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ORIGINAL RESEARCH

Resistance Training for Muscle Weakness in Multiple Sclerosis: Direct Versus Contralateral Approach in Individuals With Ankle Dorsiflexors' Disparity in Strength

Andrea Manca, PT, MSc, PhD,[a] Maria Paola Cabboi, MD,[a] Daniele Dragone, PT, MSc,[a] Francesca Ginatempo, MSc,[a] Enzo Ortu, MD, PhD,[b] Edoardo Rosario De Natale, MD, MSc, PhD,[a] Beniamina Mercante, MSc, PhD,[a] Giovanni Mureddu, PT, MSc,[c] Guido Bua, MD,[c] Franca Deriu, MD, PhD[a]

From the [a]Department of Biomedical Sciences, University of Sassari, Sassari; [b]Neurology Unit, "A. Segni" Hospital - ASL n. 1, Sassari; and [c]Neurorehabilitation Unit, Policlinico Sassarese, Sassari, Italy.

Abstract

Objective: To compare effects of contralateral strength training (CST) and direct strength training of the more affected ankle dorsiflexors on muscle performance and clinical functional outcomes in people with multiple sclerosis (MS) exhibiting interlimb strength asymmetry.

Design: Randomized controlled trial.

Setting: University hospital.

Participants: Individuals with relapsing-remitting MS (N=30) and mild-to-moderate disability (Expanded Disability Status Scale score ≤6) presenting with ankle dorsiflexors' strength disparity.

Interventions: Participants were randomly assigned to a CST (n=15) or direct strength training (n=15) group performing 6 weeks of maximal intensity strength training of the less or more affected dorsiflexors, respectively.

Main Outcome Measures: Maximal strength, endurance to fatigue, and mobility outcomes were assessed before, at the intervention end, and at 12-week follow-up. Strength and fatigue parameters were measured after 3 weeks of training (midintervention).

Results: In the more affected limb of both groups, pre- to postintervention significant increases in maximal strength ($P \leq .006$) and fatigue endurance ($P \leq .04$) were detected along with consistent retention of these improvements at follow-up ($P \leq .04$). At midintervention, the direct strength training group showed significant improvements ($P \leq .002$), with no further increase at postintervention, despite training continuation. Conversely, the CST group showed nonsignificant strength gains, increasing to significance at postintervention ($P \leq .003$). In both groups, significant pre- to postintervention improvements in mobility outcomes ($P \leq .03$), not retained at follow-up, were observed.

Conclusions: After 6 weeks of training, CST proved as effective as direct strength training in enhancing performance of the more affected limb with a different time course, which may have practical implications in management of severely weakened limbs where direct strength training is not initially possible.

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Muscle weakness and fatigue are among the most common complaints in people with multiple sclerosis (PwMS). They affect functional capacity and work endurance, reducing quality of life (QOL).[1,2] Direct strength training is safe and effective in addressing muscle weakness in PwMS, with positive effects on activities of daily living and QOL.[2,3] However, it has been

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suggested that in severely weakened and fatigable limbs, a conventional direct strength training may not always be viable.[4,5] This may be the case in PwMS exhibiting marked strength asymmetry, who often develop consistent interlimb performance disparities.[6,7] We recently proposed that PwMS with a limb markedly weaker than the contralateral one or too compromised to sustain a conventional direct strength training may benefit from exercising the more affected limb by contralateral strength training (CST).[8] CST has been demonstrated to induce strength or skills transfer to the contralateral untrained side, indicating a cross-education effect.[9] In a proof-of-concept case series, PwMS with manifest strength asymmetry of the lower limbs showed a consistent increase in performance of the ankle dorsiflexors of the weaker untrained side after a 6-week training of the stronger leg; interestingly, the improvement obtained was paralleled by ameliorations of mobility and clinical functional outcomes.[8] This study provided preliminary evidence that the cross-education effect occurs with a significant magnitude in PwMS. CST of the ankle dorsiflexors has also been tested successfully in poststroke hemiparesis[10,11] and peripheral nerve injury.[12] This muscle group is commonly impaired, particularly in multiple sclerosis (MS),[13] where nearly 40% of patients exhibit ankle dysfunction with serious consequences on gait and mobility (eg, accidental falls).[14] To date, the effectiveness of CST in PwMS with interlimb disparities in strength has not been investigated through a properly planned efficacy trial. Consequently, this study was aimed at comparing the effects of CST and direct strength training of the ankle dorsiflexors on maximal strength, endurance to fatigue, mobility, and walking outcomes in these selected patients. Maximal intensity training was used because it is considered the best strategy to rapidly improve strength and work economy without causing excessive depletion of energetic substrates, which may play a role in the onset of fatigue.[15]

Methods

Participants

Sixty community-based PwMS were screened. Thirty deemed eligible volunteered for this trial, after signing an informed consent. The study was conducted in accordance with the Helsinki Declaration and approved by the Institutional Bioethics Committee. Inclusion criteria were as follows: diagnosis of relapsing-remitting MS; Expanded Disability Status Scale score ≤6, with pyramidal functional system score ≥3; age >18 years; patient-reported evidence of strength asymmetry between dorsiflexors (peak moment interside difference ≥20%); ability to dorsiflex the ankle against gravity; and independent ambulation with or without use of unilateral aids. Exclusion criteria were any contraindications to participate in strengthening exercises; disability and/or comorbidities caused by medical conditions other than MS; occurrence of relapses; treatment with corticosteroid and/or botulin toxin, variations in disease-modifying drugs or symptomatic treatment within 6 months before recruitment; severe ataxia and postural instability (Berg Balance Scale, cutoff value for exclusion: ≤35); major depression (Beck Depression Inventory, cutoff for exclusion: ≥28); clinically relevant cognitive deficits (Frontal Assessment Battery, cutoff for exclusion: ≥14; Trail Making Test parts A and B, cutoffs for exclusion: part A ≥78s; part B ≥273s); and participation in rehabilitative/training programs in the 6-month period preceding the study. A team of neurologists performed all clinical examinations to assess eligibility.

List of abbreviations:

ANOVA	**analysis of variance**
CST	**contralateral strength training**
MS	**multiple sclerosis**
PwMS	**people with multiple sclerosis**
QOL	**quality of life**

Trial design

Design was set as a randomized controlled trial in a randomized 1:1 allocation ratio. Within 2 weeks from the first clinical examination, subjects underwent dynamometric, functional, and QOL (estimated by the Multiple Sclerosis Quality of Life) assessments before (preintervention), after 3 weeks of training (midintervention), after the 6-week intervention (postintervention), and 12 weeks from the last training session (follow-up). Once baseline evaluations were completed, 30 opaque envelopes were numbered consecutively and randomly assigned with a blocking procedure to the training of the weaker (CST group; n=15) or the stronger dorsiflexors (direct strength training group; n=15). Outcome assessors and statistician were blinded to the allocation group.

Strength testing

Ankle dorsiflexors' strength was measured by isokinetic dynamometry.[a] For reliability purposes, a test-retest procedure was used. The same examiner performed all the assessments. The test was conducted in the sitting position with the trunk inclined at 85°, knee flexed at 30°, and ankle in full plantar-flexion as starting position.[16] Participants were firmly stabilized using straps. The dynamometer shaft was aligned with the assumed axis of rotation of the ankle (lateral malleolus). Because all participants were able to dorsiflex on average the ankle 42° to 44° from full plantarflexion, the range of motion for both the tests and training was adjusted to 40°. Participants were naïve to isokinetic strength testing. In the 2 weeks preceding the criterion test, they attended a familiarization session.[17] Participants were instructed to perform a single repetition of maximal concentric dorsiflexion followed by a passive return to plantarflexion. The stronger leg was tested first. A 6-minute rest elapsed between the testing of the limbs. After a light warm-up (1 set of 2–4 submaximal repetitions at 10 and 45°/s angular velocities), the criterion test consisted of 4 maximal efforts at both 10 and 45°/s, to detect the highest value in peak moment and maximal work. The conventional peak moment–based analysis was complemented by maximal work because this is considered an excellent indicator of a muscle group function.[18,19] Low velocities were chosen because patients with neurologic impairments experience difficulties in reaching high velocities.[20] Prior to the test, participants were instructed to pull as hard and fast as possible, without visual feedback or verbal encouragement.[21]

Endurance to fatigue and clinical functional assessments

Muscle endurance of the ankle dorsiflexors was assessed through a 30-repetition bout performed at 180°/s of angular velocity to obtain the mean moment, the total work, and the fatigue index,