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Original Article

Improvement in Aerobic Capacity After an Exercise Program in Sporadic Inclusion Body Myositis

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Abstract

Objectives:
The study aimed to investigate the effects of a combined functional and aerobic exercise program on aerobic capacity, muscle strength, and functional mobility in a group of patients with sporadic inclusion body myositis (IBM).

Methods:
Aerobic capacity, muscle strength, and functional capacity assessments were conducted on 7 participants with sporadic IBM before and after a 12-week exercise program, which included resistance exercises and aerobic stationary cycling 3 times per week on alternative days.

Results:
Aerobic capacity of the group increased significantly by 38%, and significant strength improvements were observed in 4 of the muscle groups tested ($P < 0.05$). The exercise program was well tolerated, and there was no significant change in the serum creatine kinase level after the exercise period.

Conclusions:
An aerobic exercise program can be safely tolerated by patients with sporadic IBM and can improve aerobic capacity and muscle strength when combined with resistance training. These findings indicate that aerobic and functional muscle strengthening exercise should be considered in the management of patients with IBM.

Key Words: inclusion body myositis, aerobic capacity, exercise intervention

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INTRODUCTION

Idiopathic inflammatory myopathies are typified by slowly progressive muscle weakness, reduced muscle endurance, and muscle fatigue.[1,2] One of the most common idiopathic inflammatory myopathies in people older than 50 years is sporadic inclusion body myositis (IBM), which is characterized by severe muscular degeneration and preferential atrophy of the quadriceps femoris and the forearm flexor and extensor muscles.[3–5] The lower limb weakness results in a tendency to fall, whereas distal upper limb weakness results in motor control difficulties of the hand and finger.[1,6–8] Diminished aerobic capacity has also been reported in people with idiopathic inflammatory myopathies,[2] probably as a consequence of progressive muscle weakness leading to diminished mobility and fatigue during physical activity and the adoption of a sedentary lifestyle.[9,10]

Functional exercise capacity continues to decline in IBM even with standard pharmacological treatment with corticosteroid and immunosuppressant agents. However, the possibility of adding exercise therapy as an adjunct to pharmacological treatment in IBM has received limited attention because of the concern that increased physical activity could exacerbate the underlying inflammatory processes and cause additional muscle damage.[6,11–13] However, the validity of these concerns has been challenged by recent carefully prescribed resistance training programs that have not found histological evidence of muscle damage or a change in the serum creatine kinase (CK) level after training.[14–16]

In addition to resistance training, aerobic exercise has been shown to have positive

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physiological effects in idiopathic inflammatory myopathies such as mitochondrial myopathies, polymyositis, and dermatomyositis.[10,17-19] However, aerobic exercise has received little attention in IBM, although patients with IBM also have low levels of aerobic condition and endurance.[2-5]

We have previously shown that strength and flexibility training can be safely administered in IBM and can improve function.[16] In the present study, we hypothesized that the addition of aerobic exercise to a program of strength and flexibility training would be safe, well tolerated, and improve aerobic capacity and functional mobility in these patients.

MATERIALS AND METHODS

Participants

Seven participants (2 women and 5 men, mean age 66.7 ± 6.2 years) with sporadic IBM were recruited from the Centre for Neuromuscular and Neurological Disorders at Sir Charles Gardiner Hospital, Perth, Western Australia. All were in a state of progressive decline in muscle strength and function and overall functional ability for 5–9 years. Diagnosis was confirmed by clinical and histological findings and a characteristic pattern of selective muscle wasting and weakness. The study was approved by the Human Research Ethics Committees of Sir Charles Gardiner Hospital and Edith Cowan University. Each participant provided signed informed consent before participating in the study.

Experimental Design

Clinical examination, serum CK levels, muscle strength, functional assessments, and a symptom-limited peak oxygen consumption ($\dot{V}O_2$) exercise test were conducted before and after a 12-week exercise training program. The 12-week program consisted of aerobic, resistance, and stretching exercises that were individually prescribed and performed at the participant's home. Monitoring of participation was conducted via fortnightly phone contact and a home visit at 6 weeks into the program by the investigator.

Each participant was instructed to record the exercises they performed daily and their respective volume and frequency and to assign a value to the degree of fatigue, soreness, and breathlessness (based on a 1–10 scale, with 1 = no fatigue, soreness, or breathlessness, and 10 = maximal fatigue, soreness, and breathlessness) experienced during each exercise and after the completion of each day's tasks.

Depending on their tolerance and compliance to the exercise load, which was assessed fortnightly by phone contact with the investigators, and including a review of the participants' exercise logbooks, the participants were instructed to progressively increase the exercise load in mild increments and to contact the investigator by phone when changes were made, including both increases in the exercise load or reductions due to a possible intolerance. Participants alternated daily between strength training and aerobic training, and upper and lower body strength training components were performed on the same training day but in separate sessions to avoid excessive fatigue and to encourage recovery.

Each participant was counseled on the importance of doing the exercises as previously demonstrated, undertaking the exercises to the volume, intensity, and frequency prescribed and the importance of recovering from the exercises, as well as not undertaking other irregular strenuous activities.

Aerobic Training

Participants cycled 3 times per week at home on a Monark Ergomedic 894E stationary cycle ergometer at 80% of their initial maximum heart rate and for 2 minutes less than the total time achieved during their maximal aerobic test. Each patient used a Polar A3 heart rate monitor to maintain the prescribed exercise intensity and to time the prescribed duration of each session.

Progression of the aerobic training component was achieved through consultation between the investigator and the participants, based on review of the participants' rating of perceived exertion (RPE) record during their training.[20] If a participant reported that the cycling became too "easy" and was consistently reporting an RPE less than 3, they were instructed to increase the duration for which they were cycling, with a maximum increase of 2 minutes in any fortnightly period. Participants were encouraged to maintain a cycling cadence between 40 and 50 revolutions per minute.

Strength Training

The strength training program has been previously reported[16] and is outlined below. Exercises were performed in functional positions involving balance and stabilizing aspects[21] and modified according to the ability to perform functional movements and on pretraining assessments of muscle strength. A combination of isometric and isotonic exercises of the upper and lower limbs were performed. Upper limb exercises included biceps curls, shoulder flexion, and wrist flexion/extension holding a 375-g can of food. Lower limb exercises included calf raises (on tiptoe), standing hip abduction, and sitting to standing were performed from a standard height chair with arms to train the knee extensors.

Exercises were selected for their coordinated use of multiple muscle groups and their specificity to muscles affected in individual participants; however, all subjects performed shoulder flexion, elbow flexion, and knee extension exercises (Table 1). A combination of up to 6 exercises were performed twice (separated by 3–4 minutes passive recovery), once a day, 3 times per week. During the first fortnight of the program, the exercise load was kept at a low level to prevent overloading, and exercises were selected such that between 6 and 15 repetitions could be easily achieved, counting repetitions by number of breaths to avoid breath holding during isometric contractions.[22] Participants were encouraged to increase their training load over the 12-week period. However, they were instructed not to increase all strength training variables simultaneously but rather to increase 1 variable in a given fortnight and in the following order: exercise number (increased to ~4–6 exercises), then number of

TABLE 1. Range of Exercises Prescribed to the Participants (n = 7) During Their Training Intervention

	1	2	3	4	5	6	7
Stretches							
Shoulder abduction	●	●		●	●		●
Shoulder adduction			●			●	●
Calf extension	●	●			●	●	●
Hamstring extension	●			●			●
Ankle plantar/dorsiflexion	●	●	●		●	●	●
Ankle inversion/eversion			●		●	●	
Passive finger flexion/extension	●	●	●			●	
Active finger flexion/extension	●	●	●	●	●	●	●
Thumb/finger opposition	●	●	●	●	●	●	●
Upper body							
Wrist flexion/extension	●	●	●		●	●	●
Shoulder flexion	●	●	●	●	●	●	●
Elbow flexion (with ~375-g weights)	●	●	●	●	●	●	●
Upper trunk extension	●	●	●			●	
Lower body							
Hip extension	●	●			●		
Hip flexion		●					
Hip abduction	●		●		●	●	●
Knee extension	●	●	●	●	●	●	●
Knee Flexion				●			●
Calf raises			●		●	●	

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repetitions (15 maximum), and lastly, number of sets (maximum of 3).

Stretches were performed once daily to improve flexibility of movements, with passive stretches held for 15 seconds (or 5 breaths) and dynamic stretches performed for 5–10 repetitions, all to be performed bilaterally. Dynamic finger flexion/extension and finger-to-thumb opposition exercises were performed by all participants.

Measurements

Aerobic Capacity

Submaximal (symptom limited) tests of aerobic capacity were performed on a stationary electronically braked cycle ergometer. The protocol used to measure aerobic capacity was based on similar protocols previously used in inflammatory muscle disease and neuromuscular disease populations.[23–25] All participants started cycling at 20 W. Workload was then incremented every 2 minutes until voluntary cessation. Due to the differences in aerobic capacity of each participant, the workload increments, although constant for any given individual, were individualized based on the outcomes of the participants' familiarization tests, the aim being to have the participant perform the test for between 5 and 20 minutes. Participants were to maintain a cycling cadence between 40 and 50 revolutions per minute.

Throughout each test, participants wore a face mask connected to a MetaMax 3B portable breath-by-breath gas analysis system. $\dot{V}O_2$ (L/min and $mL \cdot kg^{-1} \cdot min^{-1}$), heart rate (bpm), and cardiac rhythm were continuously monitored throughout the test. The 10-point RPE scale[20] was administered at minute intervals during the test. Blood lactate levels (/mmol) were measured before and immediately after each test, taken via the fingertip.

Functional Exercise Capacity

Functional tasks included walking 30 m unaided and walking up 1 flight of stairs (11 steps). The time taken to complete each task was recorded, as was the step count during the 30-metre walk. Standard instructions and levels of positive encouragement were employed on each testing occasion.

Muscle Strength

A Penny and Giles handheld myometer (Christchurch, England) was used to measure bilateral muscle strength using a "make" test in the following movements: shoulder abduction/external rotation, elbow flexion/extension, wrist extension, hip abduction/flexion, and knee flexion/extension. Grip strength was measured using a Stabil 3 grip dynamometer (Speidel and Keller, Jungingen, Germany). Each movement was tested twice with the best effort recorded.

Data Analysis

All data were assessed for normality using the Kolmogorov–Smirnov test. Pre- and post-training comparisons for each variable were performed using a paired t test for normally distributed data and a Wilcoxon matched pairs signed ranks test for data not normally distributed. Group data are reported as mean ± standard error of the mean. The level of significance for all comparisons was set at 5% ($P < 0.05$).

RESULTS

Aerobic Capacity

After the 12-week exercise program, $\dot{V}O_2$ peak for the group significantly improved by 38% from 1.5 ± 0.2 to 2.1 ± 0.3 L/min ($P < 0.05$) (Fig. 1). This difference in aerobic capacity remained statistically significant when corrected for each individual's body weight (18.7 ± 2.9 vs. 23.7 ± 3.2 $mL \cdot kg^{-1} \cdot min^{-1}$; $P < 0.05$). There were no significant effects of training on body mass (83.4 ± 5.4, 83.9 ± 6.0 kg pre- and post-exercise, respectively), mean exercise duration (8.0 ± 0.5 vs. 8.1 ± 0.9 minutes), average heart rate response (134 ± 9 vs. 138 ± 8 bpm), lactate levels (4.0 ± 0.7 vs. 4.6 ± 0.4/mmol), or self-reported RPE (4.6 ± 0.8 vs. 4.6 ± 0.3).

Functional Exercise Capacity

Group stair climb and walk time/pace number data are presented in Table 2. After

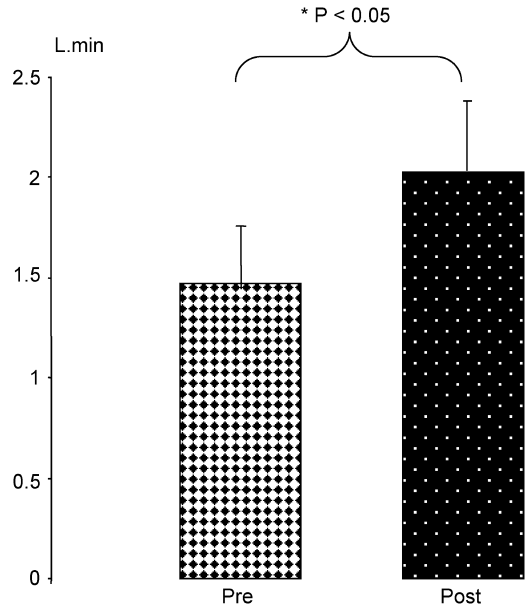

FIGURE 1. Mean (±SE) change in absolute aerobic capacity (L/min) across participants (n = 7), showing a significant improvement after the exercise regimen. *$P < 0.05$.

training, the time taken to climb 11 steps decreased by 21.7%, the time taken to walk 30 m decreased by 31.4%, and number of paces during the 30-m walk decreased by 14 steps. However none of these differences reached statistical significance (Table 2).

Muscle Strength

Significant improvements were observed in some of the trained muscles (Table 3). Hip abduction strength increased by 16.6%, shoulder abduction strength by 39.8%, hip flexion strength by 35.6%, and knee flexion strength by 10.5% ($P < 0.05$). The strength of other trained muscles did not significantly change with training (Table 3).

Serum CK Levels

CK level was unchanged by exercise training, being 405 ± 94 U/L before the 12-week training period and 409 ± 114 U/L after the exercise training program.

In review of the participants' logbooks and through conversation with the investigators during and after the exercise training program, all patients performed more than 70% of the scheduled training sessions.

DISCUSSION

Aerobic conditioning is known to offset secondary health effects such as obesity, type II diabetes, and heart disease, yet little emphasis has been placed on rehabilitation strategies addressing aerobic capacity in IBM.[17] We have previously shown that a home-based exercise program of strength and flexibility training is beneficial in IBM. Here, we have extended this program to include a high-frequency, low-intensity aerobic component and show that aerobic capacity (peak $\dot{V}O_2$) could be increased by 38% in our patient group. This improvement is comparable to or greater than that previously shown in other idiopathic inflammatory myopathy and mitochondrial myopathy populations.[10,26] The improvement is potentially important for activities of daily living, given that in pre-trained state patients, peak $\dot{V}O_2$ was close to the minimum required to meet the physiologic demands of independent living (14–15 mL·kg^{-1}·min^{-1}).[27,28] Improvement in aerobic capacity is typically associated with increased blood flow and oxygen extraction in working muscles and an increase in

TABLE 2. Mean (±SE) Pre- and Post-Training Values of Time Taken (s) by the Participants (n = 7) to Climb 1 Flight of Stairs (11 Steps) and to Walk Unaided for 30 m, and the Number of Paces Used to Complete the Timed Walk

Functional Task	Mean ± SE		*P*
	Pre-Training	Post-Training	
Stair climb	19.4 ± 10.7	15.2 ± 6.1	0.214
30-m walk	43.4 ± 20.4	29.8 ± 8.8	0.160
Paces during 30-m walk	67.0 ± 20.0	52.8 ± 7.2	0.170

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TABLE 3. Mean (±SE) Pre- and Post-Training Muscle Strength Values of the Participants (n = 7)

Muscle	Mean ± SE		*P*
	Pre-Training	Post-Training	
Untrained			
Grip strength (mm Hg)	150.2 ± 49.9	138.3 ± 55.3	0.122
Shoulder external rotation (kgf)	7.4 ± 0.0	7.6 ± 0.9	0.652
Trained (kgf)			
Knee extension	7.3 ± 0.2	6.6 ± 0.1	0.805
Wrist extension	9.8 ± 0.4	9.1 ± 0.5	0.271
Elbow extension	7.4 ± 0.5	6.8 ± 0.3	0.067
Elbow flexion	10.9 ± 0.5	11.0 ± 0.3	0.402
Shoulder abduction	12.3 ± 0.6	17.2 ± 0.5	0.000**
Hip flexion	11.5 ± 1.2	15.6 ± 0.7	0.008*
Hip abduction	9.0 ± 0.4	10.5 ± 0.2	0.041*
Knee flexion	10.4 ± 0.4	11.5 ± 0.3	0.027*

*$P < 0.05$. **$P < 0.001$.

cardiorespiratory fitness,[29] and may reflect that the heart and lung are not involved in IBM. These improvements did not translate into a measurable change in the functional assessments, perhaps because these tasks did not depend sufficiently on aerobic capacity.

Significant strength improvements were observed in 4 of the muscles tested—shoulder abduction, hip flexion/abduction, and knee flexion. In keeping with our previous study, it is believed that the improvements in strength found in this study are the result of changes in muscle fiber size[15] and the improvement in muscle activation patterns as a product of repetitive training sessions scheduled to promote memory consolidation.[30]

The home-based design of this study promoted the use of, where possible, functional exercises to make the program time and energy efficient and also to increase the likelihood that improvements would transfer into activities of daily living.[31–33] The prescribed programs were safely tolerated without unfavorable muscle symptoms or an elevation of serum CK levels. Although there was no formal assessment of changes in the participants' quality of life or capacity to perform activities of daily living, each was questioned on their subjective feelings of changes to their lives as a result of the exercise program. Participants reported a general health and well-being benefit from the exercise training.

In summary, this study has shown that significant improvements in aerobic capacity can be attained through a home-based, patient-specific functional and aerobic exercise program. Furthermore, in the absence of muscle damage, functional improvements can be made and significant strength gains can be attained in nondiseased muscles when trained. The results of this study indicate that patients with IBM can improve their aerobic capacity with training; however, the selective nature of this disease may restrict the potential strength gains in muscles involved in IBM, and it remains to be seen if exercise can produce long term disease-modifying benefits. Importantly, the training program was safe and tolerable. The findings from this study suggest that aerobic and functional muscle strengthening exercises are complementary and should be considered in the management of patients with IBM.

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