ORIGINAL ARTICLE

Effects of Aquatic Backward Locomotion Exercise and Progressive Resistance Exercise on Lumbar Extension Strength in Patients Who Have Undergone Lumbar Diskectomy

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ABSTRACT. Kim Y-S, Park J, Shim JK. Effects of aquatic backward locomotion exercise and progressive resistance exercise on lumbar extension strength in patients who have undergone lumbar diskectomy. Arch Phys Med Rehabil 2010;91: 208-14.

Objective: To compare the effects of aquatic backward locomotion exercise and progressive resistance exercise with a machine on lumbar extension strength in patients who have undergone diskectomy for a lumbar disk herniation.

Design: Prospective comparative study.

Setting: Department of Kinesiology at a state university.

Participants: Male patients (N=30) with disk herniation at spinal levels L3 to S1 completed this study as subjects.

Intervention: After the diskectomy for a lumbar disk herniation, all patients had 6 weeks of rest time. At the end of the rest period, the aquatic backward locomotion exercise and progressive resistance exercise groups, respectively, started first 6 weeks of underwater training and lumbar extension training twice per week. After completion of the first 6-week training, subjects participated in a second 6-week training. After the whole 12-week training, subjects had no training for 6 weeks (detraining) and a follow-up 6-week training (retraining). The control (CON) group did not undergo any training.

Main Outcome Measures: For each test, maximum voluntary isometric lumbar extension strength was measured in 7 trunk positions (72°, 60°, 48°, 36°, 24°, 12°, and 0° of the trunk angle).

Results: The progressive resistance exercise and aquatic backward locomotion exercise groups showed increases in lumbar extension strength after the first 6-week training, although they were not statistically different from the CON group. After a second 6-week training, the progressive resistance exercise and aquatic backward locomotion exercise groups showed statistically significant increases in their strength levels as compared with the CON group. After the detraining period, the strength levels of the progressive resistance exercise and aquatic backward locomotion exercise groups did not statistically differ from the CON group. After the retraining period, the progressive resistance exercise and aquatic backward locomotion exercise groups showed increases in their strength levels, which were different from that of the CON group.

Conclusions: The results obtained suggested that the aquatic backward locomotion exercise is as beneficial as progressive resistance exercise for improving lumbar extension strength in patients after lumbar diskectomy surgery.

Key Word: Rehabilitation.

PREVIOUS STUDIES ON rehabilitation exercises for low back pain and a postsurgery lumbar disk herniation often used strength training with exercise machines.[1-4] These exercise machines were designed to strengthen the lumbar extensors and provide rehabilitation to these patients.[5-8] Although these measurement-based machines effectively provide exercise for strengthening the lumbar extensors, they have often been considered as cost-ineffective.[9,10] As a result, more cost-effective exercises have been developed as alternative strength training methods. These cost-effective exercises and exercise machines include Roman chairs, lumbar stabilization floor exercises, and stability balls.[11-15] However, these alternatives are prone to secondary injuries in the spine and paraspinal muscles.

Recently, aquatic exercise has become popular for fitness enhancement, general conditioning programs, and rehabilitation for patients with low back pain, those with rheumatic diseases, and the elderly.[15-23] Walking and jogging in water are effective exercises for subjects with lower extremity and lumbar spine injuries.[13] These exercises are also safe and effective for elderly and middle-aged persons whose physical fitness levels have deteriorated because of physical inactivity and aging.[24] Many previous studies have demonstrated the general benefits of in-water exercises, including increased metabolic expenditure,[22] psychologic improvements,[25] cardiovascular benefits,[26] and other physiologic benefits.[16,27]

Aquatic backward locomotion exercise has been shown to be an effective mode of exercise that can provide beneficial effects during rehabilitation and a general exercise regimen.[21] Backward locomotion has been demonstrated to provide beneficial effects to subjects with lower extremity injuries and provide greater cardiovascular demands regarding heart rate and oxygen consumption.[28] Backward walking has also been shown to decrease overstretching of the anterior cruciate ligament.[29,30] Recently, Masumoto et al[20] reported that activations of the paraspinal muscles, vastus medialis, and tibialis anterior were greater during in-water backward walking as compared with

List of Abbreviations

ANOVA	analysis of variance
CON	control group
HRmax	maximum heart rate
RM	repetition maximum

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forward walking. Although these positive traits of in-water locomotion justify the use of the in-water locomotion exercises, it is still unknown whether in-water locomotion exercises are more beneficial or equally beneficial as compared with strength training exercise with dynamometers specifically designed for the rehabilitation of patients with low back pain or lumbar disk herniation problems. The purpose of this study was to investigate this question by comparing the effects of aquatic backward locomotion exercise and progressive resistance exercise with a machine on lumbar extension strength in patients who have undergone diskectomy for a lumbar disk herniation. We hypothesized that the aquatic backward locomotion exercise and progressive resistance exercise result in similar improvements of lumbar extension strength after the training.

METHODS

Participants

Thirty male adult patients with traumatic disk herniation at spinal levels L3 to S1 completed this study as subjects (mean age ± SD, 38.90±4.77y; mean height ± SD, 176.64±5.75cm; mean body mass ± SD, 79.53±6.82kg; mean duration of back pain ± SD, 18.27±4.58mo; mean duration of leg pain ± SD, 9.13±2.54mo). The disk herniation of patients was confirmed by their physicians. Each subject had low back pain for at least 11 months before undergoing diskectomy surgery. There were 3 groups of participants (progressive resistance exercise group, aquatic backward locomotion exercise group, CON group). Subjects were pseudorandomly divided into the 3 groups so that the physical characteristics and strength levels were not statistically different across the groups (fig 1). The progressive resistance exercise group was subject to a training protocol on the MedX[a] training equipment, the aquatic backward locomotion exercise group was subject to the backward locomotion in water, while the CON group agreed not to follow any kind of exercise program for the duration of the study. Physical characteristics of the subjects who completed this study are presented in table 1. All subjects gave informed consent based on the procedures approved by the university's internal review board.

Instruments

The progressive resistance exercise group used the MedX lumbar extension dynamometer for training. The MedX machine was also used to assess the maximum isometric lumbar extension torque at different lumbar spine flexion angles ranging from 0° to 72° with 12° intervals (ie, 72°, 60°, 48°, 36°, 24°, 12°, and 0°) (fig 2). For the aquatic backward locomotion exercise group, most of the exercises were performed in water. The water pool size was 25 × 25m, water depth was 1.3m, water temperature was 28°C to 29°C, room humidity was 70% to 75%, and room temperature was 27°C to 28°C. Heart rate was monitored with a pulse meter.[b] Subjects in the aquatic backward locomotion exercise group wore Aqua Jogger RX Footgear[c] that created buoyancy and provided resistance for their legs in the water.

Training Protocol

After the diskectomy surgery, all patients had 6 weeks of rest time. At the end of the rest period, the progressive resistance exercise and aquatic backward locomotion exercise groups started their first 6-week lumbar extension training and underwent training twice per week. For the progressive resistance exercise group, the training protocol consisted of 10 minutes of stretching exercises at about 40% of their age-predicted HRmax (men: 220 – age; women: 226 – age).[31] After this warmup exercise, the progressive resistance exercise group was provided with 20 minutes of progressive aerobic exercise at 40% to 60% HRmax. The progressive aerobic exercise was included to follow the suggestions from the MedX manual. After the warmup and progressive aerobic exercise, the progressive resistance exercise group had lumbar extension training with the MedX machine (2 sets of 15–20 repetitions at 50%–60% of 1 RM; 1 RM was measured every 2 weeks). Progressive resistance exercise was achieved by increasing the weight load by approximately 5% when 20 or more repetitions could be achieved. Lastly, the subjects cooled down by performing some more stretching exercises at 40% HRmax. The total workout lasted approximately 60 minutes. For the aquatic backward locomotion exercise group, the workout started with 10 minutes of stretching exercise at 40% HRmax. This was followed by aquatic exercises, with 10 minutes of leg swing, leg raise, and slow walking in wide steps at 40% to 60% HRmax. Subjects then performed backward walking and jogging for 20 minutes at 60% to 70% HRmax. This was followed by 10 minutes of vertical jumping, whole body twist, and trunk flexion and extension at 60% to 70% HRmax. Lastly, the subjects came out of the water and cooled down while doing stretching exercises for the next 10 minutes at 40% HRmax. The total workout time was about 60 minutes. The CON group was instructed to maintain everyday activities without undergoing any intensive training exercise. The details of the training protocols of the 2 groups are shown in table 2.

Outcome Measurements

Before testing, the subjects completed 2 to 3 practice sessions to become familiar with the MedX machine and measurement procedure. After the familiarization sessions, maximum isometric lumbar extension torque was tested to measure the isometric lumbar extension strength. The test was performed 6 times: before diskectomy surgery, after the 6-week rest period, after the first 6-week lumbar extension training, after the second 6-week lumbar extension training, after detraining, and after retraining. All subjects completed 2 isometric lumbar extension strength tests on 2 separate days. The testing dates were separated by at least 72 hours to allow subjects enough time to recover from any residual fatigue or soreness that might have been associated with the testing outcomes.[32-35] The results of the 2 tests were averaged for later analysis. The isometric lumbar extension strength was measured using a MedX lumbar extension machine at 7 angular positions, which included trunk angles of 72°, 60°, 48°, 36°, 24°, 12°, and 0° of the trunk angle. For each isometric lumbar extension strength test, subjects were seated and secured in the MedX machine. Subjects were then asked to slowly increase the lumber extension torque over 5 seconds. Once they reached the maximum torque, they were instructed to slowly reduce the torque.[34] A 5-minute rest period was provided between angle conditions. Subjects were positioned in an upright sitting position in the equipment according to the standardized procedure as described in previous research.[34,36-38] Previous studies showed that the MedX machine is highly reliable (r=.94–.98) and valid for the quantification of isometric lumbar extension strength.[34,35]

Statistical Analysis

Maximal voluntary isometric torque was measured in newton meters to estimate the lumbar extension strength. In order to investigate the overall strength changes after the lumbar extension training, detraining, and retraining periods, the max-