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Mini-Review: Gait and balance assessment in multiple sclerosis

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HIGHLIGHTS

- Gait and balance deficits are significant concerns for people with multiple sclerosis (MS).
- People at early stages of MS have subtle postural balance and gait problems.
- Quantitative and objective measures combined with clinical assessments are important to assess postural balance and gait in MS rehabilitation.
- Kinematics, kinetics, spatiotemporal parameters and posturography appear to be sensitive biomarkers to detect subtle impairments on gait and postural balance in MS.

ABBREVIATIONS

EDSS	Expanded Disability Status Scale
IMUs	Inertial measurement units
MS	Multiple Sclerosis
pwMS	People with multiple sclerosis

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ABSTRACT

BACKGROUND: Gait and balance deficiencies are significant concerns for people with multiple sclerosis, resulting in reduced walking capacity, falls and poor quality of life. Issues caused by sensory loss and the inability to properly reweight sensory information are often reported. Even at the early stages of the disease, subclinical gait and balance impairments can be found.

AIM: In this article, we review objective measures used to assess gait and postural balance impairment in multiple sclerosis patients.

INTERPRETATION: Although scales and clinical tests are important tools for assessing postural instability and walking performance, they can be insensitive to minor disabilities in multiple sclerosis. Instrumented measurements, such as kinematics, kinetics, spatiotemporal gait parameters and center of pressure, play an important role in detecting impairment and evaluating the effects of interventions in people with mild to moderate multiple sclerosis. Thus, objective measurements may be more suitable for tracking deficits in gait and postural balance in multiple sclerosis, contributing to the early detection of disease symptoms, and therefore allowing for the planning of effective interventions to control the speed of disease progression.

KEYWORDS: Walking | Disability | Spatiotemporal Parameters | Center of Pressure | Kinematics | Kinetics

INTRODUCTION

Multiple sclerosis (MS) is characterized by progressive demyelinating deterioration of nervous tissues in the brain and spinal cord, leading to a disruption in the ability of parts of the central nervous system to transmit signals [1]. Gait and balance deficits are significant concerns for people with multiple sclerosis (pwMS), and result in reduced walking capacity, risk of falls and poor quality of life [2,3]. Postural instability reflects, in large part, dysfunctional integration of visual, somatosensory, and vestibular sensory cues, as well as inability to appropriately reweight sensory information. Both issues can affect stability when walking under challenging conditions [4,5].

Expanded Disability Status Scale (EDSS) is the most frequently used scale to evaluate disability level and disease progression among pwMS. EDSS scores are determined based on the seven functional systems: visual, brainstem, pyramidal, cerebellar, sensory, bowel-bladder, cerebral functions, and on walking capacity [6]. In addition to the EDSS, walking capacity and functional balance are traditionally assessed for clinical and research purposes by various other measures, including patient self-reports, clinical scales, functional tests and performance measures, such as Patient-Determined Disease Step (measure of mobility disability), Berg Balance Scale (functional balance assessment), Timed Up and Go test (functional mobility) and 6-Minute Walking Test (walking capacity) [7,8]. Despite the clinical importance of these measures, it may be that these tools are not sensitive enough to detect subtle deficits at an early stage of MS (0-3.5)[9].

People at early stages of MS have subtle balance problems that may affect gait stability [10-12]. MS has a significant effect on gait, even for those with relatively low scores on EDSS [13]. Furthermore, balance and gait parameters in pwMS with different disease progression subtypes have great variability within EDSS categories [14].

Instrumentally assessed gait and postural balance provide sensitive biomarkers for detection of subtle impairments even in the

earliest stages of the disease. Posturography is considered the gold standard for objective measure of standing postural control in pwMS. This is a reliable tool providing quantitative data related to postural instability. Center of pressure (CoP) sway is an appropriate outcome measure indicating postural balance deterioration in pwMS [10,11]. Minor gait abnormalities may be detected by kinematics and kinetics variables. These measurements can provide valuable information on the underlying pathomechanisms of gait and postural control and may represent a complementary tool combined to clinical tests in pwMS [15].

A growing number of clinical trials have investigated the effectiveness of various postural balance and gait interventions in MS. Choosing objective and reliable results is crucial to screen for the disease and determine the effectiveness of interventions. Early detection of disease symptoms in MS, as well as knowledge of gait and postural balance deterioration mechanisms, allow the planning of effective rehabilitation interventions to control the speed of disease progression. This article reviews objective measures used to assess gait and postural balance impairment in multiple sclerosis.

BALANCE AND GAIT ASSESSMENT

Clinical tools and instrumental techniques are available for testing balance function, during static and dynamic situations, and walking performance. There is a growing consensus on the need for quantitative and objective measures combined with clinical assessments to assess balance and gait in MS rehabilitation.

Postural balance

Integration deficits of sensory inputs lead to inadequate motor responses. A major symptom of pwMS who have mild balance disability is poor postural control, resulting from slowed spinal somatosensory conduction [5]. The assessment of balance deficits through disturbances in standing posture with incongruent visual and proprioceptive feedback allows us to increase our knowledge of postural control. Postural balance impairments are most apparent when vision is removed, and the base of support is reduced. Unstable surfaces or incorrect visual information are also used to test the sensory systems involved in postural control.

Static posturography involves the electronic evaluation of the CoP oscillations using force platform, measuring parameters including velocity, path length, and area in different situations such as open/closed eyes and rigid/foam surfaces. Outcomes such as average sway and average speed of sway calculated from mediolateral sway amplitude have been shown to be the strongest predictors to discriminate people impaired by MS from healthy subjects [10]. CoP trajectories during quiet stance showed pwMS have considerable deficits in postural control while standing in comparison to healthy controls [10,11,16].

Gait

MS has a significant effect on gait, particularly on speed, stride length and asymmetry, even for those with relatively low EDSS. Great variability can be found in people with the same level of disability on the EDSS or with the same performance on clinical tests. This effect is amplified when walking at faster speeds or in challenging situations, such as climbing stairs or changing direction while turning, suggesting that these test conditions may be more beneficial for evaluation and treatment [17,18].

The most used outcome measures for functional walking ability assessment in MS have been the 6-Minute Walking Test, a walking capacity measure and the Timed Up and Go test [8]. They are followed by gait spatiotemporal parameters most often used to inform gait speed, cadence, and step length [8,19]. Moreover, assessment of walking speed with short walking capacity tests such as the 25-Foot Timed Walk or the 10-m Walk Test, and tests for walking an intermediate distance, such as the 2-min Walk Test, have been suggested in literature [7].

Walking performance defines the participation of pwMS in many activities of daily life, and dynamic gait stability has been identified as a key risk factor of falls. To compensate for the dynamic gait stability deficit resulting from the slow gait speed, pwMS adopt a short step length to shift the center of mass within the area of stability [12]. Changes in spatiotemporal parameters have also been associated with disability severity according to EDSS level [20].

Although those tests provide excellent information about walking performance, little is known about the biomechanics of movement (joint kinematics and kinetics) and possible compensatory movements. Such knowledge would be fundamental in the elaboration of more efficient treatment plans.

The gait analysis technique can be used to assess the three-dimensional kinematic and kinetic of gait, and allows for a better understanding of the mechanisms underlying gait deterioration in pwMS [21,22]. Even in the early stage of the disease, the most common and reported biomechanical alterations in the lower limbs of pwMS are reduced knee and ankle range of motion increased gait variability and asymmetry along with impaired dynamic stability [21,23].

Most of the propulsive energy for walking is generated around the ankle (plantarflexor power). There is a reduced ankle dorsiflexor power in pwMS, which can be the result of a reduced ankle angular motion and dorsiflexor moment. The ankle dorsiflexor power is the main predictor of step length and walking speed; hence, its reduction is likely to explain slow walking speed in most studies investigating MS related gait deterioration [24].

Furthermore, compared to health control, pwMS has a lower knee extension moment. Reduced knee extension moment is associated with low knee flexion power at initiation of the stance, indicating a reduced ability to eccentrically activate the knee extensor muscles to absorb impact energy at the foot contact point. While reduced knee extensor (quadriceps) strength may explain this, it may also result from increased knee flexion during initial stance in pwMS due to hamstring spasticity [24]. Results indicate that pwMS with a spastic-paretic gait pattern have more deterioration with regard clinical walking function [21,22].

Traditionally, gait analysis uses motion capture systems based on optical cameras and force platforms to measure three-dimensional kinematics and kinetics. Spatiotemporal parameters can be measured on electronic walkways, in addition to motion capture. Currently, new solutions have been proposed to measure kinematics and spatiotemporal parameters of gait. One of the most promising has been wearable technology or inertial measurement units (IMUs). Wearable technology refers to any sensor worn on a person, making continuous and remote monitoring available to many people with chronic disease, including MS. IMUs are small, light wearable sensors that allow accurate quantification of balance and gait impairment that can be used in both clinical and research settings [25,26].

CONCLUSION

More sensitive tools such as posturography can be used to assess postural instability in pwMS, while gait dysfunction can be detected by kinematics and kinetics variables. These measurements provide ways to objectively assess and interpret disease progression and treatment effects. The development of new technologies in biomechanics is making these types of measurements cheaper and more accessible, allowing them to be used more flexibly, in a clinical or real-world environment, in addition to research laboratories.

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