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Update on
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High- and Low-resistance Training Effective for Knee Osteoarthritis

Quadriceps muscle weakness has been linked to functional disability and pain in patients with knee osteoarthritis (OA). Although one of the primary aims of physical therapy is to increase strength of the knee joint musculature, there are concerns that symptoms may be aggravated with high joint loading. Optimal interventions that take into account the intensity (training weight) and volume (number of sets and repetitions) of exercise have not been well studied. In this investigation, Jan et al from National Taiwan University compared the effects of high-resistance (HR) and low-resistance (LR) strength training in elderly patients with knee OA.

One hundred two patients (mean age, 62.6 years) with a clinical and radiographic classification of chronic knee OA (>6 months duration) were randomly assigned to 1 of 3 groups: an HR group ($n = 34$), an LR group ($n = 34$), and a control group ($n = 34$), which received no exercise. The training weight was initially established as 60% of 1 repetition maximum (RM; approximately 45–50 kg) for the HR group and 10% of 1 RM (approximately 7–10 kg) for the LR group. The number of repetitions and sets was adjusted to keep the total volume of exercise comparable for the groups.

Training weight was progressively increased by 5% every 2 weeks. All patients warmed up on an exer-

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cise bicycle and used cold packs following therapy. Patients underwent 3 training sessions/week for 8 weeks. Only 3 patients were unable to tolerate the HR program because of knee pain and discontinued the exercises.

Outcome measures were pain and physical function using the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), walking time over 4 different terrains (level, stairs, figure 8 and spongy surface) and knee extensor and flexor muscle torques. Both exercise groups showed significant improvements in WOMAC pain and physical function scores, and in walking times on the figure-8 pattern and on spongy surfaces. There were no significant differences in improvement between the HR and LR groups. No changes were found in the control group (Table 1). Similarly, there were no differences found between the HR and LR groups for muscle torque improvement.

The peak torque of the knee extensors and flexors increased significantly over preintervention values for both groups, but not for the control group. A consistently larger effect size was found in the HR group, suggesting a greater training effect for this group than for the LR group.

The findings of this study provide evidence that patients with mild to moderate knee OA responded favorably to both HR and LR strength training. Clinically meaningful reductions in pain and improvement in functional performance were found in both groups. Although the groups were not statistically different in their responses to the intervention, it was interesting to observe consistently greater effect sizes for patients in the HR group.

Jan M-H, Lin J-J, Liau J-J, et al. Investigation of clinical effects of high- and low-resistance training for patients with knee osteoarthritis: a randomized controlled trial. Phys Ther *2008; 88:427-436.*

Using Upper-extremity Exercises to Enhance Core Muscle Activation

Decreased trunk muscle strength, altered reaction times and diminished movement control have been found in patients with low back pain. Upper limb exercises are often included in general strengthening programs, but their effect on back and abdominal musculature has not been well studied. Tarnanen et al from the University of Jyväskylä, Finland, assessed whether isometric exercises for the upper extremities could effectively activate core stabilizing muscles to increase muscle strength.

Twenty healthy women, ranging in age from 20–45 years old, were studied. Surface electromyography (EMG) data were collected bilaterally from the rectus abdominis, obliquus externus abdominis, longissimus and multifidus. EMG data from the exer-

Table 1. ***Preintervention and postintervention WOMAC pain and physical function subscale scores and walking time over 4 different terrains by treatment group***

Variable	HR group		LR group		Control group	
	Preintervention	Postintervention	Preintervention	Postintervention	Preintervention	Postintervention
WOMAC pain subscale	8.5 ± 3.8	4.8 ± 3.5*†	7.8 ± 3.3	4.8 ± 2.7*‡	8.3 ± 4.6	7.1 ± 3.4
WOMAC physical function subscale	26.4 ± 9.0	14.7 ± 8.5*†	26.1 ± 8.1	14.8 ± 9.2*‡	25.4 ± 11.3	22.5 ± 10.9
Walking time (s)						
Figure-8 pattern	11.0 ± 2.3	6.1 ± 2.0*†	10.9 ± 2.7	6.8 ± 1.4*‡	10.8 ± 1.8	12.1 ± 1.8
Spongy surface	12.6 ± 2.7	6.3 ± 2.5*†	12.5 ± 3.6	7.3 ± 1.4*‡	11.8 ± 3.0	12.5 ± 3.2

*Data are presented as mean ± SD. *Significant within-group difference ($p < .05$); †significant postintervention difference between HR and control groups ($p < .008$); ‡significant postintervention difference between LR and control groups ($p < .008$).*

cises were referenced to the EMG data and force output recorded during isometric trunk flexion, trunk extension and lateral trunk flexion.

Five isometric exercises of the upper limb were assessed:

1 shoulder flexion;

2 shoulder extension performed with elbow flexed to 90° and held against the side of the body;

3 shoulder horizontal flexion;

4 shoulder extension performed with the shoulder held in 90° of horizontal abduction; and

5 bilateral shoulder extension performed with the upper arms held in 45° of flexion.

The pelvis was stabilized during all measurements. The relative loading of the trunk muscles was determined by comparing the ratio of surface EMG during the maximal isometric effort of the upper limb exercises to the amplitude elicited during maximal isometric trunk flexion, extension and lateral flexion efforts.

Greatest surface EMG of the rectus abdominis and obliquus externus abdominis was recorded during the bilateral shoulder extension exercise. The mean activity level was 114%, compared with that of the trunk flexion reference exercise. This surprised the investigators because trunk flexion was presumed to produce the best activation of the rectus and obliquus muscles. Shoulder horizontal extension was also found to activate the longissimus and multifidus muscles on the contralateral side. However, the level of activation was 69% and 84% of the reference isometric trunk contraction for these muscles, respectively.

The pelvis was supported during these exercises, thus enabling improved isolation of the trunk musculature. Although there is an indirect relationship between muscle activation and force output, the findings of this study suggest that upper limb strengthening programs may be effective in enhancing core muscle strength, particularly for patients with low back pain.

Tarnanen SP, Ylinen JJ, Siekkinen KM, et al. Effect of isometric upper-extremity exercises on the activation of core stabilizing muscles. Arch Phys Med Rehabil *2008;89:513-521.*

Iontophoresis Facilitates Dexamethasone Absorption

Iontophoresis is commonly used to deliver medications through the skin to underlying tissues via a direct electrical current. Dexamethasone, a synthetic glucocorticoid that has both anti-inflammatory and inhibitory effects, is often administered with iontophoresis to treat dense connective tissue. Gurney and Wascher from the University of New Mexico, Albuquerque, compared the concentrations of dexamethasone in human tendon tissues using a true iontophoresis vs a sham treatment.

Thirty-one patients undergoing anterior cruciate ligament reconstruction surgery using a semitendinosus/gracilis autograft method were randomized to a true iontophoresis (TI) group (n = 16), a sham iontophoresis (SI) group (n = 13) or control group (n = 2). The treatment site was 8 cm proximal to the distal attachment of the semitendinosus attachment. In the TI group, a 40-mA/min dose of 0.4% (4 mg/mL) dexamethasone was used just prior to surgery. The SI group underwent the same treatment for 20 minutes, but the machine was not turned on. The control group received no treatment. The patients underwent surgery within the next 2 hours, at which time the surgeon extracted the semitendinosus tendon and fascial band.

Analysis of the tissue samples was completed by liquid chromatography/triple-quadruple mass spectrometry, monitoring the ratio of ions for dexamethasone and dexamethasone 21-phosphate disodium salt. The TI and SI groups were compared for dexamethasone concentration using the Wilcoxon rank sum test.

Significant differences were found (p = 0.2) between groups for the concentration of dexamethasone recovered, with the TI group averaging 14.2× greater tissue concentration than the SI group. Of the 16 samples in the TI group, 8 had measurable amounts of dexamethasone recovered with a concentration of 2.9 ng/g of tendon tissue. There was 1 sample in the SI group that had a measurable

amount, which may have occurred secondary to diffusion across the skin. Skin thickness did not have an effect on the amount of dexamethasone recovered. Half of the TI group (8 patients) responded. The investigators suggested that the 8 nonresponders may have required more time to deliver the dexamethasone by secondary transmission than that allotted for in this study, or there may be individual differences in dexamethasone metabolism.

The positive findings of this study show that iontophoresis can facilitate the transmission of dexamethasone to subcutaneous tissues in humans and should be part of the management of acute inflammatory conditions. Additional studies are warranted.

Gurney AB, Wascher DC. Absorption of dexamethasone sodium phosphate in human connective tissue using iontophoresis. Am J Sports Med *2008;36: 753-759.*

Hip Weakness a Primary Factor in PFPS

Hip external rotation and abduction weakness have been found in women diagnosed with patellofemoral pain syndrome (PFPS). Though excessive knee valgus, hip internal rotation and hip adduction have been linked to hip weakness, they have not been identified in participants with PFPS. Bolgla et al from the Medical College of Georgia simultaneously compared hip strength and hip and knee kinematics in participants with PFPS with a group of matched controls.

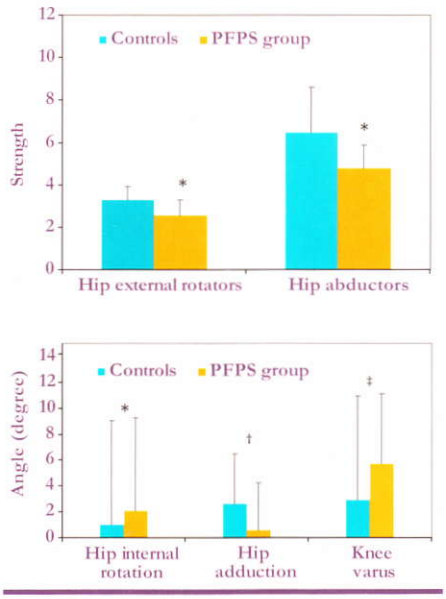

Figure 1. Top graph: Mean ± SD for strength measures normalized to patient body mass and height. *Significant differences between groups ($p < .01$). **Bottom graph**: Mean ± SD for average hip internal rotation, hip adduction and knee varus angles during the entire stance phase of stair descent. No difference between groups: *$p = .60$, †$p = .15$ and ‡$p = .28$.

Eighteen women (mean age, 24.5 years) with PFPS symptoms, including anterior knee pain during stair descent, pain for a minimum of 1 month and pain during 2 activities (squatting, stair ascent), were recruited and matched with asymptomatic participants with respect to age, height and body mass.

Pain was assessed using a 10-cm Visual Analogue Scale (VAS). Using a handheld dynamometer, isometric strength measures were taken for the hip abductors and hip external rotators. These data were then normalized to participant height and weight to allow for comparison. Kinematic data were collected for hip transverse plane (hip internal rotation), hip frontal plane (hip adduction) and knee frontal plane (knee varus) angles as participants completed a stair-stepping task.

Average VAS score for participants with PFPS was 4.4 of 10. Compared with the control group, participants with PFPS had significantly lower hip external rotation strength ($p = .002$) and hip abductor strength ($p = .006$), and generated 24% and 26% less torque for external and abductor torque, respectively, than controls. Participants with PFPS maintained their knee in greater varus (5.7° vs 2.9°) compared with controls during stair descent (Figure 1).

Participants with PFPS had weaker hip external rotators and hip abductors, thus indicating the importance of addressing these weaknesses in physical therapy interventions. The protocol of the study (a simple 2-step ascent and descent), participant compensation for pain and/or high participant variability may have minimized any movement abnormalities that may be present in this population. Additional studies are warranted to understand the relationship.

Bolgla LA, Malone TR, Umberger BR, Uhl TL. Hip strength and hip and knee kinematics during stair descent in females with and without patellofemoral pain syndrome. J Orthop Sports Phys Ther *2008;38:12-18.*

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