Cycling-Specific Leg Strength Training

There are a lot of theories on strength training for cycling out there, and unfortunately not a lot of science to back them up. Therefore, the following strength training recommendations below are based on my reading of a lot of literature, books and articles on this topic. I've put together my thoughts on what should be a sound and effective strength training program for cycling. At the very least, I don't believe it will hurt and should help. What I'm referring to here is leg strength training. This article does not cover upper body and core strength. Those are important as well, but will not be addressed here.

Rationale for strength training: Some people argue that strength training is not necessary for cyclists. They say that cycling relies mostly on cardiovascular fitness and you can get all the leg strength you need by riding. They also claim that off-the-bike strength training is not cycling-specific therefore useless. While I agree that cycling is first and foremost a cardiovascular sport, leg strength is still important. Cycling is a power sport. Power equals force times speed. Force is the amount of effort you put into the pedal stroke and speed is your leg rpm. Here's why I disagree who say strength training is not required, and why I believe it should be part of a cycling training program.

First, cycling requires leg strength. Stronger cyclists who can continuously crank out more power must also put out more force per pedal stroke. If two cyclists are pedaling at 90 rpm and one is putting out more power, he must be putting out more force on the pedals and using more strength to do so. Power = strength x speed. If leg speed is equal then the only other variable is force, which is driven by leg strength. You can work on increasing your cadence, but there is a ceiling on how fast you can pedal, so your main power improvement from increased cadence is limited. The more force you can continuously generate, the more power you can put out. Strength => force. The upward limit of strength is much more open ended than leg speed. Therefore you should work on strength. Riding a bike will give you a lot of the strength you need to ride well. However, there are times when you could use more strength to turn the pedals, such as when you are accelerating, charging up a hill or sprinting. It is possible but difficult to build this type of strength just on the bike. During the summer I typically recommend doing one strength workout on the bike each week, to maintain leg strength. But in the off-season, I believe it is a good idea to do some gym leg strength work. You can build more strength in the gym than you can on a bike. Even if strength training isn't necessary, it is certainly more efficient and time-effective to work on strength training off the bike.

Secondly, strength training has the added benefit of increasing bone strength. There is some suggestion that cyclists have less bone strength than other athletes, perhaps due to the lack of impact (such as from running) and resistance training. It may also be due to all the sweating that cyclists do, which can leach calcium from the body. Whether or not this is true, there's no doubt that resistance training can improve bone strength as well as muscular strength.

A third reason for doing strength training is that you can work on muscles that don't get used during cycling, or at least not very much, and therefore you can become more balanced. Cycling is a linear sport – we tend to move our legs in one plane and use only some of our leg and hip muscles.

Fourth, a rationale for doing strength training in the off-season is that for those of us who live in a northern climate, riding outside during the winter is difficult and often impossible. Strength training a couple times a week gives a great workout indoors and adds some diversity to your annual training routine. It can also simulate the effect of a long ride. The day after a good leg strength workout your legs should feel like you've just ridden 70 miles.

Finally, as you age, it becomes difficult to maintain muscle mass, even with training. You tend to lose your type II muscle fibers (the fast twitch ones) the most, and these are the same ones built most by strength training. If you don't lift fairly heavy weights, you will likely lose muscle mass as you age even if you continue to ride a bike.

Types of Leg Strength Training: Cycling requires several types of leg strength. It mostly requires strength-endurance, which is the ability to push the pedals around powerfully, for long periods of time. It also requires pure strength – the strength required to push very forcefully on the pedals when accelerating, climbing or sprinting. Cycling also requires you to have the ability to generate a force quickly. Think about the pedal stroke. The majority of the force to turn the cranks is generated from the 1 o'clock position to the 5 o'clock position (when looking at the right leg from the right side of the bike). This is one third of the pedal stroke. If you are pedaling at 90 rpm, you are doing 1.5 revolutions per second, or doing one revolution in 2/3 of a second. Therefore, you are generating all the down force during a pedal stroke in 0.22 of a second (1/3 times 2/3). That's quite fast! Therefore, it's important to consider some leg speed work, both with and without resistance, to train your muscles to fire quickly. So we have strength-endurance, max strength and strength-speed to think about.

Muscle groups required for cycling: In cycling, there are four basic muscle actions involved in a pedal stroke. 1) knee extension 2) hip extension 3) knee flexion 4) hip flexion. **Knee extension** is the straightening of the knee joint such as when kicking a ball. During the pedal stroke, you are extending your knee from the 11 through 5 o'clock positions. Knee extension occurs by the contraction of the quadriceps and Rectus femoris muscles – those big muscles on the front of the thigh. **Hip extension** is extending the thigh from a bent or flexed position to a straight position where the thigh is parallel to your trunk. When you stand up out of a chair, you are extending your hip. On a bike, your hip extends from the 12 through 6 o'clock positions. Hip extension on the bike occurs mainly from the contraction of the gluteal muscles (your butt muscles). The hamstring muscles are also involved in hip extension but not to a very large degree in the range of motion involved in the pedal stroke. The hip and knee extension makes up approximately 80% of the force generated during a pedal with the knee and hip each contributing roughly half of the 80%. Therefore these are important muscles to strengthen for cycling. Muscles tend to be strongest at the mid portion of their range of their motion. For the two strongest muscles, the quads and glutes, their greatest force production is at the 3 o'clock position. This is good news because this is where the foot is pushing perpendicular to the crank resulting in the greatest force transfer from the foot to the bike. Whoever invented the bicycle knowingly or unknowingly had this figured out. The greatest muscle force production coincides with the physics of the pedal motion in an optimal manner. **Knee flexion** is the bending of the knee such as kicking your foot back towards your butt. On the bike, knee flexion occurs from the 5 through 11 o'clock positions, where you are pulling back with the foot. The hamstrings are involved in flexing the knee. As you actively pull back on the pedals, you are engaging your hamstrings. **Hip flexion** involves bringing the thigh up towards the chest such as when you step up and over something. On the bike, the hips flex from the 6 through 12 o'clock positions. The psoas muscles are responsible for flexing the thigh. In actuality, most of the effort used to lift the leg up on the upstroke of the pedal stroke comes from the other leg pushing down on the pedals. Even when elite cyclists consciously pull up on the pedals, they just barely unweight the leg, and really don't produce enough force to propel the bike forward. However, anything you can do to help unweight that leg means the other leg can use more of its down force energy propelling the bike forward rather than lifting the opposing leg, so it is worthwhile trying to improve the efficiency of your pedal stroke by working on the hip flexors.

So the muscle groups involved in the pedal stroke are the quads, glutes, hamstrings and hip flexors. The quads and glutes provide the vast majority of the force and power for turning the pedals. Many other accessory muscles are involved, such as the calf muscles, but typically they get strong enough just from cycling and they don't contribute much to the overall force production so we won't worry about strengthening them in the gym.

The exercises: The **squat and leg** press work the quads and glutes simultaneously. These are the powerhouses of the pedal stroke and can handle heavy weight. The squat involves both knee and hip extension at the same time as you stand up out of a squat. Therefore it simultaneously strengthens both muscle groups in proportion to each other – the quads will be as strong as they need to be relative to the glutes. Standing up out of a squat mimics the downward pedal stroke motion very well. That's why it is such a good exercise for cyclists. The **leg curl** works the hamstring muscles, those used to pull back on the pedal. If you just do squats or leg presses, you ignore and potentially will have relatively weaker hamstrings than quads and glutes. A good way to hit the hip flexor muscles is to do **one legged**

pedaling. When you first start pedaling with only one leg (clipped into your pedal of course while the other is held out of the way), it won't take long before your pedal stroke becomes jerky and you have trouble getting your leg back up on the upstroke. This is because of weak hip flexors. When riding two-legged, we get lazy and let the downward leg push the upward leg back up. One legged pedaling does two important things: it strengthens the hip flexors and it also provides neuromuscular training so this pulling up motion becomes more automatic when pedaling with two legs. You don't want to have to consciously think about pulling up with every pedal stroke. These three exercises (squats, leg curls, one legged pedaling) will hit the four major muscle groups involved in the pedal stroke.

Strength-Endurance Training: When pedaling along at your anaerobic threshold or time trial pace, you are only using a fraction of your absolute leg strength with each pedal stroke. When a body builder or weight lifter refers to 'strength endurance', they typically are referring to 15 reps of a given exercise. However, you are doing many thousand reps per ride. Our definition of strength-endurance is a little different – a lot more endurance and less strength required. When a weight lifter is doing 15 reps of a given exercise, he can lift approximately 65% of his one rep maximum lift. So you can imagine that a cyclist doing a time trial doing thousands of reps is using an even lower fraction of his total leg strength. I can hit 800-1000 watts for a few pedals strokes but my threshold is less than 1/3 of that amount. So cycling at a fairly fast pace requires only a relatively small fraction of overall strength. This is a reason some coaches give that strength training isn't necessary for cyclists – cyclists don't need a huge amount of strength when cruising along. However, it's also been said that a strong muscle tires less quickly. Let's say you can crank out 1200 watts briefly while another cyclist can only hit 1000 watts. Let's say you both have a threshold power of 300 watts. You will be using a lower percentage of your muscle strength than the other cyclist when both of you are riding at threshold. Your muscles should tire less quickly.

Now, strength-endurance is effectively trained by riding a bike at or near your threshold level. In order to use the strength you have, you must be able to support aerobic muscular force by supplying oxygen and sugar to the working muscles. That is cardiovascular fitness. If your cardio system isn't able to keep up, then it doesn't matter how strong your legs are, they will slow down because they aren't being fed enough sugar and oxygen. I've been dropped in races doing 180 watts, much lower than my threshold, but when I am exhausted, I can no longer generate the force I could when fresh because of cardiovascular fitness, not because I was weak. So on-the-bike threshold work is very important, but the other half of the equation is having the strength to use assuming your cardio system is able to support it.

Improving your strength-endurance requires fairly high reps with moderate weights. I like to prescribe 30-50 reps per set of exercises when working on strength-endurance. This sounds huge to a typical weight lifter, but when you consider you normally do thousands of reps, 50 isn't that many, but the force (actually the torque, but we won't worry about that detail here) required for each rep is considerably higher than pedaling a bike, even uphill. I like to think of this type of training as mimicking hill work. Your leg speed is somewhat reduced, you are generating a lot of force and you may do a couple hundred reps (pedal strokes) going up a hill. At the beginning of the leg strength phase of training, you want to ease into it gradually, otherwise your legs will be extremely sore. So start off strength-endurance training with very light weight. The first time I do squats in the fall, I just use the bar. I will do 2-3 sets of 15 reps. It's amazing how sore you may feel that the next day! Once over the initial shock, your muscles will respond quickly and you will be able to increase the weight quite fast. Work your way up to 5 sets of 50 reps of each exercise. The exercises I suggest training this way are the squat and leg curl. You should also do one legged pedaling to improve strength-endurance of the hip flexors. Start out trying to make it one minute with each leg and build up to two minutes. Do at least three sets of one legged pedaling per session. Use the highest gear you can while still pedaling a smooth circle. This is actually a good exercise to do during your warmup.

A word about squats: If you do traditional back squats where you rest the barbell on your shoulders and then drop your hips towards the floor, you as a cyclist should try to go low enough so that your thighs are parallel to the floor. Some trainers suggest doing half squats, where you only go down to the point where your knee angle is 90 degrees. This is recommended for safety and for people who may have injured knees. As a cyclist, your knee is bent considerably more than 90 degrees at the 11 o'clock position. Just hop on your bike and look at your knee angle at the top of the pedal stroke. You want to mimic that with

squats, (unless of course you have knee problems), then you are better off stopping at the half squat. Another thing to consider: When doing squats, you put a lot of stress on your hamstrings when lowering yourself down to the squatted position. The hamstrings act as brakes to slow you down and prevent you from falling on your rear. This action is called eccentric muscle action, when the muscles are lengthening while under tension. It is this eccentric action that causes the most post-exercise muscle soreness (DOMS = delayed onset muscle soreness). Because cyclist never do eccentric contractions while cycling (the hamstrings are contracting while the hip is being flexed), when we start doing squats, it can be a fairly painful experience. Therefore I suggest you do box squats, where you squat down and sit onto a box or low bench at the bottom. You want the bench to be low enough so that you are able to get your thighs at least parallel to the ground. I actually do my squats standing on a board which raises me up slightly so I have the proper knee angle when sitting on my bench. What sitting does is allows your hamstrings to relax as you sit down so they don't have as much of an eccentric stretch, and they don't have to hold you up during the bottom of the squat. You will find you can squat more weight doing box squats than regular squats yet your hamstrings won't be nearly as sore the next day or two.

Max Leg Strength Training: To improve your absolute strength, which is what weight or power lifters typically do, you need to lift heavy weights. In order to do so, you need to reduce the reps you can lift. Also, because heavy weights are involved, you need to be very careful not to hurt yourself. So some modifications are in order. To build strength most effectively, you need to lift a weight that is heavy enough to prevent you from being able to lift only 6- 8 reps at a time. The last rep should be very difficult to complete. We will work on the quads, glutes and hamstrings this way, but not the hip flexors. They will get worked enough just doing one legged pedaling. For the quads and glutes, it is best to use a leg press machine. This is safer than trying to do squats with very heavy weights. First of all, when using heavy weights with a squat, most people's back muscles become limiting before their leg muscles, so you won't be able to hold as much as you can lift. You also don't want to risk injuring your back, or losing balance and falling. Instead, use a leg press machine or similar type of machine. These are safe for your back because it is stabilized. The weights are also stabilized so you won't be able to lose balance. If you run out of weight that you can push (quite possible on some machines), then you can do these one leg at a time. For the hamstrings, you can continue using the leg curl machine you've been using for strength-endurance, just increase the weight and decrease the reps. These can also be done one leg at a time. You won't start doing heavy strength work until you've had a good base of strength-endurance, to give your leg muscles a chance to get stronger and to get used to strength training.

Leg Speed-Strength Training: As mentioned above, you need to not only have strong muscles, but they must be trained to fire quickly. Strength training increases the muscles' strength but not necessarily their speed. So to work on rapid firing, we will incorporate some jumping exercises. This is not to be confused with plyometrics. I do not advocate plyometrics for cyclists. Plyometrics are a jumping exercise which begins by pre-stretching the muscles and then exploding into a jump. For example, jumping off a box and then back up in one quick motion. As you jump down, you do an eccentric stretch of the glutes and quads and then as you explode back up, they contract from this stretched condition. This type of exercise is used for ground-based sports such as football and basketball, where the players stop suddenly and jump or change direction. The pre-stretch is helpful to these athletes because a stretched muscle has elasticity which helps spring the muscle back as it is contracting. You can jump higher if you quickly drop into a squat and back up than if you just start from a dead standstill. However, in cycling there is no pre-stretch at the top of the pedal stroke so there is no elastic potential energy stored up in the muscles that we can take advantage of. So, for our jumping we will start each jump for a standstill. The other reason I don't like plyometrics is because the risk of injury is so high. Even if supervised, it is very possible to twist an ankle, strain a joint or pull a muscle. It's not worth getting injured during strength training, especially a muscle or joint injury as these take a long time to recover from.

The main jumping exercise will be the squat jump. This involves starting in a squat position and then jumping as high as you can. I find it helpful to have a step or box to jump up onto – it gives you something to aim at. But if you don't have anything available, you can simply jump as high in the air as you can. As you land, lower yourself back down into a squat position and stop momentarily before jumping again. The key is to jump from a deep squat position, similar to the joint angles when your pedal is at 12 o'clock. Jump rapidly and forcefully into full extension. Keep your hands on your hips as you

jump. Typically squat jumps are taught with throwing your arms overhead. That just creates artificial momentum. You want your legs and hips to do all the work. Anyway, you don't throw your hands in the air while riding, do you? (except when you cross the finish line first! True story: I actually saw a guy throw his hands in the air so forcefully at the end of a race that he threw himself right off his bike backwards. To make matters worse, he was second and didn't realize the winner had already crossed the line. Oops!).

The amount of power you generate while jumping is much higher than the power you generate doing squats or leg presses with weights. That's because power is a function of both force and speed. Because you are contracting the muscles so much faster when jumping, you are creating a lot more power. Keep in mind that you are still lifting your entire body weight, so just because you don't have a barbell on your shoulders, it's not like you are not lifting any weight.

Periodization of leg strength training: There is a timing element to leg strength training. Some coaches go to great detail to create a week by week periodized leg strength training plan. I prefer to keep it as simple as possible. However, there is an order in which you should do strength training. Begin at the end of your transition period, typically in October. Start by doing squats and leg curls with very light weights and increase the weight and reps as you get over your initial muscle soreness, which should only last a few days if you aren't too aggressive. Once you've had a good full month of training with high reps (strength-endurance), such as mid November, you can start adding in max strength workouts. Again, work your way up to your maximum lifting weight. Don't try to do it first time you do this workout. Do both strength endurance and max strength workouts concurrently (each workout once each week) through February. Once you get to March, you are hopefully doing more riding outdoors. Strength training is hard on the legs and takes its toll on muscles. You will notice that you don't have as much energy or pep if you ride the day after a strength workout. So as the weather starts to improve, phase out the max strength work. Continue to do the strength-endurance work but start to back off the weight and do the motions more quickly to transition the muscles into a faster, more powerful action suitable for riding.

Continue to do one legged training year round, at least once a week during the riding season just so you don't lose that muscle memory. Do them twice a week during the off-season. For squat jumps, you can do those starting in October and running through March.

Sample Plan: Here is a layout of a generic leg strength training plan by month.

October: Single leg pedaling, squat jumps, low weight, moderate rep strength endurance squats and leg curls
November: Single leg pedaling, squat jumps, moderate weight and high rep strength endurance squats/leg curls
December thru February: Single leg pedaling, squat jumps, moderate weight strength endurance squats/leg curls alternated with high weight max strength leg presses and leg curls
March: Single leg pedaling, squat jumps, high speed lower weight squats and leg curls
April – September: Single leg pedaling, on-bike leg strength workouts (low gear climbs, seated grinds, etc).

Here's what a single leg pedaling workout might look like:
Warm up. Pedal with right leg for one – two minutes. Switch to left leg. Spin easily with both legs for two minutes. Repeat for a total of 3 sets.

Here's what a squat jump routine might look like:
Warm up on a stationary bike. Do a series of 15 squat jumps. Rest (or do a different exercise). Then do 4 more sets.

Here's what a strength endurance routine might look like:
Warm up on a stationary bike. Do a set of 50 squats. Then do a set of 50 leg curls. Repeat until you've done 5 sets of both exercises.

Here's what a max strength routine might look like:
Warm up on a stationary bike. Do a set of 7 leg presses, then do a set of 7 leg curls. Repeat until you've done 5 sets of both exercises.

On days when you are doing strength endurance, here's how you might set it up.
Warm up on a stationary bike. Do a set of squats, then leg curls, then squat jumps, and finish up with a set of single leg pedaling. If you are at a gym, you can do single leg pedaling very effectively on a spin bike so hopefully you can hop on one easily between your strength sets. Go back through this routine 4 more times, or whatever is called for in your training plan.

On days when you are doing max strength, here's how you might set it up.
Warm up on a stationary bike. Do a set of leg presses, then leg curls, then squat jumps, and finish up with a set of single leg pedaling. Go back through this routine 4 more times, or whatever is called for in your training plan.

Supplemental leg and hip strength exercises: Cycling is quite one dimensional. We pedal in one plane and push and pull with the legs and hips. Never do we move our legs side to side or fully extend the hip. These motions become underdeveloped and may lead to muscle imbalances. It's a good idea to incorporate a few of these exercises to help maintain some balance.

Hip adductors: Hip adduction is the pulling of the leg in towards the center of the body. A little adduction occurs in the pedal stroke as you work to keep your knee in towards the top tube, but not much. The hip adductor muscles can be strengthened with specific hip adduction machines (where you squeeze your knees together against resistance) and it can be easily done with exercise bands or a cable machine. If using bands or a cable machine, attach to your ankle and pull one leg across the body in front of the other leg, while keeping the knee straight. Try to keep the hips stationary and only move the leg. Do both legs.

Hip abductors: Hip abduction is when you pull your leg out to the side, away from the body. Ice skaters and roller bladers use these muscles a lot but cyclists do not. Similar to hip adduction, these can be strengthened with specific hip abduction machines, where you push your knees out away from each other against resistance, and with bands or a cable machine. If using bands or cable, attach to your ankle, then pull the leg out away from the body while balancing on the other leg. Keep the knee straight and lift as high as possible keeping the hips level. Do both legs.

Full hip extension: While cyclists do hip extension during the pedal downstroke, it is only a partial extension. We rarely fully extend our hip, even outside of cycling. If you have done cross-country skiing, you will notice that your lower back and hip get tired quickly. While skiing, we bring our leg back as far as it with go while pushing off on the ski. In cycling, most of the hip flexion is due to the glutes working. When doing a full hip extension, it more fully engages the glutes and other muscles (hamstrings). This motion is best worked using bands or a cable machine. Attach to your ankle and pull the leg back, keeping the knee straight, keeping the hips stationary. Do both legs.

Putting it all together – creating a powerful, smooth pedal stroke: Leg strength is critically important for cycling, but it is also important to use this strength in a manner that creates a smooth and efficient pedal stroke. Here are some ideas for turning the pedals in a smooth fashion. You may have noticed that the knee is maximally flexed at the 11 o'clock position instead of the 12 o'clock position. This means your knee starts to extend as the foot comes over the top of the pedal stroke. Therefore, you should be thinking about pushing the foot forward as it crosses over the top of the pedal stroke, which engages the quad muscles. Starting to push at the 11 o'clock position instead of 12 or 1 o'clock results in a smoother, less choppy pedal stroke. Try this sometime when riding, especially uphill or into a headwind. You will notice a difference. It's like your leg gets a head start on the downstroke and it helps smooth out the dead spot at the top and bottom of the pedal stroke.

As your foot goes down through the downstroke, you are engaging both the quads and glutes. You really don't have to think about this, it comes naturally. But keep in mind that the most force is generated at the

3 o'clock position, as the force is perpendicular to the crank arm. However, as you get down to 5 and 6 o'clock, you are pushing mostly parallel to the crank arm and very little force is being used to turn the crank. So don't continue mashing down on the pedals once it reaches the 5 o'clock position. You are just wasting effort. Once the pedal reaches 5 o'clock, instead you should be thinking 'pull back' on the pedals. The objective is to try to put a force on the pedals in such a way that the force is always as perpendicular to the crank arm as possible throughout the pedal stroke. So at the bottom of the stroke, where the crank arm is vertical, you need to be pulling back on it to create useful force on the cranks which translate into forward motion of the bike. To pull back, you engage your hamstrings. It is commonly stated that you should be envisioning scraping mud off the bottom of your shoe as you are pulling back through the bottom of the pedal stroke. This helps visualize the feeling in your hamstrings.

Now some people recommend breaking the pedal stroke into three parts: 12 o'clock to 5 o'clock, 5 o'clock to 8 o'clock and 8 o'clock to 12. We've just covered the first two parts, the pushing down and pulling back. The third part is pulling up from 8 to 12. This engages the hip flexor muscles. However, I don't advocate breaking the pedal stroke into three parts, for a couple of reasons. First, it's more complicated. Your legs are flying around at 90+ rpm and your brain really doesn't have time to think push-pull- lift, push-pull-lift, with both legs at the same time. I find doing so, especially the lifting or pulling up phase, actually makes my pedal stroke more jerky. Plus, as mentioned above, the hip flexors are pretty weak and don't really contribute much to forward motion so accentuating this motion doesn't really help power the bike forward. So instead, I recommend just thinking 'push-pull'. Push from 11 o'clock to 5 o'clock, and pull from 5 back up to 11. By pulling back on the pedal, you will actually be flexing the hip and pulling up and lifting as the pedal comes up through the backstroke without even thinking 'lift'. If you have been doing one-legged pedaling religiously, your hip flexors will be trained to fire as you are pulling back and up. Also, you will be able to think fast enough to think "push-pull" during pedal strokes with both feet. Give it a try the next time you are out riding. I bet you find you pick up a little speed plus you should notice a smoother pedal stroke, especially if you start pushing at 11 o'clock and start pulling at 5.

Feel free to contact me if you have questions or comments about this.

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