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AMERICAN CONGRESS OF REHABILITATION MEDICINE

Archives of Physical Medicine and Rehabilitation

journal homepage: www.archives-pmr.org

Archives of Physical Medicine and Rehabilitation 2016;97:252-8

ORIGINAL RESEARCH

# Perception of Muscular Effort During Dynamic Elbow Extension in Multiple Sclerosis

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**Abstract**

**Objective:** To investigate the perception of muscular effort in individuals with multiple sclerosis (MS) and healthy controls during dynamic contractions.

**Design:** Case-control study.

**Setting:** MS day care center.

**Participants:** Individuals with MS (n=28) and controls (n=28) (N=56).

**Interventions:** Not applicable.

**Main Outcome Measures:** Perceived muscular effort during dynamic elbow extensions was rated at 9 different weight intensities (10%−90% of 1-repetition maximum) in a single-blind, randomized order using the OMNI-Resistance Exercise Scale. Muscle activity of the triceps brachii muscle (lateral head) was measured via surface electromyography and normalized to maximal voluntary excitation.

**Results:** According to OMNI-level ratings, significant main effects were found for the diagnostic condition ($F=27.33$, $P<.001$, $\eta^2=.11$), indicating 0.7 (95% confidence interval [CI], 0.3−1.1) lower mean OMNI-level ratings for MS, and for the intensity level ($F=46.81$, $P<.001$, $\eta^2=.46$), showing increased OMNI-level ratings for increased intensity levels for both groups. Furthermore, significant main effects were found for the diagnostic condition ($F=16.52$, $P<.001$, $\eta^2=.07$), indicating 7.1% (95% CI, −8.6 to 22.8) higher maximal voluntary excitation values for MS, and for the intensity level ($F=33.09$, $P<.001$, $\eta^2=.36$), showing higher relative muscle activities for increasing intensity levels in both groups.

**Conclusions:** Similar to controls, individuals with MS were able to differentiate between different intensities of weight during dynamic elbow extensions when provided in a single-blind, randomized order. Therefore, perceived muscular effort might be considered to control resistance training intensities in individuals with MS. However, training intensity for individuals with MS should be chosen at approximately 1 OMNI level lower than recommended, at least for dynamic elbow extension exercises.

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Multiple sclerosis (MS) is a progressive inflammatory autoimmune disease that affects quality of life by increasing disability and muscle weakness. Strength deficits in individuals with MS may result either from reduced physical activity or from impaired neural mechanisms (eg, reduced ability to fully activate motor units, reduced rate of force development).[1] Resistance training has been demonstrated to be an effective method to improve muscle strength and quality of life in individuals with MS.[1,2] In general, the current recommendation to determine an individual's proper training intensity is to use maximum strength testing protocols.[3,4] However, despite the common and widespread use of such protocols, contradicting evidence exists that draws into question the applicability and generalizability of the 1-repetition maximum (1RM) strength test, specifically for populations such adolescents, older adults, and cardiac patients.[4] In healthy populations, perceived muscular effort is recommended as a valid alternative to determine training intensity during resistance training.[5-7] The physical activity guidelines for individuals with MS recommend selecting an appropriate weight for exercises that are performed

Disclosures: none.

0003-9993/15/$36 - see front matter © 2016 by the American Congress of Rehabilitation Medicine
http://dx.doi.org/10.1016/j.apmr.2015.10.082

for 2 sets of 10 to 15 repetitions each; therefore, an adequate but safe resistance is provided to participants, which ensures their maximal effort during the last few task repetitions.[8] However, these recommendations allow for some interpretation in regard to the training weight. Furthermore, the rating of perceived muscular effort may be used for individuals with MS in determining their training intensity, specifically if they demonstrate muscular strength levels comparable with healthy controls. During static elbow extensions at different levels of perceived muscular effort, previous literature has reported no differences in relative torque values and relative muscle activity between individuals with MS and healthy controls.[9]

Perception of muscular effort is a cognitive ability that is based on peripheral sensory feedback (eg, information on length and tension of the muscles, central control mechanisms, previous experiences and expectations).[10,11] Proprioceptive stimuli, however, partly differ in dynamic and static muscle activity. Therefore, it is questionable if perception of muscular effort is affected by dynamic (concentric) muscle contraction compared with static contraction. Individuals with MS are recommended to perform resistance training with dynamic muscle activity[12]; therefore, the ability to perceive muscular effort during dynamic muscle activity is crucial. To our knowledge, this has not yet been investigated in individuals with MS; therefore, the objective of this study was to investigate perception of muscular effort during dynamic elbow extensions in individuals with MS and healthy controls.

## Methods

### Participants

Twenty-eight individuals with MS from the ambulatory MS day care center at the Caritas Socialis Care and Social Center Rennweg (Vienna, Austria) and the Viennese Multiple Sclerosis Society (Vienna, Austria) and 28 controls from employees and volunteers at the Caritas Socialis Center completed this study (fig 1). They were recruited through e-mails and flyers containing information about the study. Sample size was estimated to be 28 participants per group based on an $\alpha$ level of .05, power $(1-\beta)$ of .90, and effect size (partial $\eta^2$) of .14.

Inclusion criteria required participants to be between 40 and 60 years of age, be able to perform the test, and have signed a written informed consent. Additionally individuals with MS were required to have confirmed diagnosis by a neurologist based on the McDonald criteria,[13] scored <9 on the Expanded Disability Status Scale,[14] and be absent of any clinically diagnosed relapse within the last 8 weeks. Exclusion criteria included the following: missing of an appointment, performing <2.5kg 1RM during the dynamic elbow extension task with the dominant arm, having limited range of motion in the elbow of the dominant arm, experiencing pain within the last 8 weeks in the dominant arm, spasticity in the elbow muscles of the dominant arm, impaired sensibility of touch or proprioception in the dominant arm, earlier injuries in the elbow of the dominant arm, any cognitive impairments defined by a Mini-Mental State Examination score <25,[15] any symptoms of depression defined by a Beck Depression Inventory score[16] >19, any physically disabling cardiovascular diseases, or pregnancy. In addition, controls were excluded if they had any neurologic diseases. Demographic characteristics are presented in table 1.

***List of abbreviations:***

| | |
|---|---|
| **CI** | **confidence interval** |
| **ICC** | **intraclass correlation coefficient** |
| **MS** | **multiple sclerosis** |
| **OMNI-RES** | **OMNI-Resistance Exercise Scale** |
| **1RM** | **1-repetition maximum** |

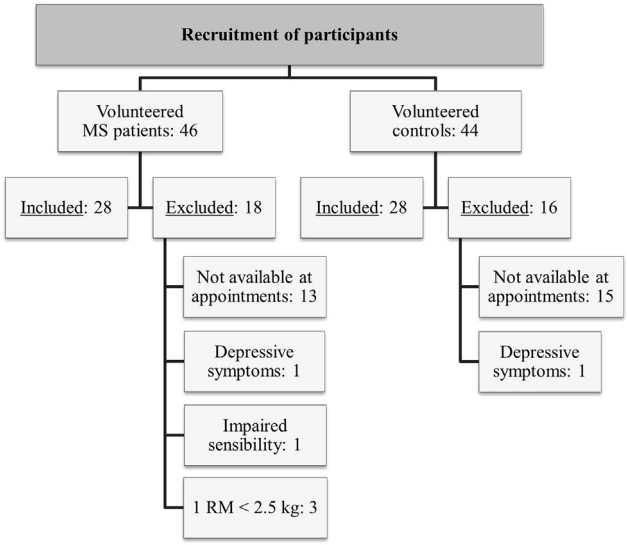


**Fig 1** Recruitment of participants.

### Study design

This study was a monocentric case-control study conducted from May to June 2013. It was authorized by the ethics committee of the municipal authorities of the City of Vienna. Each participant was required to visit the Physiotherapy Department at the Caritas Socialis Center for 3 sessions: once for familiarization (session 1) on day 1 and twice on day 2 for the 1RM test session (session 2) and rating of perceived muscular effort session (session 3). Sessions 2 and 3 were separated by at least a 3-hour rest period. The tests on day 2 took place approximately 1 week after day 1. All tests were administered by a single investigator.

Participants performed single-arm dynamic elbow extensions with different weights on a cable pulley machine.[a] Participants were seated in an upright position and their dominant hand (the arm which was raised initially to reach for an object) was placed on the handle of the cable pulley machine (forearm 80° pronation, wrist 30° dorsal extension). While maintaining the shoulder joint in a neutral position, the dynamic movement started with the elbow flexed at 90° and ended with a fully extended elbow joint with the forearm pronated and wrist extended at 30° during the whole movement (fig 2). Each weight had to be moved twice throughout the whole elbow extension range of motion (hereafter referred to as double-elbow extensions). The exercise was performed at a selected rate of 25 extensions per minute so that the average angular velocity was approximately 75°/s. To ensure precise timing of the task, all subjects received oral instructions (eg, and up, and down…) from a physiotherapist. During the task, all participants were blinded to the size of the weights. After task completion, participants were asked to rate their perceived muscular effort using the OMNI-Resistance Exercise Scale (OMNI-RES).[17] The scale