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EFFECTS OF RESISTIVE INSPIRATORY EXERCISE ON ACTIVITY PARTICIPATION, FATIGUE, AND RESPIRATORY INFECTIONS IN PERSONS WITH ADVANCED MULTIPLE SCLEROSIS LIVING IN A LONG-TERM CARE FACILITY

M.H. HUANG[1], A. BURNHAM[3], L. DOYLE[4], D. FRY[2], L. WISKE[4], M. KOLANDA[4], E. KHITRIK[4], J. GOODE[4], H. SMITH[4], K. SHEA[4], N. HOUSTON[4]

1. Physical Therapy Department, College of Health Sciences, University of Michigan-Flint. Flint, MI, USA; 2. College of Health Sciences, University of Michigan-Flint. Flint, MI, USA; 3. The Boston Home. Boston, MA, USA; 4. Doctor of Physical Therapy Program, Franklin Pierce University. Manchester, NH, USA. Corresponding author: Min H. Huang, PT, PhD, 2157 William S. White Building, 303 E. Kearsley Street, Flint, MI 48502-1950, USA, Email: mhhuang@umich.edu, Phone: 810-762-3373, Fax: 810-766-6668

Abstract: This study examined the outcomes of 10-week daily resistive inspiratory exercise in 34 adults with advanced multiple sclerosis (MS) in a long-term care facility. Respiratory muscle strength (maximum inspiratory [MIP] and expiratory pressure [MEP]) and fatigue (Modified Fatigue Impact Scale-5) were measured at pre-test, post-test, and 8-week retention. Activity participation (days/week attending group social activities) and respiratory infections were analysed during the baseline, exercise, and retention. Participants were aged 60.0±8.5 years and non-ambulatory (Expanded Disability Status Scale = 8.5±0.4). MIP ($p=0.02$) and activity participation ($p=0.019$) differed significantly by time. Bonferroni post-hoc analysis revealed that MIP was greater at post-test (41.6%±23.9%) than pre-test (35.6%±22.0%) ($p=0.004$), and participants attended more social activities during exercise phase (5.0±3.4 days/week) than baseline (4.0±2.1 days/week) ($p=0.043$). Fatigue did not change by time. Among the participants, 18%, 6%, and 9% had respiratory infections during baseline, exercise, and retention, respectively. Resistive inspiratory exercise improved activity participation without worsening fatigue during the course of exercise in persons with advanced MS.

Key words: Respiratory, resistive inspiratory exercise, rehabilitation, activity participation, multiple sclerosis.

Introduction

In persons with multiple sclerosis (MS), respiratory muscle weakness is associated with disability (1), respiratory dysfunction, and mortality (2). Among various respiratory training methods for persons with MS, resistive inspiratory exercises have consistently increased inspiratory muscle strength (3). A daily 10-week exercise program using a threshold inspiratory trainer (IMT) has demonstrated efficacy on improving inspiratory muscle strength in persons with advanced MS (4). By improving ventilation, oxygen uptake, and exercise endurance (5), resistive inspiratory exercises may positively impact a broader range of health outcomes beyond respiratory muscle strength in persons with advanced MS.

Restrictions in activities, fatigue, and respiratory infections are major concerns in persons with MS. Over 70% of non-ambulatory persons with severe MS have reduced participation in social/lifestyle activities, such as social occasions, pursuing hobby, or outdoor activities (6). Fatigue is a leading complaint affecting 80% of persons with MS (7). MS increases the risk of serious respiratory infections (hazard ratio = 1.31) (8). The investigation of effects of IMT exercises on activity participation, fatigue, and respiratory infections may provide new insight into rehabilitation interventions for persons with advanced MS. The primary purpose of this study was to examine the participation of social activities before and after 10 weeks of resistive inspiratory exercises using IMT in persons with advanced MS at a long-term care facility. The secondary purpose was to examine if the exercises influenced self-reported fatigue and respiratory infections.

Methods

Design

This study is a repeated measures within-subject design.

Participants

We recruited participants from The Boston Home, a facility specialised in the long-term care of people with advanced MS. Inclusion criteria were age>18 years, MS diagnosis, non-ambulatory with Expanded Disability Status Scale (EDSS) >=6.5, ability to follow instructions and communicate in English, and providing consent. The EDSS ranges from 0=no neurologic involvement to 10=death due to MS. Exclusion criteria were recent hospitalisation as a result of MS exacerbation within 2 months prior to or during enrolment in the study, acute illness or unstable medical conditions, and current smoker. The University of Michigan-Flint and Franklin Pierce University Institutional Review Boards approved the study. All participants provided their consent.

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Sample Size

G*Power [9] was used to estimate the sample size required to achieve a significant difference in activity participation across 3 time periods. At least 27 participants would be required based on alpha level = 0.05, power = 0.80, and a medium partial $\eta 2$ effect size = 0.06.

Resistive Inspiratory Exercises

Participants performed resistive inspiratory exercises for 10 weeks using the IMT device, which costs about $30 per unit (Philips, Andover, MA) (daily dosage = 3 sets of 15 repetitions) (4). Each participant completed 3 sets of 15 repetitions daily using his/her own IMT device. Most sessions lasted approximately 15 minutes including rest breaks to avoid fatigue and other discomfort. The participants performed the exercises sitting in a chair or bed while keeping their upper body as upright as possible. First a nose clip was applied to ensure that the participants breathed in through the mouth. The participants sealed lips around the mouthpiece and inhaled deeply through the IMT. As the air flowed in, a valve opened, and the device provided resistance to inhalation. The participants continued inhaling and exhaling without removing the IMT from the mouth unless they needed to take a break between exercise repetitions. Each participant was given an exercise log to record the repetitions completed per day. Before starting the exercise program, the research team instructed the participants on using the IMT and observing the precautions during exercises, such as pain, light headedness, dizziness, shortness of breath, perceived exhaustion as measured by a score on the Borg Rate of Perceived Exertion >=15, or other symptoms. The staff at the facility (nursing assistant, rehabilitation aide, or trained student volunteers) received training on using the IMT, documenting the exercise log, and reporting any symptoms experienced by the participants. The participants performed the exercises on their own with the supervision or assistance from the staff whenever necessary. The initial IMT resistance was 30% of baseline maximum inspiratory pressure (MIP), or the lowest IMT resistance of 9 cmH2O when 30% of baseline MIP was less than 9 cmH2O. At the end of each week, the research team progressed the IMT resistance based on symptoms, Borg Rate of Perceived Exertion, and baseline MIP (see Table 1 in (4) for protocol).

Measurements

Participant Characteristics

Demographics, body-mass-index (BMI), years of MS diagnosis, Expanded Disability Status Scale (EDSS), number of comorbidities measured by Functional Comorbidity Index [10], and cognition measured by oral version of Symbol Digit Modality Test (SDMT) (11) were obtained by interviews and reviews of medical records at the time of enrolment.

Respiratory Muscle Strength

MIP and maximum expiratory pressure (MEP) were obtained as global measurements of inspiratory and expiratory muscle strength, respectively using MicroRPM Pressure Meter (Micro Direct, Inc. Lewiston, ME) (12). During each assessment, the best values from three trials of MIP and MEP were retained for analysis. MIP and MEP values were expressed as percentages of age- and gender-adjusted predicted values (12). Participants were measured before (pre-test) and after (post-test) 10-week exercises, and 8 weeks after exercises (retention).

Participation in Group Social Activities

The number of days each participant attending at least one structured group social activity per week represents participation in social activities. The staff, residents, and family members jointly developed these programs to promote an engaging social life. Every day, each resident chose the activities to attend, such as coffee, movies, watercolors, Tai-Chi, bingo, parties, and community outings (See updated activity calendar https://www.thebostonhome.org/programs-and-services/activities.html). The activity team led activities and took the attendance of all residents using a daily calendar. To minimise bias, the activity team and participants were not informed of the study purpose. At the end of study, the author (AB) extracted the participants' attendance records. The number of unique calendar days per week on which the participants attended at least one structured group social activity was counted. For example, if a participant attended at least one activity on four out of seven days in a week, activity participation was recorded as "4" for that week. The weekly participation was calculated during baseline (10 weeks before exercises), training (10-weeks exercises), and retention (8 weeks post exercises).

Modified Fatigue Impact Scale-5 Item

Modified Fatigue Impact Scale-5 item (MFIS-5) is a self-report measurement and an abbreviated version of Modified Fatigue Impact Scale recommended for use in the MS population (13). MFIS-5 evaluates how fatigue may have affected a person's cognitive, physical and psychosocial function during the past 4 weeks. Each item is scored from 0 to 4 ('never, 'rarely', 'sometimes', 'often', and 'almost always') with higher scores indicating more severe impact of fatigue. The sum of raw scores from 5 items is the MFIS-5 total score (from 0 to 20). MFIS-5 has good test-retest reliability (ICC=0.76) (14). MFIS-5 was measured at pre-test (before exercises), post-test (after exercises), and retention (8 weeks post-exercises).

Respiratory Infections

Infectious diseases of the upper or lower respiratory tract, such as common colds, flu, or pneumonia, were documented routinely at the facility. To minimise bias, the staff recording

Table 1
Participant characteristics

Variable	Mean (SD)	Minimum	Maximum
Age, year	60.0 (8.5)	43	76
Time post-MS diagnosis, year	27.1 (10.1)	9	46
Body mass index	26.7 (6.1)	18.8	43.9
Functional Comorbidity Index	2.29 (1.99)	0	8
Expanded Disability Status Scale	8.5 (0.4)	8.0	9.5
MIP, cmH2O	27.7 (13.0)	10	57
MIP, % of predicted value	36.2 (16.9)	9	76
MEP, cmH2O	25.0 (15.1)	6	80
MEP, % of predicted value	27.7 (14.9)	8	64

Table 2
The total and average numbers of respiratory infections and resulting hospital admissions, and the length of stay during the baseline no training, IMT training and post-training retention phases

Variables	Baseline	IMT Exercises	Retention
Respiratory infection episode	6 (18%)	2 (6%)	3 (9%)
Hospital admission	1 (3%)	0	1 (3%)
Length of stay, day	3	0	0

Values are expressed as n or mean (%). N=34; IMT: Inspiratory muscle trainer.

the infections were not informed of the study purpose. At the end of study, the author (AB) extracted the participants' data using a pre-structured form. The episodes of respiratory infections, number of hospital admissions, and length of stay were counted during baseline (10 weeks before exercises), training (10-weeks exercises), and retention (10 weeks post-exercises).

Statistical Analysis

Data were analysed using IBM® SPSS Version 24 (Armonk, New York). Descriptive statistics were calculated for all variables. Repeated measures ANOVA in General Linear Model was used to compare MIP and MEP values and MFIS-5 between pre-test, post-test, and retention, and activity participation between baseline, training, and retention. Effect size of partial $\eta 2$ was calculated (small = 0.01, medium = 0.06, and large = 0.14) (15). Because of the low incidence, descriptive statistics were reported for respiratory infections. Two-tailed significance level was $p < 0.05$.

Results

Participant Characteristics

Among 38 participants who consented, one dropped out due to illness and three were absent at assessments. Table 1 presents the participants' characteristics.

MIP and MEP

MIP were 35.6%±22.0% at pre-test, 41.6%±23.9% at post-test, and 39.4%±25.6% at retention. MEP were 26.4%±14.3% at pre-test, 28.1%±13.9% at post-test, and 27.2%±14.3% at retention. MIP differed significantly by time (p=0.023, $\eta p2$=0.07 for medium effect size). Bonferroni post-hoc test showed that MIP significantly increased from pre-test to post-test (p=0.04). MEP did not differ by time. No adverse events were reported in the study.

Activity Participation

The participants spent 4.0±2.1 days/week during baseline, 5.0±3.4 days/week during training, and 4.8±3.5 days/week during retention attending at least one structured group social activity. Activity participation differed significantly by time (p=0.01, $\eta p2$=0.13 for medium effect size). Bonferroni post-hoc test revealed that activity participation was significantly greater during training than baseline (p=0.043).

MFIS-5

The MFIS-5 was 6.4±4.7 at pre-test, 5.1±4.9 at post-test, and 5.5±5.5 at retention and did not differ by time.

Respiratory Infections

Table 2 presents the data on respiratory infections. Only one participant had recurrent infections (two episodes) in the study.

Discussion

This study is the first to demonstrate that in non-ambulatory persons with severe physical limitations from advanced MS, resistive inspiratory exercises significantly increased not only inspiratory muscle strength, but also participation in group social activities. Fatigue did not change and respiratory infections remained low in the study. Benefits of resistive inspiratory exercises extend beyond improving respiratory muscle strength and likely have positive impact on societal participation in persons with advanced MS living in a long-term care facility.

MIP but not MEP increased after the IMT exercises, demonstrating a task-specific response to the type of activities being imposed. Improved social engagement is particularly meaningful for individuals with severe physical limitations. Our results indicate that resistive inspiratory exercises are a safe and effective intervention to promote participation without adverse events and increased fatigue. This study has limitations. The small sample size was relevant small but had sufficient power based on a priori estimate. Data were extracted retrospectively but blinding had been applied during measurements to minimise bias. In conclusion, 10-week daily resistive inspiratory exercises improved inspiratory muscle strength and activity participation among non-ambulatory persons with advanced MS living in a long-term care facility.

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Declaration of Interest: The authors report no conflict of interest.

Clinical Trials Registry: NCT03345199.

Ethical standards: The participants provided their written informed consent before enrolling in this study. The University of Michigan-Flint and Franklin Pierce University Institutional Review Boards approved the study.

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