

Alex Petruska, PT, SCS, LAT

Sports Conditioning for the Knee

A guide to conditioning and knee injury prevention

This program has been developed to provide a comprehensive guide to the conditioning of the knee for sports participation. Following a specific program of exercises for the knee, on a year round basis, will help to reduce the risk of injury to the knee joint.

Since 2/3 of knee injuries in sports are non-contact in nature, most knee injuries occur as a result of situations where there is a sudden knee imbalance caused by cutting, turning, twisting, stopping, jumping, landing from a jump or other high-speed, high-force athletic maneuver.

An effective knee-conditioning program should be focused on providing exercises and drills to develop coordination, balance, strength, speed, power and quick reactions in the knee and knee joint muscles. In addition to the development of strength in the knee muscles, drills to enhance and train controlled knee joint actions at high speed and force need to be specifically trained for the mechanics of cutting, turning and stopping, as well as jumping, landing and run/jump transitions.

Five components of the knee training program:

1. Warm-up
2. Flexibility and stretching
3. Strength training
4. Speed/ Agility training
5. Jump/ Plyometric training

Keys to success in training:

1. Focused effort and concentration when training
2. Always use proper form and technique
3. Quality workouts on a consistent basis
4. Avoid over-training

Warm-up and Stretch

1. Always be sure that you warm-up well and stretch lightly before workouts, and stretch well again after workouts.
2. Generally, you should do some walking, cycling, jump-rope or jogging before starting the exercise program.
3. You should warm-up until you break a sweat to assure that your whole body is ready to exercise.
4. You should **then** stretch **before** beginning the exercise program.

5. Always allow time to stretch during the cool-down period **after** finishing the exercise program.
6. 3 to 5 repetitions of each stretching exercise should be done, statically holding the stretch for 15 to 20 seconds.
7. There should be no bouncing or oscillations of the body during stretching exercises.
8. You should slowly assume the stretching position until a comfortable feeling of stretch is felt in the muscle and then held, without further movement, for the 15 to 20 second period.
9. Stretching should NOT BE PAINFUL or cause soreness after being done.
10. Stretching exercises for the knee and lower body are illustrated and described in the back of the guide.

Strength Training

1. Strength training should generally be done 2 to 3 times per week, on an every other day basis, in order to realize progressive strength gains.
2. Off-Season strength programs, which are followed when the sport that you play is not in session should be done 2 to 3 times per week.
3. During the In-Season period, when you are regularly playing your sport, strength training should continue 1 to 2 times per week.
4. During the off-season you should try to maintain the weights or resistance being used when the maintenance regime is begun.
5. The weights used in the maintenance regime remain the same for each workout and should not be increased (sometimes weights need to be adjusted lower due to injury or fatigue).
6. The goal of the maintenance regime is to use the same weight each workout, to prevent strength loss of the strength gained during a previous strength improvement program.

Precautions when strength training:

- Avoid pain at the patellar tendon
- Avoid pain and/or crepitus (grinding) at the patella (kneecap)
- Build up resistance and repetitions gradually
- Perform exercises slowly avoiding quick direction change and impact loading
- Be consistent and regular with the exercise schedule

Before Starting Your Workout

- Warm-up prior to exercising by stationary cycling, elliptical machine, jogging or jump rope for 15 to 20 minutes. You are “warmed –up” when you have started sweating
- Gently stretch all muscle groups next (see attachment for recommended stretches)
- Do exercises involving multiple muscle groups first and individual muscle groups last

- Do aerobic workouts *after* strength workouts
- Cool-down by stretching after finishing exercise

Progressive Resistance Exercise (PRE) Principle

1. To build muscle strength and size, the amount of resistance used must be gradually increased.
2. The exercises should be specific to the target muscles
3. The amount of resistance should be measurable and gradually increased over a longer period of time
4. To avoid excess overload and injury, the weight or resistance must be gradually increased in increments of 5 to 10 %
5. Resistance can be increased gradually every 10 to 14 days when following a regular and consistent program
6. Adequate rest and muscle recovery between workout is necessary to maximize the benefit of the exercise
7. If the PRE principle is followed too strictly, the weights potentially will go higher and higher.
8. At a certain point, the joints and muscles will become overloaded and injury will occur.
9. This eventuality can be avoided by refraining from using excessive weight during strength training.

Repetition-Maximum Principle.

Knowing when to increase the weight you are using in a strength-training program is based upon the 'repetition-maximum '(RM) principle.

For example, a 10 RM for the leg press exercise is the amount of weight that can be lifted "just 10 times", and No More, before fatigue or failure sets in. That is, the particular weight being lifted is so heavy that an 11th repetition is not possible.

In a typical strength improvement program, the workout might look like this:

Exercise - Leg press

Intensity - 10 RM

10 RM Weight- Determined by trial = 100 pounds

Set 1--1/2 10 RM (50 lb.) 10 repetitions

Set 2--3/4 10 RM (75 lb.) 10 repetitions

Set 3--10 RM (100 lb.) up to 10 repetitions

Set 4--10 RM

Set 5--10 RM

1. If 10 repetitions of 100 lb is achieved on the third set, then the 10 RM can be raised by 5 lb for the next set/exercise session.

2. If 10 repetitions are not achieved on the third set, then the 10 RM weight remains the same (100 lb) for the next workout or any subsequent sets.
3. If you reached the 10 RM on the third set, and wished to do a 4th and 5th set, then the weight can be raised to the new 10 RM.
4. If you did not reach the 10 RM on the 3rd set, then the 4th and 5th sets would remain at the original 10 RM.
5. The $\frac{1}{2}$ and $\frac{3}{4}$ RM set should always be done to gradually ramp-up the weight to the 10 RM set(s).
6. The 3rd, 4th and 5th sets are considered the 'working sets'.
7. The number of repetitions you choose for your RM will depend upon the goals of your strength training program:

15 to 20 RM	Builds muscle size and definition
8 to 10 RM	Builds muscle size and force capability (pure strength)
3 to 5 RM	Builds maximal Force capability, minimal size gains (high power)

Basic Knee Strengthening Program

- Frequency: 3 Times per week
- Sets: 3 to 5
- Repetitions per set: 15
- Emphasis is to build muscle strength using BOTH legs
- Progress according to the PRE and RM principles

Basic Program Exercises- see illustrations at the back of the handout.

- Leg Press
- Hamstring Curl
- Knee extension machine (short-arc 30 degrees)
- Roman Chair
- Partial Squat (hold dumbbells or barbell for resistance)
- Calf Raises
- Hip Abductor/Adductor machine (or hip pulleys or multi-hip machine)
- Hip flexor pulls
- Step Up/Down on 9 inch step (see below for progression)

The step-up exercise is the first drill to provide training for single-leg strength and balance. After you are able to perform the step-up exercise for 3 sets of 15 repetitions, without holding anything for balance, you can progress to the following advanced program.

If you have difficulty performing the step-up exercise, use the following progression as a guide:

- Start with a step of 3 inches in height
- Start with 3 sets of 5 repetitions
- Add one repetition per set, per workout, until you can do 3 sets of 10 (about 2 weeks)
- If pain free, progress to a step of 6 inches in height
- Repeat progression starting with 3 sets of 5 repetitions
- Add one repetition per set until you can do 3 set of 10 (about 2 weeks)
- If pain free, progress to a step of 9 inches in height (the height of a standard stair)
- Repeat process of progression from 3 sets of 5, to 3sets of 10 (about 2 weeks)

Advanced Knee Strengthening Program

- Frequency: 3 Times per week
- Sets: 3
- Repetitions per set: 10
- Emphasis is to continue to build muscle strength using both legs and progress to Advanced Exercises using the Single leg.
- Advanced Single leg exercises are integrated with the exercises from the Basic Knee Strengthening Program.

The following single leg drills are integrated into the workout on a rotating basis:

- Single Leg Wall Slide
- Single Leg Squat (see below for single leg drills)

So that the Advanced Knee Strengthening Program would be as follows:

- Leg Press
- Hamstring Curl
- Knee extension machine (short-arc 30 degrees)
- Roman Chair
- Chair Squat (with barbell or hold dumbbells for resistance)
- Calf Raises
- Hip Abductor/Adductor machine (or hip pulleys or multi-hip machine)
- Hip flexor pulls
- Step up/down (hold dumbbells for resistance with balance)
- Alternate workouts with single leg wall slide and single leg squat
- When starting the new single leg drills, start with 3 sets of 5, and add one repetition per set, per workout until you can do 3 sets of 10.
- When you can do 3 sets of 10 without holding anything for balance, then you can hold dumbbells to increase resistance and strength on all single-leg drills.

Instructions for Single Leg Exercises

Step Up- Down Exercise

Standing **sideways** to a step or stool, place the foot of the single limb on a step or stool. Standing on the single-leg, maintain balance if necessary, by lightly holding onto something. Keeping an upright posture and bending only at the Knee and controlling with the quadriceps muscle, slowly lower the opposite foot to touch the floor. **Do not** land on the floor, just **touch gently** and repeat the step up motion, maintaining constant muscle activity in the quadriceps. Keep the back straight and do not let your hips go backward.

Single Leg Wall Slide Exercise

Stand on the single leg with your back and buttocks touching a wall. Place the foot about 6 inches from the wall. While maintaining balance, slowly lower your body by bending the knee and slide down the wall until the knee is flexed about 45 degrees (illustration). Pause five seconds and then slowly slide back up to the upright starting position. Keep the hips level and be sure you are using your knee muscles to perform the exercise.

Single Leg Squat Exercise

In the single leg squat exercise, while maintaining balance, you stand on the single leg and then lower your buttocks toward a chair or bench. Slowly return to the standing and starting position. As you begin the squatting motion, keep your head over your feet and bend at the waist and hips as you descend. You do not have to squat all the way to the chair or bench, instead, try to stay in a comfortable range of motion where there is no knee pain or excessive strain. As you gain strength, try to do the exercise without holding on to anything, and eventually, balancing while holding dumbbells.

Some final precautions

When using the leg extension machine (quadriceps extensions), limit the lifting of the weight through the upper 30 degrees and hold for 5 seconds with the knee fully straight (see illustration in back of guide)

***Due to their potential to cause knee injury, the following exercises are **not** recommended:

- Stairmaster or stair climber machines
- Lunges with weights
- Squats past 90 degrees of knee flexion
- High impact exercises

Speed/ agility training

Goals:

1. Safely condition the knee and lower limb for the demands of sports activity.
2. Provide a logical sequence of progressive drills for pre-sports conditioning
3. Provide objective criteria for safe progression from training to sports participation.

Sports Specific Speed and Agility Training

Phases of Training Straight-ahead running phase
 Direction change running phase
 Unrestricted direction change

Warm-up and Stretch

Generally, you should cycle, jog, jump rope or use an elliptical trainer, rower or other device for 15 to 20 minutes so that you break a sweat before starting the running program.

You should then stretch before beginning the running drills.

After completing the running drills, cool down by stretching for 15 to 20 minutes.

The criteria to progress

Do not progress to the next step in the progression until the present step is pain free, without any difficulty (muscle soreness, joint pain or fatigue)

Frequency: 2 times per week.

Notes:

Each 'step' is considered one workout.

The program adds the steps together as you progress through the outlined sequence.

Repeats should not be skipped to avoid overuse injuries due to too rapid progression.

Phase 1 Straight Ahead Running

- STEP 1 Run ½ speed 100 yards, 10 repetitions
- 2 Repeat previous step
 - 3 Run ¾ speed 100 yards, 10 repetitions
 - 4 Repeat previous step
 - 5 Run ½ speed, 100 yards, 3 repetitions
 Run ¾ speed, 100 yards, 3 repetitions
 Run full-speed, 50 yards, 4 repetitions
 - 6-10 Continue workout from Step 5, adding one 50 yard run
 each workout until you can do (10) 50 yard full speed runs.

Phase 2 Basic Direction Change Running

- STEP 11 100 yard run $\frac{1}{2}$ speed, 3 repetitions; $\frac{3}{4}$ speed, 3 repetitions; full speed, 3 repetitions
Start **zig-zag run**, round corners, 50 yards, 5 repetitions, $\frac{1}{2}$ to $\frac{3}{4}$ speed
- 12 Repeat previous step
- 13 Repeat previous step, add **backward run** 25 to **gradual stop**, then **forward run** 25 yards to gradual stop, 5 repetitions, $\frac{1}{2}$ to $\frac{3}{4}$ speed
- 14 Repeat previous step
- 15 Repeat previous step, add **circle run**, 20 foot or greater diameter circle, 3 repetitions to left and 3 reps to right, $\frac{1}{2}$ to $\frac{3}{4}$ speed
- 16 Repeat previous step
- 17 Repeat previous step, add **figure of eight run**, 20 foot or greater length, 5 repetitions, $\frac{1}{2}$ to $\frac{3}{4}$ speed
- 18 **Carioca**, 50 yards, 5 repetitions left, 5 repetitions right, $\frac{1}{2}$ to $\frac{3}{4}$ speed

Phase 3 Unrestricted Direction Change Running

Current workout:

1. 100yd $\frac{1}{2}$ speed, $\frac{3}{4}$ speed and full speed each distance 2 repetitions
2. zig-zag run 5 repetitions
3. forward backward run 5 repetitions
4. circle run 6 repetitions
5. figure 8 runs 5 repetitions
6. carioca 5 repetitions each way

STEP 19 to 24 Continue current workout increasing all drills to full speed

25 Continue Current Workout above and Add at $\frac{3}{4}$ speed:

Shuttle run, 50 yards, direction change every 10 yards, 5 repetitions, alternate hands touching.

26 Repeat previous step

27 Repeat previous step

28 Repeat previous step and add **Box drill**, 20 yards square, 6 repetitions, alternate starting side.

29 Repeat previous step

30 Repeat previous step

31 Repeat previous step and add **agility run**, 5 repetitions, alternate starting side.

32 Repeat previous step

33 Repeat previous step

34 to 39 Repeat previous step working all drills to full speed.

Final workout:

1. 100yd $\frac{1}{2}$ speed, $\frac{3}{4}$ speed and full speed each distance 2 repetitions
2. zig-zag run 6 repetitions
3. forward backward run 6 repetitions
4. circle run 6 repetitions
5. figure '8' runs 6 repetitions
6. carioca 6 repetitions each way

7. Shuttle run, 50 yards, direction change every 10 yards, 6 repetitions, alternate hands touching.
8. Box drill, 20 yards square, 6 repetitions, alternate starting side.
9. Agility run, 6 repetitions, alternate starting side

When practicing the final workout, for each drill, do the first 2 repetitions at ½ speed, 2 repetitions at ¾ speed and the last 2 repetitions at full speed.

Jump/ Plyometric training

Goals:

1. Safely condition the knee and lower limb for the demands of jumping and landing during sports activity.
2. Provide a logical sequence of progressive drills for pre-sports conditioning
3. Provide objective criteria for safe progression from training to jumping-sports participation.

Sports Specific Jump/Plyometric Training

Phases of Training Double-leg training
Double-leg complex training
Single-leg training

Warm-up and Stretch

Generally, you should cycle, jog or use an elliptical trainer, rower or other device for 15 to 20 minutes so that you break a sweat before starting the running program.

You should then stretch before beginning the jumping drills.

As a further specific warm-up before beginning the jump training, the following jump rope routine is recommended:

Jump rope 50 turns, double-leg hops

Jump rope 50 turns, alternating single-hops, 2 sets

Jump rope 50 turns, Double single leg hops, alternating

Jump rope 50 turns, Double single leg hops, alternating, followed by 3 double leg hops

After completing the jumping drills, cool down by stretching for 15 to 20 minutes.

The criteria to progress

Do not progress to the next step in the progression until the present step is pain free, without any difficulty (muscle soreness or fatigue)

Frequency: 2 times per week.

Notes:

Each 'step' is considered one workout.

The program adds the steps together as you progress through the outlined sequence.

Repeats should not be skipped to avoid overuse injuries due to too rapid progression.

Technical Essentials:

Each hop or jump should be performed with concentration on good technique.

Each jump landing should be a 'stick' landing, i.e. you should land and hold balance momentarily before proceeding to the next jump.

Keep the feet apart and do not let the knees move or rotate inward when taking off and especially landing

Phase 1 Double-Leg Training

- STEP 1 Power skip, warm-up, 100 feet distance, 5 reps.
Double leg, hop-hop-stick, 5 reps.
Wall jumps, 10 reps.
2 Repeat previous step

Phase 2 Double-leg Complex Training

- STEP 3 Add Triple-broad-Vertical jumps, 5 reps.
180 degree jumps, 5 reps.
4 Repeat previous step
5 Add Triple broad jump to Vertical jump to 180 degree jump, 5 reps
Forward-Backward jumps (over 6" hurdle), 5 reps each way
Side-to-Side jumps (over 6" hurdle), 5 reps each way
6 Repeat previous step

Phase 3 Single-leg Training

- STEP 7 Add Single-leg Forward Hopping, 3 hops then stick, 5 reps each leg
8 Repeat previous step
9 Add Single-leg Forward-Backward hopping (over 6" hurdle), 5 times each leg
10 Repeat previous step
11 Add Single-leg Side-Side hopping (over 6" hurdle), 5 times each leg

Final Workout

1. Power skip, warm-up, 100 feet distance, 5 reps
2. Double leg, hop-hop-stick, 5 reps
3. Wall jumps, 10 reps.
4. Triple-broad-Vertical jumps, 5 reps
5. 180 degree jumps, 5 reps
6. Triple broad jump to Vertical jump to 180 degree jump, 5 reps
7. Forward-Backward jumps (over 6" hurdle), 5 reps each way
8. Side-to-Side jumps (over 6" hurdle), 5 reps each way
9. Single-leg Forward Hopping, 3 hops then stick, 5 reps each leg
10. Single-leg Forward-Backward hopping (over 6" hurdle), 5 times each leg
11. Single-leg Side-Side hopping (over 6" hurdle), 5 times each leg

Looking at the Whole Training Program

The following is suggested schedule of off-season workouts incorporating the strength, speed/agility and jump/plyometric programs.

The workout-week is 7 days.

The workout weeks are recycled every 5 weeks.

Aerobic workouts can be done on training days, after strength, speed or jump training.

To allow adequate rest and recovery from workouts, rest days should be observed.

Rest days can be active, participating in non-athletic activities and stretching, but avoiding exercise intensities that would require further rest and recovery.

Workout week 1

- Day 1 Strength training
- 2 Speed/Agility training
- 3 Rest day
- 4 Strength training
- 5 Jump/Plyometric training
- 6 Rest day
- 7 Strength Training

Workout week 2

- Day 1 Speed/Agility training
- 2 Rest Day
- 3 Strength training
- 4 Jump/Plyometric training
- 5 Rest day
- 6 Speed/Agility training
- 7 Strength training

Workout week 3

- Day 1 Rest day
- 2 Jump/Plyometric training
- 3 Strength training
- 4 Speed/Agility training
- 5 Rest day
- 6 Jump/Plyometric training
- 7 Strength training

Workout week 4

- Day 1 Speed/Agility training
- 2 Rest day
- 3 Strength Training
- 4 Jump/plyometric training
- 5 Speed/Agility training
- 6 Strength Training
- 7 Rest day

Workout week 5

- Day 1 Rest day
- 2 Rest day
- 3 Strength training
- 4 Speed/Agility training
- 5 Strength training
- 6 Rest
- 7 Jump/Plyometric training

In-Season Conditioning

Warm-up and Stretch

Always continue the advice on warm-up and stretching before and after practice and games.

Strength Training

Frequency: Ideally 2 times a week (one time a week better than none)

Intensity: 85 to 95 % of your 10 RM weights achieved during the off-season
Weights will vary due to fatigue, injury or illness

Sets: 2 to 3

Repetitions: 6 to 8

When: After practice or on an off day

Speed/Agility and Jump/Plyometric Training

The exercises and drills that comprise the speed and jump training programs can be easily incorporated into pre-practice warm-up and in-practice conditioning routines.