

Vision and Locomotion: The Impact of Ocular Diseases on Gait, Postural Control, and Fall Risk

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Abstract

Vision plays a critical role in locomotion by providing spatial orientation, environmental awareness, and feedback necessary for maintaining balance and safe mobility. Visual impairment resulting from ocular diseases can disrupt these processes and lead to measurable changes in gait and postural stability. This chapter synthesizes current evidence on the relationship between visual dysfunction, ocular disease, and gait performance across the lifespan. The chapter reviews and integrates findings from observational studies, experimental investigations, simulated vision research, and interventional trials examining gait parameters in individuals with visual impairment. Evidence consistently demonstrates that visual deficits are associated with slower walking speed, shorter stride length, wider base of support, increased double-support time, and greater gait variability. Peripheral visual field loss has been identified as a particularly strong predictor of gait instability and progressive mobility decline. Various ocular conditions—including cataract, age-related macular degeneration, glaucoma, diabetic retinopathy, retinitis pigmentosa, strabismus, nystagmus, and amblyopia—are linked with distinct gait alterations that contribute to increased fall risk and reduced functional mobility. Interventional studies indicate that restoration of visual function through optical correction or cataract surgery can improve gait parameters, suggesting a partially reversible component of visually mediated gait dysfunction. Age-related differences are also evident, with visually impaired older adults showing accelerated gait decline and heightened fall risk, while children with visual disorders exhibit altered balance and motor development. Overall, the findings highlight gait dysfunction as an important mechanistic link between ocular disease and falls. Integrating visual assessment with mobility evaluation may enhance fall prevention strategies and support functional independence across diverse populations.

Keywords: Visual dysfunction, Ocular diseases, Gait, Postural control, Falls, Visual field loss, Mobility Visual dysfunction, Ocular diseases, Gait, Postural control, Falls, Visual field loss, Mobility, Binocular Vision, Stereopsis.

1. Introduction

Human locomotion is a complex sensorimotor process that requires continuous integration of multiple physiological systems. Gait is defined as the cyclical pattern of lower-limb movement during locomotion, extending from the initial contact of one foot to the subsequent initial contact of the same foot.¹ It represents a coordinated sequence of biomechanical and neuromuscular actions that allow efficient forward progression of the body.

Locomotion, more broadly, refers to the displacement of the body from one location to another through coordinated actions of the musculoskeletal and nervous systems.² This movement requires precise integration of motor planning, sensory feedback, and environmental perception.

A fundamental component of locomotor stability is postural control, defined as the ability to maintain the body's center of mass within the base of support during both static and dynamic activities.³ Effective postural control depends on the integration of several sensory systems:

- Visual system
- Somatosensory system
- Vestibular system
- Cognitive processing
- Musculoskeletal coordination

Among these, vision plays a dominant role in guiding locomotion. Visual input allows individuals to perceive obstacles, estimate distances, judge terrain irregularities, and anticipate environmental hazards. Visual information also contributes to anticipatory postural adjustments and reactive balance responses during walking.

Ocular diseases are among the most common causes of sensory impairment worldwide. Conditions such as cataract, glaucoma, age-related macular degeneration (AMD), diabetic retinopathy, and uncorrected refractive errors affect millions of individuals globally.⁴ These diseases can impair various aspects of visual function, including visual acuity, contrast sensitivity, visual field integrity, depth perception, motion perception.

As a result, visual impairment contributes significantly to the global burden of disability.⁵⁻⁶ Beyond visual limitations, impaired vision has substantial systemic consequences. Numerous studies have linked visual impairment to increased risk of falls, reduced mobility, postural instability, social isolation, depression and anxiety. Older adults with visual impairment are particularly vulnerable, as vision loss compounds age-related sensorimotor decline.⁷⁻⁸

Emerging evidence suggests that gait abnormalities may represent a key mechanistic pathway linking ocular disease to falls and injury. Understanding how visual dysfunction alters locomotor control is therefore critical for clinicians and researchers working in ophthalmology, optometry, neurology, geriatrics, and rehabilitation sciences.

This chapter explores the relationship between ocular disease and locomotion, focusing on how visual dysfunction affects gait, balance, and fall risk across the lifespan.

2.1 Visual System Contribution to Gait and Postural Control

The visual system plays a critical role in guiding locomotion by providing information about environmental layout, obstacle location, and body orientation. Visual input enables individuals to plan movement trajectories and adapt gait patterns in response to environmental demands.⁹

Several oculomotor mechanisms contribute to locomotor control:

Saccadic Eye Movements

Saccades are rapid eye movements that allow individuals to quickly shift gaze between objects in the environment. During walking, saccades enable scanning for obstacles and planning foot placement.

Smooth Pursuit Movements

Smooth pursuit movements allow the eyes to track moving objects, maintaining visual fixation during motion.

Vestibulo-Ocular Reflex (VOR)

The vestibulo-ocular reflex stabilizes retinal images during head movement by producing compensatory eye movements. This mechanism is essential for maintaining visual clarity during walking.

Disruption of these oculomotor systems can impair coordination between visual input and motor output, leading to instability and altered gait patterns.

Shoja et al. (2023) demonstrated that the absence of visual input alters lower-limb motor coordination, affecting control of the center-of-mass trajectory during walking.¹⁰

Additional visual processes relevant to locomotion include:

- Dynamic contrast sensitivity, which adapts during locomotion to enhance perception of moving objects.¹¹
- Motion detection acuity, which contributes to postural stability.¹²

Peripheral visual information is particularly important for safe navigation. Peripheral vision detects obstacles, changes in terrain, and motion in the surrounding environment.

Loss of peripheral visual field significantly reduces walking speed and increases gait variability, highlighting its critical role in locomotor stability.¹³

2.2 Ocular Diseases and Gait Dysfunction

Numerous ocular conditions affect locomotion through different mechanisms of visual impairment.

Cataract

Cataracts cause progressive opacification of the lens, reducing visual acuity and contrast sensitivity.

Noh et al. (2023) demonstrated that correcting refractive error in elderly cataract patients significantly improved step length and stride length, indicating that visual clarity influences motor control during walking.¹⁴

Similarly, cataract surgery has been shown to improve walking speed, lower-limb kinematics and postural stability. These findings suggest that restoring visual input can lead to measurable improvements in mobility.¹⁵

Age-Related Macular Degeneration (AMD)

Age-related macular degeneration primarily affects central vision, impairing visual acuity and depth perception.

Varadaraj et al. (2017) reported that individuals with AMD exhibit reduced walking speed, increased double-support time, more cautious gait strategies. These adaptations likely reflect attempts to compensate for reduced central vision and increased uncertainty about environmental features.¹⁶

Diabetic Retinopathy and Diabetes Mellitus

Diabetes can affect locomotion through both visual and neurological pathways. A systematic review by Allet et al. (2008) found that individuals with diabetes often demonstrate slower gait speed, shorter stride length, Increased gait variability. These changes are particularly pronounced in individuals with peripheral neuropathy, which impairs somatosensory feedback from the lower limbs.¹⁷

Retinitis Pigmentosa

Retinitis pigmentosa (RP) is characterized by progressive degeneration of photoreceptors, leading to severe peripheral visual field loss. Timmis et al. (2017) observed that individuals with RP adopt downward gaze strategies during walking to compensate for limited peripheral vision.¹⁸ Their findings indicated that visual field extent, rather than visual acuity, was the strongest predictor of altered visual search behaviour during locomotion.

Glaucoma

Glaucoma causes progressive damage to the optic nerve, often resulting in peripheral visual field loss. Mihailovic et al. (2017) reported that glaucoma patients exhibit wider base of support, increased stride variability, and slower walking speed. Longitudinal studies further show that visual field damage predicts progressive gait deterioration over time.^{19–20}

Strabismus

Strabismus disrupts binocular vision and depth perception. A systematic review by Papalia et al. (2022) found increased center-of-pressure displacement in individuals with strabismus, suggesting impaired postural stability. Improvements were observed following restoration of binocular alignment.²¹

Downbeat Nystagmus

Downbeat nystagmus (DBN) is associated with vestibulo-cerebellar dysfunction. Schniepp et al. (2014) reported that DBN patients exhibit slower gait, increased variability, wider base of support. These findings suggest impaired integration of visual and vestibular signals during locomotion.²²

Amblyopia

Amblyopia affects binocular vision and depth perception during childhood. Hoare (2025) reported altered gait kinematics in children with amblyopia, likely due to deficits in spatial perception and binocular coordination.²³

2.3 Mechanisms Linking Ocular Disease to Gait Dysfunction

Several mechanisms explain how visual impairment influences gait:

1. Peripheral visual field loss reduces environmental awareness and alters spatiotemporal gait parameters.¹³
2. Progressive visual field damage leads to long-term decline in walking ability.²⁰
3. Increased gait variability, a known predictor of falls, often accompanies visual impairment.¹³
4. Impaired motion processing can lead to increased trunk and head instability.²⁴
5. Greater cognitive involvement in walking reduces gait automaticity and increases dual-task costs.²⁴

Together, these mechanisms contribute to increased fall risk and reduced mobility.

2.4 Evidence from Experimental and Interventional Studies Optical and Surgical Interventions

Clinical interventions demonstrate that improving vision can positively influence gait.

Evidence indicates that spectacle correction improves stride parameters,¹⁴ Cataract surgery enhances gait speed and lower-limb movement patterns,¹⁵ Visual field loss predicts long-term mobility decline.²⁰

Simulated Vision Studies

Experimental studies provide further insight by artificially manipulating visual input. Findings include blurred vision producing cautious gait patterns,¹⁵ visual deprivation increasing gait variability,²⁵ simulated peripheral field loss impairing postural control,²⁶ virtual reality perturbations increasing gait instability.²⁷ These studies support a causal relationship between visual input and locomotor stability.

2.5 Age-Specific Considerations

Older Adults

Visual impairment is a major contributor to falls among older adults. Studies show that visual deficits increase postural sway,²⁸ peripheral vision predicts walking ability,²⁹ cognitive and visual decline increase dual-task gait costs.³⁰ These effects can significantly limit independence and quality of life.

Children

Vision also plays a crucial role in motor development during childhood. Children with visual impairment often demonstrate reduced balance ability, delayed motor skill acquisition, impaired spatial navigation. Physical activity and structured movement training can improve gait stability and balance in visually impaired youth.^{31–32}

4. Discussion

The evidence synthesized in this chapter highlights the central role of vision in regulating locomotion and postural stability across the lifespan. Vision contributes not only to environmental perception but also to anticipatory and reactive motor adjustments required for safe walking.

Oculomotor mechanisms—including saccades, smooth pursuit, and vestibulo-ocular reflexes—maintain stable visual perception during locomotion. Disruption of these mechanisms compromises coordination between sensory input and motor output, leading to altered gait patterns.

Across multiple ocular diseases, a consistent pattern of gait adaptation emerges. Reduced visual input—whether due to loss of acuity, contrast sensitivity, or visual fields—results in slower walking speed, shorter stride length, wider base of support, and increased gait variability.

Among visual deficits, peripheral visual field loss appears to have the strongest impact on locomotor stability. Diseases such as glaucoma and retinitis pigmentosa demonstrate that peripheral field sensitivity predicts gait decline over time. Central vision loss, as seen in age-related macular degeneration, primarily affects walking speed and cautious gait behaviour due to impaired depth perception and obstacle detection.

Interventional evidence further supports the causal relationship between vision and locomotion. Improvements in gait parameters following spectacle correction or cataract surgery suggest that restoring visual function can translate into measurable mobility benefits.

Another important mechanism is the increased cognitive demand associated with visually impaired walking. When visual information is limited, individuals rely more heavily on attention and executive control to guide movement. This reduces gait automaticity and increases vulnerability to instability during dual-task situations.

Age plays a significant role in modulating these effects. In older adults, visual impairment compounds age-related declines in sensory integration, muscle strength, and reaction time. In children, early visual deficits may interfere with the development of motor coordination and balance.

These findings underscore the importance of viewing ocular disease not only as a sensory impairment but also as a functional mobility disorder with systemic consequences.

5. Clinical Implications and Future Directions

Understanding the relationship between vision and locomotion has important implications for clinical practice. Fall prevention strategies should incorporate comprehensive visual assessment, including evaluation of visual acuity, contrast sensitivity, visual fields, binocular vision and depth perception.

For optometric and ophthalmic practitioners, correcting refractive error, improving contrast sensitivity, preserving peripheral vision, and restoring binocular function may provide benefits that extend beyond visual clarity.

Multidisciplinary collaboration between ophthalmology, optometry, neurology, geriatrics, and rehabilitation professionals is essential for addressing mobility impairments related to visual dysfunction.

Future research should focus on longitudinal studies examining disease-specific gait patterns, development of visual-based gait rehabilitation programs, integration of wearable sensors and virtual reality for mobility training, and

early interventions for visually impaired children to support motor development. Such research may help reduce fall risk and improve mobility outcomes in individuals with visual impairment.

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