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What is so important about gearing?

Bicycle racing is one of only a few athletic sports that require people to interact with a machine in order to compete. The power and speed of the human muscles work in union with the pedals, gears and chain of the bicycle to reach speeds greater than the body alone can attain. However, the human body is only capable of producing a limited amount of power. In order to make a bicycle move as fast as possible, the power must be applied as effectively as possible. That is, the greatest speed for the power available. Since no two athletes are the same, no two approaches to solving this problem will be exactly the same. However, the goal of every athlete should still be the same; to interact with the bicycle as perfectly as is possible for them. Applying your body's muscle power to the pedals of a bicycle involves only a few simple elements.

Foremost is the proper placement of the feet on the pedals. This is an essential part of any good bike fit. If the athlete is not in their best biomechanical position they cannot work comfortably and efficiently. Because the pedals move in a circle around the bottom bracket of the bicycle, it is essential that the feet be attached to the pedals. This allows the feet to apply force to the pedals during the majority of each revolution of the pedals. Most athletes who have difficulty with their pedaling, are probably pedaling at the wrong cadence. If the cadence is too high, the athlete will be unable to properly apply enough power to the pedals. It will also not be possible to stay at that high cadence for very long. If the cadence is too low, the legs will be overloaded and the athlete will be unable to respond to changes in speed very easily.

Whenever you ride a bicycle, no matter what type of bicycle and no matter what the circumstances, these things will directly impact your ability to ride well or enjoy yourself. To find the most efficient arrangement for you will require fairly thorough knowledge of your abilities and the demands of the situations you will be facing. It is assumed that you are going to be racing a bicycle, so the text will be directed towards that end. Road bikes and mountain bikes have the ability to change gears at will. Track bikes and BMX bikes cannot change gears, so making the right choice in advance is critical.

Over a period of time, you will learn what type of athlete you are. A lot of your ability to pedal at a given cadence has to do with the ratio of the type of muscle fibers you have been born with. Slow twitch muscle fibers are able to produce longer efforts, such as climbing a long hill, or riding at a given speed along a flat stretch. Fast twitch muscle fibers produce high powered, short term efforts like quick accelerations or sprints. Most athletes who train especially for sprinting, usually develop large thigh muscles from the extensive weight training they do. They are trying to build up as many fast twitch fibers as possible, in order to accelerate with greater speed. People who can sprint well or accelerate quickly usually have a higher amount of this type of muscle tissue. Everyone has a certain amount of both types of muscle fiber. The physiology researchers at the United States Olympic Training Center have done extensive testing on athletes in many different sports. Sensors built into the pedals of test bicycles show that even the most efficient riders cannot completely overcome the difficulty of driving the pedals 360 degrees of rotation. This is due in large part to the fact that

the muscles which pull back and up on one leg, cannot equal the power of the muscles which press down on the other leg. This would only be possible if the muscles along the back of the leg were as large and powerful as the muscles on the upper part of the leg. The muscles which pull back and up during pedaling must overcome the force and weight of the other leg as it presses down on the opposite pedal. The best a rider can hope for, is to reduce the amount of opposing pressure to a minimum. This not only requires strengthening the various muscles, but continued practice of proper pedaling technique.

All this becomes even more difficult when it is done with the wrong gear combination. The challenge for you the athlete, is determining what the demands of the event will be and then selecting the correct gears to help you attain your best performance. For example, even though velodromes are somewhat standardized, each one has its own unique characteristics based on length, steepness and shape of the banking. BMX tracks are more unique in their individual designs, but the specific events determine how to set up the bike. Individual events such as the pursuit or kilo require setting up gearing that allows the athlete to accelerate quickly and still be able to reach high speeds over a set distance. Mass start events such as the miss and out or points race require constant changes in speed. If the gearing is too large the athlete cannot respond to the changes in pace. If the gearing is too small, the athlete cannot hit or maintain the speeds necessary to make it to the finish.

One of the simplest events in track racing is the one kilometer time trial. Two riders begin from a standing start on opposite sides of the velodrome and race as fast as possible for a distance of one kilometer. Because it is race from a standing start, it requires a very explosive beginning and then a very high energy output for the remaining distance. In terms of length, the one kilometer time trial is quite short, but the power output is very high and requires a lot of strength and power.

In 1996 Brian Sitcer of California, won the kilometer time trial at the U.S.C.F. Junior Track Nationals. Brian won this event with a time of 1:07:595 or 67.595 seconds. That is an average speed of about 33.1 miles per hour. Testing at the Olympic Training Center and other research facilities suggests riding at this speed would require a sustained effort of 530 watts for the 67.595 seconds.

So how does this help you with deciding about the gearing for your bicycle? Well it brings up the importance of knowing the level of work involved in the race you want to compete in. If you are not as strong as the other riders, you will not last long.

However, having enough strength and power will still not be enough if you cannot apply the power efficiently. This is where gear choices make the difference. Let’s create an example of making a track gear selection. You are a Junior who is feeling invincible tonight and you want to know what gearing to use to defeat Brian Sitcer’s time. By making your own homemade gear you can select the gearing you want. You can determine speeds by multiplying development by expected cadence. The distance on the track can be figured into feet or meters and then divided by the time required to be victorious. Remember that you do not start out at say 125 rpm, you must build up to that cadence. The key to success here is to take into consideration your ability to get up to speed as quickly as possible and then hold it.

Let's go back to looking for that gear you want so you can beat Brian Sitcer's time in the Kilo. How do you break that down?

1 kilometer = 1,000 meters
1,000 meters = 3,280.8 feet
in 1:07.595 = 67.595 seconds
3,280.8 / 67.595 = 48.536 feet per second average speed
52 tooth chainring x 15 tooth cog = 24.122 feet of development
24.122 feet x 125 rpm cadence = 3,015.25 feet per minute
24.123

3,015.25 feet per minute / 60 seconds = 50.254 feet per second
3,280.8 feet / 50.254 feet per second = 65.284 seconds

What all this means is that if you select a combination of a 52 tooth chainring and a 15 tooth cog and pedal at an average of 125 rpm, you will beat Brian Sitcer by 2.311 seconds in the Kilo. The only piece of the equation left out is the size of the tires being used.

If you look at the formulas for determining gear development, they include the circumference of the wheel. The circumference of a 700C rim is always the same, but the tires that you put on change the wheels circumference. A 700C x 23 tire has a lower profile and diameter than a 700C x 25 tire and a larger profile and diameter than a 700C x 20 tire.

When you are trying to determine the development of gearing, you must know what the circumference of the wheel is with the right amount of air pressure and the rider on the bike. A 150 pound rider sitting on a pair of Continental Sprinter 250s with 140 pounds of pressure in them, will have a different roll out on the circumference of the wheels than the same setup with a 200 pound rider.

With the proper air pressure and the rider on the bike, align the wheel so the air valve is at the bottom. Make a mark on the ground directly beneath the air valve and then roll the bicycle in a straight line until the air valve is directly at the bottom again. Then measure the distance between the marks. Use this dimension as the wheels circumference until you change tires. A gear choice may look easy on paper, but there are some other details that need to be addressed.

First, you must start the race from a standstill, which means you will not be pedaling at 125 rpm at the beginning. Therefore, you will have to make up for all the time you are below that cadence. This will take pedaling well above 125 rpm for a while, to make up time.

Second, you will not be able to pedal below 125 rpm until the race is over. You lose time at the start of the race and you lose time when your cadence drops below 125 rpm. So a chart of your cadence during the race will look kind of like a plateau.

Third and perhaps most important is the fact that no two riders are the same, but certain events are. The kilometer time trial is an explosive event regardless of what type of gearing you choose, you have to be an explosive rider. If you do not have the power and strength to accelerate up to race speed and then hold that speed, the gearing won't make any difference.

The purpose of this manual is to help you make good choices when selecting the gears you put on your bicycle. The charts in the back will be of the greatest value to people who ride bicycles with only one cog and one chainring. This primarily BMX bikes and track racing bikes. Both these categories have very specific power and cadence requirements. These charts can help ensure you have the proper gears on your bike for the race you are going to do.

Take the time to learn what the power and cadence requirements are for the races you plan on doing. Track events for example come in just two categories; Standing start events and Rolling start events.

Standing start events include the Olympic Sprint, 500 meters time trial, 1,000 time trial, 2,000 meters time trial, 3,000 meters pursuit, 4,000 meters pursuit and the 4,000 team pursuit. The gearing used for these must allow the rider to accelerate quickly and still reach a high maximum speed.

Rolling start events such as the Flying 200 meters, Keirin, Points race, Madison, Miss and out and Match sprint all begin with the riders moving in a group or alone. Gearing for these type of events does not require accelerating for a standstill. However, because there are constant changes in speed, the gearing must not be so large as to restrict the rider's ability to accelerate rapidly. These events usually have the riders reaching very high speeds, so there is a need to have flexible, but large gearing.

The key element when making any choice in gearing is to be able to actually use the gearing chosen. If you do not have the strength to turn it or the leg speed to spin it, the gearing will not help you. In order to completely take advantage of the gearing, you may have to build up slowly. Starting with a gear that allows you to spin and reach a high speed, you should work your way up slowly until you reach a gear combination that is suitable for your level of competition.

Most of the riders I coach are juniors and they are sometimes hard to convince. In an effort to help a junior rider find the best gear combination for a track event, we used his road bike, a CompuTrainer and a Polar Vantage XL heart rate monitor.

The display on the CompuTrainer gives time, distance, speed, power output and heart rate, but in addition I had him wear a Vantage XL heart rate monitor, so we could print out his results afterward for study. When he was ready, I invited him to pedal in the gear he thought would be best for the event. After warming up, he started with a 52 tooth chainring and a 15 tooth cog using 172.5 mm. crank arms, pedaling at 73 rpm for a speed of 20 mph.

After three minutes I had him increase his speed to 25 mph. He was now pedaling at 91 rpm and producing 330 watts. Three minutes later I had him increase his speed again to 30 mph, which only lasted about thirty seconds. His cadence increased to 109 rpm and a load of 525 watts. He could not go on any longer so I then gave him the opportunity to recover and rethink his gear choice. Again he chose a gear he thought appropriate (52/14) and started pedaling at 20 mph. This required a cadence of 68 rpm and a load of 190 watts.

After three minutes he increased his speed to 25 mph and a cadence of 85 rpm, which produced a load of 330 watts. Finally he attempted to ride at 30 mph with a cadence of 102 rpm and a load of 525 watts. This time he only lasted about five seconds.

When he had recovered sufficiently, I had him switch to an easier combination (52/16). He pedaled at a cadence of 90 rpm and a speed of 23 mph. This produced a load of 250 watts. To his amazement he was not only able to remain at this speed indefinitely, but could accelerate quickly and not over exert himself.

He had found a gear combination that would suit his purposes and was within his power budget. Afterward, we downloaded the heart rate monitor and found that he was pushing his threshold in the first two gear choices.

The third choice however, showed him comfortably below his threshold. I decided to repeat this experiment with other riders and they were amazed that the results were about the same.

Average watt requirements compared to speed

15 mph	115 watts
20 mph	190 watts
25 mph	358 watts
30 mph	523 watts

Again, using a CompuTrainer running the Spin Scan Program, I had another team member ride at a variety of cadences. Using 172.5 mm crankarms, with the Spin Scan set at 0% grade, the rider performed as follows.

Gearing	Cadence	Speed	Watts
53/15	85 RPM	22.5 MPH	238.5
53/15	90 RPM	23.6 MPH	275.5
53/15	95 RPM	25.0 MPH	325.5
53/15	100 RPM	26.0 MPH	380.0
53/15	105 RPM	27.2 MPH	425.0

After sufficient time to recover, the rider changed gears to a 44 tooth chainring and a 15 tooth cog. This more closely resembled the size gear the rider used on the velodrome. Here is the result of the second test.

Gearing	Cadence	Speed	Watts
44/15	85 RPM	18.9 MPH	152.5
44/15	90 RPM	19.9 MPH	174.5
44/15	95 RPM	20.9 MPH	201.0
44/15	100 RPM	22.0 MPH	227.0
44/15	105 RPM	23.1 MPH	253.0
44/15	110 RPM	24.2 MPH	305.0
44/15	105 RPM	24.9 MPH	318.0

The Spin Scan Program revealed that the rider had the best pedaling technique between 95 RPM and 105 RPM. The Vantage XL heartrate monitor also revealed that the rider was most economical energy wise, when riding at these cadences. In addition, the rider was more able to react to attacks and changes in speed when pedaling in this gear combination.

This is not hard scientific research data produced in a physiology lab. This is just the average of test results done on a small group of riders. The purpose here is to show how much the amount of energy required to ride increases as the speed increase. If you want to be able to pedal your bike to go 30 mph, you have to develop the physical strength it takes to put out that much power.

This small study is not meant to be a representation of scientific research. It is simply an observation to help in making an objective decision about gearing in regards to power requirements. When you have the ability to shift gears, you can change your mind whenever you want. When you are unable to shift, you have to be picky about what you are going to use. Again, do your homework. Watch the racer and the races. Be patient.