A High Intensity Lower Extremity Resistance Program For a Patient with Unstable Patellae

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Abstract

Background and Purpose: The purpose of this case report is to describe the use of a high resistive lower extremity circuit weight training program for a patient with a diagnosis of a right subluxed patella.

Case Description: Patient was a 27 year old male who had been diagnosed with a right lateral patellar subluxation. He presented with severe right knee pain during ambulation and stair climbing. Examination revealed bilateral patella apprehension, right lower extremity weakness, and decreased flexibility in bilateral hamstrings.

Outcomes: By the end of treatment the patient had attained all his goals. Lower Extremity Functional Scale Scores improved from 15 to 66 out of 80, Kujala Patellofemoral Scores improved from 20 to 82 out of 100.

Discussion: Currently there is no protocol in the literature of treatment for someone with a subluxed patella. Most of the research suggests bracing and pain control with modalities in the acute stages of a patella subluxation with a low intensity resistance program in the later stages. Future research may need to focus on rehabilitation in the athletic verse non-athletic populations.

Introduction:

Patellofemoral disorders are common conditions encountered by physical therapists and sports medicine doctors. It is estimated 25%-36% of the population are afflicted with some form of patellofemoral syndrome.[1]A common complaint that patients present with is anterior knee pain. There are wide ranges of knee disorders that can cause anterior knee pain such as acute trauma, overuse, chondromalacia, misalignment, and instability. Traumatic instability injuries are more likely to occur in male athletes, and other patellofemoral disorders are more likely to occur in non-athletic female.[2] Acute and recurrent instability can often be eclipsed by other injuries such as overuse. A thorough exam and evaluation are important to treating instability disorders.[3-4] Most of the research supports management of patella subluxation with conservative therapy emphasizing strengthening and flexibility programs.[1]

The intercondylar groove of the femur and the posterior surface of the patella are what form the patellofemoral joint. Working together with soft tissue structures the patellofemoral joint becomes the keystone to the knee extensor mechanisms by providing a fulcrum and increasing efficacy of lower leg extension. There are several structures that guide and stabilize the patella within the intercondylar groove. These structures include the quadriceps muscle, quadriceps tendon, patellar ligaments, iliotibial band (ITB), patellar retinacular fibers, and the shape of the articular surfaces.[3,5] Acting alone these structures exert either a medial or lateral force on the patella as it moves within the joint space. When these structures are working together, they balance the forces on the patella keeping it on track. When the forces are un-balanced the patella will track improperly causing increased

stress on the joint. Tracking problems can lead to arthritis, chondromalacia, patellofemoral joint pain, or re-current patellar subluxations or dislocations.[6,7]

Patellofemoral instability refers to both patella subluxation and patella dislocation. The difference between the two is determined by degree of slippage. Patella subluxation occurs when the patella leaves the track of the intercondylar groove, and patella dislocation occurs when the patella leaves the intercondylar groove completely. Instability is often referred to as the medical diagnosis. The majority of subluxation and dislocations occur laterally, however medial instability does occur after overaggressive surgery.[4]

Biomechanical imbalance is one of the most common reasons for patellofemoral instability. There are several anatomical and functional abnormalities that can be attributed to patellar subluxation including; "Q" angles greater than 15˚, a high riding patella (patella alta), tibial torsion, quadriceps and hip external rotator weakness, a tilted patella, or a tight ITB.[2-3,8-9]

The two structures that have been shown to have a big impact on patellofemoral treatment are the vastus medialis oblique (VMO) and ITB/lateral retinaculum. Tightness of the ITB leads to a lateral tilt of the patella stretching the VMO causing weakness in the muscle increasing the risk of lateral subluxation.[1] Patients will present with weak eccentric control of the quadriceps, frequently displaying difficulty descending and ascending stairs. The increased weakness of the VMO manifests when the patella is unable to resist lateral subluxation during stair climbing, running, and jumping activities.[1]

A common outcome to chronic patellar malalignment is patellofemoral arthrosis. For this reason surgery may be indicated for those who do not respond to conservative treatment. There are several surgical techniques that have been described in the past,

however there are three common techniques that surgeons will use.1) Correction of the valgus angle of the patellar tendon (distal re-alignment). 2) A lateral release where the tightened structures that cause excessive pressure and patellar subluxation are released. 3) Medial reefing where vastus medialis advancement and tightening of the lax medial restraints is performed. Many patients will also require arthroscopy to detect any other problems within the joint.[9]

An understanding of the knee biomechanics, pathophysiology, and theory behind surgical techniques allows the therapist to effectively treat patients with patellofemoral disorders.[9] Current literature suggests focusing on protection of the joint in the acute phase of rehabilitation after patella subluxation or surgery. Bracing after surgery has been noted in much of the research for early phases of rehabilitation.[1-2,9-11] Research on early phases, immediately after injury has also suggested bracing and usually include isometric exercises to quadriceps and hamstrings, and some closed kinetic chain exercises. Modified open kinetic chain exercises are used in the intermediate phase, such as low weight and limited arc during leg extension exercises. The goal of early therapy is to decrease pain, reduce any effusion, and provide proprioceptive feedback. In the intermediate and advanced phases of therapy the research focuses on specifically strengthening weak muscles such as the VMO which help to pull the patella away from the side of dislocation. Flexibility exercises are incorporated throughout therapy to reduce the tension from the ITB and patella retinaculum which can pull the patella laterally.[3-4,9,11-12]

It is not until advanced phases of rehabilitation that the patient begins strengthening exercises with increased loads. It has been suggested that heavy resistance exercises, exercises that are performed between 60%-95% of a person's maximal intensity are

necessary to producing significant neuromuscular activation. Isometric quadriceps contraction has shown to be below threshold in order to obtain muscle hypertrophy.[7,13] Other studies have looked at strengthening of the hip external rotators and abductors to decrease compensation of functional internal rotation which can cause patella lateralization.[1,3]

Maximal muscle strength has been positively correlated with being able to perform activities of daily living. This study looks at early heavy resistance strengthening without bracing, in a highly athletic individual. The use of isometrics and lower level strengthening were used as a supplement. In order to achieve the highest level of neuromuscular activation for an athletic individual full arc leg extension and abduction exercises with high loads were incorporated into the program. This individual needed muscle strengthening to allow his patella to resist subluxation pressure created by his own biomechanical imbalances. Exercises were needed that could challenge him, and provide the appropriate resistance in order to gain muscle hypertrophy and stabilize the patellofemoral joint.

It was hypothesized the standard low intensity strengthening/protection program would not benefit this particular patient. He would require a higher level program that would get him back to his previous level of functioning. The purpose of this study was to assess the effectiveness of a heavy resistance program for the lower extremity during the first phase of rehabilitation, for an athletic individual who had an acute subluxation of his patella.

Case Description:

Patient was a 27 year old male. He currently works at a company that requires him to sit at a desk as well as walk around often and talk to clients during the day. He leads a highly social lifestyle and competes in multiple recreational sports. He use to compete in lacrosse at the collegiate level. He was working out at the gym on a daily basis prior to injuring his right

patella. He had been referred to the clinic by his orthopedic doctor after his right patella had laterally subluxed four days prior to the physical therapy visit. The day he injured his right patella he had been hiking, biking, and sailing with friends. He had been lifting a cooler off a boat when it slammed into his right lateral thigh while his lower leg remained planted. Since he had a history of subluxation in his left knee he knew how to re-locate the right knee himself at the time of injury. After the incident he went to the emergency room where x-rays were taken and were negative for fracture. The doctors gave him crutches and a long leg knee immobilizer brace. He then went to see his orthopedic doctor who took him off crutches and gave him a patellofemoral brace as well as a physical therapy referral. His main goals for therapy were to decrease pain, prevent further subluxations of his right knee, and get back to his highly active lifestyle.

His past medical history includes multiple left lateral patella subluxations. In September 2007 he had an arthroscopic excision for loose osteochondral fragments on the medial and lateral inferior surface of his left patella. Surgeons also did a medial patellofemoral ligament and retinaculum repair, and a left lateral release. After surgery he underwent 30 days of physical therapy rehabilitation. Therapy included lower extremity stretching, strengthening exercises, modalities for pain and swelling, and functional training. He regained normal strength and flexibility of his left lower extremity which allowed him to maintain his previous level of function. However some atrophy of his left quadriceps remained.

The patient was chosen for this case report because he was an athletic individual that could possibly benefit from an intense strengthening program for patella instability. It was hypothesized this program would return him to his previous level of function.

Examination:

The patient was seen in an orthopedic outpatient clinic by me a student physical therapist as well as his previous therapist, who worked with him when he had surgery on his left patella. Structural alignment revealed bilateral patella alta, bilateral tilted and laterally glided patella, and bilateral Q angles of 12˚. General observation showed minimal atrophy to the left quadriceps (residual from previous surgery), redness and moderate swelling of the right medial peripatella and popliteal fossa regions. Palpable tenderness was elicited on the right medial and lateral patella facets. There was audible and palpable right patellofemoral crepitus. Manual muscle testing and flexibility testing were then performed results are summarized in Tables 1 and 2.[14-15]

In order to assess patella instability an apprehension test was performed to bilateral patella. Both were positive for apprehension when a lateral force was applied.[16] Ligamentous testing was not assessed due to pain and patients apprehension with medial and lateral directional force application to the knee. The patient's functional abilities were assessed through observational gait analysis and stair climbing. We had him walk without his patellofemoral brace 20 feet on a flat carpeted indoor surface. We also had him ascend and descend eight 6" steps. Observation revealed an antalgic gait with increased knee flexion during push off, and decreased weight bearing of his right lower extremity during stance phases. The patient had decreased eccentric control of his right lower extremity while descending stairs, and ascended/descended stairs with a step to pattern with a unilateral handrail.

Subjectively the patient reported pain 7 out of 10 on the Visual Analog Scale[17] when climbing up and down stairs, as well as with walking long distances, and sitting for

prolonged periods of time. At the conclusion of the evaluation the patient filled out a Lower Extremity Functional Scale assessment, he scored 15 out 80 points, sighting most difficulty with squatting, walking, running, and pivoting activities.[18] A Kujala Patellofemoral Scale was also used to assess functional ability; he scored 20 out of a possible 100 points at the time of initial evaluation.[19]

Evaluation:

The patient's biggest obstacle was pain especially with resistance. His functional status was limited secondary to pain. Climbing stairs, walking, and sitting for prolonged periods were very difficult at the time of initial evaluation. A program was needed that focused on pain control, stretching, and strengthening.

Prognosis:

Due to his athletic build and high activity level he could benefit from a high intensity lower extremity weight lifting program. He was a highly motivated disciplined individual that had a high likelihood of returning to previous level of function.

Diagnosis:

His physical therapy diagnosis according to The Guide to Physical Therapist is Preferred Practice Pattern 4D, impaired joint mobility, motor function, muscle performance, and range of motion associated with connective tissue dysfunction. The ICD-9 code was 836 dislocation of the knee.[20]

Plan of Care:

The patient would be seen three times per week, for six weeks, 30 minute sessions. Therapy sessions would include flexibility, strength and functional training. Goals were based on the patient's need and desired outcomes. Goals were as follows:

Short term goals:

Patient would decrease swelling of right peripatella region by 50% in two weeks.

Patient would increase quadriceps strength by half a grade in three weeks.

Patient will increase hamstring flexibility by 5 degrees in two weeks.

Long term goals:

Patient will have 0-1/10 pain while climbing stairs by discharge.

Patient will increase strength of right lower extremity in order to climb stairs and walk for 2 miles by discharge.

Patient will have improved score on the LEFS by 60% in order to return to previous level of function at discharge.

Intervention:

The intervention was based on the supervising therapist and student therapist's clinical judgment. The patient's program consisted of a home exercise program, modalities, manual stretching, progressive resistive exercises for bilateral lower extremities, and functional training.

From the start of the program the patient took off his patellofemoral brace, he was then placed on a lower extremity circuit weight training program. Weights were progressed each session based on patient tolerance and performance of exercise. Each session began with manual stretching of hamstrings, quadriceps, and gastrocnemius muscles. The patient was in supine while the therapist brought his leg to the end ranges. Stretches were held for 15 seconds, two times, to both legs. The patient then warmed up with straight leg raises in supine and side lying with an ankle weight, 15 reps, 3 times, to each leg (as the program progressed SLR was performed for 1 minute non-stop to BLE). Alternated hip flexion in

sitting with an ankle weights was used as a warm up as well, for 1 minute, 3 times. After the warm up was complete the patient was brought out into the gym to use standard weight lifting machines, 15 reps 3 sets of most exercises using bilateral lower extremities were performed unless otherwise noted in Table 3.

Machines used included:

Seated Leg Extension: Patient was in seated position, he performed 3 sets of 15 repetitions with bilateral lower extremities with 30 second rest between sets. Weight was adjusted and he then performed 2 sets of 15 repetitions with only his right lower extremity. At week 4 eccentric loading using only his right lower extremity was added; 2 sets 15 repetitions.

Prone Leg Curl: The patient lay prone on a bench performing 2 sets and 15 repetitions 30 second rest between sets. Weight was adjusted and the patient performed another 2 sets of 15 repetitions with only his right leg.

Seated abduction: Patient was in seated position; he performed 3 sets of 15 repetitions with bilateral lower extremities with 30 second rest between sets.

Seated adduction: Patient was in seated position; he performed 3 sets of 15 repetitions with bilateral lower extremities with 30 second rest between sets.

Seated Leg Press: Patient was in seated position, he performed 3 sets of 15 repetitions with bilateral lower extremities with 30 second rest between sets.

At week 3 functional training was added, patient performed lateral step ups on an 8" step. By the end of week 4 eccentric loading on the leg extension machine was added. By week 5 of the program the patient was running 1 mile on a treadmill at 6.0 mph. Progression of weights are provided in Table 3. The patient received 15 minutes of ice to bilateral knees at the end of each session to decrease any swelling or increased discomfort incurred from the

program. The patient also received a home exercise program that included stretching, straight leg raises with ankle weights in all four planes, isometric quad sets, and hip flexion exercises. He was to perform these at least once a day, 15 reps, 3 sets of each exercise

Outcomes:

By the end of week three the patient had reached his goals of climbing stairs with decreased pain, and walking a mile with only minimal discomfort. His Lower Extremity Functional Scale Score improved from 15 out of 80 at the initial evaluation to 66 out of 80 by week five. His Kujala Patellofemoral Score improved from 20 to 82 out of a possible 100 points by the end of the program. Manual Muscle Test revealed increased strength by a full grade to his right quadriceps and right hamstrings by week 5. Flexibility testing of his right hamstring was within normal limits at week 3 of the program. Due to the patient's progress at week 5, running goals were incorporated into his program. At the end of the program he was able to run 1.5 miles on a treadmill at a 6.0 mph pace, which he reported, being unable to do for the past 2 years.

Discussion:

Currently there is no protocol in the literature of treatment for someone with a subluxed or dislocated patella. Management of instability disorders by physical therapy clinics are based on physician and clinician judgment. A sample program can be seen in Table 4. However the research does suggest bracing and pain control with modalities in the acute stages of a patella subluxation. The middle and late stages of rehabilitation are when strengthening of the surrounding structures is implemented. Most programs involve low weight and high repetition.[4,9,11] Many programs focus on strengthening of the quadriceps and hip rotators.[3,23] The goal of therapy is to keep the patella centered and decrease the pull from

lateral structures. Protecting the knee-extensor mechanism and not over-stressing the structures is important in knee rehabilitation. Over stressing the structures that support the patella could cause increased pain and swelling to the patient's knee.[5,8,,21,22]

The program that this particular patient followed allowed him to improve strength, flexibility, and function of his right lower extremity. We focused on strengthening what was weak and stretching what was tight. This was a high intensity program that if not monitored properly could have increase the risk of further injury to the patient's patella. When pain increased during session ten on June 23, weights had to be dropped and a lighter session had to be implemented. Although this patient was an athlete with good strength to support a high intensity program, it was important for us as clinicians to know when the weights were even too much for him. Full arc leg extension with weight and seated abduction with weight were two exercises in particular that needed to be monitored closely. These exercises were performed from the very start of the program. Full arc leg extensions can put an increased stress on the knee extensor mechanism increasing risk of swelling and pain to the patella.[5,11] Contraction of hip abductors can cause the patella to pull laterally increasing the risk for another episode of lateral patella subluxation.[5,11-12] However this patient was so strong and in shape to begin with that these exercises were performed to provide the most therapeutic benefit, give his muscles the ability to hypertrophy, provide stability to the patella, and allow him to return to his previous level of function.

There were a few limitations of the current study. We were unable to finish the last week of the program due to insurance funding running out. This makes it difficult to assess whether or not the patient could have made greater gains with ongoing treatment. This patient was also a very athletic individual; someone who is not athletic may not have had the

physiological capabilities to withstand such a high intensity program. Therefore the current study cannot be generalized to the general population. This particular program was also performed in a gym with expensive equipment. Many clinics may not have access to weight lifting equipment that allowed us to give our patient such a high intensity program. The patient also had his own gym membership which allowed him to carry on the routine once therapy sessions were finished. It is important to take into account the psyche of our patient. He was a disciplined athlete with a competitive attitude. He was working out on days he did not have therapy, determined to get stronger as soon as possible in order to return to his highly active lifestyle. Some patients may not have this same attitude and therefore may not be able to follow such a disciplined routine. This can limit the amount of intensity a clinician could prescribe for their patient.

Future research could focus on conservative treatment of patella subluxations in the athletic verse the non-athletic population. Emphasis could be put on intensity of the program. Most programs are based on clinical experience and individualized for the patient, and focus on low intensity high repetition. The question of future studies could center on, how intense of a program could someone in the non-athletic population handle that would allow the best therapeutic benefit? That leads to asking if higher intensity programs are more beneficial than lower intensity programs for patients with unstable patellae.

Conclusion:

This case report was based on a 27 year old male with a diagnosis of right lateral patella subluxation. The high weight lower extremity circuit program was appropriate and beneficial for this patient. He was able to attain his desired outcomes, and improve upon his prior functional level of activity by gaining the ability to run. This was something he had not

been able to do in the past 2 years. It is important to note this was an extremely athletic, fit individual, who required a program that would induce neuromuscular activation to stimulate muscle growth and strength of his bilateral lower extremities. The program can not be generalized, but was successful in treating this individual.

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Table 1: Strength Testing

Manual Muscle Test	*Right Lower Extremity*	*Left Lower Extremity*
Hip Flexor	4/5	5/5
Quadriceps	3+/5 (pain on overpressure)	4+/5
Hamstring	4-/5	5/5
Abduction	4/5	5/5
Adduction	4/5	5/5
Plantarflexion	5/5	5/5
Dorsiflexion	5/5	5/5

Table 2: Range of Motion and Flexibility Testing

	AROM Right	*PROM Right*	*AROM Left*	*PROM Left*
Straight Leg Raise	65˚	75˚	85˚	90˚
Quadriceps	130˚	140˚	130˚	145˚
Knee Flex	WNL	WNL	WNL	WNL
ITB	Min Limited		Min Limited	

Table 3: Intervention

	5/29 & 6/1	*6/3*	*6/4*	*6/8*	*6/10*	*6/11*	*6/15*	*6/17*	*6/23*	*6/24*	*6/25*	*6/29*	*7/1*	*7/2*
Manual stretch H/Q/GS	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SLR (B) Flex & ABD	3lb/15x3	X	X	X	5lb	X	X	X	X	X	X	X	5llb 1min x3	X
HF	3lb/1minx1	X	X	X	5lb	X	X	X	X	X	X	X	X	X
LX (B)	30lb/15x3	35lb	40lb	50lb	X	60lb	X	70lb	X	X	X	X	X	X
LX ®	15lb/15x2	X	25lb	X	X	X	X	X	30lb	X	X	X	X	X
LX ® ecc											40lb 15x2	X	X	X
LC (B)	50lb/15x3	X	65lb	80lbx1 65lbx1	80lbx2	X	100lb	60lb	X	80lb	X	X	X	X
LC ®	20lb/15x2	X	X	50lb/10x1 35lb/15x1	X	50lb	X	X	35lb	X	X	X	50lb	X
ABD	70lb/15x3	X	X	100lbx2 95lbx1	X	X	110lb	X	X	100	X	X	X	X
ADD	90lb/15x3	X	X	110lb	X	X	X	X	X	120	X	X	X	X
LP (B)		160lb/15x3	X	200lb	X	240	X	X	200	X	X	X	X	X
LP ®		80lb/15x2	X	100lb	X	X	X	X	X	X	X	X	X	X
Lateral step ups						50x	X	X	X	X	X	100x	X	X
Treadmill													1 mile 6.0	X

Key: X=exercise performed same as previous session; H=hamstring stretch; Q=quadriceps stretch; GS=gastroc strectch; HF=hip flexion; LX=leg extension; ecc=eccentric contraction; LC=leg curl; LP=leg press; ADD=adduction; ABD=abduction; B=Bilateral; ®=right

Table 4: Other Facility Program vs. Current Patient's Program

Other Program[24]	Patient's Protocol
Weeks 0-2: Protection phase • Knee Immobilizer • Cryotherapy • Stretching • Open Kinetic Chain Leg extension 90-45˚;submax strengthening • Mid range strengthening with leg press	Weeks 0-2 • Discontinued Knee Immobilizer • Cryotherapy • Stretching • Full Arc Leg Extension • Full ROM with Leg press
Week 2-4 • Progress ROM • Knee Immobilizer for ambulation • Avoid Dynamic Valgus strengthening/ functional activity, lightly loaded abduction external rotator exercises • Increase angle of leg extension • Progress to full ROM strengthening per patient tolerance, low resistance	Weeks 2-4 • Flexibility/ROM exercises • No immobilizer • Heavy loaded valgus exercises • Increased resistance to leg extension and leg press
Week 4+ • Immobilizer for Sport • Continue ROM exercises to full range • Strength exercises with increased loads/full ROM • Begin running and agility program work if 75% CKC strength was achieved	Week 4+ • ROM/flexibility continued • Heavy load resistance • Began running program