Clinical Neurology and Neurosurgery 122 (2014) 97–105

Contents lists available at ScienceDirect

Clinical Neurology and Neurosurgery

journal homepage: www.elsevier.com/locate/clineuro

Recovery of peripheral muscle function from fatiguing exercise and daily physical activity level in patients with multiple sclerosis: A case-control study

Kelly Ickmans [a,b], Fauve Simoens [a], Jo Nijs [a,b,*], Daphne Kos [c,f], Patrick Cras [d], Barbara Willekens [d], Mira Meeus [e,f]

[a] Pain in Motion Research Group, Departments of Human Physiology and Physiotherapy, Faculty of Physical Education & Physiotherapy, Vrije Universiteit Brussel, Belgium
[b] Department of Physical Medicine and Physiotherapy, University Hospital Brussels, Belgium
[c] Pain in Motion Research Group, Division of Occupational Therapy, Artesis University College Antwerp, KU Leuven, Belgium
[d] Department of Neurology, Faculty of Medicine, Antwerp University , Belgium
[e] Rehabilitation Sciences and Physiotherapy, Faculty of Medicine, Antwerp University, Belgium
[f] Rehabilitation Sciences and Physiotherapy, Department of Rehabilitation Sciences and Physiotherapy, Ghent University, Belgium

ARTICLE INFO

Article history:
Received 30 August 2013
Received in revised form 20 March 2014
Accepted 23 April 2014
Available online 2 May 2014

Keywords:
Multiple sclerosis
Muscle recovery
Physical activity
Rehabilitation
Physiotherapy

ABSTRACT

Objectives: Delayed recovery of muscle function fo`owing exercise has been demonstrated in the lower limbs of patients with multiple sclerosis (MS). However, studies examining this in the upper limbs are currently lacking. This study compared physical activity level (PAL) and recovery of upper limb muscle function following exercise between MS patients and healthy inactive controls. Furthermore, the relationship between PAL and muscle recovery was examined.
Methods: PAL of 19 MS patients and 32 controls was measured using an accelerometer for 7 consecutive days. Afterwards, recovery of muscle function was assessed by performing a fatiguing upper limb exercise test with subsequent recovery measures.
Results: Muscle recovery of the upper limb muscles was similar in both groups. Average activity counts were significantly lower in MS patients than in the control group. MS patients spent significantly more time being sedentary and less time on activities of moderate intensity compared with the control group. No significant correlation between PAL and recovery of muscle function was found in MS patients.
Conclusions: Recovery of upper limb muscle function following exercise is normal in MS patients. MS patients are less physically active than healthy inactive controls. PAL and recovery of upper limb muscle function appear unrelated in MS patients.

1. Introduction

Multiple sclerosis (MS) is a chronic and progressive demyelinating disease of the central nervous system (CNS). The disease is characterized by a demyelination process that expresses itself in inflammation and damage of axons in the CNS. This damage results in an important conduction delay and eventually a conduction block of electrical potentials at the level of the lesions [1–5].

MS has a large impact on life, mainly because of the unpredictability in progression and heterogeneous presentation of symptoms. The disease presents with a wide variety of chronic and variable symptoms (including cerebellar-, motor-, sensory-, emotional- or sexual-related symptoms) depending on the affected area in the CNS [1–3,6,7].

Previous studies demonstrated various central and peripheral muscle alterations in MS during and after fatiguing exercise. Examples of these alterations are an incomplete motor unit recruitment [8], slowing of muscle contractile properties [9,10], decreased muscle oxidative capacity [8,11], impaired excitation–contraction response [8–10], impaired calcium kinetic properties [9], and altered muscle metabolic response to exercise such as a larger decrease in intracellular phosphocreatine and pH [11]. All of these can possibly influence recovery of muscle function post-

* Corresponding author at: Vrije Universiteit Brussel, Medical Campus Jette, Building F-Kine, Laarbeeklaan 103, BE-1090 Brussels, Belgium. Tel.: +32 24774489; fax: +32 26292876.
E-mail addresses: Jo.Nijs@vub.ac.be, http://www.paininmotion.be (J. Nijs).

http://dx.doi.org/10.1016/j.clineuro.2014.04.021
0303-8467/

exercise. A study by Sharma et al. [9] showed a delayed muscle recovery in MS patients after a low intensity fatiguing exercise protocol where an electrical stimulus of 50 Hz was given for 240 ms once every 3 s for a total of 9 min. MS patients showed an exaggerated metabolic response to exercise. In contrast to these findings, no difference in muscle recovery was found between MS patients and healthy controls after a short-term high intensity exercise (50 Hz stimulation trains for 500 ms with 1000 ms between the trains for a period of 90 s (60 muscle contractions/90 s)) [10]. These conflicting findings, of studies performed at the level of the lower limbs, might be due to a lack of controlling for daily physical activity level which can potentially bias the study findings. Yet, the authors of the latter study found that the maximal rate of force rise (muscle speed) was still impaired in the MS group after a 9 min recovery period, indicating their excitation–contraction coupling was still impaired [10]. This impairment was also found by Sharma et al. [9] who demonstrated this through a reduced release of calcium from the sarcoplasmatic reticulum, possibly contributing to the described delayed muscle recovery following exercise [9,12]. A delayed recovery can limit several physical functions and activities in MS patients [13,14].

It is possible that a delayed recovery of muscle function is a consequence of physical deconditioning. MS patients can have different and variable physical limitations, which can result into physical inactivity. Previous studies found that patients who suffer from MS are less physically active compared to healthy active people [15–17] and healthy sedentary persons [15]. Sandroff et al. [18] noticed that these studies overrated this difference in physical activity as a result of using non-valid assessment tools, too small sample sizes and no control group matched for age, sex, height and weight. When taking these limitations into account, Sandroff et al. [18] still found a reduced physical activity level in MS patients but this difference was smaller than in the previous studies. Apart from the latter study, to date, there is no other research on this subject with the same study conditions. Therefore, it seems warranted to further study daily physical activity level in MS patients versus matched healthy inactive controls, using a valid measure for real-time physical activity monitoring. Furthermore, examining the time spent on different types of physical activities to get a more precise image of the physical activity pattern in MS patients will provide us with some important information. Moreover, reduced physical activity has negative consequences including an increased risk of secondary conditions such as cardiovascular diseases [18,19]. Physical activity is a behavioral component which is modifiable [5,18] and may therefore play an important role in the treatment of MS.

The purpose of this study was to examine recovery of upper limb muscle function together with daily physical activity level in MS patients and a healthy age-, body mass index- and sex-matched inactive control group. It is hypothesized that MS patients present with delayed recovery of muscle function and a reduced daily physical activity level compared to the control group. Furthermore, this study investigates for the first time the association between the daily physical activity level and recovery of upper limb muscle function in MS patients and a healthy age-, body mass index- and sex-matched inactive control group. Likewise, these two variables may have an important association with each other. The hypothesized relationship between the two is based on the knowledge about modified muscle adaptations in MS patients, which can influence muscle recovery post-exercise and the knowledge that a prolonged recovery can limit physical functions. Considering the important relationship of physical activity level with both levels of self-reported fatigue and quality of life (QoL) in people with MS, as demonstrated in several previous studies [4–23], these factors will be further taken into account.

2. Materials and methods

This study was designed as a blinded case-control study. The study took place at the Pain in Motion research lab of the Artesis University College Antwerp and the Vrije Universiteit Brussel between February 2011 and December 2012. The study protocol was approved by the ethics committees of the University Hospital Brussels/Vrije Universiteit Brussel and the University Hospital Antwerp.

2.1. Participants

Patients with MS were recruited through the neurology department of the University Hospital of Antwerp. No restrictions regarding MS subtype were made for study inclusion, and MS had to be diagnosed according to the McDonald criteria [24,25]. All participating MS patients were diagnosed by an experienced neurologist at our university hospital. The diagnosing neurologist is specialized in MS patients. Furthermore, the patients had to have an expanded disability status scale (EDSS) score <6 and had to be relapse-free in the last 3 months.

Healthy control subjects were recruited via MS patients already participating in the study and via students and staff of the research group (friends, family, or acquaintances). Control subjects had to be inactive, pain-free and could not suffer from a (chronic) disease. Inactivity was defined as having a seated occupation and performing a maximum of 3 h of moderate physical activity per week. Moderate physical activity was defined as: “Activity demanding at least the threefold of the energy spent passively” [26]. Subjects of both groups could be men or women between 18 and 65 years old. Pregnancy was not allowed for study participation. All participants were asked not to start new treatments during the study period (in particular medication, rehabilitation or other consultations with paramedics or alternative medicine). Furthermore, every participant was asked not to undertake heavy physical activities and to refrain from the use of substances like caffeine, alcohol, nicotine, and benzodiazepines which could influence physical performance on the day of the second visit.

2.2. Procedure and assessments

Fig. 1 shows the flow diagram of the study. During their first visit, participants were asked to sign an informed consent form. After registering their age, sex, height and weight, they were provided with an accelerometer which they had to wear continuously on the wrist of the non-dominant hand during 7 consecutive days. After these 7 days of accelerometry their second visit was scheduled. On the second assessment day the accelerometer was returned and participants performed a fatiguing exercise test and subsequent recovery measures with a hydraulic hand dynamometer. During the recovery period they filled out the medical outcomes study 36-item short form health survey (SF-36) and the checklist individual strength (CIS). The assessor (K.I.) was blinded for the diagnosis and success of blinding was checked at the end of the second visit by asking the assessor to which group she thought the participant belonged to.

3. Real-time activity monitoring

Physical activity was measured using an Actical accelerometer (Mini Mitter, Bend, OR, USA) measuring accelerometer activity counts [27]. The Actical contains an omni-directional sensor capable of detecting accelerations in two planes. It identifies low frequency gravity forces common to human movements and registers magnitude and duration of the detected acceleration. An increase in speed and motion produces an increase in voltage. This