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# Beyond the Pavement: How to Take on Cross-Country Mountain Biking

Gregory M. Moore

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**Abstract**
Mountain biking began for me as an escape from the commotion of urban society. I was looking for a way to get out of life's normal grind and take advantage of my love for being active and outside. Mountain biking was the perfect sport to meet my desires. I have become an advocate for mountain biking early on. I am now taking this opportunity to teach people about the sport I have come to love.

The objectives of this book are two fold. *Part I* serves as a comprehensive guide to cross-country mountain biking that will provide new comers with the information they need to "slingshot" themselves into mountain biking. *Part II* will provide tips and knowledge that can help everyone improve their performance. For some, the transition from the road to the dirt is a simple task, but for others the process can be much more difficult. This book is designed for those beginners who are having a tough time adapting to the new challenges of off-road riding. It is also a book for those recreational riders who wish to gain an edge or enhance their skill level.

When using the information provided in *Part II*, it is important to put theory into practice. After reading this section, take one of the key points into mind and hit the trails. Ride the same as before, with the exception of the key point you chose to work on. With practice, the skill becomes automatic. A rider who practices often will develop a schema, or automatic path of action for each skill. Continue working on other key points, one or two at a time, until they too become automatic.

I hope that all new mountain bikers will enjoy being closer to nature, take pride in being active, and fall in love with the amazing adventure waiting on every trail. I encourage all new riders to "take on" cross-country mountain biking.

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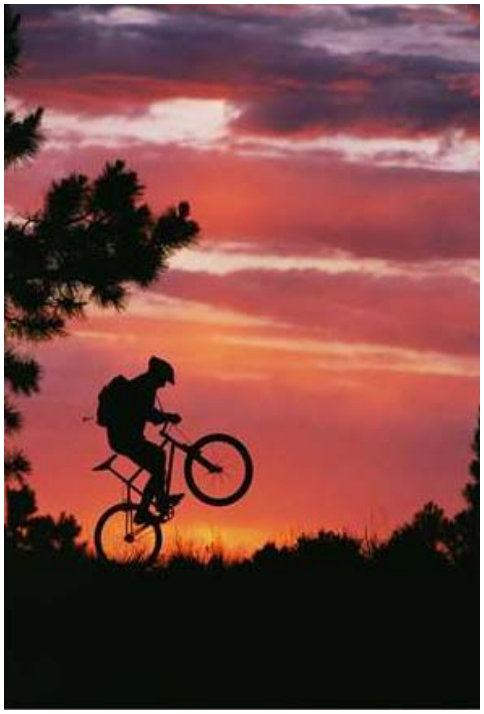
# Beyond the Pavement



## How to Take On
## Cross-Country Mountain Biking

**By: Gregory M. Moore**

# INDEX

**CONTENTS** **PAGE #**

...The adventure Starts Here

I would like to extend a special thank-you to Dr. Erik Pedersen, Dr. Doug Briggs, Dr. Peggy Daisy, Dr. Michael Paciorek, and Dr. Christine Karshin, who have worked with me to bring this book to life. I would also like to send my greatest appreciation to the members of the Michigan Mountain Biking Association who build and maintain the trails which provide all of Michigan with this cherished sport.

# INTRODUCTION

Mountain biking began for me as an escape from the commotion of urban society. I was looking for a way to get out of life's normal grind and take advantage of my love for being active and outside. Mountain biking was the perfect sport to meet my desires. I have become an advocate for mountain biking early on. I am now taking this opportunity to teach people about the sport I have come to love.

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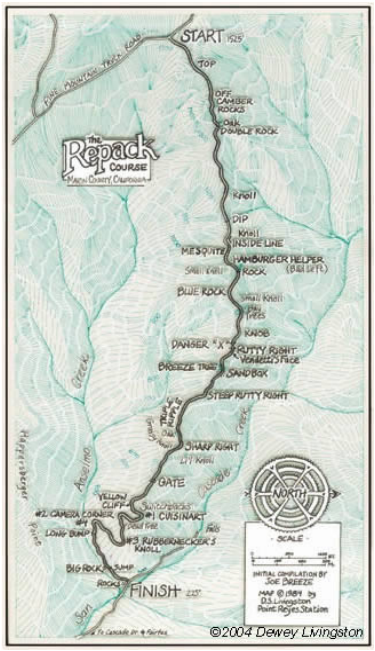
# THE HISTORY OF MOUNTAIN BIKING

What you and I think of as mountain biking began sometime between 1971 and 1974 in Marin County, California (Strickland, 1998). Mountain biking became a sport using old big-wheeled junk bikes to coast down the side of a mountain. The sport began with a group of local road racers looking for a break from the usual grind of their training regimen. They took these "klunkers" or "ballooners" as they were called and hammered, flew, crashed, and free-wheeled them down the hills. According to Strickland (1998), the most popular route was named "Repack" because the friction generated during the 2.1 mile drop would sizzle the grease out of the bikes' coaster brake hubs, requiring a teardown and repack after every ride.




Left - The famous Repack Route ran 2 miles long with over 1,300 feet of elevation change

Joe Breeze, one of the original mountain bikers developed the first true mountain biking frame in 1977. He stated, "People think there was some marketing genius behind the development of the mountain bike, but we were just having fun" (Strickland, 1998).

1974 - The first mountain bikers

These same pioneers of mountain biking also became the entrepreneurs in the development of mountain bike equipment. As they developed affection for the sport they crafted, they soon realized that they were in need of equipment that would make their sport less of a burden. Gary Fisher and Joe Breeze, two of the early mountain bikers began to think of ways to create a bike that would help riders get back up the hills that they rode down and didn't need to be fixed or replaced after every ride. Gary Fisher developed his first multiple speed bike. It weighed 41 lbs and had a totally different geometry. It had a triple crank on the front, and five cogs on the back (Richards, Brant, Worland, & Fisher, 1997). Breeze developed a bike called the "Breezer." In doing so he developed the first mountain biking frame. It was lighter and more durable than the old "klunkers". In the past twenty years, more engineering has gone into the development of mountain bikes than in the past hundred years of road bikes (Richards, Brant, Worland, & Fisher, 1997). Today, there are multiple, multi-million dollar companies who compete to create the best mountain bikes with the latest technology. The latest frames are made out of either carbon fiber that weighs only 4 lbs or they are made of an alloy material that gives a soft feel over rough terrain, yet is stronger than steel and weighs in comparably. Bikes have changed from Gary Fisher's 41 lbs, 15-speed to the elite bikes today that have 27 speeds and weigh only 19 or 20 lbs.

The sport was not labeled "mountain biking" until 1979 and the "mountain bike" tag is something of a misnomer for many of today's riders, but it is a tag that has stuck for obvious reasons (Richards, Brant, Worland, & Fisher, 1997). Most people think of the recreational riders who ride at local state and city parks. These trails are not really mountains, but they are cross-country trails with terrain too rough to pass on any other type of bike. Mountain biking has become such a popular sport that new county and city parks are opening because they have the correct terrain and acreage for mountain bike trails. The mountain bike has also become the most popular bike for a young child to own because it has multiple gears and is very durable. In fact, today, more than 8-million mountain bikes are sold per year in the U. S. alone (Strickland,

1998). This popularity is staggering, considering the mountain bike was only developed three decades ago. Mountain biking is becoming more popular every year as people are seeking new, fun ways to stay in shape and have a good time.

# PART I


# Getting Started

# How to Pick the Right Equipment

**THE BIKE**

The bike is the most important piece of equipment that you will buy. There is a large price range and many options to select from. Therefore, how do you figure out what you will need? You need to find a good quality bike shop in your area that has a trusted reputation for sales and, more importantly, service. Most bike shop personnel will help you find the bike that will meet your needs. It is a smart choice to avoid large department stores and sporting good box stores. For now, let me offer you some advice to help inform you of the advantages of specific options and help you become an intelligent consumer.

**Suspension**: Most people walk into stores and see the cool looking full suspension bikes and want to have them. The truth is that full suspension bikes at entrance level prices will not serve you as well as similarly priced hard tails (Bikes with no rear shock) on cross-country terrain. At a price range up to $800, you will sacrifice good components for a rear shock and the rear shock will bob, draining your energy and slowing you down on most cross-country terrain. Full suspension bikes in this price range also weigh more which make them less agile on the trail.


Rock Shox front suspension fork, Giant rear suspension frame

**Derailleur**: A derailleur is the piece of equipment that moves your chain from gear to gear on the cassette. Front and rear derailleurs usually come in a series. For example, the Shimano line starts with the Alivio, and increases in quality to the Deore, Deore LX, Deore XT, and Deore XTR. The derailleur found on a bike will coincide with the price range of the bike and the use of the bike. The most important fact to know about a derailleur is how well it is tuned. This is why finding a bike shop with a good reputation is important.

Shimano Deore rear derailleur

**Brakes**: There are two kinds of brakes: V-brakes and disc brakes. There are advantages and disadvantages to both of these. Most bikes come standard with V-brakes which will suffice for cross-country riding. Disc brakes are more expensive and provide a very slight advantage in stopping distance.

Left - V-Brakes, Right - Disc Brakes

**Rims and Tires**: If you plan to ride your bike off-road, it is very important to have double-walled rims. This means the rims are stiffer and more durable. They will last much longer than a single-walled rim and save you from repairs after every ride. Smoother tires are good for pavement. On the trail, front and back tires are different. Front tires are important for turning, and rear tires are important for traction, especially on climbs. Ask your bike shop specialist for more information.

Mountain bike rims and tires

**Accessories**: You will need a bike helmet for sure. Even if you do not wear one on the pavement, the trail is much more dangerous. Always pick safety first. Other accessories that are important are bike gloves and hydration packs. Hydration packs are more convenient than water bottles because they will not weigh down the bike allowing for more agility on the trail. You

will also be doing a lot of movement with your hands on the grips, and gloves will save you from blisters as well as improve your grip. Other optional accessories include small air pumps, head lights, and multi-tool kits. A small pack for under your seat is nice to keep keys and multi-tools safe and out of the way.

Common Accessories

**BIKE RACKS**

If you have a truck, there are quick release brackets available so that you can quickly place your bike in the bed of your truck without it banging around. You simply attach the bracket to the bed of your truck, or to a 2 X 4 that fits in slots that pre exist in most bed liners. Then take off the front wheel and tighten the front fork of your bike down to the bracket now in place in your truck bed. If you do not have a truck, there are bike racks available that adjust to any SUV, mini van, or car. They range from $30 - $150. The more expensive they are, the more durable and versatile they will be. A bit of consumer to consumer advice, try to catch them on sale at the large sporting good stores. There are also tie downs for the top of many cars, SUV's, and mini vans.


(Left to Right)

Yakima Mighty Joe, Yakima Locking Blockhead Bike Mounts, and Yakima Beddy Joe Truck 2 Bike Rack

# How to Find a Bike That Fits

There are multiple factors to consider when fitting a person to a bike. Frame size, seat position, handlebar placement, width, and height, brake lever reach, and crank-arm length are some of the factors to consider in assuring optimal performance. I will discuss frame size and seat position first. This is because they are the factors of bike fit that affect a biker's performance most.

**FRAME SIZE**

Choose a frame size that fits the mode in which you will use your bike. A larger frame size in comparison to your body size is appropriate for riding on smooth pavement and is more comfortable. Choosing an intermediate frame size is optimal for those who plan to use their mountain bike off-road but do not plan to do aggressive riding. Frame size is particularly important on rough, technical terrain and for those who plan on using their bike to compete or for aggressive riding. A smaller frame size will allow you to be more agile and make easier weight shifts. A smaller frame size is also safer for aggressive riders. A bike only to be rode on paved surfaces and will never be taken off-road should give you a minimum stand over height clearance of two inches (5cm). A bike to be rode on unpaved surfaces should give you a minimum of 3 inches (7.5cm) of stand over height clearance. And a bike that is used for real mountain biking on difficult, rough terrain should give you 4 inches (10cm) or more of clearance (2004). Clearance is measured from the top tube to the crease of the groin.


Correct position for measuring stand-over height.

**SADDLE POSITION**

There are three directions to move a saddle: forward and backward, up and down, or upward and downward tilt. Small changes in saddle position can have a substantial effect on performance and comfort. Only one directional change at a time and only a small change at a time should be made to your saddle position. Saddle angle is important for comfort and will adjust depending on one's body position on the bike. Having a correct saddle position will minimize the amount of blood flow occlusion. The forward and backward adjustment of the seat should be adjusted to optimally adjust weight over the back wheel. Consideration for one's reach to the handlebars should be in mind when adjusting the seat forward and backward. Frame size will be a factor, and a frame should have been chosen with the correct stand-over height. Saddle height is the most important adjustment of the saddle relative to pedaling cadence. Optimal saddle height has been calculated on the basis of power output, but this research was conducted on road bikes. For off road riding it is important to find the most comfortable position that compromises agility on the bike and the longest leg extension. The closer the knee is to full extension at the bottom of a revolution on the pedal, the more power output will be generated and the slower fatigue factors in. You need to compromise the longest leg extension desirable with being able to slide on and off the seat on rough terrain.

Skinnier racing saddles will also allow easy movement over the seat on rough terrain

leg position for testing saddle height

**OTHER BIKE FIT FACTORS**

Small adjustments for reach can be made by adjusting your seat backward and forward or by purchasing a different size stem. The handlebar width is usually satisfactory standard, but the

grip should be approximately shoulder width apart. Narrow handlebars are more agile on the trail.

There are also mountain bikes available that are especially designed for women. They adjust the length of the top tube, length of the crank arm, and the size of the brake lever grip to fit a smaller hand and body size. Remember that frame size is the most important aspect of a bike's fit. Components can be changed if necessary. Female specific designed bikes do not necessarily look much different than a male's bikes. (As pictured on the next page)

Trek 4500 WSD (Women's Special Design)

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These bikes do not have the angled top tube designed for traditional female bikes. The traditional female design is not as durable as the traditional male frames are. Along with the shorter top tube, women can choose a safe frame size for their height, as discussed in the "How to Pick the Right Equipment" chapter.

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Gary Fisher Tassajara GS (Genesisters)

# How to Find Trails

There are many ways to find trails in your area. Mountain bikers love to advocate for their sport and most are eager for new comers. The first way to find trails is to ask your local bike shop experts, because they will likely be riding local trails themselves. There are lots of resources available as well. State parks will list mountain biking trails as amenities on their website. State mountain biking associations will have a list of chapters, or regions and a list of trails they support in each region. There are privately owned websites that advertise local trails. There are published books that include trail listings, as well as further information and opportunities for recreation. There are also privately owned charter companies that provide vacation opportunities for mountain biking trips around the country or in particular states. More and more trails are being carved with the growing popularity of the sport. Following is a list of resources from my home state of Michigan and some from around the United States. Surf the net and find what you are looking for.

- www.mmba.org

The Michigan Mountain Biking Association provides you with advocacy links, current events, and group rides. They provide schools for beginners, forums to post trail conditions, directions to trails, and more.

- www.trails-edge.com

Trails-Edge is a great privately owned internet resource with information on trails in Southeast Michigan. Look at photos, read trail descriptions and difficulty ratings, and find directions.

- http://mtb.live.com/mtb-usa.html

This website provides links for mountain bikers throughout the United States.

- http://www.dirtworld.com/trails/traillist

Dirtworld.com provides you with a trail search engine to locate mountain bike trails in the Untied States.

- http://www.trailsfromrails.com/

This is the national trails from rails website. Trail listings are available. Trails from rails are bike trails that have been converted from old railways. They are not technical trails by nature, but some of them are considered epic rides.

- http://www.escapeadventures.com/

Escape adventures offers mountain bike and multi-sport vacations throughout the Southwestern United States. They have a variety of adventurous vacations for all levels and provide skill level summaries for all of their trips.

- http://www.ridemidwest.com/trails.html

Find trails in the Midwest by state. Includes: Iowa, Indiana, Illinois, Ohio, Michigan, Wisconsin, and Minnesota

- www.imba.com

This is the link to the international mountain biking association, the world's largest mountain biking association. Surf the site, you'll find everything.

# Part II

# Performance Basics

# How to Use Your Bike on the Trail

Braking and shifting are skills that you will need to understand. It is important to figure out which brake lever controls the front and rear brakes and what shifter controls each derailleur. It sounds simple and it is, but the ride improves greatly when quick reactions are made.

**Braking**: The right lever controls the rear brake and the left lever controls the front brake. The biggest keys are learning when to brake and knowing your style and your bike. As a novice, stay within your comfort level and do not exceed your limits. Take time to practice braking to learn what point the tires break loose and how hard to brake with the front brake before the rear tire lifts off the ground. The key to braking while mountain biking is to use both the front and the rear brake simultaneously in the right proportions. Practice braking around corners, down hills, and on flat surfaces. Try not to lose traction while doing so. Learning when and how much to brake will result in a smooth ride and help you float over the trails. Just like any sport, practice will help improve your mountain biking skills.

Brake levers

**Shifting**: Shifting is slightly more intricate than braking. It goes hand in hand with keeping a smooth pedaling cadence which will be discussed, in depth, in the next chapter. The more technical terrain the ride is on, (the more hills and turns) the greater the need for shifting to take place. Some recreational mountain bikes will have grip shifts but most sport or competition mountain bikes will have rapid fire shifters; shifters that shift with one touch from your thumb or your index finger. Rapid fire shifters are recommended for trails and will be discussed in this

chapter. The right hand shifts the rear derailleur and most shifting takes place on the rear derailleur. Each bike will have 7, 8, or 9 different levels on the rear cassette. The shifter on the right side of the handle bars will have numbers or a little red pin that moves with every shift. The right thumb shifter will shift the rear sprocket from smaller chain rings to higher chain rings which will make pedaling easier. This is called down shifting. The index finger of the right hand will up-shift. The left side shifter will shift the front sprocket. There are three front chain rings on most cross-country mountain bikes. Shifting on the front derailleur is the opposite of the rear derailleur. Shifting with the thumb will shift from smaller chain rings to larger chain rings, but this will up-shift or make it harder to pedal. Your left index finger is used to down-shift, making pedaling easier. Remember, this is the opposite from your right shifter.

You can shift more than one chain ring with each shift on your rear sprocket. (Right shifter) This is especially important when switching from uphill to downhill when it is important to up shift rapidly. Beginners start shifting gears more often as they become more confident, leading to improved performance.

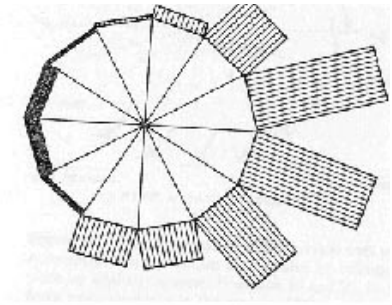
Rapid Fire Shifters w/ cable

# How to Perfect Your Pedaling

Lance Armstrong epitomizes efficient pedaling

Pedaling is the way you connect with your bike. It is the point where you turn your internal energy into the energy that propels the bike forward. Mountain biking requires very technical movement on the bike which sometimes can get in the way of a perfectly smooth pedaling cadence. Pedaling cadence is most important on flatter terrain with less turns, but an important skill to learn is how to master pedaling cadence on even the roughest terrain.

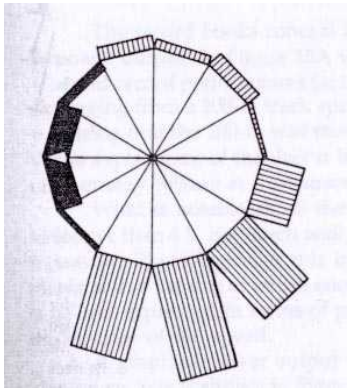
Cadence can be defined as “rhythmical flow,” or “harmony and proportion in motions.” The term pedaling cadence refers to the rhythmical pattern in which we apply internal force to the pedals to create torque of the crank which is in turn applied to the ground through the tire. Optimal pedaling cadence can vary between individuals. It is recommended that novices start at approximately 90 revolutions per minute (RPM). Force distribution, angle of applied force, and net torque of the two legs are all important aspects of pedaling cadence. Force distribution is the distribution of force over the course of one revolution of the crank arm. To optimize the transfer of torque to the road it is important to smooth out the force distribution. Herein referring to degrees of motion around the crank arm, 0 degrees is at the top of the stroke and 180 degrees is where your leg is extended at the bottom of the crank. The force is usually far greater between 60 - 120 degrees than it is between 0 - 60 degrees and 120 - 180 degrees. In fact, very small forces are usually applied to the pedals during these portions of the revolution. Even for skilled cyclists the perception of a smooth and even force distribution is false.



This diagram depicts force in each 30 degree segment of a pedaling cycle. (0 degrees is at the top)

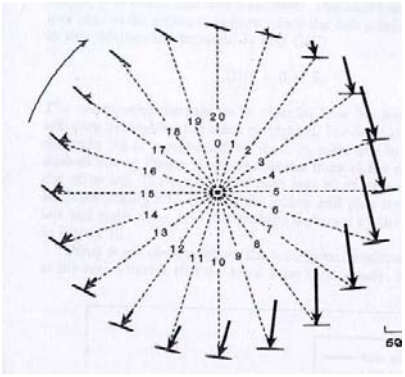
Force should only be applied in the fore stroke, the first 180 degrees of a revolution, and the backstroke (180-360 degrees) should be a rest period while the opposite leg is working. This brings up the concept of net efficiency. In order to find out how efficient a cyclist is in applying force, subtract the negative force applied from the trailing, or resting leg, from that of the leg exerting force during the power stroke.

This Diagram shows the unused and negative force applied to the pedals. Black shaded areas are negative force and the line shaded areas are unused force



Riders should focus on eliminating the negative force by simply relaxing in the back half of the pedaling cycle and decreasing the amount of unused force applied to the pedal using the ankling technique described ahead.

The last factor in pedaling efficiency is the angle of applied force. Exerting a larger force on the pedals is not the only answer, in fact if you carry one idea with you from this section, let it be this: You may be exerting a larger force on the pedal than any known cyclist before you, but unless the force is in the right direction, it will not necessarily result in larger propulsive forces at the wheel (Faria & Cavanagh, 1978). The optimal angle of applied force is perpendicular to the crank arm. This is how one will get 100 percent efficiency from the force you exert on the pedal. Moving even slightly away from perpendicular will affect efficiency greatly. It is a fact, however, that our body is not capable of bending in a way that allows us to constantly apply force perpendicular to the crank arm, but bending the lower body segments in the proper order and fashion will allow you to **optimize** your pedaling technique to your own ability.



This diagram shows the typical angle of applied force during pedaling. Larger arrows imply a larger force

So, to recap what we discussed in this section, there are four concepts to pedaling. **One** - Try to establish a pedaling cadence of around 90 revolutions per minute. Remember to adjust the gear by shifting up or down to accommodate this pedaling cadence. **Two** - Try to distribute force evenly throughout the pedaling cycle. **Three** - Only one leg should be applying force to the pedals at a time. If the trailing leg adds to the resistance of pedaling, it only slows you down. **Four** - Most importantly, try to apply force at a perpendicular angle to the pedal. This process is called "ankling," meaning the movement is not only at the knees, it is all of the joints in the lower limb working together.


Lance enjoys Mountain Biking too. He is pictured above in competition at Mt. Snow

**Special Note**: Adding clips and straps or clipless pedals to your bike will strongly increase force transfer from internal force to torque on the crank arm.

A set of toe clips and straps

Toe clips and straps will increase the efficiency greatly over pedals alone. They keep the ball of your foot on the pedal, allowing your ankling technique to be utilized. If the straps make you nervous, take the straps off and use only the toe clips. Toe clips alone will still benefit you immensely.


A set of clipless pedals and shoes

Clipless pedals are by far the best choice for optimal performance, but many people are uncomfortable being bound to the bike. If you choose to use clipless pedals, realize that it will take practice to become proficient in getting in and out of the clips.

# How to Position Your Body

In becoming a true mountain biker, you have graduated from smooth, flawless pavement. The trails you are riding now have sharp turns, steep hills and unforgiving rocks and tree roots strewn across the trails.

Loosen up

**Basic Body Position**: The first two keys to positioning your body on trails are to be balanced and to stay loose. The arms should be slightly bent and give a little-bit-like shock absorbers. Vision should be focused down the trail, so that you can foresee upcoming turns and obstacles. Do not focus on obstacles, rather keep them in your peripheral vision. Know what path you want to take before you even get there. When going over rough terrain and small obstacles, be light on the front handle bars, and you will smoothly roll over them.

Loose gravel can cause climbs to be very difficult

**Daunting Up hill Climbs**: Mountain bikers often say "You gotta go up to get down," and down is the best part. Those daunting uphill climbs can sometimes kill your stamina and they require a lot of power. As a beginner, you will find yourself walking your bike up some hills. That's okay. The idea is to set some goals to overcome the uphill struggles. In the beginning, you will find yourself having a hard time with midsize hills and looking back only to wonder how you thought it was hard. Here are some tips on how to master that one climb you never seem to be able to conquer.

**Plan your approach**. As you approach the ascent anticipate shifting, but do not shift too soon. Instead, take the bikes momentum up the base of the hill and shift just before pedaling is becoming strained.

Next, **stay in your seat**. Standing up may seem like you have a more powerful stroke, but standing up only burns more energy and a strong power stroke will lead to spinning the rear tire. Spinning the tires causes you to lose momentum and you will not regain it on the uphill. Becoming stuck in the middle of a hill without any momentum ensures the only way up is to get off and walk. Third, **pick a straight line**. The shortest line is the easiest way to reach a destination, and the destination is getting to the top of this dreadful hill as soon as possible. The only time you may want to get out of a straight line is to get the tires out of loose gravel. Fourth, **distribute your weight evenly** over the front and back tires. You need to keep weight on the back tires so it won't break loose, but you also need to keep weight on the front tire so you can keep a straight path up the hill. If you do not the handle bars will wobble around, like you were a five-year old riding without his or her training wheels for the first time. I know you know what that looks like. You can avoid looking like a five-year old by lowering your chin down toward the handlebars. This will distribute weight over the front tire while still allowing you to keep weight above the back tire. You will be able to maintain traction with the rear tire and the front tire will stay connected with the ground so you can steer. Finally, **keep a smooth pedaling cadence**. By now you have anticipated the steep ascent and have switched to a low gear. Now, maintain the momentum. This can be done by keeping constant tension on the back tire. The moment you release pressure on the crank is the moment the back tire will break loose and leave you stuck on the middle of a hill with no other option than walking the rest of the way beside your bike.

These two look defeated

Look out below

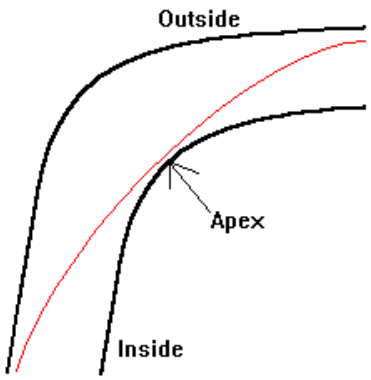
**Sweet!!! Down Hills**: Whoa. Now that you made it to the top, you have to get down. Some descents are smooth and fast, but most of them will be rather twisty or really rough from washout. So, you just made it to the top of a long climb and you are in the lowest gear. Now, you need to get back into a high gear to stop the chain from smacking against the chain-stay and possibly even bouncing off. Next, transfer your weight back with your butt hovering over the seat. Do not transfer too far back, because it will make the front tire too hard to control and can even be dangerous if you stick the front tire in a rut. Shifting your weight back will keep you from pulling an endo. That means going head over the handlebars. That is usually pretty painful, but your friends will get a good laugh out of it. Remember to crash safely and fall on your solid parts instead of your more vulnerable articulations. Keep your elbows and knees bent to absorb shock over the rough stuff. You are going to be going fast, so use the brakes intelligently. Know your limits. You can still use the front brake, but use them lightly and use the back brakes more heavily. No sudden movements, just slight adjustments will make a big deal on the downhill.


Be sure to recognize warning signs

Lean the bike over on turns

**Technical Turns**: A mountain bike turns using the body, not using the handlebars. If you try turning the handlebars while going fast around a turn you will be bucked over the handlebars or off the side. Turn by leaning the bike over while keeping your weight centered over the bike. Brake into the turn if you are going too fast or simply stop pedaling and gain control. Get the inside pedal up and apply pressure to the outside pedal, which is in the down position. Applying pressure to the outside pedal will help keep traction for the back tire, especially on off camber trails. Camber refers to the natural arc of the surface of the trail. If there is a positive camber, the trail is higher on the outside of the turn and acts like an embankment on a raceway. This turn will be able to be taken faster. On an off camber trail or trail where the inside of the turn is higher than the outside, a smaller edge of the tires will be in contact with the ground, resulting in less traction.

All corners have an apex. The apex is the middle of the turn where the bike can begin drifting back to the outside of the turn. The apex is also the point where acceleration can begin. Plan a path into the corner wide and come to the inside of the trail at the apex.



If you want another visual on how to do this, watch Superbike races on TV. Listen to the engines and watch the drivers' lines in and out of the corners. Keep in mind that the apex is not always the middle of the turn. They can be shallow or deep depending on the turns prior to and after the turn in question.

Remember that as with any sport that involves speed and unpredictable obstacles, mountain biking can be dangerous. Get out there and have fun, but remember to put safety first. Use the tips and information in this book responsibly and have fun on the trails. Mountain biking is a wonderful sport.

# BIBLIOGRAPHY

Burke, Edmund R., (2003). *High-Tech Cycling: The Science of Riding Faster.* Champaign, Illinois. Human Kinetics.

*Diamondback Owner's Manual: Multi-Speed.* Retrieved Sunday, April 4, 2004 at 2:20 PM. From: http://www.diamondback.com/pdffiles/ownersmanual_DB.ms.pdf

Faria, Irvin E., & Cavanagh, Peter R. (1978). *The Physiology and Biomechanics of Cycling*. New York, New York. John Wiley and Sons, Inc.

Pavelka, Ed. (2000). *Bicycling Magazine's Mountain Biking Skills: Tactics, Tips and Techniques to Master Any Terrain.* Printed in the USA. Rodale Inc.

Perry, David B., (1995). *Bike Cult-The Ultimate Guide to Human-Powered Vehicles.* New York, New York: Four Walls Eight Windows.

Richards, Brant, Worland, Steve, & Fisher, Gary. (1997). *The Complete Book of Mountain Biking.* New York, New York: HarperCollins Publishers, Ltd.

Strickland, Bill. (1998). *Mountain Biking-The Ultimate Guide to the Ultimate Ride.* Camden, ME: Ragged Mountain Press.

Kinematic comparative analysis of pedaling in seated versus standing cycling, Retrieved Saturday May 21, 2005 from http://www.acay.com.au/~mkrause/Cycling%20kinematics.htm

# IMAGE BIBLIOGRAPHY

www.allposters.com
www.trails-edge.com
www.mountainbikeracer.com
www.trekbikes.com
www.bikemagic.com
www.titusti.com
www.yahoo.com
www.giro.com
www.camelbak.com
www.backcountry.com
www.yakima.com
www.skisolitude.com
www.diamondback.com
www.fisherbikes.com
www.perceptivevisions.com
www.rivendellbicycles.com
www.jsmcelvery.com
www.acay.com
www.shimano.com
www.diaryofamountainbiker.co.uk
http://home.nycap.rr.com

# About the Author

Gregory M. Moore is an American Council on Exercise (ACE) certified personal trainer. He graduated from Eastern Michigan University in June of 2005 with a Bachelor's Degree in Physical Education and Health Education. Greg achieved departmental honors in Health Promotion and Human Performance. Throughout his time at EMU Greg has researched the biomechanics and history of cycling and mountain biking. He is a member of the Michigan Mountain Biking Association (MMBA), Southeast Chapter, and has been an avid cross country-mountain biker for the last 4 years in Southeast Michigan.

From Left: Greg and his Brother Dan

Gregory M. Moore
Dr. Pedersen
PHED 100
Honors-Mini Project 1
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# THE HISTORY OF CYCLING AND MOUNTAIN-BIKING

Mountain biking began for me as I was looking for an escape from the commotion of urban society. I was looking for a way to get out of the normal grind of life and take advantage of my love for being active at the same time. Mountain biking was the perfect sport to meet my demands. I have advocated the sport since I became involved in it and I am now presented with an opportunity to teach people about the history of my sport. The concept of a human powered vehicle has been around for centuries. Riding paved road bikes has been in practice since the early 19th century as a means for transportation and became a worldwide sport in the early 20th century. It is only in the past 20 years that mountain biking has emerged. It is now a growing leisure sport for the masses and has become a competitive sport for the gifted few who possess the talent. In order to properly educate you on the history of mountain biking I must first educate you on the history of the bicycle.

The bicycle was first conceived by who is believed to be an unknown associate of Leonardo da Vinci around 1493. "This bicycle is compared to the early safety bicycle that began to appear around 1885, some 400 years later (Perry, p. 6). Many two-wheeled contraptions arise in the early 19th century and become more useful through out the century as improvements are made. The first bicycles were used primarily as walking assistants and were not propelled by any machinery. They later became chain driven as

the need for more productive ways to work and provide transportation came about. The first bicycles were very awkward and dangerous to ride before the original design by Leonardo da Vinci's staff was revisited. It wasn't until around 1885 that the "safety bike" began to emerge as a safer means of bicycling. With the improvement in tire and wheel technology and the addition of brakes, bicycles were now becoming main stream. In 1896 Raleigh Bicycle Company was founded, producing 30,000 bicycles per year. "In the mid 1890's there were two patent offices in the U.S. ---one for bicycles and one for everything else (Perry, p. 37). The bicycle was now popularized and ready to be a widespread sport.

In the beginning of the 20th century cycling began to emerge as a competitive sport. Most people think of Lance Armstrong and the Tour de France when they think of cycling, but a huge portion of the history of cycling as a sport took place on a closed track. Multiple distances of sprint races took place in velodromes and eventually made its way to become an Olympic sport. "Velodromes can be outdoor, open-air tracks, semi-covered stadiums, or indoor arenas with various facilities based around the action on the track" (Perry, p. 372). The Tour de France began in 1903 and had only 60 riders, of which only 20 finished all 4 stages. The Tour now has 22 stages and travels over a distance of 4,000 Km. The Tour de France has become so popular and has such a large following that "the cost to be a stage town in the Tour has ranged from around $15,000 in the 1970's to over $1 million in the 1990's" (Perry, p.400). The Tour is now one of the most commercialized world-wide sports.

"What you and I think of mountain biking began sometime between 1971 and 1974 in Marin County, California" (Strickland, p. 4). Mountain biking became a sport

using old big-wheeled junk bikes to coast down the side of a mountain. The sport began as a group of local road racers were looking for a break from the usual grind of their training regimen. They took these "Klunkers" or "ballooners" as they called them and hammered, flew, crashed, and free-wheeled them down the hills. In fact, "the most popular route was named "Repack" because the friction generated during the 2.1 mile drop would sizzle the grease out of the bikes' coaster break hubs, requiring a teardown and repack after every ride" (Strickland, p. 4). It wasn't called mountain biking until 1979, at least 5 years after it began. "Joe Breeze, one of the original mountain bikers developed the first true mountain biking frame in 1977. He stated "People think there was some marketing genius behind the development of mountain bike, but we were just having fun" (Strickland, p. 4).

These same pioneers of mountain biking also became the entrepreneurs of developing mountain biking equipment. As they developed affection for the sport they nursed into being they were in need of equipment that would make their sport less of a burden. Gary Fisher and Joe Breeze, two of the early mountain bikers began to think of ways to create a bike that could get back up the hills that they rode down and didn't need to be fixed or replaced after every ride. Gary Fisher developed his first multiple speed bike. "It weighed 41lbs, a totally different geometry, it had a triple crank on the front, and five cogs on the back" (Richards, p.11). Breeze came out with a bike called the "Breezer" and developed the first mountain biking frame. It was lighter and more durable than the old "Klunkers" they were used to. "In the last twenty years, more development has gone into mountain bikes than in the last hundred years of road bikes" (Richards, p. 19). Today there are multiple, multi-million dollar companies who compete

to create the best mountain bikes with the latest technology. The latest frames are made out of carbon fiber and weigh only 4 lbs or are made of an alloy material that gives a soft feel over rough terrain, yet is stronger that steel and weighs in comparably. Bikes have changed from Gary Fishers 41 lbs 15- speed to the elite bikes today that have 27 speeds and weigh only 19 or 20 lbs.

Like NASCAR and Motor-cross dirt biking, "mountain biking is a race-led sport. Manufacturers use racers, races, and racing to promote and develop the sport" (Richards, p. 140). Mountain biking has even become an Olympic sport although there are many other ways to participate in competitive events, from the amateur level to the world championship level. Usually, yearly events are held at local cross country courses and are multi-lap races. "Besides the multi lap cross country events, there are down hilling, dual slalom, trials (obstacle riding), 24 hour races, triple-digit-mileage endurance events, stage races like the Tour de France, and other types of races" (Strickland, p. 5). No matter what your interest is in the sport there is a way for you to get involved. Organizations such as the Michigan Mountain Biking Association (MMBA) will have information about events and they will also have information about local club rides you can join.

"The "mountain bike" tag is something of a misnomer for many of today's riders, but it's a tag that stuck for obvious reasons" (Richards, p.12). Most people think of the recreational riders who ride at local state parks and local parks. These trails are not really mountains, but they are cross-country trails with rough terrain that could not be passed on any other type of bike. Mountain biking has become such a popular sport that new county and city parks are opening up just because they have the correct terrain and area

for mountain bikes. The mountain bike has also become the most popular bike for a young child to own, it has multiple gears and is very durable. In fact, "Today, more than 8-million mountain bikes are sold per day in the U. S. alone" (Strickland, p. 4). This popularity is staggering, considering the mountain bike was only developed 3 decades ago. The recreational sport is becoming more popular every year as people are seeking for new, fun ways to stay in shape and have a good time.

If you are looking for a recreational activity or if you are looking for an exhilarating competitive sport, mountain biking provides it all. As a recreational activity you will experience the relief of getting out of the grind, you will get an unrivaled aerobic and strength workout, you will begin to feel an accomplishment as you improve at your sport, comradery from your fellow mountain bikers, and a stress relief derived from the excitement of the technical terrain. As a sport you are looking at a challenge that is affordable and prevents a competitive outlet for those who are not talented enough to perform a competitive team sport. Either way you choose to get involved in mountain biking there is a worldwide arena, which provides you with opportunities for adventure and vacations. There has never been a better time to begin mountain biking, the sport is growing and there are more and more ways to get involved.

# WORK CITED

Perry, David B., (1995). *Bike Cult-The Ultimate Guide to Human-Powered Vehicles.* New York, New York: Four Walls Eight Windows.

Richards, Brant, Worland, Steve, & Fisher, Gary. (1997). *The Complete Book of Mountain Biking.* New York, New York: HarperCollins Publishers, Ltd.

Strickland, Bill. (1998). *Mountain Biking-The Ultimate Guide to the Ultimate Ride.* Camden, ME: Ragged Mountain Press.

# PERFORMANCE CYCLING
# MECHANICAL ANALYSIS

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# PERFORMANCE CYCLING MECHANICAL ANALYSIS

Since the mountain biking phenomenon began in the 1970's, tons of innovations in biking technology have come about. From frame materials and geometry to suspension and mechanical parts the need for a more durable and biomechanically efficient bike became evident with the new extreme terrain and quick grade changes of mountain biking. In fact, "In the last twenty years, more development has gone into mountain bikes than in the last hundred years of road bikes" (Richards, p. 19). There is however much more research on the mechanics of road cycling than there is on actual mountain biking terrain. In this mechanical analysis I am going to attempt to use the information available on cycling to focus on the benefits for cross-country mountain biking.

There are multiple considerations when fitting a person to a bike. Frame size, seat position, handlebar placement, width, and height, brake lever reach, and crank-arm length are some of the factors to consider in assuring optimal performance. I will discuss frame size, seat position, and crank arm length. These are the factors of bike fit that effect a biker's performance most.

## Frame Size

Choosing a frame size that fits the mode in which you will use your bike. A larger frame size in comparison to your body size is appropriate for riding on smooth pavement and is more comfortable. Choosing an intermediate frame size is optimal for those who plan to use their mountain bike off-road but do not plan to do aggressive riding. Frame size is

particularly important on rough, technical terrain and for those who plan on using their bike to compete or for aggressive riding. A smaller frame size will allow you to be more agile and make easier weight shifts. Smaller frame size is also safer for aggressive riders. "A bike which you ride only on paved surfaces and never take off-road should give you a minimum stand over height clearance of five centimeters. A bike that you'll ride on unpaved surfaces should give you a minimum of seven and a half centimeters of stand over height clearance. And a bike that you'll use for real mountain biking on difficult, rough terrain should give you ten centimeters or more of clearance" (Diamondback.com).

Saddle Position

There are three directions you can move a saddle; forward and backward, up and down, and upward and downward tilt. "Small changes in saddle position can have a substantial effect on performance and comfort. Only one directional change at a time, and only a small change at a time, should be made to your saddle position" (Diamondback.com). Saddle angle is important for comfort and will adjust depending on your body position on the bike. Having a correct saddle position will minimize the amount of blood flow occlusion. The front and back adjustment should be adjusted after the handlebars are adjusted to the correct height and to optimally adjust weight over the back wheel. Frame size will be a factor and a frame should have already been chosen with the correct top tube length. Saddle height is the most important adjustment of the saddle to pedaling cadence. "Optimal Saddle height for cycling has been estimated on the basis of power output" (Burke, p. 72). Greatest efficiency in oxygen consumption and has been found to be when the leg is allowed to extend almost fully. There are several methods for estimating optimal saddle height. One requires the cyclist to mount the bike with his/her

heels on the pedal and pedal backwards, adjusting the seat to the highest point where the heels stay on the pedal without the hips rocking from side to side. Two more common methods require the cyclist to measure their inseam while wearing the shoes they will be wearing while riding. In one of these methods you multiply by 109% to get the distance from the middle of the crank arm to the top of the saddle. The other requires you to multiply by .883 to get the distance from the center of the bottom bracket to the top of the saddle.

Crank-arm Length

Crank-arm length is suggested to be chosen due to the height of an individual. "The consensus is that crank arm length should match the cyclist's leg length. The standard crank arm length of 170mm suits cyclists of average proportions between 5 ft 5 in. and 6 ft. Shorter cyclists should consider crank arms of 165 to 167.5mm. Cyclists under 5 ft should consider 160mm crank arms. Cyclists 6 ft to 6 ft 2 in. might try 172.5: 6 ft 2 in. to 6 ft 4 in. should try 175mm crank arms: taller cyclists should try 180 or 185mm crank arms" (Burke, p. 84).

Cadence can be defined as "rhythmical flow" or "harmony and proportion in motions." The term pedaling cadence refers to the rhythmical pattern in which we apply internal force to the pedals to create torque of the crank which is in turn applied to the ground through the tire. Force distribution, angle of applied force, and net torque of the two legs are all important aspects of pedaling cadence. Force distribution is the distribution of force over the course of one revolution of the crank arm. To optimize the transfer of torque to the road it is important to smooth out the force distribution. "The maximum force is usually reached at about 120 degrees- that is, about 30 degrees past

horizontal" (Faria, p. 92). The force is usually far greater between 60 and 120 degrees than it is between 0 and 60 degrees and 120 and 180 degrees. In fact, very small forces are usually applied to the pedals during these portions of the revolution. Even for skilled cyclists the perception of a smooth and even force distribution is false. Force should only be applied in the first 180 degrees of revolution and the following 180 degrees should be a rest period while the contra lateral side is working. This brings up the concept of net efficiency. In order to find out how efficient you are being in applying force you have to subtract the negative force applied from the trailing, or resting leg from that of the leg exerting force during the power stroke. The last factor in pedaling efficiency is the angle of applied force. Exerting a larger force on the pedals in not the only answer in fact "if you carry one idea with you from this report, let it be this one: you may be exerting a larger force on the pedal than any known cyclist before you but, unless the force is in the right direction, it will not necessarily result in larger propulsive forces at the wheel" (Faria, p. 92). The optimal angle of applied force is perpendicular to the crank arm. This is where you will get 100 percent efficiency from the force you exert on the pedal. Moving even slightly away from perpendicular will affect your efficiency greatly. It is a fact however that our body not capable of bending in a way that allows us to constantly apply force perpendicular to the crank arm, but bending your lower body segments in the proper order and fashion will allow you to optimize your pedaling technique to your own ability.

"Roughly speaking, the intensity of cross country mountain bike races are similar to that of time trials or mountain ascents for the best road cyclists, that is above 90% of the maximal heart rate" (Burke, p. 116).Mountain biking requires many demands for

short bursts of energy and sudden changes in pedaling cadence. Mountain bikers have to constantly avoid obstacles such as rocks, ruts created by washed out trails and technical turns. "Because of these constant, abrupt variations in power output, optimal cadence might vary considerably during the race" (Burke, p. 116). It is very difficult to recommend an optimal pedaling cadence for mountain bikers although some of the aspects discussed in the previous section can be applied to cross country mountain bikers. Proper force distribution, angle of applied force, and net torque are skills that can all be practiced and mastered to benefit riders on even the toughest terrain.

From reading through this mechanical analysis you will find two major issues covered on cycling. Fitting an individual to a bike and proper pedaling technique are likely the most important factors to consider when beginning to cycle. Having the proper equipment and expending your energy in an efficient manner are the key points that are emphasized. IT is also important to remember that mountain biking presents many different, unpredictable factors that road cycling is not concerned with. Noting that a smaller frame size is recommended for aggressive off road riders and that no "optimal pedaling cadence has been recommended for mountain bikers is an important note to take when reviewing this report.

# WORK CITED

*Diamondback Owner's Manual: Multi-Speed.* Retrieved Sunday, April 4, 2004 at 2:20 PM. from http://www.diamondback.com/pdffiles/ownersmanual_DB.ms.pdf

Burke, Edmund R., (2003). *High-Tech Cycling: The Science of Riding Faster.* Champaign, Illinois. Human Kinetics.

Faria, Irvin E., & Cavanagh, Peter R. (1978). *The Physiology and Biomechanics of Cycling*. New York, New York. John Wiley and Sons, Inc.

Richards, Brant, Worland, Steve, & Fisher, Gary. (1997). *The Complete Book of Mountain Biking.* New York, New York: HarperCollins Publishers, Ltd.