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Review Article

Muscle strength and power in persons with multiple sclerosis – A systematic review and meta-analysis

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ABSTRACT

Background: Multiple sclerosis (MS) is a chronic disease in the central nervous system which causes a number of physical symptoms including impairments of muscle mechanical function (muscle strength, muscle power and explosive muscle strength (~rate of force development, RFD)). However, a full overview of the existing knowledge regarding muscle mechanical function in persons with MS (PwMS) is still pending.
Objectives: To systematically review 1) the psychometric properties of isokinetic dynamometry testing in PwMS, and 2) studies comparing muscle mechanical function in PwMS to matched healthy controls (HC). In addition, a meta-analysis will evaluate 3) the effects of progressive resistance training on muscle mechanical function in PwMS.
Methods: A systematic literature search was performed in eight databases. To be included in the review, the study had to 1) enroll participants with a confirmed diagnosis of MS; 2) assess muscle mechanical function 3) had undergone peer-review. The psychometric properties of isokinetic dynamometry were reviewed with respect to validity, reliability, and responsiveness. Comparison of muscle strength between PwMS and HC was performed across contraction velocities, contraction modes and muscle groups, as were the rate of force development. The effects of progressive resistance training on muscle mechanical function were evaluated in a meta-analysis using a random effects model and standardized mean difference (SMD).
Results: A total of four, twenty-four, and ten studies were identified for aim 1, 2, and 3, respectively. High Intraclass correlations coefficients (range: 0.87–0.99) for isokinetic dynamometry was reported when assessing knee extensor and knee flexor muscle strength independent of contraction velocity. Compared to match HC, PwMS display impaired muscle strength, power and explosive muscle strength. Muscle strength impairments were most pronounced during maximal moderate to fast dynamic muscle contractions of the lower extremities. Progressive resistance training has a small but significant effect on muscle mechanical function in PwMS (SMD = 0.45, 95% CI: 0.18–0.72, $p = 0.001$).
Conclusions: The present review showed that 1) isokinetic dynamometry has a high reliability in PwMS; 2) muscle strength, power and rate of force development is impaired in PwMS compared to HC, and muscle strength impairments are most pronounced during maximal moderate to fast dynamic muscle contractions of the lower extremities; and 3) progressive resistance training can improve muscle mechanical function in PwMS. Future studies should evaluate progressive resistance training designed to optimize maximal moderate to fast dynamic muscle contractions of the lower extremities.

Contents

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1. Introduction

Multiple sclerosis (MS) is a chronic inflammatory disease of the central nervous system. In the developed countries MS is the leading cause of disability in young adults [1]. While the exact etiology of MS still remains unclear, an interaction between environmental and genetic susceptibility are believed to be involved [1]. Consequences of MS involve destruction of myelin, oligodendrocytes, and axons, with demyelination compromising nerve fiber function by slowing axonal conduction velocity leading to an assortment of impairments [2]. One of these impairments concerns reduction in muscle mechanical function (i.e. isometric strength, dynamic strength, explosive strength (rapid force development), and muscle power) [3], as often reported in PwMS [4–6].

Reductions in muscle mechanical function are likely to have critical implications in people with MS (PwMS) at all levels of the ICF model [7]. Studies show that reduced lower extremity muscle strength and power negatively influences walking performance [6,8–10], balance [9], stair climbing and sit-to-stand ability reported both objectively [10,11] and subjectively [12]. This could potentially translate into the lower physical activity levels observed in PwMS compared to healthy controls (HC) [13,14]. The lower activity level could potentially also increase the risk of all-cause mortality, cardiovascular diseases (CVD), metabolic syndrome, osteoporosis and some types of cancer [15,16]. Ultimately, PwMS are likely to experience an impaired health-related quality of life, worsening of impairments and an increased risk of CVD and other comorbidities [17–20]. It is of great importance to expand our understanding of muscle mechanical function in PwMS, in order to optimize and develop future interventions aimed to improve muscle mechanical function in PwMS.

Despite the existing knowledge covering muscle mechanical function in PwMS, three aspects have received less attention. First, it is essential to apply valid, reliable, and responsive methods/techniques when performing quantitative measurements of muscle mechanical function in PwMS. While isokinetic dynamometry is viewed as the "gold standard" when assessing muscle strength and has been widely used in PwMS, no review has summarized the psychometric properties of isokinetic dynamometry in PwMS. Second, several cross-sectional studies have compared muscle mechanical function in PwMS to HC [4,5,21]. While these comparisons can provide detailed knowledge on some of the consequences of MS, and help elucidate if any muscle groups (e.g. lower vs. upper body and extensors vs. flexors), contraction modes (i.e. eccentric, isometric or concentric) or contraction velocities are more affected than others, no review has summarized the current knowledge on muscle mechanical function (including dynamic and isometric muscle strength, explosive muscle strength (RFD), and muscle power) in PwMS compared to HC. Third, muscle mechanical function is known to be responsive to progressive resistance training (PRT) interventions in healthy subjects [22,23]. Previous reviews on PRT in PwMS report positive effects on muscle mechanical function (i.e. isometric muscle strength, dynamic muscle strength, explosive muscle strength (RFD), and muscle power) in PwMS [24,25]. However, only one meta-analysis investigating the effects of general exercise training on muscular fitness could be identified in PwMS [26]. The meta-analysis showed a small positive effect of exercise training on muscular fitness, but no distinction was made between the type of exercise modality, which may have diminished the effects since exercise modalities such as balance training and aerobic training would normally not be expected to improve muscle strength. Consequently, an updated meta-analysis including studies with well-defined PRT regimes are still warranted.

Thus, the aims of this review were to systematically review 1) the psychometric properties of "gold standard" isokinetic dynamometry in PwMS, 2) the literature that compares muscle mechanical function in PwMS to HC, and 3) to conduct a meta-analysis of studies evaluating the effects of PRT on parameters of muscle mechanical function in PwMS.

2. Method

The current systematic review and meta-analysis were conducted in accordance to the PRISMA guidelines [27]. All included studies had to have undergone peer-review, had to be in English, Danish, Swedish, or Norwegian, and have enrolled patients with a confirmed diagnosis of MS according to established criteria [28]. Furthermore, studies had to fulfill the following specific criteria in order to be included in Aim 1–3:

Aim 1

Assessment of the psychometric properties of isokinetic dynamometry in PwMS.

Aim 2

Assessment of muscle mechanical function (maximal voluntary isometric or dynamic strength (MVIC and MVDC, respectively), power, RFD) in both PwMS and HC reported as bodyweight-adjusted or absolute values, from upper and/or lower limbs (hands and feet excluded). Studies assessing muscle strength using hand held dynamometer or manuel muscle testing were excluded.

Aim 3

Application of a randomized controlled or non-randomized clinical study design, with ≥8 participants in each group; Assessment of the effects of a ≥ 3 week resistance training intervention (in accordance with American College of Sports Medicine guidelines for resistance training interventions [29]) on parameters of muscle mechanical function compared with no training or usual care.

2.1. Literature search

Separate systematic searches combining free text words and subject headings for each of the three aims were performed.

The systematic searches were performed in eight databases (PubMed, Embase, CINAHL, SPORTdiscus, Cochrane Library, PEDro,