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Inter-limb Center of Pressure Changes and Stance Asymmetry during Long Duration Quiet Standing in Individuals with Hemiplegia Post-Stroke

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Abstract

This study aimed to investigate center of pressure (COP) changes and stance asymmetry during long-duration quiet standing in individuals with hemiplegia secondary to stroke. A total of 10 stroke participants and 12 healthy controls stood on a level floor with eyes open for 120 seconds while their COP displacement, velocity, and loading forces were measured. Inter-limb stability was assessed using COP distance and velocity-dependent phase plane analysis.

The findings revealed significant asymmetry in COP measures, with greater values observed on the non-paretic side in the anterior-posterior direction among the stroke group. This indicated that the majority of weight bearing during the 120 seconds of quiet standing was imposed on the non-paretic side. The over-utilization of the non-paretic side may contribute to increased COP displacements, velocities, and potential postural instability in the anterior-posterior direction. However, the loading forces, COP range, root mean square (RMS) COP, and COP velocity medial-lateral (ML) ratios showed symmetry and were not significantly different from the healthy control group.

These findings highlight the asymmetrical weight distribution and the compensatory "switching" strategy observed in individuals with hemiplegia post-stroke during quiet standing. Understanding these inter-limb differences and postural control patterns can contribute to the development of targeted interventions for improving balance and reducing the risk of falls in this population.

Keywords: Hemiplegia, Stroke, Quiet Standing, Center of Pressure, Stance Asymmetry, Postural Stability

I. Introduction

Balance refers to the ability to maintain equilibrium and center of gravity within the body's base of support during static or dynamic activities. It is controlled by the central nervous system, integrating various peripheral pathways such as visual, somatosensory, vestibular, and motor control systems. Impairments in these systems can significantly reduce balance performance and lead to disability. Post-stroke rehabilitation outcomes indicate varying levels of independent standing ability, with 40% able to stand independently for one minute, 20% with assistance, and 40% unable to stand at all [1-2]. Hemiparesis resulting from stroke affects distal limb muscles more than proximal ones, potentially disrupting postural control. The paretic leg contributes less to corrective torque in the anterior-posterior direction compared to the non-paretic leg [3].

Weight loading strategy between limbs is another crucial aspect of balance control in individuals post-stroke. Many stroke survivors with chronic hemiplegia tend to shift more weight onto their non-paretic side, reducing reliance on the impaired limb for balance [4]. However, some patients may prefer standing over the paretic limb, which can increase instability. Understanding and characterizing balance control require analyzing the center of gravity position and momentum. Phase plane analysis of the center of pressure (COP), incorporating both position and velocity, has shown promise in evaluating balance control. However, its application in post-stroke balance dysfunction has not been thoroughly explored, particularly during long-duration quiet standing [5].

The duration of data recording during upright standing can influence stability analysis. Previous studies have indicated that the magnitude of COP measures in the time and frequency domains is significantly affected by sampling duration. Most investigations on inter-limb COP changes, synchronization, and weight bearing in individuals with hemiplegia have used sampling durations of up to 40 seconds. However, studies recommend longer sampling durations of at least 60 seconds to capture the unique characteristics of postural sway during extended periods of quiet stance. This is particularly relevant for individuals unable to stand for long durations, including those

stability using COP distance and velocity-dependent phase plane analysis during long-duration (120 seconds) upright standing in individuals with post-stroke hemiplegia and compare these measures to age-matched healthy controls.

VI. conclusion

In this study, individuals with hemiplegia post-stroke were examined to assess inter-limb synchronization and postural stability during 120 seconds of quiet standing (QS). The control group demonstrated greater symmetry in center of pressure (COP) measures, evenly distributing weight on both limbs. In contrast, the stroke group exhibited a significant preference for loading weight on the non-paretic side, likely due to reduced muscle activity at the ankle on the paretic side in the anterior-posterior (AP) direction. The overutilization of the non-paretic side, which plays a crucial role in maintaining balance, resulted in larger and faster COP excursions, potentially indicating postural instability in the AP direction. This asymmetry in the AP direction also led to a compensatory weight "switching" strategy in the medial-lateral (ML) direction during long-duration quiet standing. Such a strategy would not have been observed with smaller sampling durations for QS data collection.

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