



Restoring prolonged standing via functional electrical stimulation after spinal cord injury: A systematic review of control strategies

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ABSTRACT

Background: Functional Electrical Stimulation (FES) technologies can facilitate standing in persons with spinal cord injury (SCI), and prolonged standing elicited via FES may offer both functional and therapeutic benefits to users. However, the current attainable FES-evoked standing duration is typically short and below the threshold for clinical efficacy. To promote the objective selection of suitable control strategies to restore prolonged and higher-quality standing duration, this study summarised current and emerging approaches to FES standing.

Method: PubMed, IEEE Xplore, Web of Science and Google Scholar databases were searched for relevant studies on FES-evoked standing after SCI between the earliest return date and December 2017. Thereafter, the quality of all included studies was objectively evaluated using the Downs and Black methodological assessment checklist.

Results: Twenty-five full-length articles, with mean methodological quality score of 56%, met the inclusion criteria and were retained for analysis. Recent advancements to promote prolonged standing relied greatly on the use of voluntary upper extremities for balancing with arm engaged or disengaged. Some widely-reported constraints were issues of unpredictable postural sway, and unusual muscle responses and perturbations, such as spasm or spasticity, which diminished the reliability of the standing control sensors and algorithms.

Conclusion: Closed-loop control of FES-supported standing with arms-free modality and voluntary upper extremity balancing promoted the “longest” standing duration and “highest” efficacy among the reported methods, albeit with a limited successful transfer of the technology into the routine clinical practice or community deployment. However, open-loop control of FES standing appeared popular, particularly for its therapeutic gains, simplicity of use and other health and psychological benefits associated with weight bearing through the legs. The information from this study could stimulate useful knowledge that may promote clinically significant FES-supported standing duration.

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Contents

1. Introduction.....	35
2. Methods.....	35
2.1. Literature search strategy.....	35
2.2. Eligibility criteria.....	35
2.3. Data extraction from selected articles.....	36

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