THE ADDED EFFECT OF HIP ADDUCTION TO LEG PRESS ON PATELLAR REALIGNMENT- A COMPUTED TOMOGRAPHY STUDY

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The purpose of this study was to explore the probable added effect of hip adduction to leg press exercise training on patellar realignment in patients with patellofemoral pain. Twelve women and five men with age between 21 to 53 yrs participated the study. Triweekly leg press with hip adduction (LPHA) or leg press (LP) training was randomly performed for 8 weeks. An axial CT imaging of patellofemoral joint was performed without and with maximal quadriceps isometric contraction at full knee extension to determine the patella tilt angle of Sasaki and bisect offset index before and after the training period. 10cm-VAS was also measured for pain. No differences in patellar alignment were found with quadriceps relaxed or contracted following LPHA or LP while significant pain reduction was shown. Hip adduction had no added effect on patellar realignment.

KEY WORDS: patella, leg press, computed tomography.

INTRODUCTION:

Patellofemoral pain syndrome (PFPS) is a common musculoskeletal problem of the knee in orthopaedic and sports medicine that occurs in association with lateral malalignment of the patella. Numerous rehabilitation protocols have been described for treating patellofemoral problems that include therapeutic exercise, taping and bracing. Among them, exercise (i.e., quadriceps strengthening and stretching) is a generally accepted conservative treatment. Incorporating hip adduction with knee extension is a popular strategy for strengthening quadriceps, especially emphasizing the vastus medialis obliquus (VMO), with the aim to alleviate pain by correcting or improving proper patellar tracking. Despite an excellent success rate of clinical efficacy was documented, few studies, however, addressed the underlying mechanism. It remained unclear how patellofemoral malalignment changed with physical therapy interventions. The purpose of this study was to investigate and compare the effects of leg press with hip adduction (LPHA) and leg press (LP) exercises on patellar alignment and pain in patients with PFPS.

METHOD:

Seventeen patients (12 women and 5 men) with a diagnosis of PFPS were referred to our kinesiology laboratory by an orthopaedic surgeon (YFL) and participated in the current study. The inclusion criteria were: (1) experience of anterior or retropatellar knee pain after performing at least two of the following activities: prolonged sitting, stair-climbing, squatting, running, kneeling, hopping/jumping and deep knee flexing; (2) insidious onset of symptoms unrelated to traumatic accident; (3) presence of pain for more than 1 month. In addition, participants had to exhibit at least two of the following positive signs of anterior knee pain during the initial physical examination: (1) patellar crepitus; (2) pain following isometric quadriceps contraction against suprapatellar resistance with the knee in slight flexion (Clarke's sign); (3) pain following compression of the patella against the femoral condyles with the knee in full extension (patellar grind test); (4) tenderness upon palpation of the posterior surface of the patella or surrounding structure; (5) pain following resisted knee extension. Participants were excluded if they had: (1) self-reported clinical evidence of other knee pathology; (2) a history of knee surgery; (3) central or peripheral neurological pathology; (4) obvious knee deformity or lower extremity malalignment; (5) severe knee pain (VAS>8); (6) received non-steroidal anti-inflammatory drugs, injections or physical therapy in preceding 3 months.

All volunteers were enrolled after providing written informed consent. The study was performed in a blind manner. One physical therapist (TCW) was responsible for intervention. Participants were randomly assigned to LPHA or LP group (Table 1.) by numbered opaque envelopes, and received triweekly treatments for 8 weeks. LPHA was performed unilaterally starting from 45° knee flexion to full extension using an EN-Dynamic Track machine (Enraf-Nonius B.V., Rotterdam, The Netherlands). A blue thera-band (The Hygenic Corporation, Akron, OH) was tied from an arm of the machine to the distal 1/3 of each patient's thigh, offering about 50N resistance to isometric hip adduction (Figure 1.). In LP group, the thera-band was only tied on patient's thigh without resistance to maintain consistent tactile stimulation between groups. Prior to the beginning of exercise training, unilateral 1 RM strength of the lower extremity was determined by Odvar Holten Pyramid Diagram with repetition-to-fatigue testing. Patients were unilaterally trained at 60% of 1 RM for 5 sets of 10 repetitions. The 1 RM was re-measured every 2 weeks and the exercise intensity adjusted accordingly. A 60-Hz metronome was used to control the exercise pace at 2-s concentric and eccentric contractions from 45° of knee flexion to full extension. There was a 2-s break between each repetition, and a 2-min break between each set. Limbs were alternatively trained between each exercise set. A hot pack was applied to quadriceps for 15 minutes before exercise. After exercise, participants were asked to stretch their quadriceps, hamstrings, iliotibial band and calf muscle groups and were given a cold pack for 10 minutes. Stretches were maintained for 30 seconds and were repeated 3 times for each muscle group. Two assessment sessions were performed by another physical therapist (CYS) before and after the intervention. All patients underwent axial CT imaging of both knees at full knee extension, without and with maximal quadriceps isometric contraction by Pace General Electric Machine (GE Medical Systems, Milwaukee, Wisconsin). Scans were obtained with the subjects in supine position, ankles restrained with felt strips to prevent leg rotation, and a thick padded towel placed underneath the knees. Axial sections were obtained through the widest diameter of the patella, allowing for the best view of the patellofemoral joint for the measurement (Gigante et al., 2001). Centricity radiology RA 600 image software (version 6.1, GE Medical Systems, Milwaukee, Wisconsin) was used to determine the patellar tilt angle of Sasaki (PTA-S) and bisect offset index for the measurement of lateral patellar tilt and displacement. The between-days intra-rater and inter-rater reliability (ICC value) ranged from 0.91 to 0.98 and from 0.76 to 0.86 that indicated good to excellent reproducibility. In addition, the 10-cm VAS pain score was measured both before and after 8-wk intervention period.
Data analysis was performed using SPSS 11.0 (SPSS, Inc., Chicago, IL). A three-way mixed ANOVA was performed with group (LPHA or LP), assessment point (pre- or post-training) and muscle condition (quadriceps relax or contraction) as factors for PTA-S and bisect offset index. VAS was compared between group and assessment time by two-way mixed ANOVA. Differences were considered significant when $p< 0.05$.

Table 1. Demographic Data for Participants[a]

	LP (N= 15)	LPHA (N= 13)
Sex (M：F)	2：7	3：5
Age (y/o)	40.8±11.0	38.6±11.8
Height (cm)	161.1±7.4	163.9±7.8
Weight (kg)	59.1±10.5	55.5±8.7
Involved side (Bil.：unil.)	6：3	5：3

[a] Data are presented as mean±SD

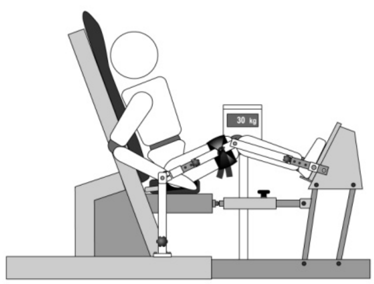

Figure 1. LPHA Exercise

RESULTS:

There were no significant differences in PTA-S and bisect offset index between LPHA and LP groups, and the training of either group with quadriceps relaxed or contracted while statistically significant pain reduction occurred following the training of either group (Table 2).

Table 2. Comparison between Pre- and Post-training Changes of Patellar Alignment and Pain in LP and LPHA Groups[a]

	LP (N= 15)		LPHA (N= 13)	
	Pre-training	Post-training	Pre-training	Post-training
PTA-S (°)				
Without contraction	17.39 (4.65)	17.61 (5.37)	19.18 (2.41)	18.87 (3.62)
With contraction	17.78 (5.50)	17.59 (6.44)	18.69 (4.50)	18.28 (4.71)
Bisect offset index (%)				
Without contraction	63.9 (12.2)	64.7 (8.4)	66.4 (12.9)	66.4 (13.5)
With contraction	67.0 (14.6)	68.9 (13.9)	68.7 (15.8)	68.9 (12.6)
VAS pain score (cm)	4.65 (2.18)	2.25 (2.36)*	4.55 (1.90)	2.65 (2.04)*

[a] Data are presented as mean (SD)
* denotes significant difference between pre- and post-training (p= .001).

DISCUSSION:
Strengthening of the knee extensor together with hip adduction is one of the most common therapeutic approaches for treating PFPS. This intervention takes the fact into consideration that the VMO is connected to the adductor magnus and longus (Bose et al., 1980). Training of the adductor muscles uses the anatomical link to provide a more stable proximal attachment and transfers physiological stretch to the VMO, a major medial stabilizer of the patella, thereby enhancing the contraction force. Despite that the patellar malalignment was thought to be associated with PFPS, there has been limited evidence to date that addressed therapeutic exercise effect on patellar realignment. In the present study, 8-wk LPHA and LP exercises significantly reduced the pain, however, they did not do so by medializing the patella. Furthermore, hip adduction had no added effect on patellar realignment. To detect the statistical difference in PTA-S and bisect offset index after training or between both exercise groups, at least 887 participants were required to have 80% power.
This is the pioneer study to quantify patellar alignment changes via computed tomography following 8-wk exercise training. Ingersoll and Knight (1991) once investigated the patellar location changes via x-ray following EMG biofeedback or progressive resistive terminal extension exercises. Although the results indicated the use of EMG biofeedback was superior to terminal knee extension for correcting patellar malalignment at 45° of knee flexion, these data were gathered from normal subjects. Doucette et al. (1992) investigated the effects of individualized and progressive therapeutic exercises in patients with PFPS that consisted of 5-stage programs, including VMO strengthening, stretching, patellar joint mobility, taping and orthoses. The radiographic results showed patients who were pain-free after averaged stage 4.33 and 8-wk rehabilitation programs demonstrated significant mean decrease in patellofemoral congruence angles of 6.62° but not in patellofemoral index (PFI, an indicator of patellar tilt), indicating more medial tracking of the patella at 30° of knee flexion. The other group, who still had pain after averaged stage 2.75 and 14-wk exercise, however, did not show any improvement in patellofemoral congruence angle or PFI. This study was not a RCT design that the patients were grouped according to their treatment response (pain-free or not). Care must be made while interpreting and comparing these results with the current study since the index chosen for patellar alignment, subjects' knee flexion angle and image-measuring methods were inconsistent.
As regarding to the values of the PTA-S and bisect offset index measured in the present study, the mean tilt angle of 17.39-19.18 was similar with 18.9 of Koskinen et al. (1991) but much smaller than 24.4 of Biedert and Gruhl (1997), and 21.80 of Lin et al. (2008). This may due to sampling difference that they recruited patients with a wide range of patellar tilt from 6 to 80 and 7.1 to 33.1 degrees, respectively. The bisect offset index measured was in accordance with Powers et al. (1999, 2004) who reported the value about 60-70%.
Although the patellofemoral malalignment was most often believed to the major cause of PFPS, the issue is currently questioned. Despite various imaging-measurement techniques

exist, the questionable reliability and validity, and an absence of appropriate normative data and gold standard remain a challenge for malalignment theory. Further, no consistent differences in patellofemoral malalignment were found between symptomatic and asymptomatic knees. Patellofemoral malalignment were poorly correlated with PFPS symptoms and successful outcome of conservative treatment. Wilson (2007) summarized and passed the information that maybe we are confusing assumption with evidence in the measurement of patellar alignment in PFPS. Other contributing factor, for instance, the tissue homeostasis (Dye, 2005), may need more consideration.

It is still unclear why patellofemoral pain decreases with exercise. Even though, LPHA and LP exercise, with combined lower extremity stretching exercise, are effective in controlling patellofemoral pain, like past studies. The pain score changes, in the current study, were clinically significant (Crossley et al., 2004).

The study had several limitations. First, only lateral patellar tilt and displacement were evaluated with quadriceps relaxed and contracted at full knee extension. It is possible that the patellar alignment would change in other degree of freedom or with different knee flexion angles or other contractile states of the quadriceps, as thus a further investigation is warranted. Furthermore, there was a lack of sufficient patient populations. It would be of interest to ascertain whether patients with different type of malalignment (i.e., lateral displacement alone, lateral tilt alone, a combination of both, or normal alignment) would demonstrate different trends of patellar movement in response to therapeutic exercise trainings. The classification may help guide a more selective clinical management of PFPS.

CONCLUSION:

The results did not demonstrate the repositioning effect on patellar alignment by either LP or LPHA. Patellar realignment apparently was not responsible for pain alleviation after LP or LPHA training.

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