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ORIGINAL ARTICLE

Effectiveness of Home Exercise on Pain, Function, and Strength of Manual Wheelchair Users With Spinal Cord Injury: A High-Dose Shoulder Program With Telerehabilitation

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Abstract

Objective: To test the effectiveness of a high-dose home exercise/telerehabilitation program for manual wheelchair users who have a spinal cord injury (SCI) by determining whether the intervention would reduce pain and increase function, as we hypothesized.

Design: A pre-post trial with outcomes measured at 3 time points: baseline, postintervention (12wk), and follow-up (>24 wk).

Setting: Subjects performed an exercise program at their homes using telerehabilitation for therapist monitoring of technique and exercise advancement. Baseline and postintervention data were collected at a motion analysis laboratory in a tertiary medical center.

Participants: A convenience sample of manual wheelchair users (N=16, 3 women; average age, 41y; average time in a wheelchair, 16y) with shoulder pain (average pain duration, 9y) and mechanical impingement signs on physical examination.

Interventions: A 12-week home exercise program of rotator cuff and scapular stabilization exercises was given to each participant. The program included a high dose of 3 sets of 30 repetitions, 3 times weekly, and regular physical therapist supervision via videoconferencing.

Main Outcome Measures: Primary outcomes of pain and function were measured with the Wheelchair User's Shoulder Pain Index (WUSPI), Disabilities of Arm, Shoulder, and Hand (DASH) Index, and Shoulder Rating Questionnaire (SRQ). Secondary outcomes of strength were measured with isometric strength tests of scapulothoracic and glenohumeral muscles, and a static fatigue test of the lower trapezius.

Results: Pain was reduced and function improved after the intervention. There was a significant main effect for pain and function between the 3 time points based on the Friedman signed-ranked test, WUSPI ($\chi^2_2=5.10$, $P=.014$), DASH Index ($\chi^2_2=5.41$, $P=.012$), and SRQ ($\chi^2_2=23.71$, $P\leq.001$). Wilcoxon signed-rank tests demonstrated that isometric strength measurements of the serratus anterior and scapular retractors increased after the exercise intervention ([$t=2.42$, $P=.04$] and [$t=4.67$, $P=.003$], respectively). Muscle impulse produced by the lower trapezius during a fatigue task also improved ($t=2.2$, $P=.02$). No differences were measured in isometric strength for the lower trapezius, glenohumeral rotators, and abductors between the baseline and 12-week time points.

Conclusions: A high-dose scapular stabilizer and rotator cuff strengthening program using telerehabilitation for supervision holds promise for shoulder pain treatment in manual wheelchair users with SCI. Additional work is needed to determine the effectiveness compared with other interventions, as well as the potential for earlier intervention to prevent development of shoulder pain.

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People who are dependent on manual wheelchairs for mobility and activities of daily living have their shoulder joints become primary load-bearing structures. The architecture of the shoulder, because of its inherent limited stability and small supporting musculature, is not well designed for tasks required of manual wheelchair users. Thus, a large proportion (30%–75%[1-6]) of manual wheelchair users report shoulder pain, which is believed to be predominantly from mechanical subacromial impingement (SAI).[4,6,7] Exercise interventions to treat SAI syndrome have been shown to successfully reduce pain.[1,8-16] A few studies[1,17-19] of manual wheelchair users have documented a reduction in shoulder pain after an exercise intervention. However, the diversity of study designs and interventions has limited the ability to reach a consensus about the most effective exercise prescription.

Previous clinical trials[1,12,14,16,18-20] to treat SAI pain with exercise commonly used protocols requiring doses of 3 sets of 10 to 15 repetitions. Literature investigating the dose-response relationship of exercise in treating SAI is minimal. However, Osteras et al[21] studied high dose (30 repetitions × 3 sets) versus lower dose (10 repetitions × 2 sets) in a randomized controlled trial in an able-bodied population. The high-dose group had a larger reduction in pain and improvement in function than the low-dose group.

In addition to differences in dosing, assorted environments have been used for exercise interventions. Both clinic-based and home-based exercise programs have proven to reduce SAI pain in clinical trials.[1,8-11,13-15,17-19,22] Home-based exercise protocols have commonly included supervisory visits in the clinic during the period of intervention in order to verify correct technique of the exercise performance, and to appropriately progress the participant to more advanced exercises.[1,8,9,14,16,17,19] To our knowledge, telerehabilitation has not been used to provide supervision for at-home shoulder rehabilitation programs. However, this approach may be effective for situations in which travel would be a burden.

Therefore, we implemented an exercise program for manual wheelchair users with shoulder pain that varied from previously reported studies by using (1) high repetitions per set of exercise, and (2) remote supervision using videoconferencing software for maintenance of technique and exercise progression. The purpose of our study was to test the effectiveness of this program primarily on altering pain and function, and secondarily strength. We hypothesized that our participants would have reduced pain and improved function, with a secondary hypothesis that our participants would have increased strength after the implementation of this intervention.

Methods

Participants

Participants who use manual wheelchairs (N = 16, 13 men/3 women; 15 who had a spinal cord injury, 1 post-polio) were recruited as a convenience sample from area clinics and organizations that provide treatment and services for individuals with disabilities. A repeated-measures design was used with data collected at 3 time points: (1) baseline; (2) immediate postintervention (12wk); and (3) follow-up, at least 12 weeks after completion of the intervention (>24 weeks). These time points will be referred to as baseline, 12 weeks, and >24 weeks. The study protocol was approved by the Mayo Clinic Institutional Review Board, and written informed consent was obtained from all participants before initiating test procedures.

Participants were eligible for the study if they (1) were between 18 and 65 years of age; (2) had used a manual wheelchair as their primary means of mobility for a minimum of 1 year; (3) were able to perform transfers and sit independently; (4) had shoulder pain with a date of onset no sooner than 2 weeks from the date of consent; and (5) had access to high-speed internet. Participants were excluded if they had (1) cognitive impairments that limited their ability to independently follow instructions; or (2) previous significant traumatic injury to the shoulder in which preinjury status was not attained. The aforementioned criteria were screened over the phone. Additional screening was done via physical examination performed in the laboratory by a licensed physical therapist just before the baseline data collection. If shoulder pain was deemed to be of cervical origin, or if there was a presence of adhesive capsulitis (defined as a loss of >25% of range of motion) or gross instability, participants were excluded from the study. Participants were required to have shoulder pain of which a major contributor was believed to be SAI (eg, positive Neer, Hawkins-Kennedy, or Jobe impingement signs, pain with humeral elevation, or complaints of anterior lateral shoulder pain during activity).[23-25]

List of abbreviations:

DASH	Disabilities of the Arm, Shoulder, and Hand
MDC	minimal detectible change
MVC	maximum volitional contraction
SAI	subacromial impingement
SRQ	Shoulder Rating Questionnaire
WUSPI	Wheelchair User's Shoulder Pain Index

Intervention

Twelve weeks of strengthening exercises using resistive bands (TheraBand[a]) was prescribed for the serratus anterior, scapular retractors and depressors, and glenohumeral external rotators (fig 1A, 1B, and 1C, respectively). The target dose used for each strengthening exercise was 3 sets of 30 repetitions with a 30-second rest between sets, 3 times per week. Participants were instructed to hold each end position for 3 seconds and control the speed of the eccentric phase. Emphasis was placed on maintaining a neutral thoracic and cervical posture, and avoiding scapular elevation throughout the exercises. Movement from the scapulothoracic junction, rather than the glenohumeral joint, occurred during correct performance of these scapular exercises. Scapular retraction and depression were emphasized during external rotation exercises. If the participant was unable to perform the entire dose of exercise with the lowest level of resistance using proper technique in sitting, the exercise was modified to be performed in supine, instructed to be isometric rather than isotonic, and/or the number of repetitions per set was reduced. After proper technique was achieved for 3 sets of 30 repetitions, advancement of the exercise was prescribed. Examples of exercise advancement included increasing the resistance to a stiffer band, advancing the position to sitting, and advancing the plane of movement for the external rotators to diagonal movements with the arm abducted. In addition to strengthening exercises, each participant was given an anterior chest "open book" stretch (fig 2A). A stretch of the posterior joint structures was prescribed if isolated glenohumeral passive internal rotation of the shoulder measured <60° (fig 2B).

Hands-on instruction of these exercises occurred during the initial laboratory session. During this session, photographs were taken of each participant in order to provide a handout that included participant-specific photographs performing the prescribed exercises (supplemental fig S1-S3, available online only at http://www.archives-pmr.org/). Participants were instructed to exercise free of symptoms. Temporary discomfort in the location