

Eye Body Connection in Rehabilitation The Influence of Visual Function on Balance, Posture, and Physical Performance - A Narrative Review

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Abstract

Postural control and mobility are complex functions that require continuous integration of visual, vestibular and somatosensory information with appropriate motor responses. Vision is one of these sensory systems, and it plays an important role in balance and locomotor control by providing crucial information about body position, environmental boundaries, direction of movement, and spatial relationships. Impaired visual function may therefore have an impact on postural stability, gait, mobility and activities of daily living. These interactions are particularly relevant in older adults and patients with neurologic, musculoskeletal, vestibular, and visual disorders. Traditionally, physiotherapy has focused on postural and mobility limitations through balance training, strengthening, gait rehabilitation, proprioceptive exercises and task-specific interventions. However, the growing recognition of the role that visual information plays in motor control has increasingly led to the integration of visual and sensorimotor strategies in rehabilitation. This narrative review considers the physiological relationship between vision, postural control and mobility; mechanisms of sensory integration and sensory reweighting; implications of visual impairment for balance and gait; and the role of physiotherapy-based rehabilitation in optimising functional performance. Specific attention is paid to multidisciplinary collaboration between optometrists and physiotherapists, visual assessment, balance retraining, gait rehabilitation, environmental modification and emerging technologies. An integrated approach of visual and physical contributions may provide a more holistic framework for rehabilitation and functional independence. Future research should aim at individualised vision-movement rehabilitation protocols and standardised approaches to the integration of optometric and physiotherapeutic care.

Keywords: vision, postural control, mobility, balance, physiotherapy, rehabilitation, optometry, sensory integration, visual impairment.

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Introduction

Postural control is an important aspect of human movement as it allows the body to remain stable during standing, walking, change of direction, reaching and activities of daily living. Although postural control seems automatic, it is a continuous interplay between sensory information and motor responses. The visual, vestibular and somatosensory systems provide information to the central nervous system [1]. The central nervous system integrates this information to estimate body position and movement in relation to the environment. Then the

correct motor responses are produced in an effort to achieve stability and efficient movement [2]. Vision is one of the most important information sources used during postural and locomotor activities. Visual information offers a reference for orientation, recognises obstacles and environmental boundaries, and helps the nervous system to detect self-motion and the movement of objects in the surrounding environment [3]. Thus, the visual system is involved not only in seeing objects but also in maintaining spatial orientation and coordinating

movement. Changes in visual input can affect how people allocate attention, alter the base of support, control body sway, and adjust their gait to the demands of the environment. The contribution of vision is particularly evident when other sensory systems are compromised. For example, standing on an unstable surface increases the dependence on visual and vestibular information, while walking in a visually rich environment requires constant interpretation of spatial information. The central nervous system can adapt the relative amount of different sensory systems it uses depending on how reliable they are. This is often referred to as sensory reweighting. Thus, the functional significance of visual impairment is increased when compensatory sensory information is insufficient or when challenging environments are encountered [3,4]. Refractive errors, reduced visual acuity, impaired contrast sensitivity, loss of visual field, binocular vision disorders, ocular disease, age-related changes, or neurological conditions affecting visual processing may all cause visual dysfunction. These impairments may affect the ability to see obstacles, judge distances, negotiate uneven terrain, and maintain orientation while moving. Visual impairment is often also considered in relation to falls and mobility limitations in older adults [3,5]. Physiotherapy has an important role in the management of functional consequences of poor postural control and mobility. Conventional rehabilitation approaches include strengthening exercises, balance training, gait training, flexibility exercises, proprioceptive training, functional activities and task specific practice [6]. Growing evidence that the sensory and motor systems interact has encouraged rehabilitation professionals to include sensory challenges and visually guided tasks in treatment programs. Thus, the relationship between optometry and physiotherapy is of growing clinical importance. An optometric evaluation can identify visual factors that may contribute to functional limitations, and physical therapy can address the physical and motor consequences related to altered postural control and mobility. An integrated approach that considers visual and physical impairments as a combined phenomenon rather than separate problems may broaden the concept of functional disability. This narrative review is concerned with the relationship between visual function and postural control and mobility, with particular attention to physiotherapy-based rehabilitation consequences. It also explores the potential advantages of multidisciplinary collaboration between optometry and physiotherapy in the assessment, intervention and long-term functional management of the patient.

Physiological Basis of Postural Control

Postural control requires the nervous system to continuously estimate the position and movement of

the body and produce appropriate muscular responses. Three major sensory systems contribute to this process: the visual system, the vestibular system, and the somatosensory system [7].

The visual system provides information about the external environment and the body's relationship with surrounding objects. The vestibular system detects head movement and orientation relative to gravity, while the somatosensory system provides information regarding joint position, muscle activity, pressure, and contact with the supporting surface [6,7].

These sensory systems do not operate independently. Information from different sources is integrated within the central nervous system to generate an internal representation of body orientation and movement. The importance assigned to each sensory source can change according to environmental conditions.

For example, when an individual stands on a firm surface with good lighting, somatosensory and visual information are readily available. However, when standing on an unstable surface, somatosensory information becomes less reliable and greater reliance may be placed on visual and vestibular information. Similarly, walking in darkness reduces visual information and requires greater reliance on vestibular and somatosensory inputs [7,8].

This ability to alter the relative contribution of sensory information is referred to as sensory reweighting. Efficient sensory integration allows individuals to maintain balance despite changes in the environment. Failure to appropriately integrate or compensate for altered sensory information can contribute to postural instability.

Role of Vision in Postural Control

Vision contributes to postural control through several mechanisms. Visual information helps individuals identify vertical and horizontal references, estimate distances, detect environmental movement, and determine their position relative to surrounding objects.

Even during quiet standing, small body movements produce changes in the visual image projected onto the retina. The nervous system can use these changes as information about body sway. Visual feedback therefore contributes to the continuous adjustment of posture.

The importance of vision becomes particularly apparent when the eyes are closed. Many healthy individuals demonstrate a modest increase in postural sway after visual information is removed. The effect may be considerably greater among people who have vestibular, somatosensory, neurological, or musculoskeletal impairments [5,7]. Visual acuity alone, however, does not completely describe the contribution of vision to postural control. Contrast sensitivity, peripheral vision, depth perception, binocular function, and visual motion

processing can also influence functional mobility [8,9].

An individual may have relatively good visual acuity under standard clinical conditions but experience difficulty detecting low-contrast obstacles or navigating complex environments. Consequently, functional visual assessment may be important when evaluating patients with unexplained balance or mobility problems [9,10].

Visual Function and Mobility

Mobility involves more than the ability to walk. It includes initiating movement, maintaining balance, negotiating obstacles, changing direction, climbing stairs, transferring between positions, and adapting movement to environmental conditions [11].

Visual contributes to each of these activities

During walking, individuals continuously use visual information to anticipate changes in the environment. Before stepping over an obstacle, for example, the person must identify the obstacle, estimate its location and height, determine an appropriate foot trajectory, and modify gait accordingly. Visual information also contributes to foot placement and navigation.

Reduced visual information may result in slower walking, increased caution, changes in step characteristics, and greater dependence on environmental support. Individuals with visual impairment may also restrict their activities because of concerns about falling or difficulty navigating unfamiliar environments [10,12]. The relationship between vision and mobility may become particularly important in older adults. Age-related vision changes can occur alongside reductions in muscle strength, reaction time, proprioception, and vestibular function. When several systems are simultaneously affected, the ability to compensate for one impaired sensory source may be reduced.

Thus, mobility limitations should not always be attributed exclusively to muscular weakness or joint dysfunction. Visual factors may also contribute to functional limitations and should be considered during comprehensive assessment.

Visual Impairment and Risk of Falls

Falls are multifactorial events involving interactions among individual, environmental, and behavioural factors. Visual impairment is one of the factors that can contribute to reduced environmental awareness and impaired navigation.

A person with reduced visual function may have difficulty identifying changes in floor level, steps, obstacles, or uneven surfaces. Reduced contrast sensitivity can be particularly relevant in environments where objects and surfaces have similar colours or brightness levels.

Visual field loss can also affect environmental scanning. For example, individuals with neurological or ocular conditions affecting part of the visual field may fail to detect obstacles located outside their remaining functional field [5,8].

However, visual impairment should not be regarded as an isolated explanation for falls. Falls generally result from combinations of risk factors, including impaired balance, reduced lower-limb strength, medication effects, neurological disorders, environmental hazards, and previous falls.

This reinforces the importance of multidisciplinary assessment. Optometrists can evaluate visual function, while physiotherapists can examine strength, balance, gait, functional mobility, and physical risk factors.

Sensory Reweighting and Physiotherapy Rehabilitation

A key principle in physiotherapy is that the nervous system can adapt to changes in sensory information. Rehabilitation can therefore be designed to challenge sensory integration in a controlled and progressive manner [11,12].

Balance exercises may manipulate visual, somatosensory, and vestibular conditions. For example, a physiotherapist may ask a patient to maintain standing balance with different visual conditions or on different support surfaces. Such activities can encourage the patient to develop more effective strategies for processing available sensory information.

Examples of rehabilitation approaches include:

- Static and dynamic balance exercises
- Weight-shifting activities
- Single-leg and tandem stance exercises
- Gait training
- Obstacle negotiation
- Direction-changing exercises
- Dual-task activities
- Proprioceptive exercises
- Strengthening of lower-limb and trunk musculature
- Functional reaching activities
- Stair training
- Environment-specific mobility practice

Visual challenges can be incorporated progressively rather than simply removing vision. For example, rehabilitation may involve changes in lighting, visual targets, moving targets, obstacle detection, or visually guided reaching and stepping.

The objective should not be to make patients unnecessarily dependent on one sensory system but to improve their ability to use available sensory information effectively.

Vision-Dependent Motor Strategies

Human movement frequently depends on anticipatory motor control. Before an individual moves, the nervous system prepares the body based partly on visual information about the intended movement and the surrounding environment[10].

For example, before stepping onto a staircase, the individual visually identifies the stairs and adjusts movement accordingly. During walking, gaze is often directed toward future stepping locations

rather than only toward the immediate position of the feet.

This relationship between vision and motor planning has important implications for rehabilitation. Physiotherapy interventions that incorporate visually guided movement may help patients practise the interaction between perception and action.

Visual targets can be used during reaching, stepping, walking, balance tasks, and coordination exercises. These activities may be particularly relevant in neurological rehabilitation, where patients can experience difficulties with movement planning, spatial orientation, and motor coordination.

Neurological Conditions

The interaction between vision, postural control, and mobility is particularly complex in neurological disorders. Following stroke, for example, individuals may experience weakness, altered sensation, visual field deficits, neglect, impaired coordination, and reduced balance. These impairments can interact and produce substantial mobility limitations. Similarly, individuals with Parkinson's disease may experience changes in gait, postural stability, movement initiation, and visual-motor processing [13]. Visual cues are sometimes incorporated into rehabilitation to assist movement initiation and gait performance. Patients with multiple sclerosis, traumatic brain injury, and other neurological disorders may also experience combinations of visual, vestibular, sensory, and motor impairments. In such cases, rehabilitation should consider the patient's complete sensory-motor profile rather than treating mobility as an exclusively musculoskeletal problem.

Optometric Assessment in Rehabilitation

Optometric assessment can contribute important information to the rehabilitation process.

Relevant visual factors may include:

- Visual acuity
- Refractive status
- Contrast sensitivity
- Binocular vision
- Depth perception
- Visual fields
- Ocular motility
- Accommodation
- Eye alignment
- Visual symptoms during movement
- Functional visual performance

The identification of correctable visual problems is particularly important. Appropriate refractive correction, management of ocular conditions, and advice regarding visual aids may improve the information available to the patient during mobility [12].

However, correction of vision does not necessarily resolve all balance problems. A patient may continue to experience impaired postural control because of vestibular, neurological, musculoskeletal, or sensory

deficits. Therefore, optometric management and physiotherapy rehabilitation should be regarded as complementary rather than interchangeable interventions.

Physiotherapy Assessment of Vision-Related Mobility Problems

Physiotherapists play an important role in identifying functional mobility problems associated with visual impairment. Assessment involves evaluation of balance, gait, functional mobility, environmental interaction, and dual-task performance to determine how visual deficits affect daily activities [11,14].

Then :

1. Static balance assessment – evaluating postural stability under different sensory conditions.
2. Dynamic balance assessment – examining the ability to maintain stability during movement.
3. Gait assessment – observing walking speed, step characteristics, turning, and environmental negotiation.
4. Functional mobility testing – assessing transfers, stair negotiation, and directional changes.
5. Obstacle negotiation – examining the patient's ability to detect and safely cross obstacles.
6. Dual-task assessment – evaluating mobility while simultaneously performing cognitive or visual tasks.
7. Environmental assessment – identifying lighting, contrast, floor-surface, and obstacle-related challenges.

When visual factors appear to contribute substantially to functional limitations, referral to an optometrist or ophthalmic professional may be appropriate.

Vision-Based Strategies in Physiotherapy

Visual strategies can be deliberately incorporated into physiotherapy programmes to improve visuomotor coordination, balance control, gait performance, and safe interaction with the environment. These approaches may include visual target training, obstacle negotiation, gaze stabilization exercises, visual cueing, and environmental modification according to individual functional requirements [15,16].

1. Visual Target Training

Patients can perform reaching or stepping exercises toward clearly defined visual targets. This can encourage coordination between visual perception and motor execution.

2. Obstacle Negotiation

Walking around or over obstacles can train visual scanning, anticipatory postural adjustments, foot placement, and dynamic balance.

3. Gaze Stabilization and Head Movement

Selected rehabilitation programmes can incorporate controlled head and eye movements, particularly when vestibular and visual interactions contribute to dizziness or balance difficulties.

4. Visual Cueing

External visual cues may be used to support movement initiation and gait in selected neurological populations.

5. Environmental Adaptation

Improving lighting, increasing contrast between surfaces and obstacles, reducing clutter, and clearly identifying changes in floor level may improve environmental safety.

The choice of intervention should depend on the patient's diagnosis, visual status, physical capacity, cognitive status, and functional goals.

Role of Multidisciplinary Collaboration

An integrated model involving optometrists and physiotherapists may provide advantages for patients with combined visual and mobility problems.

The optometrist primarily evaluates visual function and identifies ocular or visual problems that may affect functional performance [11]. The physiotherapist evaluates movement, balance, strength, gait, and physical function.

Emerging Technologies

Technological developments are creating new possibilities for assessing and rehabilitating vision-related mobility problems [17].

- Wearable sensors can measure gait characteristics, postural sway, and movement patterns. Motion-capture systems can provide detailed information regarding body movement during visually guided tasks.
- Virtual reality and augmented reality technologies can create controlled environments in which patients practise navigation, obstacle avoidance, balance, and visual-motor coordination. These technologies may allow clinicians to manipulate environmental complexity while monitoring patient responses.
- Eye-tracking technology is another potentially valuable tool. It can provide information regarding gaze behaviour during walking, obstacle negotiation, and other functional tasks.
- Artificial intelligence may further contribute to individualized rehabilitation by identifying movement patterns and assisting with data-driven monitoring of treatment responses.

Despite these opportunities, technological interventions should complement rather than replace clinical assessment. Accessibility, cost, patient tolerance, clinical validity, and real-world transfer of training effects remain important considerations.

Clinical Implications

The relationship between visual function and mobility has several important implications for clinical practice. Vision should be considered as an integral component of balance and mobility assessment, particularly in individuals who experience difficulty navigating visually complex environments or conditions with reduced illumination [18].

- First, vision should be considered as part of a broader assessment of balance and mobility, particularly when patients report difficulties in visually complex or poorly illuminated environments.
- Second, visual acuity alone may not adequately represent functional visual capacity. Contrast sensitivity, peripheral vision, binocular function, and environmental visual demands may also influence mobility.
- Third, physiotherapy programmes can incorporate visually guided activities alongside conventional strengthening and balance exercises.
- Fourth, rehabilitation professionals should distinguish between problems that can be improved through physical training and those requiring correction or management of underlying visual disorders.

Finally, multidisciplinary communication may reduce fragmented care and facilitate individualized rehabilitation.

Advancing Research in Visual-Motor Integration and Rehabilitation

Although the relationship between vision and postural control is well established conceptually, several areas require further investigation. Future research should examine how specific visual deficits influence different components of mobility rather than treating visual impairment as a single condition [19]. More studies are also required to determine which visual rehabilitation strategies produce meaningful improvements in real-world mobility. There is a need for standardized interdisciplinary assessment protocols that combine optometric and physiotherapeutic measures [20]. Such protocols could improve identification of patients whose mobility limitations arise from interacting visual and physical factors. Further research should also investigate whether individualized sensory-reweighting programmes provide greater functional benefits than conventional balance training alone. Emerging technologies such as virtual reality, wearable sensors, eye tracking, and artificial intelligence warrant further investigation, particularly regarding their long-term clinical effectiveness and cost-effectiveness.

Research should ultimately focus on patient-centred outcomes such as confidence, participation, community mobility, independence, quality of life, and fall-related outcomes rather than relying

exclusively on laboratory measures of postural sway.

Conclusion

Vision is an integral part of postural control and mobility, working in concert with vestibular and somatosensory systems supporting orientation, balance, movement planning and navigation of the environment [1,5]. Visual function changes can thus have effects beyond visual performance and may affect gait, balance, obstacle negotiation and functional independence.

Important elements of physiotherapy to address the physical and functional consequences of impaired postural control are balance training, strengthening, gait rehabilitation, sensory integration, task-specific practice, and environmental adaptation [10,13]. The incorporation of visual information and visually oriented activities in rehabilitation may contribute to a more comprehensive strategy in patients with visual dysfunction affecting mobility. In this process, optometry and physiotherapy are complementary. Optometric assessment can identify visual factors that may impair mobility, and physiotherapy can address associated motor, balance, strength and functional deficits. Thus, more communication between these disciplines may aid in individualised and function-oriented rehabilitation. Future rehabilitation models should move beyond isolated treatment of visual or physical impairments and increasingly consider the interaction between vision, sensory integration, postural control and movement[10]. More research is needed to determine standardised interdisciplinary assessment strategies and the effectiveness of integrated vision–movement rehabilitation approaches in various clinical populations. In the end, a multidisciplinary approach could result in safer mobility, better functional performance and more independence among individuals with combined visual and physical challenges.

Conflict of Interest

The authors declare that they have no conflict of interest related to this study, its findings, or the publication of this manuscript.

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