A Theoretical Review of Patello-Femoral Pain Syndrome Etiology and an 12-Week Rehabilitation based Exercise Prescription

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A review of the literature concerning athletic injury reveals that the knee joint has the highest incidence rate in sport (8), and that it is a condition highly prevalent among adolescent and young adults, particularly women (17,25,26,32,35).

Knee pain is related to many pathological conditions, and is the product of morphological changes in joint structure due to internal and external stressors.

More specifically, Patello-Femoral Pain Syndrome (PFPS), is a pathological knee condition that is known to be multi-factorial in its origin (1,12,16,17,18,24,25,29,38,39,42) and diverse in its physical expression and functional limitation; and as such, warrants further clinical etiological investigation.

A review of the literature indicates that PFPS is characterized by retropatellar, and peripatellar knee pain (10,27), joint swelling, and cracking, snapping, and popping sounds (crepitus) when the knee is in flexion or extension (37,43). It is reported that these symptoms are triggered while active in ascending and descending stairs, squatting, kneeling and sitting, walking, or running for prolonged periods of time (10,26,36).

A review of the literature reveals several clinical investigations, and numerous theoretical reviews assessing PFPS etiology.

A general summarization of the most common etiological theories, suggest that PFPS is caused by vastus medialis weakening relative to the vastus lateralis induced patellae maltracking through the femoral trochlea (29,36). It is proposed that patellae maltracking or 'malalignment' leads to an accumulation of joint stress and subsequent articulating cartilage wear (39,42).

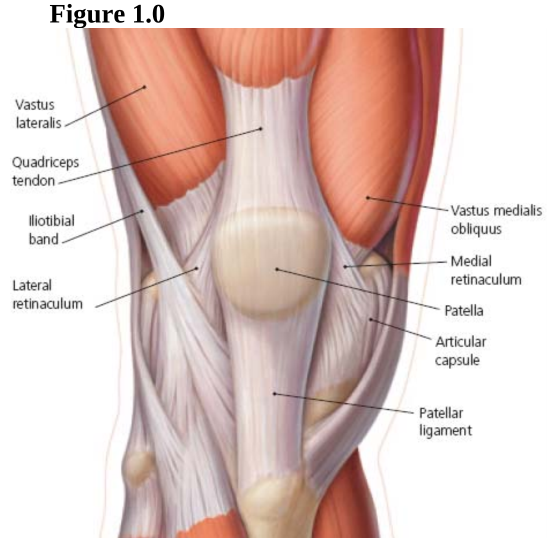
It is speculated that progressive degradation of femoral condyle, and retropatellar hyaline cartilage is the source of the pathophysiological relationship between the reported pain symptoms described by PFPS patients.

Upon further theoretical review, several biomechanical (1,16,18,19), neuromuscular (1,12,17,18,19), musculoskeletal (1,17,18,42), and hormonal (1,17,24) factors are thought to have etiological connections to PFPS.

The intended scope of this review is to provide a concise rather than comprehensive conceptual framework of PFPS etiology. The exact pathophysiology of each of these factors will not be addressed in detail, rather noted, to illustrate the multi-factorial origins of PFPS.

Figures 1.0 & 2.0 identify the anatomical location of the various tissues within the knee joint. Depending on the etiological mechanisms responsible for the symptoms expressed, any number of these tissues may be of pathological significance. Current PFPS etiological theory suggests that rehabilitation programs isolate and target the Vastus Medialis Obliquus (VMO), the Iliotibial Band (IT Band), the Quadriceps, Hamstrings, and decreasing ligament and tendon strain and cartilage wear through instruction of proper joint movement mechanics.

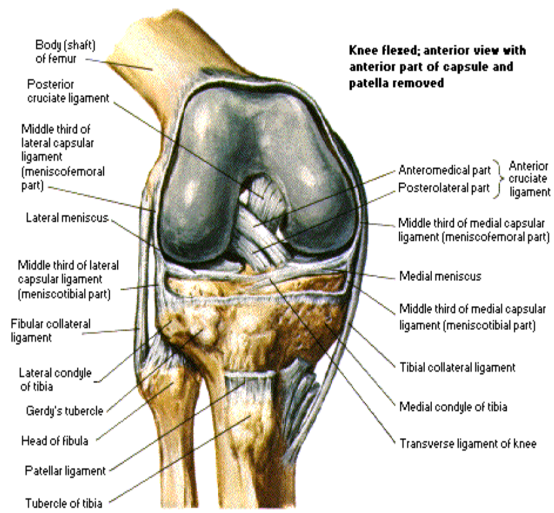
Figure 1.0



Referenced from (9)

Due to the multi-variable pathological mechanisms associated with PFPS (1,12,17,18,19,24,26,29,36,39,42), many different 'medical management' strategies have been recommended to prevent, and rehabilitate PFPS. These strategies include conservative and aggressive administration of NSAIDS, physical therapy / exercise, knee joint bracing, patellar-taping, rest, ice, orthotic support, surgery, and 'spontaneous resolution' techniques. However, as will be discussed with greater detail in Part 'B', there is a significant (18,40) lack of published research reporting specific PFPS rehabilitation protocol.

Figure 2.0



Referenced from (16)

Estimated time to PFPS recovery is individually specific, and varies dependant on the complexity of the etiology related to symptoms expressed. Recovery can be experienced within 6-8 weeks through conservative treatment modalities if surgery is not required, or physical maturation factors are not related to the symptoms. If surgical interventions are required, recovery may take 8 to 24 months depending on the rehabilitation protocol administered (aggressive or conservative).

A full recovery can be expected in all PFPS cases. The degree of variance in recovery is dependant on the nature of the etiological mechanisms, and subject to the efficacy and specificity of the therapeutic interventions applied. A review of the literature indicates that there are 5 distinct phases involved in developing an effective rehabilitation program to treat PFPS. In order these phases include a) a physical examination and limitations assessment, b) a period of isolated pathological tissue rehabilitation training, c) a period of muscle synergy and co-activation through functional multi-joint conditioning, d) a phase of 'return to sport' and dynamic activity preparation exercises, and e) which can be integrated following all of the above mentioned phases, a period of evaluation.

Appendices 1.0, and 3.0 through 5.0 contain detailed clinical assessment procedure and phase specific training program recommendations designed to isolate the pathological mechanisms, and rehabilitate the tissue irregularities responsible for the PFPS.

Consistent with other training purposes, a periodized approach, of fluctuating volume, work-load and intensity, has a theoretically justifiable position within rehabilitation training. Review of Table 1.0 identifies a proposed 12 week PFPS rehabilitation training program phase to phase training model.

Table 1.0

Full Phase by Phase Model of a 12 Week Patellofemoral Pain Syndrome Rehabilitation Program

Week 1	Weeks 2 - 4	Weeks 5 - 8	Weeks 9 - 11	Week 12
Physical Examination & Testing	*Pathological Isolated Training*	*Coactivation & Dynamic Training*	*Return to Sport Preparation*	Physical Testing & Testing
	Open Chain & Isometric Strength Training	Closed Chain Strength Training	Closed Chain Strength Training	
	Light Aerobic Exercise that is not symptomatic	Progressively higher intensity Aerobic Training	Progressing from low intensity plyomtric training to sport specific	
	Daily Stretch Program	Daily Stretch Program	Daily Stretch Program	

The phase scheduling described in the above model is representative of a modified periodized approach. Note that the 12 week training period is divided into 5 distinct phases of 'pyramid' structured length (1 week, followed by 3 weeks, followed by 4 weeks, then descending in the same order), where by each phase (mesocycle) has a distinct purpose, program design, and exercise selection.

Table 1.0 in Appendix 1.0 is a hierarchal list of patient specific subjective, and clinical, or field based physical examinations reported to assess PFPS pathology. Application of these testing procedures should take place during the initial rehabilitation consultation after doctor referral.

The severity of the symptoms expressed by the patient, and the conclusions made by the rehabilitation professional through combined objective and subjective analysis of the physical assessments, and their understanding of PFPS anatomical etiology, they are able to build a conceptual framework for rehabilitation based program design.

For the purpose of practical application of the above noted theory, and to limit the scope of the following discussion on appropriate program design principles and exercise selections, a case study model will be used.

The rehabilitation prescription provided is based on a 17 year old female soccer player, who is 16 weeks out from the beginning of their pre-season training camp, who over the off season began feeling PFPS symptoms bi-laterally.

Upon clinical assessment, it was recommended that this athlete undertake a conservative rehabilitation approach over a 12 week period.

PART B

Tables 1.0 and 2.0 in Appendices 3.0 through 5.0 are representations of a phase specific, weekly 'microcycle', and the associated training program and exercise prescription for the rehabilitation training phases previously mentioned.

The justification for each training phase is based upon tissue recovery and remodeling theoretical principles, and PFPS pathological etiology.

PFPS specific etiological theory suggests that the 1st training phase be representative of isometric, Open Kinetic Chain (OKC), quadriceps, hamstring, Vastus Medialis Obliquus, Hip Adductor and Abductor strength training, and depending on the physical maturation of the patient, be representative of conservative therapy.

As the realm of orthopedic instrumentation and practical application continues to grow, and the perceived demand for rapid return from injury rates rise, the trend of using aggressive over conservative rehabilitation therapies is growing. The scope of this review will not investigate these issues, nor their effectiveness in relation to one another, simply noted to indicate the issue, and to classify the rehab protocols recommended in this review as 'conservative'.

In addition, in compliance to a reported relationship between lower limb flexibility and PFPS etiology, a regimented daily stretch program is recommended. The strength of this positive correlation supports the inclusion of a daily lower body stretch program, and that it be completed every day, throughout all phases of the full rehab program.

Refer to Table 1.0 in Appendix 2.0 for the recommended daily stretch program to be integrated into a PFPS rehabilitation program.

It is suggested that due to the compensatory activation of the muscles in the ankle and hip during squatting activities, OKC quadriceps exercises be selected for increasing quadriceps strength (3), rather than Closed Kinetic Chain (CKC) exercises.

The primary focus of Phase I is Quadriceps and Hip (24) strengthening as it has been reported that the Quadriceps to Hamstring strength ratio (8), and weak Hip flexor strength are pathological mechanisms of knee pain. A more detailed discussion of this relationship and joint strength will be covered in the 'Evaluation Methods' section.

More specifically O'Sullivan et al. (36) reported that isometric leg OKC exercises that utilized terminal knee extension with medial tibial rotation, optimally activates the VMO, and that conclude that this exercise technique should be included in rehabilitation programs.

For full Phase I strength training, program design, and training expectations, refer to Appendix 3.0.

Phase II of the 12 week PFPS rehabilitation conditioning program is intended to target more specific pathological mechanism, particularly the Vastus Medialis Obliquus (VMO) (3,36), the glutes, the remaining quadriceps muscles, and the hamstring groups through muscle specific isolated training and exercise mechanics modification.

Review of Table 1.0 in Appendix 4.0 presents the order of recommended exercises for this phase of PFPS rehabilitation. The exercises provided are considered CKC exercises, as they are reported to be the preferred method of strengthening when in rehabilitation programs (3).

Exercise selection was based on the reported force transmission response of exercises which increase muscle co-activation, and were placed in a conservative program design.

A review of the literature reveals that CKC exercises which synerginistically activate the quadriceps and hamstrings while in squatting movements help to stabilize the hip and knee, and decrease the anterior shear force expressed at the tibiofemoral joint (3). Brindle et al (3) suggest that this effect decreases patellofemoral pain.

While the research indicates that seated machine leg extensions are ideal for targeting the quadriceps group, Phase II exercises are free body oriented. This decision was made based on the increased neuromuscular adaptation associated with free body and free weight exercise, leading to greater muscle fibre recruitment and joint stability capabilities (1).

In addition, exercise selection was based on research reported by O'Sullivan et al. (36) who found that CKC squat exercises (Table 1.0 Appendix 4.0), with the knees flexed at 60^o with external hip rotation increase VMO activity and should be included in a PFPS rehabilitation program.

Review of Table 1.0 in Appendix 4.0 also indicates the length of the strength training program. This phase of the program is structured through 4 weeks, the longest phase of the program, as it is meant to build muscle strength and joint stability.

In addition to the strength training, 'Pool' training is integrated on a progressive basis, which extends into Phase III. The additional muscle recruitment and strength adaptation provided by water based training, will help to promote joint strength.

Working in water has been associated with increasing muscle and cardiovascular benefits as the thickness of water as a medium increases the physical stress placed on the body. Water training is also recommended as the thickness of the medium provides greater movement support and balance while executing dynamic movements.

This additional support provides the rehabilitating athlete with a supportive environment, providing her with the confidence to work the tissues with more intensity than in a 'dry-land' environment, with the purpose of triggering greater muscle and joint strength adaptation.

Phase III (Table 1.0, Appendix 5.0) is designed with the intent to prepare the athlete to return to sport specific activity.

At this point (9 weeks into the program) the athlete has focused on increasing range of motion through the lower body, increased Quadriceps, specifically MVO, Hamstring, and Core strength, and joint stability, and is expected to be in a position to begin high intensity , sport and dynamic activity based exercise.

Phase III marks the introduction and integration of 'plyometric' based exercise. This style of exercise involving the rapid acceleration and deceleration of the body/limb segment, is associated with mimicking the physical demands of sport performance, and should be integrated to help prepare the athlete to handle the force magnitudes and volumes that they are expected to handle in game situations.

Effective lower body plyometric training is based on joint and movement mechanics. Focus on deep flexion, joint stability, and deceleration impact forces must be understood, and executed to minimize the joint degradation of accumulating excessive valgus and varus compression forces at the joint.

Upon completion of Phase III, the athlete must return to the rehabilitation or strength and conditioning professional to have their training progress assessed.

The degree of progress must be evaluated against the initial screening subjective and objective feedback, and against known strength and performance standards.

Di Brezzo & Fort (8) produced knee strength norms for women 25 and older. While the age group of the results represented by Di Brezzo & Fort (8), are not specific to the age of the athlete this review is indicative of, the lack of reported research in knee strength standards suggests that the values reported in (8), Table 2.0 provide a reference for progress assessment.

Table 2.0

Percentiles of Peak Torque Values				
Percentile	*Quadriceps 60^o*	*Hamstring 60^o*	*Quadriceps 180^o*	*Hamstring 180^o*
100	212	112	140	106
90	178	97	113	76
80	165	90	103	67
70	155	84	95	63
60	143	78	90	59
50	133	75	83	54
40	124	71	78	52
30	117	65	75	49
20	113	60	68	45
10	103	54	61	42
0	75	30	42	15

* Peak Torque Values were measured in Newton Meters

Modified from Di Brezzo et al. (7)

In addition, the reported relationship between the Q/H ratio (Quadriceps strength relative to Hamstring strength) and knee integrity and stability (8), several values have been reported (7,21,22,31,40). A review of the literature reports the following;

- Klein and Hall investigating the relationship of muscular strength of the thigh muscles to knee injury, tested 537 football players in 16 colleges and universities. The 60% ratio of knee extension strength to knee flexion strength was recommended for sound strength balance.21
- Similarly, Klein & Alman (22) reported that collegiate football players exhibit a ratio of 10:6 quads strength to hamstring strength.
- Moffroid et al reported a 50% ratio or 2:1 quad to hamstring (31)

- Scudder reported the ratio to be 63% at 60 degrees per second (40).
- Di Brezzo et al. investigating peak torque values for the knee flexor and extensor muscles for 250 untrained women aged 18-27 2:1 ratio between knee flexors and knee extensors (7).

Interpretation of these reported knee strength standards across sports, genders, and age, suggest that there are standards for minimal quadriceps to hamstring strength in clearing an athlete for athletic play.

Di Brezzo et al (7), report a 54% ratio of quadriceps strength to hamstring strength (quadriceps being twice as strong as the hamstrings) would be appropriate, and follows that recommendation with the suggestion that peak knee torque values at of above the 70th percentile would be considered a minimum level of strength to provide safety for participation in sports activities and/or training (8).

Other Therapeutic Interventions

It is important to note, that in addition to physical therapy and exercise progressions to treating PFPS, other therapy interventions are reported throughout the literature. The most frequently assessed is Patellar taping.

Referred to as McConnell taping (29), medial aligning the patella has the ability to improve patella tracking and eliminate abnormal joint forces.

McConnell found that a medial glide increased the VM/VL ratio and suggested that medial glide taping could in the long-term rectify the VM/VL imbalance in PFPS by selectively strengthening the VM during exercise (29).

Criticism to this approach has been reported in studies finding that patellar taping has no effect of the VM/VL ratio in PFPS (6).

In addition, recent evidence suggests that medial taping may decrease the VM/VL ratio (34). It was proposed that the latter occurred because the tape medially stabilized the patella; thus, placing less need for VM activity, which may defeat the purpose of McConnell's therapy which was to increase the VM/VL ratio. (4).

Ryan and Rowe (40) showed that laterally gliding the patella with tape during a single leg static squat can significantly increase the VM/VL ratio compared with a medial and a neutral glide, and that laterally gliding the patella increases the VM/VL ratio above that recorded when no tape was applied, but the change was not significant.

Their study showed that the magnitude of the effect of taping on vasti activity is relatively small (~5%). Although such a change has been found to be statistically significant, it is doubtful that it would be clinically significant (40).

Ng and Cheng (34) explained the decrease in the VM/VL ratio caused by medial taping to be related to the medial stabilizing role of the VM and the medial stabilizing effect of the tape. They speculated that if the patella were already medially stabilized there would be less need for the VM to be active relative to the VL. The results of this study support this theory. In the lateral glide, the VL needed to work less to stabilize the patella laterally, and the VM needed to increase its activity to stabilize the patella.

In review of these reported findings, the practicing rehabilitation and strength and conditioning professional may take the opinion that medially taping the patella has the potential to induce vasti strength ratio changes reflective of producing changes in PFPS symptom severity, but that the reported therapeutic effect may not be experienced in everyone.

Practical Applications

A review of the literature concerning the etiology of Patellofemoral Pain Syndrome indicates that there are a number of mechanisms; either biomechanical, musculoskeletal, hormonal, gender, and age related, that compromise normal joint function and contribute to the pathology of PFPS.

It is further reported that depending on the severity of, and degree of structural pathology experienced on a patient specific basis, the therapy prescription is multi-variable, ranging from administration of NSAIDS, physical and/or massage therapy, exercise programming, ice, rest, surgical interventions, and 'spontaneous resolution'.

Due to the considerable lack of published research reporting 'best practice' methodology and rehabilitation program design variables, the practicing strength and conditioning and rehabilitation professional is left to their own interpretation of clinical assessment results and patient subjective symptom description, and summarization synthesis of reported pathological etiology to develop effective rehab programs.

The research reveals that both OKC and CKC exercises that utilize both isometric and isotonic muscle contraction, and isolated and co-activation of the Quadriceps, particularly the VMO, the Hamstrings, the Glutes, and the Hip Adductors and Flexors are effective means in rehabilitating PFPS pathological mechanisms.

It is reported that leg extension with terminal knee extension with medial tibial rotation, and squat exercises at 30-60^{o} knee flexion produces the greatest amount of VMO activation, and that a Quadriceps to Hamstrings strength ratio of approximately 2:1 and a peak knee torque value at the 70th percentile is the recommended strength standard for returning to athletic activity following a knee injury.

Further investigation into PFPS rehabilitation program design is warranted; specifically, pathological etiology, and rehabilitation program design ‘best practices’.

Appendix 1.0

Physical Examination Protocols Reported to Identify Positive Patellofemoral Pain Syndrome Pathologies & Protocol Description

Table 1.0

Initial Examination Protocols

Test Order	Test	Description
1	Subjective Survey - Causes, location of pain, severeity etc	
2	Lateral Patellar Tracking - 'J' Test	Figure 1.0
3	Patellar Glide Test	Figure 2.0
4	Patellae Tilt Test	Figure 3.0
5	Patellar Grind Test	Figure 4.0
6	Kendall's Manual Test of the Hip Abductors	Figure 5.0
7	Trendelenburg Test	Figure 6.0

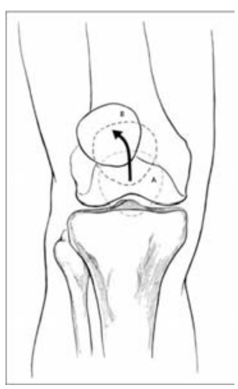


Figure 1.0 ***Lateral Patellar Tracking 'J-Sign' Test.*** As the knee is extended 90^{o} flexion *(A)* to 180^{o} extension *(B)*, a positive test is indicated if the patellae moves in a 'J' pattern as illustrated.

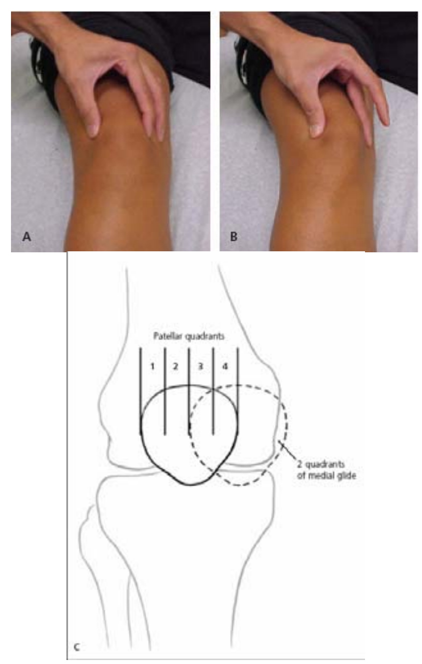


Figure 2.0. ***Patellar Glide Test.*** Patella is grasped in the resting position *(A)*, then translated medially *(B)*. The degree of displacement is described in relation to the width of the patella and measured in quadrants *(C)*. Displacement of more than 3 quadrants is indicative of hypermobility

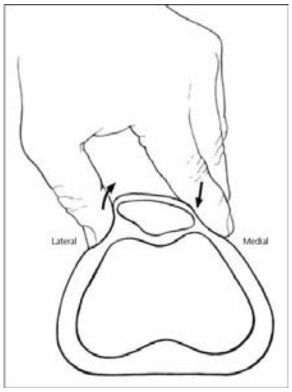


Figure 3.0. ***Patellae Tilt Test.*** The leg is extended and the patella is grasped between the thumb and index finger. The medial aspect is compressed while the lateral aspect is elevated. If the lateral aspects of the patellae is fixed and cannot be raised to at least the horizontal position, the test is positive and indicative of tight lateral structures.

Figure 4.0 ***Patellar Grind Test***. With the patient in a supine position, with leg extended, examiner displaces patellae inferiorly to the trochlear groove. Patient is asked to contract the quadriceps, while the examiner continues to palpate the patellae and resistance it's anterior movement. Test is positive of PFPS if pain is present.

Figure 5.0 Kendall's Manual Test of the Hip Abductors

Appendix 2.0

Table 1.0

Patellofemoral Pain Syndrome Rehabilitation Conditioning Program - Daily Stretch Program

Training Notes

The Following Stretch Program is to be completed on a Daily basis, during 3 points through the day.
It is recommended that you perform these stretches in the morning after waking, at the conclusion of a rehabilitation work-out or other form of activity, and after any prolonged periods of inactivity.

A review of the literature concerning effective length one should hold a stretch it is recommended that you hold each stretch for 30 to 60 seconds, passively breathing during each stretch.
To perform an optimal stretch, reach a length that induces a noticable 'pull' sensation, and hold that length for the duration of your 30 to 60 seconds count. Do not bounce, or progress the length of your stretch during your hold.
Refer to Appendix 2.0 for Stretch Specific Illustrations

Daily Stretch Exercises
Modified Hurdler Hamstring Stretch - Figure 1.0
Glute Stretch - Figure 2.0
Hip Rotator Stretch - Figure 3.0
Piriformis and Iliotibial Band Stretch - Figure 4.0
Wall Lean Iliotibial Band Stretch - Figure 5.0
Kneeling With Foreward Lean Hip Flexor Stretch - Figure 6.0
Butterfly Stretch - Figure 7.0
Wall Lean Gastrocnemius Stretch
Bent-Over Cross Legged Iliotibial Band Stretch - Figure 8.0

Stretch Descriptions for all Phases of a 12 Week Patellofemoral Pain Syndrome Conditioning Program

Figure 1.0 Modified Hurdler Stretch

Figure 2.0 Supine Glute Stretch

Figure 3.0 Hip Rotator Stretch

Figure 4.0 Iliotibial Band & Piriformis Stretch

Figure 5.0 Wall Lean Iliotibial Band Stretch

Figure 6.0 Kneeling with Stability Hip Flexor Stretch

Figure 7.0 Butterfly Stretch

Figure 8.0 Iliotibial Band Stretch

Appendix 3.0

Table 1.0

Patellofemoral Pain Syndrome Rehabilitation Conditioning Program - Phase I (3 Weeks) - Week 2 to Week 4

Day 1:

Rehab Program Outline

- 10 min. of Cardio warm-up
- 30 Minutes of Strength Training
- Stretch Protocol - Table 1.0 in Appendix 2.0

Training Notes

Phase I is intended to target pathological tissues and improve their strength and flexibility fibre composition profiles through isolated stretch and stregth training.

Phase 1 is designed to be completed 4 times a week over the next 3 weeks.
Phase I includes a Strength Training Program, a Flexibility Training Program, a Core Training and an Aerobic Conditioning Program.
Refer to Table 2.0 for Phase I Weekly Training Model for daily training expectations.

Phase I is designed to strengthen muscles in the Quadriceps, Hamstrings, Glutes and Hips through a combination of isometric and Open Chain Exercises. More specifically it is recommended that exercises against a self restrained resistance
Progressions will be introduced based on technique mastery and symptom severity, and will be applied after consultation with your rehabilitation professional.

Attempt to complete each exercise through the recommended set and repetition ranges provided. If a Set Box 'S1' or 'S2' etc is shaded you are not required to perform that set.
Refer to Figures 1.0 - 5.0 for exercise descriptions

Progression Tracking Chart

		Date:				Date:				Date:				Date:				Date:				Date:				Date:				Date:				Date:				Date:			
		Workout 1				Workout 2				Workout 3				Workout 4				Workout 5				Workout 6				Workout 7				Workout 8				Workout 9				Workout 10			
	Rps	W	S1	S2	S3	W	S1	S2	S3	W	S1	S2	S3	W	S1	S2	S3	W	S1	S2	S3	W	S1	S2	S3	W	S1	S2	S3	W	S1	S2	S3	W	S1	S2	S3	W	S1	S2	S3
Dynamic Warm-up																																									
10 Minute Cardio Warm-Up																																									
Strength Training Exercises - Complete each repetition through a 2-1-4-1 tempo (lift for a 2 count, pause for 1, lower for 4, pause for 1, repeat) - allow 90 seconds rest																																									
1. Sidelying Leg Raise	20																																								
2. Clamshell	20																																								
3. Seated on Floor Isometric Extended Leg Raise	20																																								
4. Seated Legs Extended at 30° Self Restrained Isometric Adductor Squeeze	20																																								
5. Wall Lean Adductor Sqeeuze	20																																								
Core Exercises - Hold the midsection tight through each repetition - feel as if the abs are being pulled to the spine - complete 3 sets of each across full reps.																																									
Stability Ball Crunches	40																																								
Plank - Hold Till Fatigue																																									
Roman Bench Back Extensions	15																																								

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Table 2.0

Phase I - Weekly Rehabilitation Training Expectations

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Planned Light Cardio	Strength & Core Training	Planned Light Cardio	Strength & Core Training	Planned Light Cardio	Strength & Core Training	Planned Light Cardio
Daily Stretch	Daily Stretch	Daily Stretch	Daily Stretch	Daily Stretch	Daily Stretch	Daily Stretch

Exercise Descriptions for a Phase I of a 12 Week Patellofemoral Pain Syndrome Rehabiliation based Conditioning Program

Figure 1.0 Side lying Extended Leg Raise

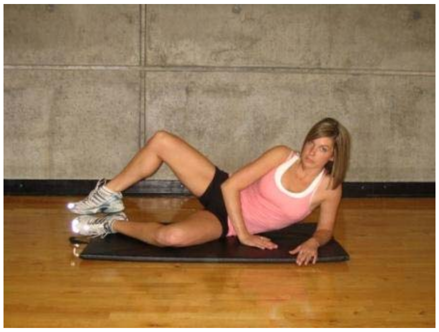

Figure 2.0 Clamshell

Figure 3.0 (A) Bicycle Isometrically Stabilize the hip, 90^{o} flexion of knee.

Figure 3.0 (B) Bicycle Start/Finish

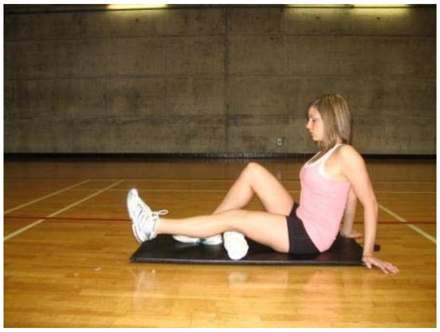

Figure 4.0 Isometric Quadriceps contraction

Figure 5.0 Seated Self Resisted Adductor Squeeze.

Appendix 4.0

Table 1.0

Patellofemoral Pain Syndrome Rehabilitation Conditioning Program - Phase II (4 Weeks) - Week 5 to Week 8

Day 1:

Rehab Program Outline

- 10 min. of cardio warm-up
- 5 min. of Dynamic warm-up
- 50-60 Minutes of Strength Training
- Stretch Protocol
- Stretch Protocol

Training Notes

This program is designed to place greater muscle activation and limb sement musculature synergy, througth the integration of Closed Kinetic Chain Exercises.

A review of the literature recommends that Quadriceps, Hip, and Hamstring Strengthening be the primary focus of this phase of rehabilitation conditioning - specifically MVO isolated MVO activation.

MVO activation is to be achieved through concentrating on targeting the inside of you thigh as you perform your exercises where indicated. In performing exercise 1 & 5, attempt to reach a knee extension angle of approx. 30 to 60^o and push to terminal extension with slight medial tibial rotation. These actions will increase MVO activation and decrease the magnitude of shear forces displaced within the knee joint - leading to a decrease in pathological conditions.

Refer to Table 2.0 for weekly training expectations and to Table 3.0 for the Pool Conditioning Program.

Complete this work-out 3 times a week for the next 4 weeks, recording your work across all sets and exercises. For exercise 9 record the weight pushed in the top triangle, and the reps completed in the bottom triangle.

Progressions will be made upon patient subjective symptom feedback, and on the strength and conditioning and rehabiliation professionals opinion on mastery of exercise technique and volume progressions

Refer to Appendix 4.0 Figures 1.0 - 12.0 for the following recommended exercise descriptions

		Progression Tracking Chart																																							
		Date:				Date:				Date:				Date:				Date:				Date:				Date:				Date:				Date:				Date:			
		Workout 1				Workout 2				Workout 3				Workout 4				Workout 5				Workout 6				Workout 7				Workout 8				Workout 9				Workout 10			
	Rps	W	S1	S2	S3	W	S1	S2	S3	W	S1	S2	S3	W	S1	S2	S3	W	S1	S2	S3	W	S1	S2	S3	W	S1	S2	S3	W	S1	S2	S3	W	S1	S2	S3	W	S1	S2	S3
Dynamic Warm-up Exercises																																									
1. Body Squat	15																																								
Strength Training Exercises																																									
2. Blue Box 30^o Step Down to terminal extension	15																																								
3. Dynaband Lateral Walk	25																																								
4. External Hip Rotation Step-Up	15																																								
5. Stability Ball Wall Squat Adductor Squeeze	20																																								
6. Forward Lunge - progress by adding weight	15																																								
7. Seated Hip Adductor Medicine Ball Squeeze	15																																								
8. Lateral Lunge	15																																								
9. Hip Sled Leg Press with MVO Squeeze	15		/	/	/		/	/	/		/	/	/		/	/	/		/	/	/		/	/	/		/	/	/		/	/	/		/	/	/		/	/	/
Core Exercises																																									
10. Stability Ball Prone Back Bridge	15																																								
11. Medicine Ball BOSU Crunches	30																																								
12. Prone Lying Bilateral Leg Raises	15																																								

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Table 2.0

Phase II - Weekly Rehabilitation Training Expectations

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Planned Light Cardio	Strength & Core Training	Planned Light Cardio Pool	Strength & Core Training	Planned Light Cardio Pool	Strength & Core Training	Planned Light Cardio
Daily Stretch	Daily Stretch	Daily Stretch	Daily Stretch	Daily Stretch	Daily Stretch	Daily Stretch

Table 3.0

Phase II Pool Conditioning Program

Exercise	Sets	Reps
Warm-Up		
Hi Knee Raises	2	20
Forward Walking	2	2 lengths
Forward Lunge Steps	2	2 lengths
Lateral Steps	2	2 lengths
Exercises		
Flutter Board Kicks	3	40 seconds
Jumps	4	10
Forward Running	5	1 length
Lateral Shuffle Steps	4	12
Backward Lunges	4	15

Progressions will be made based technique mastery and symptom supression
Program design and exercise selection will be modified throughout based on strength gains

Exercise Descriptions for Phase II of a 12 week Patellofemoral Pain Syndrome Rehabilitation Based Conditioning Program

Figure 1.0 Body Squat

Figure 2.0 (b)

Figure 2.0 (a) Unilateral Step Down

Figure 2.0 (c) Lateral View

Figure 3.0 (A) Dynaband Lateral Walk – Start

Figure 3.0 (B) Dynaband Lateral Walk – Stride Length

Figure 4.0 External Rotation Step Up

Figure 5.0 Stability Ball Wall Squat with 30^{o}-60^{o} Knee Extension

Figure 6.0 Forward Lunge (Phase II – no BOSU)

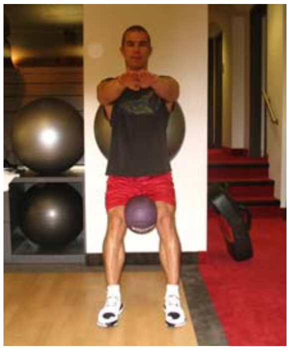

Figure 7.0 Stability Ball Wall Squat Hip Adductor Ball Squeeze

Figure 8.0 (A) Lateral Lunge – Frontal View

Figure 8.0 (B) Lateral Lunge – Lateral View

Figure 9.0 Hip Sled with Hip Adductor Squeeze

Appendix 5.0

Table 1.0

Patellofemoral Pain Syndrome Rehabilitation Conditioning Program - Phase III (3 Weeks) - Week 9 to Week 11

Day 1:

Outline

- 5 min. of cardio warm-up
- 10 min. of Dynamic warm-up
- 50-60 Minutes of Strength Training
- Cardio Exercise
- 5 minute cool-down stretches

Training Notes

Phase III is designed to increase neuromuscular control, and to begin introducing exercise progressions which mimic sport specific demands. This program is intended to increase rotational strength, joint stability, and load compression forces.

Phase III includes Strength, Jump, Pool, Flexibiliy, Cardio and Core Training Programs.

Refer to Table 2.0 for for weekly training expectations - only complete what is required - follow the structure provided to limit / prevent the potential build-up of neuromuscular fatigue.

For exercises 5,7, & 9, record the weight lifted in the top triangle of the set box, and the reps completed in the bottom triangle.

Progression Tracking Chart

		Date:				Date:				Date:				Date:				Date:				Date:				Date:				Date:				Date:				Date:			
		Workout 1				Workout 2				Workout 3				Workout 4				Workout 5				Workout 6				Workout 7				Workout 8				Workout 9				Workout 10			
	Rps	W	S1	S2	S3	W	S1	S2	S3	W	S1	S2	S3	W	S1	S2	S3	W	S1	S2	S3	W	S1	S2	S3	W	S1	S2	S3	W	S1	S2	S3	W	S1	S2	S3	W	S1	S2	S3
Dynamic Warm-up																																									
1. Body Squats on Inverted BOSU	15																																								
2. Single Leg Squat on BOSU	16																																								
Strength Training Exercises - Focus on maintaining joint stability, and on terminal extension while executing each repetition. Drop hips to a depth of 90^{o} in all squats																																									
3. Rotation Single Leg Squat	15																																								
4. Forward Lunge on BOSU	15																																								
5. Olympic Bar Back Squat	12																																								
6. 45^{o} Lateral Stability Ball Lunge	10																																								
7. Advanced Stability Ball Wall Squat	15																																								
8. Bulgarian Squats on BOSU	15																																								
Jump Exercises - Focus on Knee Stability and Deep knee Flexion during the landing phase of the jump - refer with your strength coach for biomechanic assistance.																																									
9. Medicine Ball Jump Squats	10																																								
10. Low Intensity Box Depth Jumps	10																																								
11. Lateral Box Jump	10																																								
Core Exercises -Keep the core tight through each repetition																																									
Plank on Stability Ball - Hold till fatigue																																									
Pike Crunches	20																																								
Prone Lying Vertical leg Raise Hand to Toe Crunc	30																																								
Balance on Hips Medicine Ball Twists	20																																								

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Table 2.0

Phase III - Weekly Rehabilitation Training Expectations

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Planned Light Cardio	Strength, Core & Jump Training	Pool Planned Light Cardio	Strength & Core Training	Planned Light Cardio	Strength, Core & Jump Training	Planned Light Cardio Pool
Daily Stretch	Daily Stretch	Daily Stretch	Daily Stretch	Daily Stretch	Daily Stretch	Daily Stretch

Exercise Descriptions for Phase III of a 12 week Patellofemoral Pain Syndrome Rehabilitation Based Conditioning Program

Figure 1.0 Body Squat on Inverted BOSU

Figure 2.0 – (A) Single Leg Squat at Terminal Extension

Figure 2.0 – (B) Single Leg BOSU Squat to 30-60^o Knee Flexion

Figure 3.0 – Single Leg Rotation Squats – Reference (25)

Figure 4.0 – Forward Lunge on BOSU

Figure 5.0 – Olympic Bar Back Squat **–** for description see (1)

Figure 6.0 - 45^o Lateral Stability Ball Lunge

Figure 7.0 – Advanced Stability Ball Wall Squat on Inverted BOSU

Figure 8.0 (a) BOSU Bulgarian Squat – Lateral View

Figure 8.0 (b) BOSU Bulgarian Squat - Frontal View

Figure 9.0 – Medicine Ball Jump Squat (A) Start Position

Figure 9.0 – Medicine Ball Jump Squat (B) in Air

Figure 10 (A) – Low Intensity Depth Jump - Start Phase

Figure 10 (B) – Low Intensity Depth Jump – Ground Contact Phase

Figure 10 (C) – Low Intensity Depth Jump – Jump Phase

Figure 11 (A) Lateral Box Jump – Start Phase

Figure 11 (B) Lateral Box Jump – Jump Phase

Figure 11 (C) Lateral Box Jump - Finish

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