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Relationship between muscle strength parameters and functional capacity in persons with mild to moderate degree multiple sclerosis

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Abstract
Background: Maximal muscle strength has been shown to be an important predictor of functional capacity for persons with multiple sclerosis (PwMS). Another muscle strength parameter known to be important for functional capacity in other patient groups is rate of force development (RFD) in knee extensors and flexors. This has not been investigated for PwMS. Thus, the purpose of this study was to investigate the relationship between RFD and maximal muscle strength of knee extensors and flexors and measures of functional capacity in PwMS.
Methods: 35 PwMS (Expanded Disability Status Scale 2–4) underwent isokinetic dynamometry to determine RFD and maximal isometric and isokinetic muscle strength for both legs. Furthermore all participants performed timed 25 foot walk tests (T25FWT), two minute walk tests (2MWT), stairclimb tests and 5-time sit-to-stand (5STS) tests to determine functional capacity. Multiple linear regressions were performed to determine which muscle strength parameter would serve as a stronger predictor of walking performance.
Results: Both RFD and maximal muscle strength correlated with functional capacity. Correlations were strongest for knee extensors and flexors of the weaker leg, while no clear ranking of the influence of the knee extensors vs. flexors on walking was evident. Multiple linear regressions showed that maximal isokinetic strength of the weaker leg is a better predictor for T25FWT and 2MWT performance than RFD.
Conclusions: Maximal muscle strength of the weaker leg is the better predictor of walking performance in persons with mild to moderate multiple sclerosis. RFD, although also important for

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functional capacity, is a less strong predictor. Maximal strength of the knee extensors, rather than the knee flexors, predicted performance in the stairclimb and 5STS tests.

1. Introduction

Multiple sclerosis (MS) is a chronic, progressive, auto-immune, and neurodegenerative disease of the central nervous system (Compston and Coles, 2008), with unknown aetiology (Kantarci, 2008). A common symptom of MS is reduced functional capacity (Savci et al., 2005), which manifests itself as reduced walking speed/distance and impaired ability to perform activities of daily living (ADL). For persons with MS (PwMS) walking is perceived as the most important bodily function (Heesen et al., 2008) and walking speed/distance is a significant predictor of perceived difficulties or independence (Paltamaa et al., 2007). Compared to healthy control subjects, many PwMS walk slower in short (Morris et al., 2002; Thoumie and Mevellec, 2002) and long (Savci et al., 2005; Schwid et al., 1999) walking tests, when applying both preferred/comfortable (Morris et al., 2002; Schwid et al., 1999) and maximal walking speed (Savci et al., 2005; Thoumie and Mevellec, 2002). Furthermore, many PwMS self-report impaired walking capacity (Larocca, 2011) and show progressively reduced walking speed as the disease progresses (Kempen et al., 2011) due to increased spasticity and other indicators of impaired motor control (Bethoux, 2013). PwMS also self-report difficulties in other ADL such as stair case climbing and getting out of a chair (68% and 18% report problems, respectively) (Larocca, 2011). Consequently, it is important to identify and understand modifiable predictors of walking and other ADL, to optimise rehabilitating interventions.

A well-known predictor of walking is lower-body muscle strength which is often impaired in MS patients (Schwid et al., 1999). Also rate of force development (RFD) (Chen et al., 1987) is impaired in PwMS. RFD is another muscle strength parameter that correlate to functional activities such as walking for healthy elderly people (Holviala et al., 2014) and also relate to balance and falls (Aagaard et al., 2007). Moreover, other parameters related to walking performance in PwMS, comprise knee joint muscle strength (Thoumie and Mevellec, 2002; Thoumie et al., 2005; Broekmans et al., 2013; Yahia et al., 2011), knee joint muscle strength asymmetry (Sandroff et al., 2013), knee extensor power asymmetry (Chung et al., 2008) and ankle dorsiflexor strength (Wagner et al., 2014) and RFD (Ng et al., 2004). Knee extensor and flexor muscle strength of the weaker leg (Thoumie and Mevellec, 2002; Thoumie et al., 2005; Broekmans et al., 2013) shows a stronger relation to walking performance than that of the stronger leg, with one study, however, reporting inconsistent results (Yahia et al., 2011). Furthermore, knee flexor muscle strength has been suggested to be better related to walking performance than knee extensor muscle strength (Thoumie and Mevellec, 2002; Thoumie et al., 2005; Broekmans et al., 2013; Yahia et al., 2011). Until now, however, the existing studies have focused on the relationship between functional capacity and maximal muscle strength rather than RFD, despite RFD being shown as an equally important predictor of functional capacity in other functionally impaired groups (Holviala et al., 2014). Consequently, the relationship between functional capacity and knee extensor and flexor RFD remains to be established in PwMS.

The present study therefore aimed to determine the relationship between functional capacity and knee joint muscle strength parameters in terms of muscle strength and RFD. We hypothesised that knee joint RFD as well as maximal muscle strength would be related to functional capacity. A secondary purpose of the study was to examine if we could reproduce findings from previous studies indicating that knee flexor muscle strength (Thoumie and Mevellec, 2002; Thoumie et al., 2005; Broekmans et al., 2013; Yahia et al., 2011), and knee joint muscle strength of the weakest leg (Thoumie and Mevellec, 2002; Thoumie et al., 2005; Broekmans et al., 2013) predict walking performance better than knee extensor muscle strength and knee joint muscle strength of the strongest leg, respectively.

2. Materials and methods

2.1. Subjects

Thirty-five subjects were recruited from the MS Clinic at Aarhus University Hospital and MS Clinic of Southern Jutland. Inclusion criteria were 18–60 years, a definite relapsing-remitting MS diagnosis according to the McDonald criteria (McDonald et al., 2001), Expanded Disability Status Scale (EDSS) 2.0–5.5 (with a 'pyramidal functions' subscore ≥ 2), interferon-based medicine (Avonex, Rebif, Betaferon and Extavia). Exclusion criteria were; co-morbidities preventing participation (cardiovascular disease, metabolic diseases etc.), pregnancy, relapse eight weeks prior to inclusion, systematic resistance training three months prior to inclusion. All participants gave written informed consent, which was approved by the ethics committee of Region Midtjylland (M-20110178) in accordance with the Declaration of Helsinki. The data of the present study is baseline data from a clinical trial designed to investigate the underlying mechanisms possibly explaining the beneficial effects of progressive resistance training for PwMS (ClinicalTrials.gov ID: NCT01518660).

2.2. Demographic measures

EDSS was assessed by trained neurologists. Height was measured and weight was determined using a body composition analyser (Tanita SC220, Tanita, IL, USA). In addition to this, the 12-item MS Walking Scale (MSWS-12) (Hobart et al., 2003) was completed.