Patellofemoral Pain Syndrome: Patellar Malalignment, Muscle Imbalance, Proper Mechanics, and the BASI System

Christina “CJ” Kelly
June 2, 2013
California Pilates Center, Oceanside, CA
Abstract

Patellofemoral Pain Syndrome (PFPS) is more than meets the eye. While a common diagnosis, it often goes mistreated due to the complexity involved in proper care. Patellar Malalignment, muscle imbalance, proper mechanics, age, and gender are all factors contributing to the severity and complication of the PFPS case. While it is true that PFPS is common in young female athletes it does not discriminate. Anyone with muscle imbalance and poor mechanics will at some point suffer from patellofemoral pain. This paper serves as an example of how to take an active female in her late twenties and rehabilitate using the BASI Block System.
Table of Contents

Anatomical Overview 4
Introduction 5
Case Study – Kayla K.*, San Diego, CA 6
Application of the BASI Pilates Method 8
Conclusion 14
Bibliography 15
Anatomical Overview

Knee:

*Rectus femoris:* hip flexion, knee extension.

*Quadriceps tendon:* controls knee flexion and extension.

*Iliotibial (IT) band:* flex, abduct, and medially rotate the hip; lateral knee stabilization.

*Patella:* kneecap; articulates with the femur and cover covers/protects anterior surface of knee joint; connected to tendons of quadriceps femoris group.

Muscles of the Pelvis & Thigh:

*Gluteus maximus:* hip extension, external rotation.

*Gluteus medius* (*posterior fibers*): external rotation, hip extension.

*Gluteus minimus:* internal rotation, hip flexion.

*Iliopsoas:* hip flexion, lumbar lordosis.

*Hamstrings:* hip extension, knee flexion

---

1 Neumann, *Kinesiology of the Musculoskeletal System: Foundations for Rehabilitation*

2 Biel, *Trail Guide to the Body*
Patellofemoral pain syndrome (PFPS) is the most common knee injury among active females with women twice as likely as men to be effected (Willson). Cases in women are higher due to having a wider pelvis and corresponding quadriceps angle, also known as the q-angle. Women also have societal factors affecting their footwork (such as wearing high heels) or imposed posture factors (such as crossing their legs at the knee).

Patellar malalignment is a rotational or translational deviation of the patella relative to any axis (Grelsamer). Dr. Grelsamer, an Associate Professor of Orthopedics at Mount Sinai Hospital, states that “the greater the underlying malalignment, the greater the tendency of the dislocation to recur.” He goes on to say that the younger a patient is at the time of injury, the more likely they are to dislocate in the future due to instability. In many cases, patellar malalignment can be explained due to a direct trauma but it can also be explained by muscle imbalance.

There are three main muscular factors contributing to imbalances and PFPS. First, Many suffering from PFPS have tight hamstrings. A tight hamstring often results in the knee remaining in flexion longer during walking and running. This excess time translates into increased force on the knee joint. This is also the case for the second cause, those individuals with tight iliitobial (IT) bands. Tight IT bands is an issue very common with runners, another group predisposed to suffering from PFPS. The final muscular source of imbalance considered can stem from the inner thighs, or specifically the vastus medialis obliquus (VMO), contracting abnormally or not at all.

Improper mechanics can also lead to pain. If the foot remains in pronation through the gait cycle it can contribute to patellofemoral pain syndrome. Pronation causes the femur and tibia to internally rotate, resulting in a lateral pull of the patella (Grelsamer). A lack of hip strength can make symptoms worse as those muscles control internal rotation.
Case Study

Kayla K. is a 28 year-old female living in San Diego, CA who suffers from right knee pain.

In summer and fall of 2012, Kayla’s physical regime consisted of mat Pilates four times a week, a private reformer session once a week, and running on the elliptical for 30 minutes three times a week. This was all in addition to living an active lifestyle of hiking, biking, and healthy eating choices. She wore a barefoot style shoe for work and her hiking and running shoes were specifically designed for moderate over-pronation.

By the beginning of the following year, Kayla replaced her running shoes with a neutral shoe at the recommendation of a gait analyst specifically for running. She decreased her elliptical time and began running outside more frequently. During this time she began to notice severe pain under her patella. Being an active person, she followed R.I.C.E (Rest, Ice, Compression, Elevation) and the pain subsided. She began running outside more in addition to jump work on the reformer. The pain became so intense she ended up on crutches, with no weight bearing on the affected leg. After seeing an orthopedic surgeon, she was informed she had Osteoarthritis though tests were not necessarily conclusive on this diagnosis. Kayla modified her physical regime to fit the diagnosis, and was limited to mat Pilates three times a week and limited walking or hiking. After almost a year under these limited conditions, Kayla was able to see a Physical Therapist who concluded that Kayla suffered from Patellofemoral Pain Syndrome (PFPS), more commonly referred to as “runner’s knee”, with right side patellar maltracking and muscle imbalances due to poor mechanics and compensations made for pain relief. At the initial evaluation by the Physical Therapist, Kayla was unable to walk more than one mile, participate in daily aerobic exercise, negotiate stairs without pain and had severely limited her Pilates mat regimen.

Manual muscle testing (MMT) was completed finding that the hip abductors (specifically gluteus medius and gluteus minimus) are weak. MMT also revealed knee flexion has room to improve with hip flexion range of motion, though within normal limits, causing pain. The hip flexors were tight, overused and unable to “turn off”;

3 Client has agreed to be the subject of this paper. The name has been changed to protect their privacy.
subsequently taking over for the gluts increasing their weakness. Currently, there is mild internal rotation noted at the hip/femur and Kayla lacks control of femoral torsion during loading phase. This combination results in placing increased pressure at lateral and medial knee with mild arch collapse. This hip dysfunction pattern gave the appearance of a mild case of Genu valgum, commonly called "knock-knee" though with time this is expected to decrease. Also noted during testing was illotbial band (ITB) and hamstring tightness with quad dominance - all combining with the above to cause lateral pulling on the patella. She also presents with mild lumbar lordosis probably caused by excessive tightness in the hip flexors and weaker abdominals. Previous injuries include: stress fractured metatarsals and dislocated right shoulder from running and playing competitive softball throughout her life.

Treatment
In order to provide relief, the hip flexor muscles (iliopsoas, rectus femoris, sartorius) must be stretched, the gluts strengthened specifically the gluteus medius (posterior), and hip extensors strength and stretch (gluteus maximus strengthened and hamstrings stretched) in order for all groups to activate properly.

Rehabilitation Treatment includes therapeutic exercises, soft tissue/joint mobilization, neuromuscular re-education, posture/body mechanics instruction, home/pilates exercise program, and patellar taping for medial glide and tilt correction as needed. Ice should be used as needed to reduce swelling after exercise.

Limitations
Specific exercises to avoid until patella is stabilized: Hip Opening (Cadillac), any kneeling exercises where force is put on patella such as reverse knee stretch (Reformer), gluteal kneeling series, or the use of ankle weights. Though she has been practicing Pilates for many years, until Kayla is stronger and has more control, I am omitting the Full Body Integration (A/M) block.
Application of the BASI Pilates Method

The Physical Therapist informed the client to foam roll at least twice a day, once in the morning and evening, in addition to before exercise. The two foam rolling exercises prescribed are Iliotibial (IT) band (60 seconds, each side, staking legs as necessary to increase pressure) and quadriceps (60 seconds, bending the knees to increase pressure as needed).

Iliotibial (IT) Band Foam Rolling

Quad Foam Rolling

I have heard people say “you need to release the ITB” but I like to think of it as a rubber band. In order for it to do its job it needs to have tension in the band, but overuse makes it become tight and stair climbing can become daunting. In Kayla’s case, the ITB was so tight it was laterally pulling the knee. Foam rolling helps to “release” those knots or trigger points. The same goes for quad dominance. With overuse, the quads become tight, pulling the tendons attached to the patella.

My philosophy with clients is to treat them as they feel in that moment – every day is different. One day Kayla may feel more tightness in her shoulders or lower back or she may be fatigued from a hike the previous day and needs to rest the knee. The following program is a guideline for working with her specific injuries, providing a challenge and increasing her strength, while still allowing for her limitations. As such, not every exercise listed will be used in every session though the BASI Block System will be followed.

---

4 Men’s Health UK
Evaluation: Roll Down
We begin and end every session with the roll down to evaluate Kayla’s postural alignment. We will do this three times – inhaling to prepare, exhaling chin to chest and gently rolling down to the mat, cueing her to relax in the shoulders and the arms. By allowing a pause/inhale at the bottom, she can then feel that stretch in the low back and hamstrings before rolling back up. As she does these, I evaluate her movement. I can tell if she is internally rotating at the hip and knee, or collapsing in her arches.

Warm Up
  Mat
  - Pelvic Curl
  - Supine Spine Twist
  - Chest Lift
  - Chest Lift w/ rotation
  - Roll up (used for transition from the mat)

Though Kayla is an intermediate level client, we always begin with the fundamental warm up. With her known hip, pelvis, and knee issues she can focus on basic mechanics and appropriate muscle recruitment.

Foot Work
  Cadillac
  - Parallel Heels
  - Parallel Toes
  - V Position Toes
  - Open V Heels
  - Open V Toes
  - Calf Raises
  - Prances
  - Single Leg Heel
  - Single Leg Toes

Footwork on the Cadillac is chosen to focus on hip extensor strength and, in Kayla’s case, a deep stretch. This work also helps with knee extensor strength, pelvis lumbar stabilization, and proper mechanics both at the hip, knee and foot. A cue used for her is to feel as if her muscles are wrapping externally around her thigh as she pushes out. This gives her a visualization to assist in keeping her properly aligned and not internally rotated.
Abdominal Work

Chair
- Standing Pike
- Reverse Standing Pike

Cadillac
- Breathing with the Push Through Bar (Cadillac)

The abdominal work on the chair requires Kayla to focus on keeping her shoulders stable and controlling the abdominals and back extensors while simultaneously providing the lumbar stretch needed to help with her lordosis. Breathing with the PT bar is one of Kayla’s favorites because it allows her to get into the teaser position without pain. This movement for her is all about the mind-body connection to improve coordination and balance as she is articulating the spine.

Hip Work

Cadillac
*Basic Leg Springs; Supine Leg Series*
- Frog
- Circles (Down, Up)
- Walking
- Bicycle

With a muscle focus of the hamstrings, this series’ objectives strengthen hip extensors and help to achieve hip adductor control and hip disassociation. Kayla must maintain pelvis stabilization throughout and since each leg is independently in a spring, it gives me feedback on if one leg is weaker or has less control. If I chose this series on the reformer it may be easier for her to compensate for weakness on one side only reinforcing the imbalance instead of correcting it. Equal and proper movement is key – paying special attention to control at the hip and knee joints.

Spinal Articulation

Reformer
- Short Spine

Cadillac
- Tower Prep
- Tower
Hamstring control and stretch is vital to all three chosen exercises. The deep lumbar flexion of tower and requirement to maintain hip extensor engagement throughout is a perfect match for helping to lengthen out and correct Kayla’s mild lumbar lordosis.

**Stretches**
- **Reformer**
  - Full Lunge
  - Side Split
- **Ladder Barrel**
  - Hamstring
  - Gluteals
  - Hip Flexors
  - Shoulder stretch 1
  - Shoulder stretch 2
- **Cadillac**
  - Shoulder stretch

Due to the force on the patella during standing lunge and kneeling lunge, Kayla felt more comfortable with the full lunge though it is a very deep stretch for the tight hamstring. The challenge is to keep the hips square and front knee and hip in line so. As an instructor, I cue to focus on pulling the front leg/hip back. Stretches on the ladder barrel would target the appropriate muscle groups for both the tight shoulders and legs. As time allows, I will start to incorporate the shoulder stretch on the Cadillac increase shoulder mobility (rotator cuff) and deepen the stretch.

**Full Body Integration (F/I):**
- **Cadillac**
  - Push Through Group
    - Sitting Forward
    - Side Reach
- **Reformer**
  - Up Stretch Group
    - Up Stretch 1
    - Elephant
    - Up Stretch 2

Both groups above are excellent in their own right. Each group will allow Kayla to focus on abdominal strength, while providing a stretch in the hamstrings and shoulders. The
push through group allows her to increase spinal mobility and the up stretch group
increases stabilization in the trunk and shoulders.

**Arm Work**
  **Reformer**  
  *Sitting Arm Series*  
  - Chest Expansion  
  - Biceps  
  - Rhomboids  
  - Hug-a-tree  
  - Salute

While this series may seem easy to some, it presents quite the challenge for Kayla. She
must use her back extensors and abdominals to stabilize the trunk in order to sit upright
with her legs straight out in front. She tends to move into lumbar hyperlordosis so cueing
to visualize a slight tucking of the pelvis appears to help. She also responds well to the
cue of keeping her chest forward, heart beaming out across the room – which keeps her
lengthened (or sitting tall) through her mid and upper back.

**Leg Work**  
  **Chair**  
  - Forward Lunge (with padded handles as needed)  
  - Backward Step Down  
  - Hip Opener

  **Mat (Leg weights excluded)**  
  *Side Lying Series*  
  - Side leg lift  
  - Forward and lift  
  - Forward with drops  
  *Gluteals Kneeling Series (modified)*  
  - Hip abduction bent knee (done lying side)  
  - Hip Extension bent knee (prone)  
  - Hip extension straight leg (prone)

Kayla may fatigue quickly as the gluteal muscles are fairly weak and there is a lack of
control of femoral torsion during loading phase. It is important to make sure proper
muscular recruitment and mechanics are maintained throughout the movements.
Repetitions of five are the max at the present time, so a future goal is to increase this to
ten on each side without stopping. The final choice of hip opener allows Kayla to focus
on her hip external rotator control. The gluteals kneeling series is modified in order to take pressure off of the patella. Hip abduction bent knee can be performed lying on one’s side similar to side leg lift with the bottom arm extended. The knees are bent at 90 degrees and using the abductors the top leg opens up toward the ceiling. In order to focus on single leg movement and build strength independently, I chose to keep both hip extensions lying prone in lieu of the prone series with the magic circle where both are engaged simultaneously.

**Lateral Flexion/Rotation:**

- **Chair**
  - **Side Stretch**

The side stretch on the chair is a great way for the client to focus on the abdominal obliques while getting a lateral flexor stretch. It is also a movement that requires her to keep herself “between two panes of glass” – meaning she needs to keep her side inline and lengthened. One thing to watch, as always, is to make sure she is not internally rotating at the hip joint.

**Back Extension**

- **Chair**
  - **Swan Basic**

Though fundamental, swan basic is great for back extensor strength, abdominal control, and scapular stabilization. The legs must be adducted throughout and in this case she will need to keep energy in those leg to keep them lifting. With such weak hip extensors, this can present a good challenge.

**Evaluation: Roll Down**

At the end of our session, I have Kayla do a roll down to evaluate where she started at the top of the hour and where her body allows to go now. This last roll down also gives her a moment to do a final stretch before returning to standing and about her busy day.
Conclusion

As a Pilates enthusiast, Kayla committed to equipment sessions no less than twice a week for six weeks in addition to her physical therapy regimen. She also continued her mat Pilates twice a week and walking. At the six-week mark, the glutes had progressed significantly. Specifically, Kayla was able to do ten repetitions on each leg utilizing the chair without stopping. Hip rotators show significant improvement but still need more control. Running is still a challenge for Kayla. She is able to navigate stairs without pain and walk more than two miles without stopping. By eight weeks, she was able to walk five miles without pain and progress to kneeling exercises. Proper mechanics and muscle imbalance correction were vital in her journey to being pain free in her knees. Pilates has reinforced good and correct movement patterns that she can take into her daily life.
Bibliography


Medical Records for Kayla K*, July 2013.


S. Sargent, PT, DPT, ATC (Personal Communication, July 26, 2013)
