Cyprus University of Technology
Faculty of Heath Sciences

**Doctoral Dissertation**

# THE IMPACT OF IN-PHASE BILATERAL UPPER LIMB EXERCISES IN PEOPLE WITH MULTIPLE SCLEROSIS

**Dimitris Sokratous**

**Limassol, April 2025**

CYPRUS UNIVERSITY OF TECHNOLOGY

FACULTY OF HEALTH SCIENCES

DEPARTMENT OF REHABILITATION SCIENCES

Doctoral Dissertation

# THE IMPACT OF IN-PHASE BILATERAL UPPER LIMB EXERCISES IN PEOPLE WITH MULTIPLE SCLEROSIS

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Limassol, April 2025

## Approval Form

Doctoral Dissertation

# THE IMPACT OF IN-PHASE BILATERAL UPPER LIMB EXERCISES IN PEOPLE WITH MULTIPLE SCLEROSIS

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To my dear Stylianos: I truly hope you grow to be much smarter than me and achieve all your dreams. I hope that this shared journey and the lessons learned along the way will serve as a guiding light and inspiration for you in everything you do.

# ABSTRACT

Multiple Sclerosis is an autoimmune disease of the central nervous system, marked by relapses, progressive neurological deterioration, or both. The predominant clinical symptoms include motor dysfunction and cognitive deficits. Relapsing-Remitting Multiple Sclerosis primarily involves motor impairments due to corticospinal tract dysfunction, while Progressive Multiple Sclerosis is associated with significant cognitive and motor decline, often beginning with cognitive processing deficits often appearing first. This thesis examined the effects of in-phase bilateral upper limb exercises on neurophysiological, cognitive, and clinical outcomes in people with Multiple Sclerosis. A 12-week program (30 – 60 minutes/session, three sessions/week) incorporated sports-based and functional motor training. Two clinical trials were conducted across different phenotypes of Multiple Sclerosis. The first clinical trial study used a single-case design with one Relapsing-Remitting Multiple Sclerosis participant, followed by a multiple baseline study with five participants. Visual and statistical analyses assessed intervention effects on corticospinal plasticity, motor and cognitive measures. The second clinical trial study included 20 participants with Progressive Multiple Sclerosis allocated into an experimental group performing in-phase bilateral exercises and into an active control group following conventional exercises. Motor and cognitive improvements were observed using repeated measures ANOVA with Post Hoc Bonferroni corrections. Results showed bilateral reductions in resting motor threshold, measured by Transcranial Magnetic Stimulation, and improvements in motor and cognitive functions in Relapsing-Remitting Multiple Sclerosis. In Progressive Multiple Sclerosis, the experimental group showed significant improvement in motor and cognitive functions compared to the active control group. These findings suggest that in-phase bilateral exercises enhance cortical excitability in Relapsing-Remitting Multiple Sclerosis and improve motor and cognitive functions across people with Multiple Sclerosis in general. This thesis supports in-phase bilateral exercises as an effective neurorehabilitation strategy. Further research should refine methodologies to maximize intervention efficacy.



**Keywords:** Multiple Sclerosis, corticospinal plasticity, Transcranial Magnetic Stimulation, cognitive processing in-phase bilateral, exercise