyes-open vs. eyes-closed conditions suggest that those with visual deficits demonstrate higher sway velocities, larger sway areas, and greater difficulty maintaining an upright stance, reflecting a critical role of vision in both static and dynamic stability. In cases of blindness, individuals' balance parameters further deteriorate.[15]

Binocular vision supplies essential cues for depth perception and distance estimation, allowing precise alignment of the body in space. When binocular function is disrupted by conditions such as strabismus or amblyopia, these depth cues are degraded, increasing sway and forcing the central nervous system to rely on somatosensory and vestibular inputs.[16] The developing postural system of children is particularly dependent on visual input.[16] Early disruption of binocular vision can therefore lead to greater instability and slower maturation of balance skills, underscoring the importance of multisensory integration in pediatric populations.

The incidence of ophthalmologic disorders in children is increasing due to the rising popularity of entertainment activities such as cell phones and televisions with small screens. Ophthalmologic disorders are reported to be the second most common cause of dizziness and balance disorders in the pediatric population.[17] Research indicates that young children heavily rely on visual cues for postural control, with this reliance decreasing as they grow and their somatosensory and vestibular functions mature, peaking around ages 12 to 17 years.[18] Therefore, it is crucial to conduct an ophthalmologic examination for every pediatric patient presenting with vertigo.[17]

Vision loss leads to neuroplastic changes in the brain, resulting in the visual cortex being activated by tactile, auditory, and olfactory stimuli. These structural changes and neuroplastic adaptations help compensate for postural control but do not necessarily lead to improved postural stability.[19] Visual disturbances cause sensory reweighting in the acute phase, a process where the brain adjusts the importance of different sensory inputs to maintain balance when some modalities are impaired, affecting postural stability.[20] While this reweighting can support balance in static conditions, it may not suffice during dynamic tasks such as walking or head movements, further emphasizing the complexity of vestibular and somatosensory interactions in those with visual deficits. This effect is especially pronounced in the geriatric population.[20] The reliance on somatosensory inputs increases in individuals with visual disorders. Therefore, those with visual disorders experience greater balance challenges in conditions where somatosensory information is also compromised.[21]

Visual disorders can have notable consequences for older adults. Vision problems can contribute to difficulties with walking and an increased risk of falls. Aging modifies multisensory integration: older adults show increased reliance on visual cues and may exhibit diminished ability to reweight sensory inputs when vision deteriorates. In blind individuals, compensatory reliance on somatosensory and vestibular inputs often proves inadequate. Those with residual vision may remain overly dependent on visual input, hindering proprioceptive compensation.[22] Age-related declines in visual acuity, contrast sensitivity, and depth perception may make it harder for elderly individuals to judge distances, potentially heightening their fall risk.[23] Additionally, aging can affect eye movements, resulting in decreased smooth pursuit gain and prolonged saccadic latency.[24] Given these factors, it is crucial to develop appropriate strategies to address visual disorders in elderly individuals to help reduce their risk of falls.[23] Globally, the leading causes of visual disorders include

MAIN POINTS

- *Balance relies on integrated visual, vestibular, and somatosensory inputs; visual disorders disrupt this integration, impairing both static and dynamic stability despite sensory reweighting efforts.*
- *Common visual disorders (cataract, refractive errors, age-related macular degeneration, glaucoma, diabetic retinopathy, strabismus, and amblyopia) affect balance via distinct mechanisms, such as contrast sensitivity reduction and visual field loss.*
- *For pediatric populations, early identification of visual and auditory deficits, comprehensive ophthalmological and audiological evaluations, and age-appropriate balance training are critical.*
- *In older adults, age-related vision loss significantly elevates fall risk, necessitating fall-prevention strategies that address the decline in multisensory interactions.*
- *A multidisciplinary approach involving ophthalmologists, audiologists, physiotherapists, and rehabilitation specialists is essential for comprehensive assessment and targeted interventions like low-vision rehabilitation.*

cataracts, refractive errors, glaucoma, diabetic retinopathy (DR), and age-related macular degeneration (AMD). Each of these conditions affects millions worldwide and significantly impacts balance and mobility. Given their diverse clinical presentations and prevalence across age groups, tailored approaches are essential.[25]

Across diverse visual disorders, common mechanisms underlying balance impairment emerge. The central nervous system integrates inputs from the visual, vestibular, and somatosensory systems to maintain posture. When visual input deteriorates, the CNS reallocates weight to proprioceptive and vestibular signals; however, this compensation may be insufficient, particularly in low-vision individuals. Older adults may exhibit limited sensory reweighting capacity, while individuals with residual vision may remain overly reliant on visual cues, hampering proprioceptive compensation. These shared pathways—visual–vestibular integration, sensory reweighting, and muscle co-contraction—should inform targeted rehabilitation and fall-prevention programs.[22]

Cataracts: The term cataract refers to a partial or complete opacification of the lens.[26] Although it can be treated surgically, it remains one of the leading causes of blindness and visual disorders worldwide.[27,28] While its global prevalence is on a declining trend, it is estimated that more than 10 million people are blinded by cataracts, and over 35 million people have moderate or severe visual disorders.[29] Additionally, cataracts have become a major health problem, causing visual disorders in approximately 95 million people worldwide.[30]

Cataracts are particularly problematic among older adults, who are highly susceptible to this condition due to age-related changes in the eye.[31] Cataracts, which are a major factor negatively affecting the quality of life in the elderly, are also one of the leading causes of childhood blindness in the pediatric population.[32-34] Although the prevalence of cataracts is higher in older adults, cataracts also occur in the pediatric population and are associated with significant visual impairment in children. The prevalence of cataracts in children is approximately 1.03 per 10 000.[35] Among congenital cataract cases, 27% are associated with ocular abnormalities, and 22% are associated with systemic abnormalities.[36]

Cataracts significantly impair visual acuity, contrast sensitivity, and depth perception. These visual deficits can contribute to difficulties with balance, reduced independent mobility, and an increased risk of falls and injuries, potentially impacting overall mortality. Specifically, cataracts impair both static and dynamic postural control, leading individuals to rely heavily on proprioceptive and vestibular cues. Patients with cataracts often exhibit increased sway during quiet standing, particularly under low-light conditions, and tend to adopt cautious gait patterns, further elevating their risk of falls and mobility restrictions.[26,37] For instance, one study observed notable improvements in visual acuity and functional balance within one month following cataract surgery.[38] Another study has highlighted a higher incidence of falls among elderly individuals with cataracts.[39] However, it has been noted that visual impairment in elderly individuals with cataracts is not always correlated with falls and balance disorders, emphasizing the need for detailed assessments of postural stability using advanced device measures and for considering other fall risk factors.[40] Surgical extraction of the opacified lens with intraocular lens implantation remains the definitive treatment. Postoperative rehabilitation, including mobility training and environmental adaptations, can further improve functional balance and reduce fall risk.[41,42]

Given the presence of multiple risk factors for falls,[43] continued research that integrates both visual and systemic comorbidities is crucial to fully understand how cataracts affect balance and to develop effective interventions in populations of different ages.

Refractive Errors: Refractive errors refer to the inability of parallel rays entering the eye to focus on the retina, reflecting a mismatch between the axial length of the eye and its optical power. This results in blurred retinal images. Refractive errors can occur at any stage of life and are classified into 3 types: hyperopia, myopia, and astigmatism. Myopia is a condition where light entering the eye is focused in front of the retina, causing difficulty in seeing distant objects. Hyperopia is a condition where light entering the eye is focused behind the retina, leading to difficulties, especially with near vision. Astigmatism is a refractive error in which light entering the eye is not focused properly on the retina, leading to distorted or blurred vision.[44,45]

The number of visual disorders due to uncorrected refractive errors has increased since 2000, with reports indicating that 157 million people experienced moderate-to-severe visual disorders in 2020. This figure is expected to rise with the aging global population, highlighting the need for new approaches to managing refractive errors.[46] Refractive errors can also affect school-age children, with a prevalence of 11.6% for myopia, 6.7% for hyperopia, and 28.9% for astigmatism.[47]

As the impact of refractive errors increases, postural instability also rises, particularly when inputs from other sensory systems are impaired. This negatively affects the quality of life of individuals.[48,49] Beyond any changes in vestibulo-ocular reflex (VOR) function, blurred or distorted visual information compromises the ability to accurately judge distances or locate obstacles, thereby increasing sway and fall risk during both quiet standing and walking tasks. Glasses, contact lenses, or eye surgery can mitigate these issues by providing a clearer visual reference.[49] A study has demonstrated that the use of corrective eyeglasses reduces body oscillation in individuals with myopia and hyperopia.[50] Myopia-induced blurred visual information interferes with postural stability. When the effect of spectacles on postural stability was examined in cases of myopia and hyperopia, it was found that the postural instability index significantly decreased in myopia, indicating increased postural stability while using spectacles; no significant change was observed in hyperopia. This difference is thought to be related to the interaction between optical correction of refractive errors and the sensory structures responsible for postural control.[51] These findings underscore that the relationship between refractive correction and postural stability may differ across refractive error types and should be evaluated through standardized static and dynamic balance tests (e.g., eyes-open vs. eyes-closed posturography). Further research is needed to clarify how best to optimize refractive correction for different patient populations in order to reduce fall risk and maintain functional mobility.

However, the impact of refractive errors and their correction on the VOR, a crucial component for maintaining balance, is less clear. The VOR generates short-latency eye movements to compensate for head rotations, ensuring clear vision and stable gaze during head movements.[52] The video head impulse test (vHIT) is used to evaluate the VOR originating from the semicircular canals.[53] A study investigating the effect of daily spectacle wear for correcting refractive errors on VOR measured with vHIT found that wearing corrective spectacles or contact lenses did not impact VOR gain. It was noted that corrective measures were not necessary when performing vHIT on individuals with refractive errors, regardless of the correction method used.[54] These findings provide valuable insight for determining the approach to individuals with refractive errors presenting for balance assessment in clinical settings. Corrective lenses, contact lenses, or refractive surgery can restore a clear visual reference; such correction has been shown to reduce body oscillation and improve postural stability.[16] However, further research is needed to enhance the validity and generalizability of these findings.

Age-Related Macular Degeneration: Age-related macular degeneration(AMD) is a chronic, progressive degenerative disease of the macula that leads to central vision loss due to abnormalities in the photoreceptors, retinal pigment epithelium, and Bruch's membrane. The disease may result in geographic atrophy and/or neovascularization. There are 2 main types: dry and wet. While dry AMD accounts for the majority of diagnosed cases, wet AMD is responsible for most cases of severe vision loss.[55-57] AMD is the leading cause of severe vision loss in individuals over 55 years of age and is expected to affect approximately 288 million people worldwide by 2040.[12]

Decreased contrast sensitivity and visual acuity in older adults with AMD have been associated with increased fall rates.[58] Furthermore, impaired contrast sensitivity in this group has been linked to postural instability, slower walking speed, increased stride width, and decreased stride length. Visual field loss has also contributed to balance and mobility issues.[59] These static and dynamic balance challenges often reflect a reduced ability to detect obstacles or judge terrain changes, making patients more prone to slips and trips. In another study, individuals with AMD were found to have poorer postural stability compared to normal individuals.[60] With AMD, the fovea may shift to another locus on the retina due to central vision loss, leading to abnormal VOR gains.[61] Nevertheless, the most pressing issue is the compromised central visual field, which substantially affects day-to-day mobility, heightens fall risk, and may also indirectly impact the vestibular system, a key component of balance. Consequently, multidisciplinary interventions, including low-vision rehabilitation and postural training, may be essential for reducing accidents and improving overall quality of life in individuals with AMD. Anti-vascular endothelial growth factor injections and photodynamic therapy slow disease progression, while low-vision rehabilitation—including eccentric viewing training, assistive devices, and home modifications—maximizes residual vision and enhances safe mobility.[41,62,63]

Glaucoma: Glaucoma is a chronic and progressive disease characterized by degeneration of the optic disc and retinal ganglion cells. This degenerative process leads to structural changes in the optic nerve fiber layer and functional loss in the visual field.[64,65] The incidence of glaucoma increases with advancing age.[66] The global prevalence of glaucoma is estimated to be 3.5% among individuals aged 40-80 years. Considering the increase in both the number and proportion of the elderly population, it is estimated that 111.8 million people worldwide will have glaucoma by 2040. These data underscore the potential public health impact of glaucoma and suggest that its incidence will increase significantly with the aging global population.[67]

Although visual acuity is usually preserved until the later stages of glaucoma, even early stages of the disease can severely restrict peripheral vision, significantly limiting the visual field necessary for stable balance, mobility, and performance of daily activities.[68,69] Glaucoma limits mobility, which significantly increases the risk of falls.[70,71] In particular, patients with defects in the inferior visual field are at a higher risk of falling compared to those with defects in other visual fields.[64] Additionally, individuals with glaucoma exhibit worse postural stability compared to normal individuals.[72] Targeted interventions that address scanning techniques, lighting adaptations, and compensatory strategies may help mitigate these balance deficits, especially in more advanced glaucoma cases. Further research is needed to identify which adaptive behaviors or rehabilitation programs best preserve mobility and reduce fall risk in this population. Disease control relies on intraocular pressure lowering via topical medications, laser trabeculoplasty, or filtration surgery. Orientation and mobility training, improved lighting, and scanning techniques may mitigate balance deficits during activities of daily living.[73,74]

Diabetic Retinopathy: Diabetes mellitus (DM) is a chronic disease characterized by elevated blood glucose levels and impaired fat and protein metabolism.[75] The global prevalence of DM is estimated to reach 578 million in 2030 and 700 million in 2045. Diabetic retinopathy (DR) is a major ocular complication of DM and remains a significant cause of vision loss.[11] DR affects approximately 25%-35% of individuals with diabetes.[76,77]

Diabetic macular edema is the most common cause of visual loss in patients with DR. Diabetic macular edema is characterized by swelling or thickening of the macula due to the accumulation of subretinal and intraretinal fluid, triggered by the breakdown of the blood-retinal barrier. Diabetic macular edema can occur at any stage of DR and may lead to a disorder of visual stimuli and reduced visual acuity.[78] Impaired retinal function in patients with DR can adversely affect postural control, with the severity of retinal damage often correlating to the degree of balance dysfunction.[79] Furthermore, among individuals with diabetes, those with mild or moderate DR have approximately twice the risk of falling compared to those without DR. Therefore, clinical approaches for individuals with diabetes should include preventive measures to reduce the risk of falls, especially for those with early-stage DR.[80] Reduced contrast sensitivity, fluctuations in vision, and peripheral neuropathy (common in diabetes) may collectively worsen both static and dynamic stability. Strict glycemic control, pan-retinal photocoagulation, and intravitreal anti-VEGF (vascular endothelial growth factor) therapy help preserve vision. Multidisciplinary management—including foot care, neuropathy management, and balance training—can reduce fall risk.[81,82]

Strabismus: Strabismus is a condition characterized by the misalignment of the visual axes, which impairs binocularity and prevents both eyes from focusing on the same object simultaneously.[83] The global prevalence of strabismus is reported to be 1.93%.[84] Although the precise causes of childhood strabismus are not entirely understood, it is thought to arise from a combination of genetic factors and environmental influences.[85] Several risk factors have been associated with the development of strabismus, including low birth weight, maternal smoking during pregnancy, refractive errors, astigmatism, cerebral palsy, and retinopathy of prematurity.[86]

Strabismus not only disrupts visual alignment but also has significant implications for postural control and overall development. Children with strabismus generally show lower postural control in both static and dynamic tasks compared to their peers with normal vision, partly due to difficulties integrating binocular cues.[87,88] Strabismus negatively affects optokinetic and pursuit systems as well as balance in children. Moreover, an increase in the angle of strabismus is associated with greater negative effects on these functions.[89] This impaired postural stability is closely linked to visual inputs, and corrective measures such as strabismus surgery have been reported to improve postural control.[88,90] However, early intervention is key, as persistent misalignment can disrupt sensory-motor development and exacerbate coordination deficits. The impact of strabismus extends beyond balance; abnormal binocular vision in childhood can lead to difficulties in coordination, affecting both gross and fine motor skills. Consequently, children may experience decreased academic performance, delayed social development, and negative effects on overall health, self-confidence, and safety.[16] In adults, strabismus may also be associated with increased body sway, reflecting weakened oculomotor signals.[91] In both pediatric and adult cases, targeted rehabilitation and careful follow-up can help restore binocular function, enhance balance, and improve overall quality of life. Treatment includes refractive correction, vision therapy, and surgical alignment. Early intervention not only restores binocular fusion but also improves postural control and motor development.[92-94]

Amblyopia: Closely related to strabismus, amblyopia is a neurodevelopmental visual disorder in which abnormal visual experience during early life disrupts the normal development of visual acuity and binocular function.[95,96] It is commonly described as reduced best corrected visual acuity in 1 eye, or less commonly both eyes, without structural ocular pathology on routine examination, and it is typically classified as strabismic, anisometropic or refractive, deprivation, or combined forms.[96,97] Epidemiological reviews consistently note that amblyopia remains a common childhood vision disorder, although prevalence estimates vary across populations and study designs.[98-100] Beyond reduced acuity, amblyopia is strongly linked to binocular imbalance and interocular suppression, which can reduce stereopsis and disrupt binocular functions important for spatial orientation and visually guided motor behavior.[97,101] This has motivated binocular and dichoptic treatment concepts that reduce suppression by manipulating contrast and related stimulus parameters across the 2 eyes, with the aim of improving binocular cooperation and stereopsis rather than focusing only on monocular acuity.[97,99,101]

Because binocular cues support stable posture, binocular disruption in amblyopia can be reflected in postural instability and broader motor deficits.[102,103] In a pediatric cohort comparing amblyopia, strabismus without amblyopia, and visually normal controls, Bruininks-Oseretsky Test of Motor Proficiency balance scores were lower in the amblyopia group (mean 9.0 ± 3.1) than in controls (mean 18.9 ± 4.2), and the authors emphasized that even mild binocular discordance may increase postural instability.[103] Similar findings have been reported in younger children, with lower balance performance in children with amblyopia compared with controls at ages when postural control relies heavily on vision.[102] In strabismic and anisometropic children, amblyopic participants also showed reduced performance in manual dexterity, aiming and catching, and balance tasks, with greater deficits in children with infantile onset, a history of strabismus, and reduced binocularity.[104]

Management traditionally begins with refractive correction and optical treatment, followed by patching or pharmacologic penalization such as atropine when amblyopia persists.[105-107] However, adherence is a recurring limitation for occlusion-based approaches, with reported psychosocial and practical barriers that can reduce consistent treatment use.[99,100,106] Systematic reviews and trials describe growing use of binocular and dichoptic methods, including interactive platforms and balanced binocular viewing approaches, and meta-analyses suggest that binocular therapies can improve visual acuity and binocular outcomes and may complement conventional patching in selected patients.[95,99,105,106,108] Importantly for this review's focus, an app-based multimodal visual therapy study in pediatric anisometropic amblyopia reported improvements in visual outcomes alongside gains in motor proficiency and postural stability composite scores, suggesting potential benefits beyond acuity alone.[109] Treatment therefore commonly includes refractive correction, occlusion or pharmacologic penalization, binocular or vision therapy approaches, and strabismus surgery when ocular misalignment contributes to the clinical picture, with early intervention and follow-up also relevant for functional outcomes such as balance and motor development.[103,104,106,107,109]

Conclusions

Visual disorders significantly impair balance, mobility, and overall quality of life across all age groups, from children to older adults. As highlighted in this review, visual input plays a crucial role in maintaining postural control, and its disruption by conditions such as cataracts, refractive errors, age-related macular degeneration, glaucoma, diabetic retinopathy, and strabismus can lead to marked deficits in both static and dynamic balance. Each of these disorders alters sensory integration in distinct ways, often increasing reliance on the vestibular and somatosensory systems. However, such compensatory mechanisms are frequently insufficient, leading to a heightened risk of falls and reduced functional independence. Understanding the balance-related consequences of visual impairments is essential for comprehensive assessment and the development of preventive strategies tailored to at-risk populations. Future research should examine longitudinal changes in sensory reweighting across the lifespan, evaluate the efficacy of multisensory training and low-vision rehabilitation programs on postural control, and investigate neuromuscular strategies to develop evidence-based interventions for different age groups and severity levels of visual impairment.

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