POWERCRANKS™

Instruction and Installation Manual

Oct. 2008, for model 6 and earlier cranks

WARNING—FOR YOUR SAFETY READ THIS FIRST

To the PowerCranks™ novice, riding a bicycle with PowerCranks™ will feel substantially different than when using regular cranks and could be more dangerous if you will be riding them on a bicycle outdoors. For your safety, get used to these differences, especially before riding in areas that may involve increased danger, such as in traffic, around potentially unpredictable people (such as on "jogging" or "bike" paths), or on rough or uneven ground. I recommend riding in a totally controlled environment, such as an empty parking lot or on a training stand for a few rides, until these differences are well understood. **Riding safely is your responsibility! PowerCranks, Inc. will assume no liability for any accidents or injuries that occur as a result of unfamiliarity with or misuse of PowerCranks™,[1] and/or increased speed and/or riding in an uncontrolled environment and/or failure of the cranks while riding. If others use your PowerCranks™ you will be responsible for their safe use of this product. If you do not wish to assume these responsibilities do not install them and return them to us for a full refund.**

While your PowerCranks™ are intended to be used just like ordinary cranks in training you will not be able to do so until you get used to some major strangeness (which our PR person insists we should call features) and get through a very quick learning curve. How strange are they? Just let me say, don't let your grandmother ride on them (unless she competes competitively)! These features include:

- Getting into toe clips/cages is very difficult. Getting attached to pedals is easily done, once learned, but different and, therefore, initially, more difficult. Unclipping to stop on a street can also be different.
- Coasting is different and feels strange.
- Cornering could be more dangerous.
- Rising out of the saddle while going over bumps and obstructions is impossible.
- Stopping, especially emergency stopping, can be different and more difficult for two reasons. 1) You may be riding faster and 2) you cannot raise out of the saddle to move your center of gravity backwards, as some do.

One more warning, PowerCranks™ have precision moving parts and have limited strength so can be broken. Although strong and reliable, they may not be capable of taking everything you might be able to dish out. Early model clutches are rated to accept a tangential force to the pedal of over 100 lbs (most people hardly ever exceed 40) while the stronger model 5 clutches are rated at over 150 lbs. Clutch failure from exceeding these limits is most likely to occur once some facility with the cranks has been achieved and one is trying to power away from a stop, when clutch torque can be very high. If the clutches are torqued beyond their rated limit they can break. Sometimes some internal springs break and the clutches fail on their own. Either way, clutches are warranted against breakage during normal use for two years. If this occurs, return them for prompt replacement or repair.

As you get more time on these things all the strangeness will start to go away and it is "normal" cranks that will start to feel strange to you (although the adaption period going back only takes a few minutes). Have "fun" and be safe.

Frank Day, Inventor

Introduction

Is this really possible? After many years of riding around on a bicycle you are now (and, probably, for the very first time) going to read an instruction book on how to use a pair of bicycle cranks! Aren't you glad your parents didn't make you do this before they let you ride your first bike? Of course, that was in the days before you took your athletic performance seriously. Although you may think you pedal properly now, you are about to find out that you really don't, at least not all the time. Unfortunately, regardless of how many times you read these instructions, the first time you use your PowerCranks™ they will feel very strange and most feel very humbled.

This manual assumes you have purchased your PowerCranks™ because you want to improve your athletic performance and you are mounting your PowerCranks™ on a bicycle to ride on the road. The fact that PowerCranks™ have humbled essentially every new user (including some of the best athletes in the world) means they must be training muscles not easily trainable (at leastusing previously available techniques). As it is not possible to achieve PowerCranks™ benefits in any other realistically available way I consider PowerCranks™ to be one of the greatest athletic training tools invented for the serious athlete. As long as your sport relies on your legs for speed and/or coordination, training with PowerCranks™ will improve your performance. Unfortunately, the key word in the previous sentence is TRAINING as proper PowerCranks™ use requires a lot of hard work before the benefits are realized. This is especially true if your primary sport involves cycling since it is just as important to retrain the brain as it is to train the muscles and retraining the brain takes much longer than simply training muscles. The amount of improvement you'll see from training with PowerCranks™ is dependent on your current abilities how you, and you alone, use them.

How much improvement is possible?

Our data shows a 40% increase in cycling power is probable, in less than one year, for most new users (the better you are now, of course, the less potential for improvement there is). For most of you that means a year from now you could be 2-3 mph faster. For runners, speed skaters, cross country skiers, etc., the degree of potential improvement is also substantial in that the average runner can improve his/her marathon pace 30-60 seconds per mile in 3-4 months and sprinters should be able to take 0.2-.3 seconds off their 40 - 100 meter time in the same time frame. About 80% of users who run will set a personal record in a running race within 3 months of starting regular PC training.

For other athletes, where speed, coordination and endurance is important to their sport but not measured directly (hockey, soccer, football, figure skating, etc.), quickness and acceleration improvement should be easily noticeable to the athlete in a very short period of time but the agility, balance and coordination benefits are much more subtle and difficult to measure. Most of the time the athlete will "know" they are better without necessarily knowing why or how much.

One more thing, in almost all sports the rate of injuries should be reduced. Injury rates (especially major knee injuries, hamstring and/or "groin" pulls) in several sports have been correlated to muscle imbalance in the legs and/or hip flexor aerobic capacity. With improved muscle balance in the core and between the right and left legs and the agonist/antagonist (flexor/extensor) muscles, and improved lower extremity coordination, and improved aerobic capacity of all the LE muscles injury rates should be reduced. For the already injured, doing all this will also result in faster and improved rehabilitation. Many injured athletes have reported setting running personal records immediately after rehabilitation with PowerCranks™.

So, welcome to the world of PowerCranking, where, at first, even the best get to experience a very humbling experience, pedaling with PowerCranks™. But, if you will do the work, PowerCranks™ will improve your performance – the amount of improvement only being limited by your own effort and desire.

Warning

I know you're anxious to get started with the cranks but please, please, please read the following instructions before doing so because the first time you are going to find these cranks REALLY strange. This "strangeness" could affect your safety, especially if riding in traffic or other uncontrolled situations.

Frank Day
Inventor and founder of PowerCranks

Contents

Congratulations on your purchase . . . get ready to have some "fun"

These instructions assume you made this purchase because you are a serious or fairly serious athlete and want to improve your performance in either cycling or running. Please read this instruction manual to help you better understand the differences between PowerCranks™ and what you are used to so you can transition safely and then to understand how to maximize your benefits from training with this device. Good luck in your athletic endeavors.

What's Different About PowerCranks

Your PowerCranks™ are meant to be used, at least most of the time, just like ordinary bicycle cranks but, at first, you will notice some major "strangeness" affecting how you ride the bicycle which might affect your safety. These "strange" features include:

Strange Feature #1. Getting attached to your pedals.

PowerCranks™ will not operate without each foot being firmly attached to the pedal in some fashion since the pedal will not come up unless you can and do pull it up. If you will be using them on the road, toe clips (cages) are not recommended as it is much more difficult to get into or out of toe clips, especially in an emergency. Clipless pedals (cleats) are recommended - every brand works acceptably well. Cages are perfectly acceptable for indoor use on an exercise bicycle or training stand, especially if you are mostly interested in running improvement as it is easier to run immediately after your PowerCranks workouts (more about this later). If you will be using cages it is important that your foot is snugly tied in so the foot does not feel loose and so you foot cannot pull out when pulling back or up. If riding on the road and using clipless pedals, clipping in is quite easy but at first will be somewhat difficult because with PowerCranks™ the first foot is clipped in normally but the second pedal will be found pointing down towards the ground and unsupported. This takes a little getting used to and if you start off going uphill you could quickly coast to a stop and fall while you are trying to get clipped in. But, once you learn this new skill, getting attached is not difficult. If you are new to clipless pedals be sure you understand how to unclip before venturing outside.

Strange Feature #2. Coasting and cornering.

Whenever you stop pedaling you will find both feet, immediately, go to the bottom of the pedaling arc. This feels really weird but it is not a particularly bad thing (other than looking funny because, in fact, it actually lowers your center of gravity) unless you are going around a corner rather sharply when your inside pedal could hit the ground and cause you to fall or unless you are going over a speed bump (see below). One more thing, when you find yourself riding faster you must be concerned with traction on corners due to increased speed so you may not be able to take corners as sharply as you are accustomed. Therefore, practice cornering. With practice you will be able to hold the inside leg up during sharp corners to avoid the possibility of hitting the ground. This difference actually improves your cornering technique because proper cornering technique requires one to unweight the inside pedal. Always be aware of the hazards of increased speed when cornering.

When cornering one must lift the inside leg just enough to miss the ground. Here triathlete Courtney Ogden is preparing to corner on PowerCranks during the 2006 Ironman Canada race. Of note: he had the fastest bike split in this race!

Strange Feature #3. Going over bumps and obstructions.

Going over speed bumps or pot holes will be another new experience for you if you, like many people, rise up off the saddle to negotiate these obstructions. The first time you try to raise off the saddle you will find both feet at the bottom of the arc and (if your saddle height is adjusted properly) your buttocks only about 1/2 inch above the saddle. This feels really strange and, with both feet down, your pedals can hit the speed bump as you go over it (depending upon the height of the obstruction). Don't expect to be able to bunny hop anytime in the near future. Get used to this "feature" before you venture into unfamiliar territory.

Strange Feature #4. Riding out of the saddle.

Riding out of the saddle is really hard for most people and is the last skill most people learn. Don't even bother trying until you have the mechanics of normal riding down pat. It can be done and there are some drills to help you learn this which are covered later. With practice, this will become easy (as if pedaling out of the saddle was ever "easy") and natural.

Strange Feature #5. Braking.

Well, not really a feature, except as related to the major feature, increased speed, but I didn't want to break the flow. If, as expected with PowerCranks™ you are moving faster than you are used to, stopping distances will be substantially longer than you are used to because of increased speed. Your total energy is proportional to the square of your velocity and so stopping distance increases with the square of the velocity. **Beyond simply taking longer to stop, emergency braking poses another potential problem.** Many people perform an emergency stop by rising out of the saddle and then pushing their body rearwards (which moves one's center of gravity back) so they can brake harder with the front brake without going over the handlebars. It is hard to do this with your PowerCranks™ since it is difficult to rise out of the saddle enough to move back. Practice your emergency stop technique before venturing into traffic or other uncontrolled environments. **Riding safely is your responsibility**.

Strange Feature #6. Be Careful.

Just as your bicycle chain, wheel, tires, or frame can suddenly fail during use, causing a dangerous situation, so can the PowerCranks™. If a PowerCranks™ clutch suddenly fails under high load it will be similar to a chain breaking. There are two major causes for these failures. There are some small springs in the clutch necessary to proper clutch functioning, and these sometimes break on their own (this type of failure usually doesn't result in complete failure but, rather, slipping under load). The second reason is exceeding the rated torque of the clutches. Our newest clutches are 50% stronger than our original clutch which we hope will take this clutch failure rate close to zero. Of course, no component can have a zero failure rate so be careful. These failures occur most often starting up from a stop quickly after people have started to become comfortable with the cranks and are starting to ride then hard. Strangely, this rarely occurs to pros, who you would expect to put the most force on the pedals. Perhaps the pros have put more effort into becoming "smooth" over the less experienced. So, as you develop your PC pedal stroke you should become smoother and risk of clutch failure should go down even though you are riding with more power. Anyhow, be aware of the possibility and please ride with caution and in control.

Strange Feature #7. Cornering and Stopping.

Whenever you stop pedaling you will find both feet, immediately, go to the bottom of the pedaling arc. This feels really weird but it is not a particularly bad thing (other than looking funny because, in fact, it actually lowers your center of gravity) unless you are going around a corner rather sharply when your inside pedal could hit the ground and cause you to fall. One more thing, when you find yourself riding faster you must be concerned with traction on corners due to increased speed so you may not be able to take corners as sharply as you are accustomed. Therefore, practice cornering. With practice you will be able to hold the inside leg up during sharp corners to avoid the possibility of hitting the ground. This difference actually improves your cornering technique because proper cornering technique requires one to unweight the inside pedal. Always be aware of the hazards of increased speed when cornering. Another issue related to this has to do with the need to be aware of the curb when stopping at stoplights, etc. The problem occurs after unclipping to put the foot down when stopping as we always do that with the curbside foot and, when doing this, the curbside crank will fall to the bottom of the arc and, if the bike comes too close to the curb, the pedal/crank can hit the curb, which could cause you to fall (see picture).

Strange Feature to your lawyer: Your responsibility

Bicycling is inherently dangerous. Always wear a helmet and don't expect others to see or look out for you. While it is possible to ride PowerCranks™ in most environments (such as in traffic, etc.) with reasonable safety (as it is a regularly equipped bicycle) it is your responsibility to ride safely in all situations.

Summary

To summarize, if, at first, PowerCranks™ don't feel strange to you, don't tell your friends because the fact that you are really a space alien will be exposed.

10 years, 6 models, big changes.

The model 6 improvements.

PowerCranks were introduced to the world in 1998. Over the years they have gone through many interations to improve reliablity and function. The last model (model 5) introduced the major improvement of a larger clutch to minimize the incidence of clutch failure. This has worked very well and clutch failures have become quite rare since this change. The latest version keeps this stronger clutch and offers two major improvements. First, we have simplified the selection process since all models now include the adjustable crank feature and all include the ability to use either 135, 130, or 110 mm BCD chain rings. The only thing the new user has to know when ordering his cranks is what type of bottom bracket axle they will attach to. Second, we are offering a model that answers one of the major objections that many elites have to the PowerCranks, the fact that they will take a hit in their mileage during the adaption process and they are afraid their "fitness" will suffer. This "problem" is answered by a new "click-crank" model (they will make a "clicking noise" that you can hear and feel when you "fail" to pedal circles) that work essentially like regular cranks with very subtle feedback when the technique is not "perfect." We don't think these will be quite as powerful training tool (it should take a little longer to achieve equivalent improvement) but everyone will be able to ride these the very first day as far as they can normally ride now and they are track legal. This manual is primarily devoted to the proper use of the standard PowerCranks. The "click-crank" model will be discussed in an addendum to this manual.

The philosophy of this manual

While many users see quick improvement in both cycling and running ability we see PowerCranks as being a long-term commitment to getting the best benefit of the cranks. For most users, the first year is just developing familiarity with the product and getting a good base in the new muscles you will be using (don't worry, you will see improvement in this year). The second year can be used to take the base you have established and convert this into a really improved racing capability. After this, improvements will come more slowly, as is seen with normal training. Our users include the entire spectrum of athletes and sports. This manual is primarily interested in helping the athlete to get through this initial transformation process and to understand the various ways different athletes with different needs might use the product differently to achieve their goals. Once you are through the transition period use your good judgment to move forward with your training. Most importantly, examine the requirements of your sport and your weaknesses and use the cranks to train those weaknesses into strengths.

How to Use Your PowerCranks™

How to Start Pedaling

This may seem like a silly topic heading directed to professional cyclists, triathletes, and others who are very experienced in riding a bicycle, but I have actually seen people, while they were looking at their feet, both at the bottom of the arc, laughing at how silly they feel and trying to figure out how to get clipped in or how to start, forget to pedal, coast to a stop and fall over. So, whether you are a professional cyclist or a cycling beginner, read on.

To ride a bike with PowerCranks™ requires the feet to be firmly attached to the pedals. If you are using PowerCranks on an exercycle indoors toe clips or cages will work fine. If using them outside on a bicycle clipless pedals are a necessity for both convenience and safety. Even though some brands are a little easier to use becauseit is easier to clip into them, almost any brand will work acceptably — it is just a matter of practice. If you are relatively inexperienced you should talk with your local bike shop about a brand that would be appropriate for the type of riding you will be doing.

The first thing you must do to start pedaling is to get your feet attached to the pedals. This is easy on an exercise bike as you can take as much time as necessary to get secured. On a bicycle this is a different story because you must do this while keeping moving or you will fall over. The first pedal is easy to get clipped into because the bicycle will be stopped and the other leg will be on the ground. The second, however, is not as easy as you are used to since the second crank will not be where you expect it when you go to get clipped in because the second pedal will be at the bottom of its arc and unsupported. If you have trouble getting in quickly after pushing off remember to pedal some with the other leg to keep the bike speed up so you won't coast to a stop and fall over while you are trying to get in (make sure the bike is in an "easy" gear). Also, don't run into anything while you are looking at your foot trying to get things together. **The easiest way to get started is to bring one**

leg up "backwards" to an approximate 2 o'clock power position then start pedaling with this one leg while in a small gear. This is to get some speed on the bike quickly so you can then keep it going on the backstroke. Once the second leg is clipped in, when that first leg is coming over the top start pedaling with the other leg. If you time it right your legs will be 180º apart. If you are not sure you understand this, I recommend that the first time you use your PowerCranks™ you should do so on a stand or have someone hold or be available to balance your bicycle until you understand how to get into the cleats and start pedaling. Many people worry about how will they know if the cranks are not at 180º. It is much simpler doing it than thinking about it. If the pedals are not right you <u>will</u> know it (your timing will be off and it will feel like you are galloping)! If they are right, the timing will feel 50-50 and they will "feel" right. If they don't feel quite right go back to riding with one leg, wait for what seems like a right moment as that leg comes over the top, and start pedaling with the other leg. While this sounds difficult it really is quite simple and natural, and will soon become easy and natural. The goal, most of the time (there are special drills and needs), is to ride these where they look just like regular cranks, 180º apart at normal cadences, for as long as you need to depending upon your sport. Almost everyone has this figured out within a minute or two. Soon, you won't have to think about this.

OK, so now you can pedal the bike. But, we expect, you will find them extremely difficult. All kinds of athletes with a wide variety of needs will be using these things. What should you do to get up to speed so you can start seeing improvement in your sport?

General adaption hints for all

The best use of PowerCranks will depend upon what you are trying to get out of them. Cyclists will use them differently than runners or football players. However, everyone tends to have similar difficulty in the beginning since almost everyone has the same set of undertrained muscles. This section is to help you get through this early adaption process.

1. Ride in a more open position, at a low cadence, and with shorter cranks.

Lifting your feet completely over top dead center requires you to lift each leg about 14 inches (normal crank lengths) and put it back down at the cadence rate you are pedaling. The longer your cranks (the higher you have to lift the foot), the higher the cadence (the faster you have to lift with a shorter rest period), and the more you bend over when riding (making you bring your knee closer to the chest) the harder this is. Few will have much endurance for this at first (the typical first ride only lasts 10-15 minutes - even with a lot of coasting), especially at any cadence above 70 or so. This is especially true in the "aerodynamic" position, where one has to bring the knee up closer to the chest without any help. Try this drill. Stand up straight and lift one foot 14 inches off the floor. Now repeat this with your upper body bent over, like riding a bicycle. Then try it repeating at different speeds. Notice, the more you are bent over and the faster you go the harder this becomes to get the foot the entire 14 inches off the floor. This is why the aero position and high cadences is so hard to do in the beginning with PowerCranks™ and going into the aero position (or, riding at too high a cadence) can actually rob you of power, even on regular cranks. Start training these new muscles using baby steps. Make it "easy" by keeping the cadence low, shorten the cranks some, if necessary, and open the hip angle. Don't worry, you will see rapid improvement and after a few weeks you will be ready to try to assume a more aerodynamic position (and higher cadence), and after several months you should be able to return to (or close to) your present position, if you so choose, if you practice and work on it. Hint: You may find it useful to raise your handlebars and slowly lower them as you adapt. **A highly aerodynamic position will not increase your speed if it robs you of more power than you gain in aerodynamic benefit.** If you lose too much power in the aero position with PowerCranks you will also (as soon as you start to get tired) be losing that power on your regular cranks (even though they will seem easy at first). Your fastest position will probably change as you develop your knee lift ability more fully. Don't worry too much about this in the beginning as your first job is to simply develop those new muscles to get a good base and good aerobic endurance. Whatever aero position you race in you need to train yourself to ride in that position on PowerCranks. If you do not, you will lose power when you go back to racing on regular cranks in that position. further, once you have a reasonable base and low cadence coordination, you should spend some time on most rides working on training the high cadence coordination and endurance.

2. Training your brain is as important as training your muscles (and much more difficult).

In both cycling and running, it doesn't matter if all of your muscles are fully trained if your brain does not have the proper unconscious pedaling or running coordination to use those muscles optimally without your needing to think about it, especially at the end of the race when you are tired. This brain retraining may take many

years to occur fully (think of a pianist) such that, until this time, at least for the cyclist, racing speeds on regular cranks may be substantially less than that seen during training on PowerCranks™, especially for the longer distances. It is one of the reasons we have come up with our limited motion cranks, they will work like regular cranks but give the rider PC feedback when the brain is incompletely trained. **As a result we suggest that you consider even racing on your PowerCranks until you are certain the brain is completely retrained - as long as there is an adequate base or race on our limited motion cranks.** In 2006 Courtney Ogden raced Ironman Canada on regular PowerCranks, after only 10 months of training on PowerCranks, and had the fastest bike split of the day and finished 2nd overall, this despite having a hip injury an only running 8 times in the prior 3 months in training. Racing on PowerCranks will keep your brain honest if the muscles have an adequate base for the distance you are going. If you insist on racing on regular cranks, suggestions on how to minimize this problem can be found below in the section entitled "Preparing to race on regular cranks." In running, it is important that the cranks be used to improve running form and efficiency beyond the training of the new muscles. To encourage this, every session on the PowerCranks™ should be followed by a short running session if possible. This run does not have to be long but is intended to incorporate the PowerCranks™ neuromuscular memory into the actual running form. Whether running or cycling, the more time you spend on your PowerCranks™, the faster and better you will develop your new muscles and the more you will be changing your unconscious brain coordination to better use those muscles in your sport. Time is the saddle is the key element to seeing the big improvements and improvements will continue for many months or years. PowerCranks are a long-term, hard-work, project to see maximum benefit.

3. Adapt your training based upon your strengths, weaknesses, and sport.

See below.

SUGGESTIONS FOR CYCLISTS

All cyclists should endeavor to get to the point that they could race on PowerCranks. Whether you actually race on PowerCranks or not (in track racing, for instance, they are illegal – although the limited motion cranks are not – but, in general, we think most people who could race on them would actually do better if they do race on PC's, but you can make your own decision). If you do not have the ability to do so then you also don't have the ability to race using regular cranks using the more efficient and powerful PowerCranks style. Depending upon your level and what kind of racing you do it may takes months or, even, a year or more to get to the ability to race aggressively on PC's, especially if we are talking longer races. The below suggestions are meant to help those with different race emphasis to start seeing benefit as quickly as possible.

Does your typical cycling race involve mostly aerobic efforts (road racing, triathlon)?

1. Work on Endurance First

Time-trialing and triathlon requires sustained good cycling form and sustained high power aerobic efforts while in a good aerodynamic position. To best prepare for this type of racing, new PowerCrankers should first work on their aerobic base. Therefore, the more time you spend riding with your PowerCranks™ the faster you will improve and the faster you will see performance improvement riding in the race environment. This is psychologically very difficult for the serious cyclist because most will see a reduction in weekly mileage for awhile and they will not be able to ride the PowerCranks™ at the cadences or speeds they are used to (that they have come to feel is important for racing) so they will be afraid of losing ground or afraid of not performing at their usual level. However, if you put a full effort into this transition, this period of reduced mileage and reduced performance will not last very long (and, the reduced performance will only be noticeable while riding the PowerCranks™) and most will start to see benefit in their racing in 4 to 6 weeks. It is rare that any new user reports a lessening of performance during this transition period so it seems efficiency improves faster than fitness is lost. New users have actually, during the racing season, started using PowerCranks™ about 6 weeks before a big race, used PowerCranks™ exclusively in the build up for the race and, despite somewhat reduced mileage, seen improved performance over what they would have otherwise expected before PowerCranks™. One pro triathlete actually raced a 1/2 Ironamn on the PowerCranks in 6 weeks. He did this by mistake as he had traveled to the race and didn't have everything he needed to switch back, but since it was a "training race" for him he decided to see what would happen. He amazed himself with the third fastest bike split and fastest run split of the day. New users who keep going back to regular cranks (or the lock-up feature) to keep the mileage up routinely see disappointing early results and any PowerCranks™ performance improvement is usually substantially delayed and reduced. PowerCranks™ makes no claim about cycling performance improvement if PowerCranks™ are not used exclusively in training.

Most users find that the key to quickly increasing distance and endurance is to pedal at low cadences (70-75) rather than high cadences and starting with 2 or 3 a day work outs. If all you can do is 5-15 minutes you will be surprised as to how quickly you will recover from those efforts and how many of those you can do in a day. Also, don't be afraid to take short little 5-10 second "coasting" breaks when riding. Most new users are up to 1 hour rides on them in about one week. A typical experienced cyclist new user can get to 100 mile PowerCranks™ endurance in less than one month, if needed.

2. Push Big Gears and work on climbing

It is easier to get your endurance up by riding at low cadence than at high cadence. And, working on big gears will allow you to keep your "pushing" fitness up. Most find it optimum to keep the cadence down to between 70 to 80 rpm's but I recommend that a lot of time in training be spent keeping the cadence below 65-70. This requires using very big gears (or climbing) for most but will really keep the pushing muscles tuned up and help you to find your "most optimum" cadence. Because of this, most find climbing "fun" as climbing keeps the natural cadence low (something your new muscles can sustain), The improved speed benefits of the PowerCranks™ is usually first seen climbing

3. Worry about cadence and aerodynamics last

Once you have developed the ability to ride reasonably long distances "easily" in big gears, then you can start working on increasing efficiency at higher cadences for the periods of time when acceleration becomes an important part of the race and working on pedaling in your aerodynamic race position. Once you have reasonable endurance put some efforts in low gears and high cadences into each ride. One way to do this would be to alternate between the biggest and smallest gear on your bike, working on your spinning in the smallest gear and keeping your quads in shape and power up in the big gear. The best part of this is as you develop your PC ability your "natural" cadence will increase but you will be in bigger gears, which means faster speed. Soon you will be back riding with your friends, using less energy than before when riding with them but being ready to use increased power reserves to match any break away efforts by others or for bridging efforts, when necessary.

4. Don't forget to work on pedaling out of the saddle

Learning how to pedal out of the saddle is important to becoming a complete "well-rounded" cyclist. a few are able to do this on the first day, most are able to do this by the third week. See "Learning how to pedal out of the saddle" below.

5. What to do as you learn to spin but feel like you are losing "quad strength"

Many former "masher" users report they feel like they lose some quad strength as they develop their PC abilities. This happens because it is necessary to back off on the quad push in the beginning because, otherwise, the cadence would come up faster than the rider can pull the foot up. Once one has developed the ability to unweight at high cadence for long periods one can go back to riding just like before. This loss is easily preventable if one is concerned about it. Simply increase the resistance on the bike such that increasing force does not bring the cadence up beyond what the lifting muscles can do. Then push away. This is "easiest" to do by riding hills and choosing appropriate gearing. Some try to do this by doing a proportion of their workouts on regular cranks. The problem with this is if one can't do this on PowerCranks then one really can't pedal in this fashion on regular cranks and the increased resistance has to be coming from increased back resistance on the upward moving pedal. This forces the rider to go back to the old style of pedaling and one is untraining the retraining of the brain. Where is the benefit in that?

6. Use your PowerCranks to optimize your positioning and fit on your bike.

Lifting your feet completely over top dead center requires you to lift each leg about 14 inches and put it back down at the cadence rate you are pedaling. The longer your cranks (the higher you have to lift the foot) and the higher the cadence (the faster you have to lift and the less "rest" your muscles get between efforts) the harder this is. Few will have much endurance for this at first, especially at any cadence above 70 or so. Many find this becomes "easier" if they make some adjustments in their bike fit, especially saddle height and stem height.This is especially true in the "aerodynamic" position, where one has to bring the knee up closer to the chest without any help. (see: general adaption hints for all.) So, even though your aerodynamics may improve in this position you might, actually, slow down if you lose too much power. Use what you can do with the PowerCranks to help you tune in your racing bicycle with regular cranks. **A highly aerodynamic position will not increase your speed if it robs you of more power than you gain in aerodynamic benefit.** If you lose too much power in the PowerCranks you will also be losing that power on your regular cranks (even though they will seem easy at first). Your fastest position will probably change (becoming more aerodynamic) as you develop your knee lift ability more

fully. Don't worry too much about this in the beginning as your first job is to simply develop those new muscles to start getting a good base and good aerobic endurance. But, once you have developed good power and endurance on the PowerCranks make sure your racing position is the same as how you ride your PowerCranks. If it is not you need to either keep adjusting your position on the PowerCranks to how you race or adjust your racing position to be the same as you can ride your PowerCranks, or some combination in between.

7. See "Preparing to race on regular cranks." below.

Does your typical cycling race involve short, anaerobic efforts such as track racing?

1. Work on a base endurance first

Depending on the event track cycling can mostly involve riding at very high cadences for relatively short periods of time. However, we recommend that track cyclists, even the most diehard sprinter, must first work on a minimum of base endurance before worrying about acceleration and high cadence work. This will help them to recover better between efforts when racing and training devoted to working on developing high cadence capability. Very high cadences are extremely difficult and the better endurance your muscles have the better you will be able to work on attaining and maintaining very high cadences. This means, to see maximum benefits, one should do all bicycle riding on PowerCranks™ until one has enough endurance to ride reasonable distances, pedaling constantly at reasonably high cadences and not having to think about the pedaling motion. This type of racing may not need 4 hour endurance, 30 minute endurance should feel "easy" before starting to work on increasing cadence.

2. Work on Cadence next

Once you have developed a minimal aerobic capacity, then you can start working on increasing efficiency at higher cadences for the periods of time becomes an highest cadence you can sustain for the period of your typical race effort.important part of the race. The best part of this is as you develop the ability to bring the cadence up you will be in bigger gears which means faster speed. But, also alternate time in a small gear so you are developing the high cadence coordination. Soon you will be back riding with your friends, using less energy than before when riding with them but being ready to use increased power reserves to match any break away efforts by others or for bridging efforts, when necessary.

3. What to do as you learn to spin but feel like you are losing "quad strength"

Many former "masher" users report they feel like they lose some quad strength as they develop their PC abilities. This happens because it is necessary to back off on the quad push in the beginning because, otherwise, the cadence would come up faster than the rider can pull the foot up. Once one has developed the ability to pull up at high cadence for long periods one can go back to riding just like before. This loss is easily preventable if one wants too. Simply increase the resistance on the bike such that increasing force does not bring the cadence up beyond what the lifting muscles can do. Then push away. This is "easiest" to do by riding hills. Some try to do this by doing a proportion of their workouts on regular cranks. The problem with this is if one can't do this on PowerCranks then one really can't pedal in this fashion on regular cranks and the increased resistance has to be coming from increased back resistance on the upward moving pedal. This forces the rider to go back to the old style of pedaling. Where is the benefit in that?

4. Use yourPowerCranks to optimize your positioning and fit on your regular bike.

Lifting your feet completely over top dead center requires you to lift each leg about 14 inches and put it back down at the cadence rate you are pedaling. The longer your cranks (the higher you have to lift the foot) and the higher the cadence (the faster you have to lift and the less "rest" your muscles get between efforts) the harder this is. Few will have much endurance for this at first, especially at any cadence above 70 or so. This is especially true in the "aerodynamic" position, where one has to bring the knee up closer to the chest without any help. (see: general adaption hints for all.) So, even though your aerodynamics may improve in this position you might, actually, slow down if you lose too much power. Use what you can do with the PowerCranks to help you tune in your racing bicycle with regular cranks. **A highly aerodynamic position will not increase your speed if it robs you of more power than you gain in aerodynamic benefit.** If you lose too much power in the PowerCranks you will also be losing that power on your regular cranks (even though they will seem easy at first). Your fastest position will probably change (becoming more aerodynamic) as you develop your knee lift ability more fully. Don't worry too much about this in the beginning as your first job is to simply develop those new muscles to get a good base and good aerobic endurance.

5. Consider training using the new limited motion "click-clack" cranks.

Adding our new click-cranks, which are track legal, during your track workouts will let you see how your form

deteriorates at very high track cadences and allow you to work on fixing same.

6. See "Preparing to race on regular cranks" below.

Are you a Mountain Biker?

1. Work on endurance first, stay on the road

It would be very difficult to take your PowerCranks™ into extreme off-road conditions safely without the dual mode lock-out capability (or if using the new click-cranks). In general, I recommend that mountain bikers do most of their PowerCranks™ training on a road bike (or their mountain bike on the road) while using regular cranks off-road. Don't really worry about going off road until PowerCranks™ riding is very comfortable on the road and some reasonable endurance has developed. It would be best if one could start PowerCranks™ training in the off season, so substantial PowerCranks™ endurance can be developed before one needs to start working on off-road technical skills training. During the season, one should try to ride on the PowerCranks™ immediately before off-road training rides and one should spend well over 50% of your riding time using PowerCranks™. Some mountain bikers have developed sufficient skill to do almost all of their training, including much off road training, on PowerCranks™.

2. Practice climbing both in and out of the saddle.

Learning how to pedal out of the saddle is important to becoming a complete "well-rounded" cyclist.

3. See "Preparing to race on regular cranks" below.

SUGGESTIONS FOR TRIATHLETES

1. Work on endurance first, spend more time on the bike, and cut back on your running

PowerCranks™ are the ideal training tool for the triathlete since the single activity of riding the bike equipped with PowerCranks will improve both running and cycling speed while reducing risk of injury. Therefore, I recommend, especially in the beginning, devoting much more time than usually allotted for cycling training (once you have worked through the very early adaption - you don't want an overuse injury). As with cyclists, the more time you spend riding with your PowerCranks™ the faster you will improve both your running and cycling. Read the specific recommendations for road cyclists. To see maximum benefits, one should do essentially all bicycle riding on your PowerCranks™ (train as if you intend to race on them even though you might not).

2. Think about both running and cycling when planning your training

We think the most time-trial type cycling benefits (the kind of racing most triathletes do) will come from learning to push big gears and keeping the cadence down whereas we think runners improve most working on low resistance, high cadence work, working on leg speed. Triathletes need to do both (see "Suggestions for runners" below). When you plan your training say this is going to be a cycling day or a running day on the bike (or plan some combination) but work on both skills, emphasizing your weaknesses. Read the section for runners.

2. Again, spend more time on the bike and watch your running improve

Even with almost no running activity, you will probably start to notice a sense of running smoother and easier after only a few weeks. Many have reported that they feel running improvement is the first noticeable improvement (most triathletes report running improvement starting within about 2 weeks). Part of each ride, after the basic adaption, should contain some low gear, high cadence work to help develop your running leg speed. Frequently after rides you should get off the bike and immediately go out for a short run to ingrain the PowerCranks™ cycling motion into your running form. Or, on days you actually run, do a short ride as a warm-up before every run workout.

3. Evaluate your strengths and weaknesses and divide your time appropriately

After you have developed endurance whereby you can ride all of your regular training rides "easily" with PowerCranks™ you will have to decide how to best divide your training time between the three sports as it should vary considerably between individuals, depending upon their specific strengths and weaknesses.

4. If you will race on regular cranks see "Preparing to race on regular cranks" below.

SUGGESTIONS FOR RUNNERS OR OTHER ATHLETES

Do you want to improve running speed and agility?

1. Ride with your hands on the handle bars with a high saddle

Except for road and track athletes, running in most sports involves short bursts and the need to acceler-

ate quickly. This is usually done in a "semi"crouched" position used in acceleration or cutting. Although it is not necessary to fully emulate your cycling friends in proper aerodynamic pedaling technique riding with your hands on lowest part of the handlbars, semicrouched over will be a good simulation of how one runns in most sports activity. The lower you are expected to "run" in your sport the lower you want to ride the PowerCranks. Even for long distance runners this is harder to do than being upright so it is an excellent training position for everyone as lowering the saddle and lowering the upper body will make the PowerCranks harder as you become adapted to them (training is supposed to be hard isn't it?). For those who want to simulate a more open running position of the distance runner one should move the saddle as far forward as possible and raise the handlebars as high and as far back as possible. Also raising the saddle is helpful. If you raise the saddle above a "normal" cycling position you can even simulate running ankle movements and running on the toes by making the foot go to about 30-45º at the bottom.

If one wants to truly simulate upright running one can "run" on the PowerCranks out of the saddle with the hands off the handlebars, although this requires another device sometimes used in rehab to unweight the athlete running on a treadmill. Without this unweighting it is impossible to control the pedal speed to something doable.

2. Cut back on your actual time running. Don't overtrain

There is no need to keep pounding your body with high mileage after you start training with PowerCranks™. Keep you total training time the same by cutting back on your running as much as you add PowerCranks training. This will substantially reduce your risk of injury. The optimum starting ratio is probably about 50/50. If you are injury prone you should run less and PC more.

3. Work on attaining base endurance first.

Depending upon the event you are training for, aerobic capacity will be more or less important than leg speed. A marathoner clearly needs more aerobic capacity than a sprinter or football player although improved aerobic capacity is even important in sprinters as it will allow improved recovery between efforts and more sustained PowerCranks™ training efforts. Substantial aerobic capacity starts to develop with only 20-30 minutes continuous exercise 3 days a week. This should be the minimum amount of time for every athlete then modify your workouts based upon your need for aerobic capacity (e.g., marathoners need substantially more aerobic capacity than sprinters or football players) before working on leg speed and coordination. If you are injured then you should greatly increase your time on the PowerCranks™ because of the reduced pounding your body takes compared to running on the road and the balance the PowerCranks™ will force .

4. Work on leg turnover rate next.

Work on developing the coordination to ride at the lowest resistance and highest cadence possible for slightly longer than your average race or effort then do active recovery and repeat. As you start to see the low resistance coordination improve you should start to see running improvement come. It would also be useful after each PowerCranks™ ride to go for a short run to help ingrain the motion into the running motion. Team sport athletes should try to reproduce the type of effort seen during the game on the bike such as short 5 - 10 second high speed efforts followed by 30-60 second active recovery, then repeat for 20 - 40 minutes. One more thing to note. Cyclists are frequently coasting when riding, giving their muscles a little break or rest. Runners do not have that option. But, runners do not have any resistance to foot movement, except when on the ground like cyclists. One must really work on the low resistance coordination at running turnover rate for the typical time one races. Some runners may also want to intersperse some high resistance - high cadence PC training to work on leg power. Adapt your workouts to your weaknesses and the demands of your sport.

4. Adjust crank length according to your needs.

The more force one lifts the knee when running the faster they will go but the harder it is to do. Sprinters need to accentuate this motion while, someone like a marathoner needs to deemphasize it if one is to achieve the endurance required of that event in a reasonable period of time. Here is where the real benefit of the adjustable crank length comes into play.

Do you need to improve core strength and balance?

Almost every athlete would benefit from improving core strength and balance. However, this is especially true for strength sports like wrestling, football, rugby and weight lifting and agility athletes like soccer, basketball, and other like sports.

1. Work on attaining base endurance first.

Substantial aerobic capacity starts to develop with only 20-30 minutes continuous exercise 3 days a week. This should be the minimum amount of time for every athlete and is enough to ensure good core balance.

2. Do the core strengthening drills.

Regular PowerCranking is great for improving hip flexor and hamstring aerobic capacity but does little to improve strength in these muscles because all one must do when riding with the cranks at 180º is unweight on the backstroke, lifting no more than the weight of the leg. If you want to strengthen these muscles (plus the abs) one must increase the resistance on the upstroke. Simply do one of two things. You can ride with your legs together (start with both feet up and keep them together) and clamp down on the resistance on the bike (ride bigger gears if on the road). Or, ride one leg at a time with high resistance on the bike.

SUGGESTIONS FOR THE INJURED OR REHAB FACILITY

For those with lower extremity problems.

1. Ride in a comfortable position

On many exercise bikes it is possible to put a chair behind the bike and use it as a recumbent if one cannot get on the regular bike. Or, of course, it is possible to mount the PowerCranks™ on many recumbent machines. The PowerCranks™ are actually easier to use in the recumbent position because the user does not have to lift the thigh as much against gravity in this position.

2. Don't aggravate your injury.

Check with your doctor or therapists to make sure your particular type of problem will not be aggravated by using PowerCranks™. In general, only those with unstable knees or those that try to do too much too fast will have problems with PowerCranks exercise. If you have limited range of motion in one of your hips or knees and you have PowerCranks adjustable cranks, shorten the crank length to accomodate this problem.

3. Do multiple short sessions with minimum resistance until improvement allows more.

The most important thing to do is to get the repetitions in on the injured extremity. Because there is "no cheating" with PowerCranks, the bad leg is forced to do its fair share. As the leg rehabs it will gradually become the equal of the good leg. When the two legs have equal ability in both strength and endurance you will know you are completely rehabilitated.

For those with other problems preventing athletic participation.

1. Ride the PowerCranks as hard as you can, replicating the kind of efforts your sport requires.

Doing this you will maintain full cardiovascular capability such that when your injury is healed, you will return to duty without losing a step.

Learning how to pedal out of the saddle

As you move forward on the bicycle to come out of the saddle the pedaling coordination changes substantially. Most users are ready to learn how to pedal out of the saddle with PowerCranks after about 3 weeks with them. Some do it the first day. Others are struggling to do it after months with them. If you are having trouble learning this skill, try these hints. A short video is available on the web site showing these hints also.

1. Practice one legged out of the saddle pedaling.

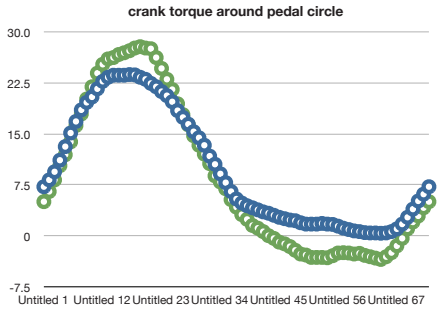
Doing one legged out of the saddle pedaling allows you to feel and understand the different coordination involved in this form of pedaling. The further forward you are the more you use the hamstrings to get the foot up against gravity. It is a much different feeling and coordination. If you understand this coordination difference then you can better concentrate on it when trying both legs together out of the saddle.

2. Keep the pedal speed low and under control.

It is easier to learn if the pedal speed is kept low and under control. At high cadences the different coordination can be quite difficult and pedaling out of the saddle takes a huge amount of energy since you should be applying your full weight to the pedals while, at the same time, pulling up, at least some, on the “recovery” pedal. On regular cranks one can control power out of the saddle by subtly adjusting the back pressure on the upward portion of the stroke but you cannot do that on PowerCranks™. The best way to control your power out of the saddle on PowerCranks™ is by varying the weight you put on the handle bars. Every pound you put on the handlebars takes a pound off the downward pedal and you will be able to eventually learn how to control your cadence and power to sustainable levels. Other methods to control cadence while learning this include riding uphill and using bigger gears. **The key to learning how to pedal out of the saddle is keeping the pedal speed under control while understanding the different coordination.**

Preparing to race on regular cranks

Many find they are faster on their PowerCranks™ in training than they are on regular cranks in races (in other words, they are disappointed with the results when they go back to regular cranks). Why? Well, two things tend to happen when one goes back to regular cranks. First, without the feedback as to what you are actually doing there is a natural tendency to revert to the most ingrained coordination, which is the coordination you are trying to undo. The figure shows actual pedal torque of a PowerCranks trained rider riding on PowerCranks and the same rider on regular cranks. This rider could easily ride his PowerCranks but not well trained on PowerCranks. Notice this rider, as soon as he got on regular cranks, started putting negative torque on the backstroke and had to compensate by increasing the pushing force. In addition, he made the other most common "mistake", he increased the cadence above what he was comfortable with with PowerCranks, increasing the cadence from 81 to 88. So, even though he was riding at a higher cadence (which should lower pedal forces and torque at the same power) he found himself pushing harder. If he hasn't been training himself to push harder he is likely to start to tire and fail if he tries to do this for a long period during a race. Further, it is hard to ride PowerCranks™ in the aero position but it is relatively "easy" to ride in this position using regular cranks and so one would, again, be forced to return to old patterns just to survive. If one wants to pedal in the PowerCranks™ fashion in the aero position for 5 or 6 hours during a race on regular cranks then one better be able to pedal in this fashion for this length of time on the PowerCranks™ in training. If you can't do it on the PowerCranks™ you can't do it on regular cranks. The second half of the race is just as important as the first half. Train for it.



The above is an actual pedal forque graph of a trained powerCranker comparing his pedal forces riding powerCranks and regular cranks at the same power (250 watts). Most interestingly this rider increased his cadence on the regular cranks from 81 to 88 RPM. One would normally expect increasing the cadence to reduce the pedal forces to achieve the same power. Yet, we see the forces are actually greater (the rider has to push harder). This shows the huge significance of those small negativ forces on the upstroke and why there is great benefit of eliminating them.

Even if one takes care to try to race on regular cranks within their PowerCranks™ capabilities, if the brain is incompletely trained then, when you start to tire during the race, it may return to more familiar patterns, even though the muscles are capable of doing more. It is for this reason that most will find themselves faster if they race on PowerCranks™ and some have started to do so. But, that is not what this section is about, you want to find out how to best prepare to race on regular cranks.

This problem is solved now that we have our limited motion click-cranks. They work just like regular cranks but give you the feedback when you have bad form. They could be used during the race in place of regular cranks (giving the cyclist feedback when they start to have bad form, something that is not possible on regular cranks) or used as a more specific race training tool for fine tuning the technique on regular cranks.The most important thing to racing on regular cranks with PowerCranks™ efficiency for an entire race is to have the basic endurance down for the type of racing you are doing and to ensure you pedal in the PC fashion during the race, even though you won't have the PC feedback. This will require having race endurance in all your muscles and a way of keeping your form honest! The best way to do this is to train as if you are going to race on Powercranks™. If you can race on PowerCranks™ then you should be able to race reasonably well on regular cranks in the PC fashion. If your typical race is a track race that lasts 2 minutes this is a very different story than an Ironman race where the bike may last 5 or 6 hours. Don't ever expect to be able to race for 6 hours at PowerCranks™ speeds or efficiency if one cannot get above 2-3 hours on the Powercranks™ in training. That is why the basic endurance is so important. Once the basic endurance is down one should then practice riding regular cranks in the PowerCranks™ fashion. The only way to be pretty sure that you will be able to ride in the PowerCranks™ fashion is to keep the cadence below what you can do for these distances on your PowerCranks™ and to ride in the same position you train on the PowerCranks™. Therefore, as an important race approaches I recommend that once a week or so you do a long training ride on regular cranks concentrating on pushing bigger gears and keeping the cadence at or below your PowerCranks™ cadence and concentrating on pedaling in the PowerCranks™ manner. Set your countdown timer to go off every 5 minutes during the ride to remind you to think about what you are doing, especially note that your cadence is within your capabilities. This will take some mental discipline to ride regular cranks as your PowerCranks™ but if you don't practice it you will not ride your true potential come race day. Someday your natural PowerCranks™ cadence will come up to a point where one will not have to work on this skill, but this may take a couple of years. If you have this ability mastered it is not necessary to ever go back to regular cranks until a day or two before your race.

How to train with the dual mode (lock-out) cranks

Many elites find the PowerCranks™ so difficult that they are unable to start PowerCranks and maintain the

training schedule dictated by their coach or the racing schedule dictated by the team. Therefore, many have requested cranks that easily lock-up into regular cranks mode so they can "ease" into PC training. The dual mode cranks satsify that request. Although we do not see any benefit to ever using regular cranks in training, if you have them, these are our recommendations to minimize any potential "training regression" from using the lock-out feature.

1. Use the feature only when absolutely necessary and as little as possible since most of the PC training improvement occurs when you are tired.

2. If you are on a long ride and have used the feature because your legs have "given out" we would suggest that after 10-30 minutes or so you go back to PowerCranks mode. You will be surprised how hast those muscles recover when you stop using them — and you will stop using them as soon as you go back to regular cranks. This will facilitate your transition as the more you ride PowerCranks the faster you will adapt and see improvement. Further, we would recommend that you be in PowerCranks mode for, at least, the last 10 minutes of every ride.

3. If you are going to be racing on regular cranks then we also recommend that as you get close to your ‘A’ race you train one day a week in the lock-out position, or on regular cranks, or on our new “click-cranks” limited motion cranks, as discussed above.

DRILLS and TESTS

The following drills and tests are designed to help you improve specific skills and or evaluate your progress. One should look at the kind of racing you do and your weaknesses and choose those that seem to best fit your needs. Any of these tests can be done on the road or on a trainer. If done on the road you need to keep in mind varying climatic (esp. wind) or road (esp. hills) conditions could affect results, interfering with an accurate evaluation of your progress.

Measuring PowerCranks™ adaptation tests.

Maximum cadence test - Put your bike in the lowest gear and see how high you can get your cadence before falling out of synch. This test should probably not last more than 15 seconds. If you do not have the ability to monitor cadence directly, monitor your top speed in your smallest gear. Increasing top speed (cadence) is the indicator of improvement. The well-adapted PowerCranker should be able to get to a cadence of 170-180 without failure, at least for brief periods. Sprinters should work on getting even higher.

Sustained maximum cadence - Put your bike in the lowest gear and see what is the highest cadence you can maintain for one minute before falling out of synch. If you fall out of synch before one minute is up, repeat at a lower cadence. If do not have the ability to monitor cadence directly, monitor your lowest speed in your smallest gear during this minute (highest sustained speed). The well-adapted PowerCranker should be able to get to maintain a cadence of 150-160 for this period of time without failure,

Sustained high cadence - Put your bike in the lowest gear and see what the highest cadence you can maintain for ten minutes is before falling out of synch. If you do not have the ability to monitor cadence directly, monitor your lowest speed in your smallest gear during this period. The well-adapted PowerCranker should be able to get to a cadence of 130-140 without failure,

Sustained endurance cadence test - Put your bike in the lowest gear and see what the highest cadence you can maintain for one hour is before falling out of synch. If you fall out of synch before one hour is up you should repeat the test on another day at a lower cadence. If you do not have the ability to monitor cadence directly, monitor your lowest speed in your smallest gear during this hour. The well-adapted PowerCranker should be able to get to a cadence of 110-120 without failure,

Improving pedaling smoothness drills.

Isolated leg drill - put it in an easy gear and while riding at a moderate speed start pedaling with one foot for 30 seconds. Try to maintain speed and concentrate on a smooth even pedaling stroke. After thirty seconds start pedaling with both feet, concentrating on smoothness. Then do this same drill with the opposite leg. Keep repeating for 10 repetitions on each leg. You can modify the times to 45/15 secs, 60/60 secs,, etc. for variety.

CompuTrainer smoothness drill. Put the CompuTrainer on SpinScan. The weakest part of most peoples stroke is the top. Concentrate on increasing the force at the top of the stroke and see if you can increase this force and watch your spinscan number increase.

Spinning hell - For those with adjustable cranks, increase the crank length as long as possible (don't forget to adjust your saddle) and then push the cadence. You won't believe how much difference even a few millimeters makes. This forces you to lift your legs higher, improving your lifting ability when you go back to your regular crank length and enhances your ability to pedal efficiently and to attain a good aero position.

Spinning made easy - For those with adjustable cranks, decrease crank length slightly (don't forget to adjust your saddle)You should be able to increase your cadence well above your normal top, working on fast twitch fibers and high speed coordination.

Bounce test - Put your bike in the lowest gear and see how high you can get your cadence without "bouncing" in the saddle. This really works on improving the transition between "pushing" and "pulling" at the top and bottom of the stroke which is what "spinning" is all about. It is a great test for runners also. Increasing top speed (cadence) without bouncing is the indicator of improved smoothness.

Optimum cadence and gearing testing

These tests are probably best performed on a calibrated ergometer, such as CompuTrainer™ or using a new power measurement device, in which conditions can be controlled (don't forget to calibrate the CompuTrainer™ before each session) but can be done on the road or using uncalibrated training stands if one accounts for variations between or during sessions due to weather or possible calibration variables.

Optimum Cadence Test #1 - Put your bike on the largest front chain ring and then vary the rear cog in a series of tests. Ride a similar flat course (about 1 km to 2 mile) at a constant heart rate near your race heart rate.

See which gear gives you the highest average speed. Note your cadence at this speed. This should be close to your optimum cadence for sustained speed at that level of effort. For most people optimum cadence increases with power. A mistake many make is coping the cadence of professional cyclists, who may be putting out 350 watts, when they can only put out 180.

Optimum Cadence Test #2 - Put your bike on the largest front chain ring and then vary the rear cog in a series of tests. Ride a similar flat course (about 1 km to 2 mile) at a constant speed near your race speed. See which gear gives you the lowest heart rate. Note your cadence at this speed. This should be close to your optimum cadence for sustained speed at that level of effort. For most people optimum cadence increases with power. A mistake many make is coping the cadence of professional cyclists, who may be putting out 350 watts, when they can only put out 180.

Optimum Gearing Test #1 - Put your bike on the largest front chain ring and then vary the rear cog in a series of tests. Ride a similar flat course (about 1 km to 2 mile) near your optimum sustained racing heart rate. See which gear gives you the highest average speed. Note your gearing at this speed. This should be close to your optimum gearing for sustained speed at that level of effort.

Optimum Gearing Test #2 - Put your bike on the largest front chain ring and then vary the rear cog in a series of tests. Ride a similar flat course (about 1 km to 2 mile) at a constant speed just under your racing speed. See which gear gives you the lowest heart rate. Note your gearing and cadence at this speed. This should be close to your optimum gearing for sustained speed at that level of effort.

Leg control and coordination drills for field athletes (and how to impress your friends)

These drills are useful to help you gain improved leg muscle control and to help prevent boredom on long winter nights. These are probably most useful for field athletes looking for improved coordination and leg control. Don't worry, these can and have been done (except Look ma, no brains).

The FROMC - pedal both legs together dolphin style. This is a full range of motion cruch (hence the name). If you have a computrainer try to maximize your spin scan number while doing this drill. Increasing the resistance really makes this hard.

Front and Back - Pedal forwards with one leg and backwards with the other. Switch.

Two for one - Pedal forwards with one leg and forward with the other leg at half the cadence. Switch.

Two forward, one back - Pedal forwards with one leg and backward with the other, at half the cadence. Switch.

Look ma, no hands - (This is a training stand only drill) Pedal out of the saddle with your hands off of the handlebars. You will be "running" on your PowerCranks™. This is really tough, unless the body weight can be partially supported. I don't believe this has ever been done unsupported but it should be theoretically possible.

Look ma, no brains - Perform "Look ma, no hands" on the road. (just kidding)

Drills for runners

Put the seat of the bicycle very high such that your foot has to be angled down like you are pushing off at the bottom of the stroke. Then ride the bike and concentrate on getting the toes up on the recovery. This is called ankling. Try to ride at the highest cadence possible in this fashion.

Installation and Removal of your PowerCranks

PowerCranks have come in many different iterations through the years. As many of you will be trying to replace lost instruction manuals and downloading over the web this manual will attempt to describe all the verious iterations, whether your cranks are brand new or 10 years old. Understand that each crank consists of three parts. What we call a spindle adapter (the part that actually attaches to your bottom bracket upon which the clutch rides), the crank arm (that contains the clutch) and and "end cap" (which holds the other two parts together. Over time different methods of manufacturing and interfacing these components have been tried in order to reduce customer misunderstanding and improve reliability. Be assured that whatever system you have, when installed correctly the function of the PowerCranks is identical. Understanding these differences greatly facilitates installation and removal. This section will help you understand the installation and removal of these various iterations, whichever one you have, from the first edition to the latest.

How to identify your particular cranks configuration .

Model 1 cranks have end caps (the outside part that holds everything together.) that are solid, with no hole to give access to the crank bolt. All spindle adapters are right threaded in this configuration and accept standard crank removal tools.

Model 2, 3, and some model 4 cranks have end caps with holes in them which allow access to the crank bolt. In most of these model crank sets (but not all) the drive side spindle adapters are left threaded so the standard crank removal tool will not work on this side. (this was done to help reduce risk of vibratory loss of the end cap during rides which worked but really confused people, so we stopped) When the spindle adapter is left threaded, a standard crank removal tool cannot be used to remove the crank but, because of the hole, the end cap will also double as a self extraction tool. Others, have right threaded drive side spindle adapters which will allow the use of a standard crank removal tool or using the end cap as a self extraction device, ehichever you prefer. Pay attention to how yours is threaded when you take the end cap off the first time for the first installation. If you try to turn it the wrong way when you come to take them off it will not come off. This results in many emergency calls and emails with the question of "how do I get my cranks (or end cap) off". It is the reason all the later models use standard right threading.

Some Model 4 cranks have a combination crankbolt-end cap that are tightened using an 8 mm hex wrench. Both spindle adapters on these are right threaded and will accept a standard crank removal tool. Later M4's have an end cap with an o-ring that is designed to interface with the spindle adapter to help prevent vibratory loss.

Model 5 cranks have end caps with holes in them similar to most model 2, 3, and 4 cranks. The major change in the Model 5 cranks is they contain a larger, stronger clutch than the earlier models.

Model 6 cranks are similar to model 5 cranks except all the basic cranks have the adjustable crank length feature. With the model 6 cranks the limited motion crank is also introduced.

Installation

Note: If you are installing our dual mode (lock-up) cranks on an ISIS BB or Lemond Revmaster be sure to install in the lock-up position as they are shipped to ensure they can be fixed at 180º. This isn't a problem if you have Shimano octalink or tapered square adapters as our current lock up models generally have 4 or 8 different positions such that however they are installed they will be able to be locked at 180º. If you are having trouble getting your cranks to lock-out at 180º you probably have an ISIS type and need to remove and reposition one of the spindle adapters. Older lock-up versions (friction lock-up) must be installed with the lock-up pins retracted.

1. If you are a man (women rarely need this advice) change into old clothes and clean your chain and chain rings! If you do not you may find yourself in trouble with your, wife, girlfriend, or mother. If you ladies forget this step, I expect, it is unlikely that your husband, boyfriend, or father will notice. You may also want to wear something like latex gloves while doing this work. An alternative clean approach is to let your local bike shop (where they are paid to get dirty) do this.

2. Remove your present cranks from your bicycle and remove the chain rings from your bicycle cranks (unless you have separate chain rings for your PC's). Some types of crank axles (spindles) require changing the bottom bracket type to be compatible with PowerCranks™ (all current 10 speed, outboard bearning systems are an example because there is no separate bottom bracket axle for the PC's to mount to when the cranks are removed). Some tapered square adapters will be slightly larger or smaller than our adapter such that you may need to change your BB to one that fits better as a small difference when dealing with a 2º taper moves

the cranks in or out quite a bit. If you have an incompatible type of bottom bracket axle you will need to replace your bottom bracket. If your taper is too small and our adapter hits your frame, this can be fixed by adding shims rather than changing the BB entirely. If you ordered the wrong adapter type for your bottom bracket type you can return the cranks for a replacement (we will only make you pay shipping costs) or you will need to replace the bottom bracket assembly to the type you ordered. If you need to replace your bottom bracket assembly, a cheap one will do and the size will need to be determined by your bicycles physical dimensions but a good starting size is 109-112 mm, unless you have a triple chain ring option where you may need an even longer spindle. Too wide and you may not be able to shift the chain onto the large chain ring, too narrow and the cranks will rub against the frame or hit the bike chain stay. If you have problem with this ask your local bike shop for advice.

3. Reattach your chain rings to the PowerCranks spider. The model 6 spider accomodates all common chain ring patterns from Camagnolo 135 mm BCD pattern, the common 130 mm BCD 5 hole pattern, and the 110 mm BCD (compact) pattern. If you have something else you will need to purchase new chain rings. If you need to purchase new chain rings, I recommend that you increase the size of your large chain ring at least 3 or 5 more teeth than your present chain ring, as you will probably soon want and need it (this is mostly necessary to prevent spinning out too soon on long straight downhill stretches as the ability to ride at high cadences will come slowly). You can even go much larger. Your author is currently riding a 73/38 tooth combination to good effect. Note: if you have compact chain rings (110 BCD bolt pattern) and your small chain ring is less than 38 teeth you will need to use the chain ring spacers to ensure proper shifting. Do not use these spacers if your chain ring has 38 or more teeth. If you have compact chain rings and the triple chain ring spider and your middle chain ring is less than 38 teeth you will need to use the spacers to move both chain rings to ensure proper shifting. Occasionally, if your chain ring is configured differently than most you may need to additional shims to make everything work well. If you are having problems with shifting after installing the cranks we suggest you consult your local bike shop as they usually have shims available to easily fix such problem. Another issue that can occur with chain rings has to do with variations that can lead to incompatibility or “wobbling” when installed. An example is shown in which a chain ring has some indentations to fit the manufacturers cranks (and no others) compared to a normal “flat” chain ring.

4. Put the PowerCranks™ on the bike being careful to line up the keyways if you have ISIS or Shimano V1Ultegra/DA octalink type bottom bracket spindles. If the assembly rubs up against the bottom bracket housing you should replace your bottom bracket assembly with a longer spindle size. As an alternative, in tapered square spindles, shims (a cut up soda can usually will work well for this purpose) can be used to “thicken” the BB spindle and move the PowerCranks™ away from the frame.

5. Place your chain on the chain ring. This step is necessary now to help you support the spindle in order to properly tighten the spindle bolt on the drive side crank in the next step.

6a. If you have an end cap that is separate from the crank bolt (currently everyone unless you ordered the Revmaster kit), the first thing you should do is check to see if your crank bolt is compatible with our end cap. Some crank bolts have heads that are too large to fit into our end cap which would prevent the end cap from being tightened down completely and make sure the plastic cover on some bolts is removed. Take the crank bolt that you removed from your crank and see if it fits into the depression meant to accomodate it. The pictures show a proper bolt fit. If it does not go in you will need to get another crank bolt that does fit. Thread the crank bolt and tighten very tightly. (Note: occasionally, with the tapered square adapter, the wedging can change the dimensions of the clutch race, causing the clutch to bind and not freewheel backwards. If this happens, remove the crank and reapply using slightly less force). Thread the end cap and tighten snugly using the supplied washer or a coin to tighten (note: on some older models the drive side end cap is left threaded). The O-ring is designed to make it reasonably hard to tighten and remove this part. If it is very hard to move it is designed such that a 10mm allen wrench can also be used for this purpose but it is important to not over tighten as it is possible to strip the threads (see picture) on this part if one uses a huge wrench like this. The part should not require more than 25 in-lbs torgue to get the o-ring over the “hump” and the part has been tested to accept a torque as high as 200 in-lbs without damaging the threads. If it is difficult it can be made easier by putting a little oil on the o-ring. Tighten until it hits the stop then, if the crank does not spin freely backwards when tight,

backoff 1/8 turn. Check regularly (especially at first) to ensure it is staying tight. If you lose the end cap during a ride (a problem in the past) your cranks will be unusable until you get another. A nice feature of this end cap is one can check the tightness of the crank bolt by placing an 8 mm hex wrench through the hole in the end cap (except model 1 end caps) and the end cap can act as a self extraction tool

6b. If you have a combination end cap crank bolt (curently these only ship with our Revmaster adaption kits), install the combination crank bolt and end cap using an 8 mm allen wrench and tighten tightly. Most bike mechanics use grease on this bolt but we do not recommend using grease on the bolt and, instead, recommend putting some thread locker on the bolts because, while unlikely to vibrate off during use, any bolt can loosen with use and if the PowerCranks spindle bolt comes off it makes the PowerCranks unusable until replaced. While this occurs infrequently, it is such a big problem when it does occur I recommend that mild thread locker be used when attaching this bolt. Check regularly (especially at first) to ensure it is staying tight. If you loose this bolt your cranks will be unusable until you get another.

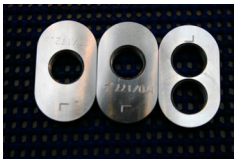
7. Reattach your pedals. Caution, if you are not careful about how you screw in your pedals the steel threads of the pedal can damage the threads of the aluminum crank arm, eventually making your cranks unusable. Make sure these are tight and do not come loose during use as this, also, can ruin your cranks if these threads become stripped.

8. Before riding the first time review this instruction booklet for hints and cautions.

Fixed/Changeable Crank instructions

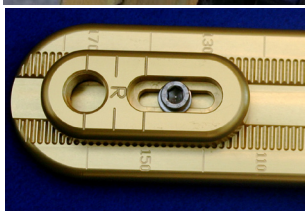
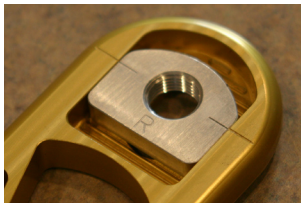
In general, model 5 “fixed length” cranks could actually be changed. The cranks have an insert that sets the proper crank length. There are three pedal holder inserts available. Each insert will allow for two or four different lengths, depending upon how it is inserted in the retaining slot. Available are inserts for 172.5/175, 170/177.5, 165/167.5/180/182.5. Your cranks will ship with the proper insert for the crank length you requested. You may purchase additional inserts should you need them. There will also be a steel washer that must be used to prevent the pedal from damaging the aluminum when it is tightened down. Make sure the left adapter goes into the slot on the left crank and the right in the right slot as left pedals are left threaded and right pedals are right threaded. There are three marks on the outside of the crank, at 170, 175, and 180 mm to help you know you installed the pedal holder properly. To change the crank length requires completley removing the pedal, removing the insert and reorienting it or replacing it with another oriented properly.to the length you want.





Adjustable Crank Instructions

All adjustable length cranks can be adjusted in 2.5 mm increments. The method of adjustment is easy, simply loosed the locking bolt a few turns (this locking bolt is the pedal itself on all the cranks except the basic long-adjustable cranks and move the pedal holder to the new length, then retighten. The X-lite “racing” edition of the adjustable cranks is marked at 172.5 mm on the inside (see figure) and there are scribes on the outside at 170, 175, and 180 mm lengths. Each movement increment is 2.5 mm. They can be adjusted from 165 to 180 mm in model 4 cranks and 167.5 to 182.5 in Model 5 and 6 cranks. All of these comes with a steel washer that must be used between the pedal and the crank to prevent damage from occuring to the aluminum slot when the pedal is tightened down. If the two parts are not snugged together then movement can occur which will eventually damage the locking interface if ridden in this condition. Earlier long-adjustable cranks were not marked but the length can be known by counting increments from the end. The illustration shows the adjustment for 175mm in this earlier model. Regarding the current model of the basic long-adjustable cranks it can be adjusted from 85 to 220 mm and are scribed in 10 mm increments so the length should be easy to determine by lining up the scribe next to the pedal hole with the scribes on the crank arms (the extra scribe marks on the pedal holder are to help you determine the crank length when the hole is past any of the crank length markings. These are 10 and 20 mm from the pedal hole. The extreme lengths require moving the bolt and the short lengths require turning the pedal holder 180º. Each movement increment is 2.5 mm.

Lock-up Crank Instructions

Early lock-up cranks are "locked-up" by tightening one or all of the three set screws around the hub using a 3 mm allen wrench. It is recommended that they all be tightened equally and very snugly to prevent slippage occuring at light pressure. The lock-up position is infinitely adjustable so it is simply a matter of lining them up at 180º and tighening the screws. To go back to independent cranks just loosen the screws. They should be backed out until they stop so they do not vibrate tight and inadvertently interfere with the independent operation.

Second generation lock-up (dual mode) cranks have a moveable collar that when lined up properly can be pushed in to lock or pulled out to unlock. While much more secure than the early friction lock-up mechanism, one should not assume that these are as strong as regular cranks and start doing bunny hops, etc. The first model of this variety could only be locked up at 180° separation. Later models can also be locked up at configurations other than 180º for special needs or drills.

To lock the cranks up the collar must be lined up with the associated detents on the locking flang or spider and then pushed all the way in until you hear or feel it "click" into position. When you desire to return to Power-Cranks mode simply grab the locking collar on both sides and pull evenly all the way out until, again, you feel or hear a "click". (It might be very snug and require a pretty good force, depending upon how much back pressure you put on them when riding. In this instance "whack" the crank arm with your hand, to get it to vibrate, which will reposition the clutch slightly, making it easier to pull the collar out. A video of this may be found on the CD that came with your cranks or at our web page.)

If not used regularly they can become “tight” to move. They may arrive in this condition. This can usually be fixed by ensuring there is some oil between the surfaces and moving back and forth several times to loosen things up.

Removal

In general, PowerCranks™ are removed just like regular cranks, using a normal crank removal tool or using the self extraction end cap, if present. If your cranks have a left threaded drive side spindle adapter, where a standard right threaded crank removal tool will not work, you must use the end cap as a self extraction device. To use the end cap as a self-extraction device, put an 8 mm hex wrench through the end cap hole and back off the crank bolt to cause the crank bolt to push against the end cap and push the crank off the spindle. You can then remove the end cap to gain access to the crank bolt to use in attaching your regular cranks. Occasionally the end cap will be very difficult or "impossible" to remove. The most likely reason for this is yours is left threaded and you are turning the wrong way but sometimes these become "wedged" in place and be very difficult to remove even if you are turning the correct way. In the past the only way to get it off was to use something to impact the end cap and get it started, when it will then come off normally, once started. Our current generation of end caps will accept a 10 mm allen wrench so it is easy for you to get the necessary force to get this started. Do not use this wrench to tighten the end cap. One more reason the end cap can seem stuck is a thread locker was put on the threads. In this instance you may need to use heat the cap to weaken the thread locker to get it off. Be careful not to burn yourself.

See Storage below for long-term storage instructions.

Maintenance

Your PowerCranks™ are almost maintenance free. They do have two enemies however, water and dirt in the clutch. Water will not damage the clutch or interfere in its operation per se as these have been used in very rainy climates for extended periods and carried exposed on the back of cars through all sorts of awful weather then used without anything special being done. Water is only bad because it can cause rust and will only be a problem if the cranks will not be used for a prolonged period of time. Water, if it is left in the mechanism can rust the hardened steel clutch components. To minimize this possibility, the clutches should be kept well oiled (grease is not recommended because too much grease can interfere with the proper functioning of the clutch — if greasing use very judiciously). Also, dirt or grit could theoretically damage the clutch directly although after 8 years I am not aware of a single failure coming directly from riding in dirty conditions. So, even though it seems not a big risk, if ridden in very severe rainy weather or dust storms or through lakes or steams or left in the rain, disassemble the crank arm from the spindle adapter, clean and dry the clutch and bearing surface using a hair dryer then re-oil. Only in the instance of known contamination should it be necessary to remove the crank arm from the spindle adapter for cleaning the clutch. Otherwise, you should keep the clutches lightly oiled, the main purpose

being to prevent oxidation (rusting) of the clutches, and the surfaces that lead to the clutch lightly greased (to help keep out water and dust). DO NOT USE WATER BASED OR PARAFFIN CONTAINING CHAIN LUBRICANTS, SUCH AS WHITE LIGHTING, AS THE PARTICLES IN THESE LUBRICANTS CAN DAMAGE THE CLUTCH.

If you have the Dual mode cranks, you may need to occasionally to clean and re-oil or regrease the locking collar if it begins to bind and not slide easily. If the O-ring that keeps the collar from moving on its own should break it can be replaced with another that you can obtain locally or from PowerCranks if necessary. If you need to replace the O-ring what we use is a 1.75" x 1/16 but anything close to that should work. Make sure it is in the groove evenly or it will bind the collar.

Annually.

Simply remove the crank arm from the spindle adapter. While oil or grease is not really necessary for proper clutch function (after all, when pedaling correctly there is no motion between the parts) it is necessary to repel water and prevent rust. Therefore, ensure there is an adequate amount of bicycle oil in the clutch and make sure there is oil or grease in the gaps leading to the clutch to help repel water. Do not pack the clutch with grease as this can prevent proper functioning. DO NOT USE WATER BASED OR PARAFFIN CONTAINING CHAIN LUBRICANTS, SUCH AS WHITE LIGHTING, AS THE PARTICLES IN THESE LUBRICANTS WILL INTERFERE WITH PROPER CLUTCH FUNCTION AND COULD DAMAGE THE CLUTCH.

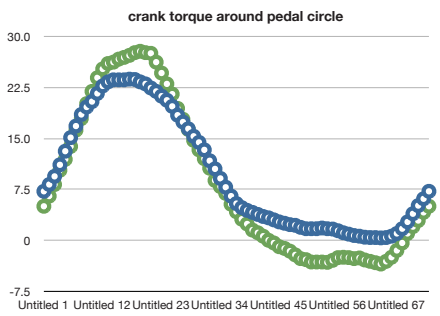
Storage

PowerCranks™ need to be stored in a manner that will prevent rust from forming in any of the steel clutch components.

Frequently asked questions, FAQ's

Why does PowerCranks recommend cyclists do all of their training on PowerCranks?

For the cyclist, retraining the brain is just as important as training the muscles. It does no good to train muscles if the brain is not going to use them. Retraining the brain is necessary since it is rare that anyone acutally thinks about pedaling when riding, especially during a race, so, you will only pedal in the manner that is most natural or ingrained, especially when tired. The figure shows what happens to the pedaling dynamics between riding regular cranks and PowerCranks of a person who pedaled part time on the PowerCranks but thought he was reasonably well trained on the PowerCranks. He immediately goes back to a less effective pedaling technique. Retraining cannot occur effectively if regular cranks are frequently used because regular cranks give you (and your brain) absolutely no feedback when you start pedaling in the old fashion, confusing the brain as to what is acceptable technique and what is not. So, even though you may develop substantial muscluar aerobic capacity riding your PC's 50% of the time, that would allow you to pedal properly for longer periods of time, you probably won't be able to do so on regular cranks because you won't pedal in that fashion unless you are thinking about it (especially when you are tired), and no one really thinks about pedaling while riding. So, while training on PowerCranks does result in substantial improvements for many, we feel, if one is going to be racing on regular cranks, the maximum benefit will not occur until the brain becomes as well trained as the muscles.



How long does it really take to get my mileage back up? I don't want to lose any fitness!

There is a huge variation on how fast people adapt. If your hip flexors are above average (XC skiers, professional cyclists who have done hours of one legged drills?) your muscle adaptation will go very quickly and you will be back to your current time and mileage in 2 - 4 weeks. If you are more typical and you put a good effort into adapting you will be back to your normal times and distances in 6 - 8 weeks. Some will take a little longer. If you are impatient, and keep going back to regular cranks to keep your time and distance up then you may never fully adapt to Powercranks™ (see above). The longer it takes you to adapt suggests you will see more improvement than those who adapt quickly so don't be afraid to stay with it.

I am a runner, how much should I cut back on my running?

This is not clear at this time. It may depend upon the distance and what your event is. Runners must continue to run to maintain form and keep the body used to actual running. Sprinters must, of course, continue to practice starts and work on form. At the present time it would appear that a good starting poing would be the runner cut their current base mileage about in half and substitute PC's for the remaining time, sprinters concentrating on leg speed and endurance runners concentrating on endurance.

How long does it take to really see improvement?

Depends upon what you are looking for. You will see improvement in your ability to use PowerCranks™ every day in the beginning. If you are a runner you will probably start to see running improvement in about 2 weeks. For cyclists, even though you may train properly, using only your PowerCranks™, do not expect any substantial overall power improvement for about 6 weeks, and then only for shorter distances. This has to do with the time it takes to develop some aerobic capacity (training effect) in the new muscles you will be using. While some efficiency improvements will be seen at lower power outputs on short rides very early, the user must expect this process to take some time. "Improvement" may come slower to those who continue to race on regular cranks, because of the difficulty in changing the way the brain unconsciously thinks about pedaling. Therefore, if your endurance and skill will allow you, I recommend doing all of your riding, including races in the beginning, on your PowerCranks™. Of course, improvement will continue to occur for many years just as it would for someone new to cycling or running, training in conventional fashion.

I find it almost impossible to get my feet consistently over the top. HELP!

At first, most users will find it very difficult to consistently raise the legs over top dead center of the pedaling arc. But, within a couple of weeks almost everyone should be able to pedal properly without too much problem for reasonable periods of time. If you are still struggling I suspect one of four main culprits contribute to this. 1. Your handlebars may be too low. 2. Your seat may be too low. 3. You may be trying to assume too much of an

aero position. 4. Your crank length is way too long for your leg length.

The common element in all of these problems is the need to bring the knee too close to the chest, a very difficult thing to do 80 - 90 - 100 times a minute without any help from the other leg. Almost everyone has to start riding in an upright “touring” position, which opens the hip angle, making it easier to lift the leg the 13 - 14 inches necessary to get the leg over the top. If you have adjustable length cranks, shorten the crank length. After several months you should be able to return close to your present position and crank length, if you so choose. The lower you are trying to go and the longer crank length you are riding the longer it will take you to fully adaapt. Trying to improve body position aerodynamics too much can actually slow you down if it causes a bigger drop in power than you gain in reduced drag.

I can’t learn to pedal out of the saddle

As stated earlier, pedaling out of the saddle seems to be the most difficult skill to learn for most users. This probably has to do with the fact that we don’t spend as much time out of the saddle and the pedaling motion is much different. Read the section in the manual for suggestions as to how to do this. A Quicktime video demonstrating how to learn this skill is available at the web page, www.powercranks.com.

How do I identify which model PowerCranks™ I own?

Model 1 cranks have solid end caps, aluminum spindle adapters with steel races for the clutches and the cranks are smaller. All the end caps are right threaded

Model 2 cranks have donut shaped end caps with left threaded end caps on the drive side. The cranks are more massive with squared ends. The spindle adapter is made of aluminum with a steel race for the clutch.

Model 3 cranks are similar to Model 2 cranks except they have solid steel spindle adapters and the spider is threaded onto the drive side spindle adapter.

Model 4 cranks have a different shape crank arm, being more massive still with a rounded end, except for the XLite model which was not available before.They have had a variety of connection types from the combo bolt to donut style end cap.

Model 5 cranks look similar to Model 4 but are slightly larger to accomodate the larger clutch.

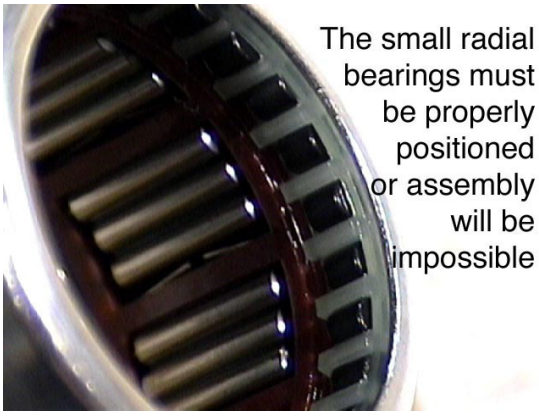
Model 6 cranks are similar to Model 5 but all models are adjustable. We also started using the “one spider fits all chain rings” (at least the usual ones) in this model

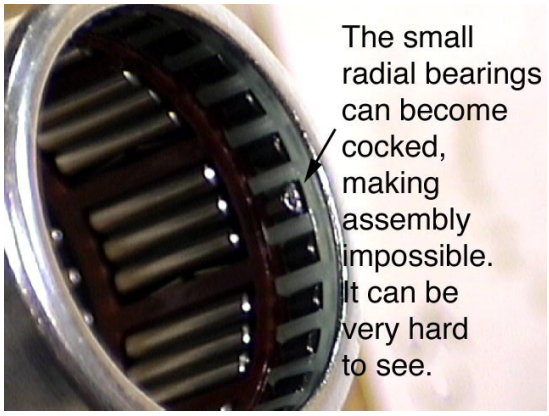
One or both cranks do not free wheel backwards. Is there something I can do.

If you have a tapered square adapter you could have tightened down the crank bolt so tight that it is changing the dimension of the clutch race, causing binding (the tolerances here are pretty tight). In this instance, remove the cranks and reinstall, not tightening the bolt quite so hard. It is possible that the clutch has migrated in its housing, causing binding between the end cap and the clutch. If this is the case you will need find a press to push it back in (it will take about 2,500 lbs to do so) or send it back to us to do so for you (the charge is minimal for this). You could try adding a little grease or oil to see if this solves the problem. A little bit of binding won't affect what they do for you unless it is strong enough to actually push your foot up. It is also possible you may have a foreign substance binding the cranks. Remove and clean to see if this fixes the problem.

I took my cranks apart and cannot get them back together. Help!

Answer: One or more of the very small outer bearings have probably become cocked. Inspect carefully (as this is difficult to see, the figure shows an example) and push back in place any offending bearings. The parts should go together easily. If they don't there probably is a problem with these bearings.





My cranks have some lateral motion in them. Is this normal?

Answer: Yes. As long as it is less than about 1 mm. If it is more than 1 mm then you probably have some interference between the crank bolt and the end cap preventing the end cap from going down as far as it is supposed to. The most common reason for this is the user forgets to remove the plastic or rubber cover that is on the crank bolt (see the instructions). Or, the crank bolt head is too wide (see instructions). In this instance you will have to replace the crank bolt.

My locking cranks keep unlocking while I am riding. Why?

Answer: This usually occurs when there is too much lateral motion in the crank arm allowed which will allow the locking ring to walk off to the unlocked position as you ride. There must be a very minimal amount of lateral motion in the lock-up cranks. See the above question to diagnose this problem.

How do I remove them from my bicycle?

Answer: The cranks are self extracting. If you have taken off the end cap and removed the crank bolt and are looking at a hollow tube and can't figure out how to use your crank removal tool then, STOP. Put the crank bolt back in, put the end cap back on then put your allen wrench through the end cap hole, back off on the bolt and it will push the cranks off the bicycle as it comes out. If you are having trouble getting counter torque on the left crank you need to have the right crank on the bike with the chain ring and chain attached to the wheel. You can then use the wheel to provide counter torque.

Why don't you make cranks that work with the new integrated crank systems?

Answer: Well, we do. It is just that we cannot make them to work with the outboard bearing systems without affecting the Q factor because what limits us is the width of the clutches we use. So, simply pop in an "old-style" BB, attach our cranks to it, and all the new stuff works just fine with them.

PowerCranks™ Science

The athletic training problem.

Athletes rely on brain, nerves, and muscles to perform specific actions for varying periods of time. In order to optimize performance the athlete must do several things in training. 1. The athlete must learn optimum technique. 2. The athlete must train the muscles necessary for the sport to the right balance of strength and endurance. 3. The athlete must avoid injury. Optimum performance in any sport requires all the parts of the athletic training problem to be optimized at once. Doing all this at once is not so easy. PowerCranks can help the athlete achieve this goal.

Athletic training involves much more than just making muscles big and strong as each sport has specific skills and technique that must be optimized to reach elite levels. If your sport involves running or cycling PowerCranks help teach proper running and cycling technique (yes, they are related) and, if incorporated properly can help train all the muscles optimally, whether training for strength or endurance or both. So much for numbers 1 and 2 above. How about injury prevention? There are 2 major areas where elite athletes tend to get injured. 1. discoordinate movements from muscle imbalance and poor coordination (these tend to be major muscle pulls or knee injuries) and 2. overuse/stess injuries.

Muscle and skill improvements only come from training. Knowlege and tactics improvements come from experience and study. Sometimes the various training needs can run at cross purposes or be incompatible fully with one another. For instance, weight lifting can result in extremely strong muscles but these improvements might come at the expense of aerobic endurance or good coordination. An athlete who needs both strength and endurance must usually make a choice in training as to the proper trade-off between strength and aerobic conditioning training. Even an athlete with optimally trained muscles for the event may perform at less than the full potential if the coordinate use of the muscles (technique) is less than optimum or tactics are less than the competition.

So, the training problem for the athlete becomes one of allotting the available time available to the various needs to include muscle strength improvement, muscle aerobic capacity improvement, nervous system coordination (technique) improvement, getting enough rest, and avoiding injury. The natural and unconscious nerve firing and muscle contraction pattern when doing anything is called coordination or form. Everyone can run or ride a bike but not everyone does this with equal form. Those with better form will generally win. But, even perfect form is not enough for most sports because without sufficient training the muscles will not have sufficient blood flow to sustain repeated contractions for any period of time, such ability is called endurance. If one has perfect form but can only sustain it for 5 minutes that person is unlikely to win an event that lasts one to 5 hours. For almost every sport athletic performance is generally improved with both better technique (coordination) and better endurance.

Lucky for us we don't need to know every little nuance that needs to change to improve muscles strength and endurance. All that is required is we regularly stress the muscles and the body knows exactly what to do to improve the ability of those stressed muscles to better perform the next time that stress is seen, as long as it is given enough rest and nutrients to make the change. However, improving technique or form is not quite so simple to accomplish. In order to improve technique or form we must first know that there is a better technique or form over what is currently done AND there must be an effective method of retraining the unconscious coordination to this more effective better coordination. This requires a feedback system to inform the body when it is doing it right and when it is doing it wrong. Depending on the skill, trying to be changed this feedback problem can be relatively easy (rare) or extremely difficult or somewhere in between. In most cases, these skill improvements are the most difficult areas for the athlete to improve.

The response to stress or no stress.

Generally, as noted above, when our bodies are subject to a stress it will respond to that stress by setting into motion mechanisms that improve the body's ability to meet that stress should it be seen again. However, if the stress is not repeated then these mechanisms will slowly fade away or no improvement will be seen if the stress should only recur infrequently and irregularly. With repeated similar challenges, not only does the muscle learn to respond better but the brain learns muscle firing patterns so responses become natural and unconscious. If the stress is stopped then these mechanisms are not reinforced and the improved ability of the body will slowly go away. However, if the stresses come regularly then these mechanisms are reinforced and soon the muscles involved (including the heart) have more capillaries, more enzymes to convert sugar and fat into useful energy molecules, more contractile elements, etc and the ability of the body to sustain work is improved and the nervous system more easily fires the necessary muscles without thinking about it. If the stress is again regularly

increased then the body will try to continue to adapt. Our ability to improve is primarily limited by the need for rest time as these changes only occur when the body is resting (which is the main reason for a “taper” before a big race). Voluntary and regularly applied stresses are generally called practice or training, whether a pianist learning the coordination and control to play beautifully or an athlete developing the power and coordination necessary to optimize performance. The improved ability of the body, in response to these stresses, over time is usually called the training effect.

Muscles respond to stress in two way that interest athletes. One is they increase the number of contractile elements so they become stronger. The other is they increase the ability to convert oxygen and fuel into energy so contractions can be repeated for a long period of time. In general, it is not possible maximize both of these types of response to stress in one individual. There is not enough room in the muscle to maximize the amount of contractile elements and maximize the energy conversion abilities. Sprinters and weight lifters have little need for aerobic conditioning but need to improve anaerobic capacity and technique, whereas marathoners need to improve muscular endurance and technique. These two different types of athletes will train quite differently. Other athletes will have needs that fall between these two extremes. For those just looking to improve fitness and aerobic conditioning it is generally accepted that the minimum stress necessary to condition a muscle aerobically is 30 minutes 3-4 times per week. Of course, the more aerobic stress the sport puts on the muscles, the harder one must work in training to develop the muscles to perform at that stress. Since many muscles are involved in any athletic endeavor, all the muscles needed to perform in any manner must be trained equally or all the muscles will not be able to be utilized to their potential. Or, to put it another way, it does no good to train a muscle if it is not going to be used and one is only as good as the weakest muscle required to be used.

Every joint in the body has at least two muscles that go across the joint doing the opposite thing, flexing or extending the joint. In order to move a joint the one set of muscles must contract and the other relax. It actually takes energy to relax a muscle and training improves the ability of the muscle to both contract and relax. In humans the muscles in the leg used to cause standing are called the antigravity muscles. The antigravity muscles (the gluts, quadriceps, and calf muscles) get a reasonable amount of exercise in just performing everyday activities (walking, sitting and standing, and picking things up from the floor). The opposing muscles of the legs are also very strong (the iliopsoas, the major hip flexor, is the major muscle used when doing sit ups) but they have almost no aerobic capacity because they are only rarely called upon to perform any sustained hard work. Almost all normal activity can be performed without severely stressing these muscles aerobically. Because of this difference, these muscles have, until the development of PowerCranks, been almost impossible to train as aerobic muscles. These are the muscles that have tended to limit athletic performance.

One of the major benefits for PowerCranks is turning these underutilized muscles into aerobic muscles, then they can be used more effectively in all sports that rely on leg speed, endurance, and coordination. This is what PowerCranks™ are designed to do because they actually force the athlete to train these muscles so they can be incorporated into their athletic activities.

The “optimum technique”problem.

Unfortunately, when we are learning to run and cycle, learning our natural coordiantion for these skills almost no one is looking at improving our technique, and even if they did, few of us would probably listen. so, when we are at an age when it is easy to tech good technique, no one is trying. When we are willing to learn to change, these “natural” patterns are so ingrained it is almost impossible to change.

The “cycling technique” problem.

Most people think that cycling is a pretty simple activity and we all do it pretty much the same way. But studies of pedaling efficiency show that pedaling efficiencies range from a low of abut 16% to a high of about 26%. This means the most efficient riders on this scale are putting out almost twice as much power as the least efficient for the same energy expended! This is a huge improvement that can come from just changing to a more efficient pedaling style. Most serious cyclists have heard of "pedaling in circles" as being more efficient (as much as 25% of ones energy can be used pushing the recovery leg up on the backstroke) and have purchased clipless pedals to allow them to pedal in this more efficient fashion. But, unfortunately, just buying pedals that allow the rider to pull up on the backstroke, to "pedal in circles" does not mean it happens. Why? Since our first tricycle, we have **always** pedaled using crank arms fixed 180˚ apart — and, until we became serious about cycling as a sport, we were **never** attached to the pedals. Therefore, during its most formative stages, our nervous system learned that “best” pedaling technique involves keeping contact with the pedal on the upstroke — which requires a small amount of back

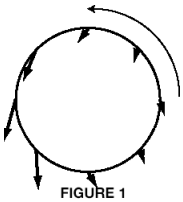


FIGURE 1

pressure on the pedal during the recovery as illustrated in figure 1. In order to pedal a bicycle when you are not attached to the pedal requires that you learn to under utilize the full potential of the hip flexor and hamstring muscles. When not attached to the pedal, keeping contact with the pedal through back pressure facilitates rapid application of power on the down stroke. This is the most efficient pedaling dynamic if one is not attached to the pedals **but it is not if you are attached!** So, learning to pedal as a kid, not attached to the pedals, has led to a pedaling dynamic as shown in figure 1. The theoretical ideal would be a pedaling dynamic as shown in figure 2, which would be what is referred to as pedaling in "perfect circles". Note that even though this dynamic is considered "perfect circles" the forces are not the same on the downstroke and upstroke. There is one big reason for this which comes from the effects of gravity. Even if the muscles are working equally the force on the pedals on the upstroke will be reduced by the weight of the leg, as this must be overcome by the muscles before any force can be applied upward on the pedal, and, on the downstroke, the weight of the leg will be added to the force of the muscles. These forces will never be the same (unless you are in space where the effects of gravity are nil) and there should be no attempt to make them so. Simply unweighting on the upstroke is adequate to get all the efficiency benefits of "pedaling in circles".

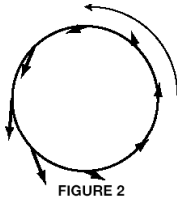
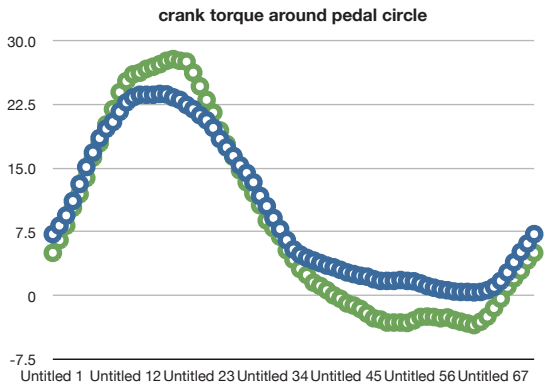


FIGURE 2

Changing to this more efficient PowerCranks pedaling dynamic we theorize results in three major improvements, and one minor improvement, allowing for large increases in cycling power and efficiency for the cyclist. First, and probably most important, one becomes aware of the entire pedaling circle and must learn to anticipate the changes in direction. This will substantially change the coordination making the pedal forces more tangential. If the pedal forces become more tangential to the pedaling circle large increases in power can be seen with absolutely zero increase in total muscle force. This would make the cyclist more efficient and this PowerCranks change has been demonstrated in independent University research. Second, more muscle mass is involved in the pedaling motion because the upgoing leg must be completely unweighted. Utilizing more muscle mass should eventually lead to an increase in VO2 max. This change due to PowerCranks use has also been demonstrated in independent University research after only 6 weeks of use. This is true whether one actually eventually applies positive force during the upstroke or not. We think that most users will never learn to develop substantial positive force on the upstroke as just lifting the weight of the leg 90 or so times a minute is enough. Third, we think most people tend to ride at too high a cadence, one that actually reduces their power. PowerCranks helps the user to determine what is the most efficient and powerful cadence for them. Studies have repeatedly shown that cyclists tend to ride at cadences that are higher than that which is the most efficient for them. And lasty, if one is pushing less hard on the downstroke at high power, one is probably invoking fewer fast twitch fibers, which utilize energy less efficiently than slow twitch fibers. We expect this to be a very minor benefit adding to improved efficiency and endurance. But, all of these changes, when added together can add up to really very large increases in performance ability. It is how we explain the fact that many users are seeing cycling power increases of about 40% in only 6 months or so.

Before PowerCranks™, studies consistently showed **even professional cyclists, most of the time, pedal with backpressure on the upstroke, contributing negative torque during the recovery portion of the pedaling movement** (See: Whitt and Wilson, Bicycling Science, The MIT Press 1995, p. 63). This is such a difficult coordination to undo that even cyclists who have been training on PowerCranks for some time will tend to revert to this earlier way of pedaling when they return to regular cranks. The figure shows the tangential forces of someone who has been training on PowerCranks comparing the forces of that person riding on PowerCranks and regular cranks. So you might ask, “Why do I (and everyone else) continue to pedal in this inefficient manner, even though I have clipless pedals, know better, and have tried to change?” The answer derives from how all of us learned to pedal as children and what it takes to change ingrained neurologic patterns. One cannot change these patterns without the proper feedback and enough repetitions of doing it right to ingrain the new patterns into what is "natural". Regular cranks offer no feedback and trying to change this pattern using regular cranks is almost impossible. By age 7 or 8 your nervous system could pedal in this “most efficient” manner (if you are not attached to the pedals) without thinking and you continued to reinforce this motion for many years. In order to actually lift completely over the top for an hour at a cadence of 90 one must be attached to the pedal and then lift each foot about 14 inches 5,400 times an hour. So, even



though you now have and “use” clipless pedals your pedaling dynamic has not changed substantially from when you were a kid. By now you have probably several millions of repetitions using this less than optimum technique. PowerCranks make it possible to change this pattern but it still isn’t easy. The more “experienced” and better you are now, the more difficult this ingrained pattern is going to be to change. **If it were possible to “easily” correct this poor pedaling dynamic by previously available techniques the pros would have figured out how a long time ago, but they did not! At least, with PowerCranks, it is possible.** Even the best pro cyclists currently training using conventional techniques can improve pedaling efficiency and power training with PowerCranks and the list of top pros using them is very long indeed including Olympic Gold Medalists, World Time Trial champions, and winners of all three Grand Tours.

The “running technique” problem?

During our formative years running technique for any individual can and will change with time. Our natural running technique changes greatly between the age of 2 and 15 or so as our nervous system and muscles mature. During this time some of us developed a naturally efficient style and most of us didn’t. After this “fixing”, additional efficiencies can be achieved but they do not occur easily because our "natural" patterns have been set and ingrained. Those of us who developed a naturally good style probably learned to like to run, because they tended to win races when they were growing up. Those of us who weren’t very good tended to no like running.

Running speed is determined by two things, stride length and cadence. A few are born with good running form, most are not. Very few parents try to change the running form of their children, they are just glad they are out playing. But, just because you now want to run faster doesn't make it happen and how to improve form is a lot more complicated than just running harder.

There are several things that set the efficient fast runner apart from the average or slow runner. Let us talk running efficiency. There are two major parts of the running stride. When the foot is on the ground and when the foot is off the ground, preparing for the next ground strike. First, once up to speed, all the foot on the ground does is impart enought force to maintain speed and to push up enough to keep us from falling down. It is inefficient to hit the ground too far in front of the center of gravity as this imparts a braking force that then must be made up with the push-off. Good runners minimize this braking force. Further, if the time on the ground can be minimized then there is more time to do the recovery to get the foot ready for the next foot strike at any given cadence. Better runners tend to get their foot off the ground faster than lesser runners. Then, getting the heal up during recovery changes the center of mass of the lower leg and will shorten the lever arm from the hip, making it “easier” to swing the leg forward. Shortening this lever arm makes it easier to swing the leg forward making it easier to have a high cadence for the same “effort expended”. It turns out that good recovery form for both cycling and running are inherently the same. Both involve lifting the foot off the ground and getting the toes going forward quickly. Cyclists refer to the motion as “pedaling in circles” while sprinters refer to the motion as “cycling”. Running coaches have come up with a wide variety of drills to try to encourage on or another of the movements involved in efficient, fast running form but these are not dynamic and similar to actual running. PowerCranks help encourage these changes without needing to “think” about anything.

PowerCranks train all the muscles necessary to run with good form in a manner that is close to actual running. Even the best and most natural runners can improve form and could use better endurance to help them better maintain form the last half of the race.

If you are still confused, there is a video on our web page that discusses the difference between good and "ordinary" running form and how PowerCranks encourage these changes, even without running.

Recovering from or avoiding injury

Another important aspect of athletic performance is avoiding injury. Injuries can occur in many ways. Several things can make the athlete more prone to injury. Studies have consistently shown that poor core strength and muscle imbalance will increase the risk of serious injury. Further, discoordinate movements and poor form will also set the athlete for injury. One more thing, elite athletes are always pushing the body to the limit and on the edge of injury. This is expecially true of runners who are pounding the joints with every running step.

PowerCranks help with all of these issues. The independent nature of the cranks insure the athlete become balanced, both right/left and fore/aft. In addition, lifting the hip flexors insures the core is stronger and balanced. Any athlete who is unbalanced on PowerCranks should seriously consider "taking themselves out of competition" until balanced. Nothing will ruin your seaon more than a serious injury. Obtaining balance comes pretty quickly with regular PowerCranks use.

Further, for runners, regular use, as discussed earlier, improves running coordination and form, which should also reduce risk of discoordinate injuries.

And, of course, for the injured, PowerCranks allows the injured to continue to exercise in a totally non-impact fashion, using good coordination, while regaining 50-50 right/left and fore-aft balance.

The Solution

PowerCranks™ have solved all of these training problems and put them into one product;

1) A patented technological innovation forces the user to train all the major muscles in the proper coordination pattern for efficient running and cycling and,

2) The independent nature of the cranks prevents compensation for any muscle imbalances or weaknesses, forcing the athlete to become balanced and,

3) The ability to mount them on your everyday bicycle (or an exercise machine) so enough repetitions is easily achievable to turn the muscles into effective aerobic muscles and retrain the unconscious coordination to this better motion. This innovation trains all the muscles necessary to use good form and retrains the muscle memory patterns such that this use will eventually become natural. It is not possible to do one without doing the other

The technological innovation places a very strong one-way clutch between each crank arm and the crankshaft. Because of this, PowerCranks™ work like regular cranks when pedaled as in Figure 2 but they don't work at all if you try to pedal as in Figure 1. If either leg ever stops pedaling in the more efficient fashion of Figure 2, even briefly, **you get immediate feedback as your pedals fall out of synch**. In medical terms, this type of feedback is a simple operant conditioning system (positive feedback when you pedal correctly, negative feedback when you do not) used to effectively change unconscious behavior. **It is the failure to insure regular and frequent long-term repetition of the proper pedaling motion that results in the failure of other training methods to effect this change**. **Therefore: PowerCranks™ has solved both the pedaling and running efficiency training problem!**

So the way to the winners podium for the athlete is the same as the way to Carnegie Hall for the pianist — improving technique and ability through years of practice, practice, practice. PowerCranks cannot help the pianist. They can help the cyclist/runner/athlete/injured better achieve their goal.

Addendum: PowerCranks Limited Motion Crank

What are they?

The PowerCranks are similar to regular cranks but have a small amount of motion to give the rider feedback as to when they are not “pedaling in circles”. But, as opposed to regular PowerCranks, these cranks will still allow you to continue pedaling the bike despite your “deficiencies”.

How to use them?

Well, it is pretty simple. Use them like regular PowerCranks (see the front part of this manual). The more you use them the more benefit you will potentially receive. The difference is the degree of the feedback the rider receives when they have a flaw in their technique. With regular PowerCranks there is no denying that the deficiency was there and you are forced to recognize and fix it. With the limited motion PowerCranks it is possible for the rider to ignore the feedback and simply continue riding using awful technique. This makes them great for racing (if one is PowerCranks trained) but less effective as a training tool since the rider must be thinking about the motion to be aware and to make the changes.

The goal of the rider on the Limited motion cranks is to be able to keep them quiet for the entirety of the ride. Everytime the rider hears or feels the pedaling discrepancy the rider is losing efficiency.