Systematic Review: Effects of external perturbations on reactive balance control in people with stroke

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Background

Fall Rates[1]

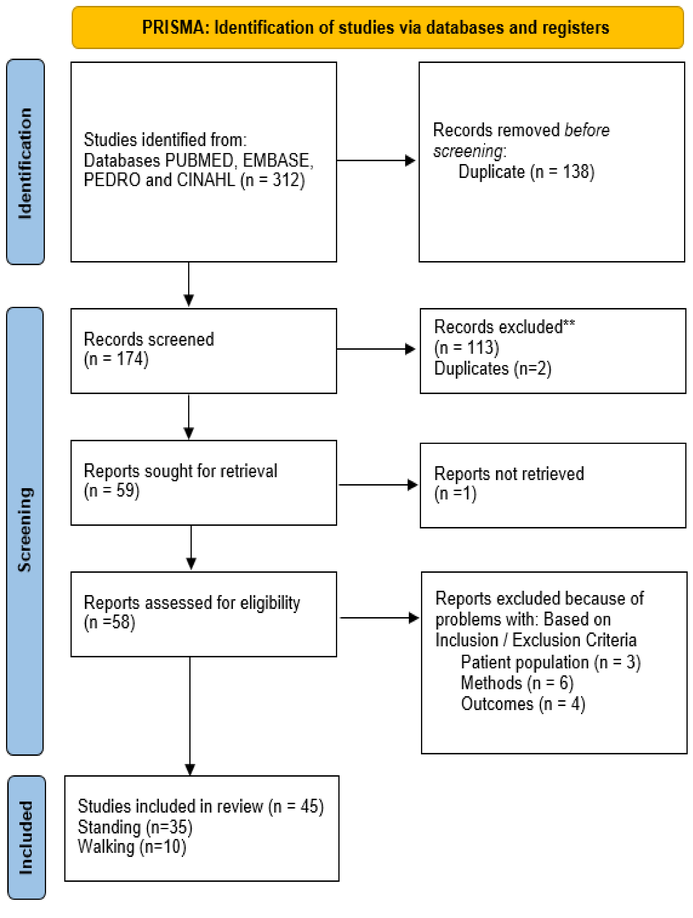
People with Stroke: ~1.4 – 5 falls/ person-year

Comparable healthy older adults:~0.65 falls/person-year

Objectives

To characterize the impairments in reactive stepping in people with stroke, when they respond to a fall caused by external factors.

Methods



Summary of Results

We compared changes in the outcomes listed below, in 3 postural conditions:

1. Walking: Reactions to a mid-step perturbation, given while they were walking
2. No Step: Reactions when subjects resisted a perturbation, given while they were standing still.
3. Single/Multi Step: Reactions when subjects responded to a perturbation, given while they were standing still, with a single step or multiple steps.

Variables	Walking N = 10	No Step N = 16*	Single/ Multi Step N = 21*
Step Width	↑ [2,3,4,5]	NA	Not examined
Step Length	↓ [2,3]	NA	↓ [20, 21, 22, 23, 24, 25]
Number of steps needed to recover balance	↑ [2,3]	NA	↑ [21, 23, 25, 26, 27, 28, 29, 30]
Recovery step characteristics: Step initiation, duration, velocity, clearance	Paretic: Delayed [6,7]	NA	Paretic : Delayed and Reduced [23, 25, 26, 29, 31, 32]
Changes in lower limb joint angles/trunk angles, displacement and velocity	↓ [8,9]	↓ [14,15]	↓ [21, 22, 24, 33]
Electromyography Muscle activation onset, Amplitudes, Strength Response	Paretic delays[10]	Paretic delays[16,17,18,19]	Paretic delays[34]
Correlation between biomechanical variables and clinical outcome measures	Peak CoM ~ 6MWT/ 10MWT/ FSST/ TUG/ FIM/ One-legged stance test displacement in forward perturbations for the paretic leg[11]	CoP stabilization velocity predicted FSST scores in individuals with Stroke[14]	Stepping thresholds ~ FMA[27]; Fall thresholds ~ BBS/ 6MWT/ 10MWT [35]

* 45 papers were included in the systematic review. However, some papers examined no-step, single-step and multi-step responses in a single study. For ease of analysis, we included relevant parts of the same paper in the corresponding categories.

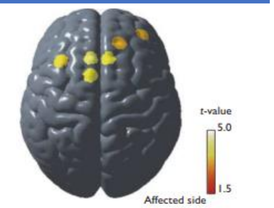
Some of the Outcome Variables Examined:

References

For a complete list references and details of papers included in the systematic review please refer to the attached handout.

Key Additional Findings

- Areas of the cortex in people with stroke, that are activated during reactive stepping[36].



- ~70% of patients had an impaired reactive stepping response as characterized by a need for assistance, an inability to take a reactive step with either lower limb and multi-step responses[26, 37].
- Reactive balance responses vary based on starting position (standing, walking), variations in perturbation intensity, mechanism and direction, and stroke location (Right > Left)[38,39] and residual sensorimotor impairments.
- Impaired foot cutaneous sensation[31] may lead to an increase in falls in individuals with stroke.
- Both paretic and non-paretic sides experience deficits. The non-paretic side compensated for the weaker paretic side[40,41], with anticipatory activation of the non-paretic[12] side muscles, especially during standing.
- The balance and sequence of muscle activation was preserved after a stroke in both the paretic and non-paretic legs, despite deficits[42]. Both legs can modulate foot placement during balance recovery[3].
- Cueing may be used to increase paretic stepping, paretic weight bearing and inter-limb coordination[43, 44].
- Biomechanical adaptations and alterations in stepping strategy occur, even with a single repeated exposure[5] to external perturbations, in people with chronic stroke.

Conclusion

The reactive balance responses characterized by this review, may help determine the most effective strategies to prevent a fall in community ambulatory people with stroke.