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Anti-gravity training improves walking capacity and postural balance in patients with muscular dystrophy

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Abstract

Recent studies in patients with muscular dystrophies suggest positive effects of aerobic and strength training. These studies focused training on using bicycle ergometers and conventional strength training, which precludes more severely affected patients from participating, because of their weakness. We investigated the functional effects of combined aerobic and strength training in patients with Becker and limb-girdle muscular dystrophies with knee muscle strength levels as low as 3% of normal strength.

Eight patients performed 10 weeks of aerobic and strength training on an anti-gravity treadmill, which offered weight support up to 80% of their body weight. Six minute walking distance, dynamic postural balance, and plasma creatine kinase were assessed 10 weeks prior to training, immediately before training and after 10 weeks of training. Training elicited an improvement of walking distance by $8 \pm 2\%$ and dynamic postural balance by $13 \pm 4\%$, indicating an improved physical function. Plasma creatine kinase remained unchanged. These results provide evidence that a combination of aerobic and strength training during anti-gravity has the potential to safely improve functional ability in severely affected patients with Becker and limb-girdle muscular dystrophies.

Keywords: Becker muscular dystrophy; Limb-girdle muscular dystrophy; Rehabilitation; Training; Gait; Dynamic postural balance

1. Introduction

Recessively inherited Limb-Girdle Muscular Dystrophy type 2I (LGMD2I) and X-linked inherited Becker Muscular Dystrophy (BMD) are muscle diseases, characterized by progressive, proximal muscle weakness and wasting.

There is no cure for LGMD2I and BMD, but several studies have shown that aerobic exercise is safe and beneficial in a number of muscle diseases, including LGMD2I and BMD [1–3]. Supervised resistance training may also improve muscle strength and endurance in patients with LGMD2I and BMD [4], and has been shown to improve postural balance and flexibility in elderly people [5]. Previous training studies of muscular dystrophy have all been conducted in ambulatory patients, able to exercise unassisted for 30 min per day. The question is whether patients, who are too weak to undertake independent, unsupervised aerobic training, can also benefit from training.

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This question has not been studied before because of; (1) concerns that repeated muscle contractions could accelerate muscle degradation, (2) limited practical possibilities for training very weak muscles, and (3) patients with initial strength levels of <10% of normal have been considered too weak to gain any training effect [6]. This is regrettable, since health risks and increased morbidity associated with a sedentary inactive lifestyle are no different in patients with neuromuscular diseases as compared to the rest of the population [7].

A recently developed "anti-gravity treadmill", has been proven an effective and safe rehabilitation tool for patients to reduce loads on lower limbs while preserving gait pattern and free range of motion [8]. This tool offers the opportunity to train individuals with reduced muscular strength, injuries or other conditions that could potentially limit the possibilities to perform physical exercise in a natural environment.

We hypothesized that patients with severe LGMD2I and BMD may benefit from moderate aerobic and strength training in a weight-supported environment, giving this group a possibility to gain from physical exercise and safely improve their functional level. Since patients with LGMD2I and BMD share a similar phenotype, as evident from the differential diagnostic problems with these diseases [9], and since moderately affected patients from both groups have shown positive effects of aerobic training [1,2], we chose to include both patient groups in this training study.

We aimed to investigate the functional effects of 10 weeks of combined aerobic and strength training performed in an anti-gravity environment in patients with moderate to severe BMD and LGMD2I.

2. Materials and methods

2.1. Subjects

Eight patients (age; 36 ± 4 years: weight; 73 ± 5 kg: height; 176 ± 3 cm) completed a 10-week training program. Five men had BMD, and one man and two women had LGMD2I (Table 1). Patients were recruited from the Neuromuscular Clinic, Rigshospitalet in Copenhagen.

Inclusion criteria were; genetically verified BMD or LGMD2I; age 18–65 years; and ability to stand and walk, but not able to perform unsupervised physical exercise, such as running, bicycling, or endurance training, due to severely affected motor function. Exclusion criteria were; predictable compliance problems to complete tests and training program; medical conditions, such as symptoms of impaired heart function, that could contraindicate physical training or in other ways confound interpretation of the effects of training.

Five patients had no cardiac involvement and normal echocardiographs. One of these five patients with BMD had undergone heart transplant surgery due to severely dilated cardiomyopathy 5 years before this study. Among the remaining three patients, one patient had asymptomatic dilated cardiomyopathy (ejection fraction; 45%), another patient had marginally decreased ejection fraction (55%) without dilatation and one patient had severely decreased ejection fraction (25%) and a moderately dilated left ventricle, but had no cardiac complaints. In addition, we used electrocardiograms, to secure that training did not elicit cardiac arrhythmias.

All patients led sedentary lifestyles i.e. with a minimum of physical exercise due to their condition. Three patients used walking aids. Oral and written informed consents were obtained from all patients, and the study was approved by the Regional Committee on Health Research Ethics (j.nr. H-3-2011-059) and the Danish Data Protection Agency (j.nr. 2007-58-0015).

Patients completed the SF-36 questionnaire on self-reported quality of life [10,11] before the training intervention. Isometric maximal voluntary contractions in knee-extension and knee-flexion were measured with the patient sitting in a specially designed chair, using a cuff around the ankle attached to a strain gauge dynamometer (PMH Electronic, Denmark). The patients performed 2–5 repeats of maximal voluntary contractions with each leg, and were instructed to gradually increase force (1–2 s) to achieve and maintain a maximal force-plateau (1–2 s). Values are presented as Nm/kg body weight. The SF-36 questionnaire and knee muscle strength were used to determine baseline characteristics.

2.2. Training intervention

The study consisted of a 10-week control period followed by a 10-week training intervention. A series of tests were performed before the control period, just before the intervention and at the end of the training period. Additionally, we performed a mid-intervention test after 5 weeks of training (Fig. 1). During the control period the patients maintained their normal daily lives with no increase or decrease in physical activity level. The training program consisted of supervised "one patient–one coach" combined aerobic- and strength training in an anti-gravity treadmill (G-trainer P200, Alter-G, Fremont, CA, USA). The anti-gravity treadmill is constructed as a treadmill surrounded by a pressure chamber. The user wears a special pair of shorts and zips the waist into a pressurized airtight enclosure, which is suspended over the treadmill surface. By controlling the pressure in the enclosure it is possible to reduce the body weight of the individual accurately to as low as 20% of normal body weight in 1% increments.

Training sessions took place three times per week, lasting approximately 40 min per session, and were divided equally between aerobic and strength training. Supervision was given by verbal encouragements and to a certain extent physical assistance to enter the anti-gravity treadmill. Since the group was clinically heterogeneous, the training

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