

Welcome to the Nordic Skiing Technique.

We would like to take a moment to explain in the introduction, where this DVD fits into the xczone.tv product line, the nordic skiing project, and the science of nordic skiing series. Then, we will give you an idea of who the target audience is, provide a guide for viewing the material, a background for the evolution of modern nordic skiing, and an idea of who we are, our philosophy for the progressive nordic skiing method.

In the context of technique, we will establish the building blocks for skill development, train your eye to observing good technique, explain the paradoxes within the sport, and ground you in applied biomechanics.

The primary chapters delve into the fundamental techniques under classic, skating and downhill skills, with an introduction to the most advanced moves.

## NORDIC\_SKIING\_PROJECT

The Nordic Skiing Project is the most comprehensive library ever produced for nordic skiing. It is delivered in a progressive series of DVD's starting with beginners learning to nordic ski; followed by an in-depth examination of the sports science; art and history of nordic skiing for aficionados. It is the essential owner's manual for every nordic skier, and an enduring product in a box, for the price of a ski lesson.

Every DVD in the series provides a highly interactive toolkit; using menus, multiple viewing angles, alternate audio tracks, and subtitles. The DVD-ROM features also include: technical manuals, multimedia explanations, critical and alternative analysis, bio-mechanical modeling, narrative scripts, hyperlinks to on-line resources, MP3 audio books, a photo gallery, behind the scenes footage and bonus movies.

The project has been undertaken with the utmost of care and the highest professional quality production using expert resources, talent and broadcast facilities.

xczone.tv uses only Certified Professional Skiers for films and instructional DVDs.

The Nordic Skiing Project recognizes and appreciates the involvement of stakeholders in the Nordic Skiing community including: the Canadian Association of Nordic Skiing Instructors, Cross Country Canada, Biathlon Canada, the US Ski Association, the Professional Ski Instructor Alliance, the Federation Internationale de Ski, the International Olympic Committee, key athletes, coaches and instructors. The script was provided to all skiing associations and was posted publicly since June 2004 with a Request for Comment. By the time of publication we have received and incorporated much valuable input from a number of reputable sources.

## THE SCIENCE OF NORDIC SKIING

The "science of nordic skiing series" addresses: technique, training, equipment and advanced moves in four volumes. These series are intended for intermediate, advanced and expert level skiers, coaches and instructors.

## TECHNIQUE VOLUME

The technique volume in the Science of Nordic Skiing series represents a clear view to the most current understanding of technique and instruction. The project has engaged key principals, elite skiers, recognized experts and thought leaders in the sport; consolidated their ideas and arrived at a progressive and highly effective approach to the technique which you can apply directly to your skiing.

This is a professionally produced instructional DVD using World Cup and Olympic athletes, which was rehearsed on a closed set for the best technical quality. If you are simply looking to license or purchase race footage, then contact the International Olympic Committee or the Federation Internationale de Ski. These organizations own all the rights to all Olympic or World Cup Footage respectively. Buying pirated race footage is illegal and it hurts both the athletes and the ski industry.

xczone.tv supports all the athletes in our films.

## TARGET AUDIENCE

We have provided a number of products for various skiing levels. It is important for a skier to have a fundamental grasp of the basics explained in the "Learning

Series" before effectively applying the more advanced concepts addressed in the "Science of Nordic Skiing" volumes. The technique that an elite Olympic skier employs is not directly obtainable by novices. A skier must move through various stages with drills and learning progressions that are characterized by deliberate, well-emphasized and easy-to-grasp mechanics, before eventually stripping the movement down to subtle, fluid, and minimal elements - ones that are difficult to observe. As a skier, you have to make a decision whether you want to move in a manner that is either the easiest or the fastest.

## VIEWERS GUIDE

Nordic skiing technique requires practice and best under the guidance of a competent instructor, coach... or ideally, a mentor.

The viewer must also realize the challenge in presenting something as complex as Nordic Skiing in a complete, yet concise manner, within the scope of a video or book.

All technical assessments made from either video or photographic imagery need to take into account distortions owing to the position and angle of the camera. The central perspective is critically effected by the lens selection, frame rate, aperture and focal length. Serious interpretative mistakes are made by skiers, coaches and instructors based upon the most recent World Cup television broadcast footage or photos placed in magazines to illustrate points.

For this reason, we have relied on re-shooting elite world cup skiers outside of a race environment and on a controlled set. We are also able to achieve a far superior quality in the footage and a precise biomechanical picture.

More specifically, photography or video is generally not geometrically accurate or planimetric, owing to plane and angle, radial or relief displacements. These images require restitution before you should attempt to draw conclusions regarding biomechanical angles or positions of the skiers. Photography that is plainmetrically correct is known as an orthophotographic image.

Similarly, we have chosen our words carefully, and have kept the explanations succinct, rather than providing long-winded and overly-technical rambles, which are unworkable for the skier. In our experience, brief phrases are needed to

capture the essence of the technique.

Given the inherent limitations with the language, we have also sought to minimize any ambiguity through extensive public consultation and collaboration with leading authorities in the sport. The skiers chosen to demonstrate technique possess attributes consistent with the level of skill being presented. That is to say, Olympic or pro-elite athletes would be used to show advanced skills whereas intermediate level skiers may be chosen to depict learning progressions.

This Nordic Skiing Technique DVD is a key resource for beginner and experienced skiers, coaches and instructors looking for clear, correct and easy-to-understand guidance for improving their Nordic Skiing technique.

The theory and application depicted in this DVD are carefully aligned with current and evolving doctrine.

## EVOLUTION

Have you been confused about technique and various schools of thought? Let's start talking about the evolution of technique from the beginning...

Over the years, coaches and elite skiers have searched for the most efficient skating technique. To some, efficiency meant speed with the least effort, whereas to others efficiency means tackling terrain with the least amount of effort, irrespective of speed. At times, some schools pursued a method that involved too much side-to-side motion, rotation, and a prolonged upright unassisted glide phase. Conversely, other schools emphasized a restricted straightforward motion that did not allow enough weight transfer or athletic coiling or rotation to skate powerfully. This DVD will hopefully show where skating, in particular, has evolved.

It is neither new nor revolutionary, but up until recently, there has not been much in the way of up-to-date technical material available on the market published by elite skiers who are fresh off the World Cup circuit.

## WHO WE ARE

Just so you appreciate...

The producers behind this DVD are real skiers. Between them, they have raced

2 Olympic Games and 200 World Cups; winning 7 medals, including one Gold. Each of them holds past National Champion titles. Lise is a sports physiologist and educator and David is a practicing biomechanical engineer. Together, they have mentored thousands of people to ski to their potential - including Olympics dreams.

xczone.tv is one of the most trusted sources of skiing knowledge.

## PROGRESSIVE NORDIC SKIING TECHNIQUE

Before proceeding, it is worthwhile explaining the difference in ski skating philosophies.

The methodology taught on this DVD is that of progressive nordic ski skating technique. It emphasizes a more direct, simple and efficient motions, based upon key skiing fundamentals of: body unity, symmetric form, coordinated timing; with blended pull, push and glide phases. The propulsion comes from a decisive weight transfer onto a flat glide ski assisted by preload, the first phase of the double poling motion and an unweighting push of the free leg edged only so much as is necessary to transfer power without slipping. On uphill, the skier may feel as if his ski is flat as it is placed on the snow, but the cant of the hill caused the edge to be the first part of the ski in contact with the snow. The weight is on the heel to mid-foot. A skier's orientation is predominately in the intended direction of travel while conceding some twisting to assist weight transfer in the initial stages of the cycle. The emphasis changes from beginner to expert; a typical beginner who straddles the track stiffly is locked in a forward-facing position and will have to try to twist more and rock more aggressively over each ski. Whereas, an expert, who already has good weight transfer, will concentrate more on a motion this is directed down the track. Weight shift from ski-to-ski is accomplished, more through movements of the lower body, core and hips. In the first phase of the arm movement, the weight is applied onto both poles to the snow at the same time. The arm pull is driven by force of weight, abdominal and back muscles before finishing with the pull and then push by the arms.

## OLD SKATE

By contrast, older ski skating technique, which was taught in the early 1980's, placed too much importance on full body twisting, asymmetric movement, an independent timing of arms, continuous edging and pushing without glide phases. The body is completely orientated perpendicular over the pushing ski at all times as the nose, head, hip and knee align fully over the tip of the ski. The skier never faced the intended direction of travel down the trail; opting to twist quickly from facing towards one side to the direction of the ski on the other side. The ski was ridden on an edge with the skier's weight on their toes. Weight transfer was accomplished by rocking the upper body side-to-side with an aggressive push backward. Where the upper body is concerned; there is a clear distinction between a prominent hang-arm and cross-body push-arm. Force is applied to the poles sequentially, one pole plant at a time, using only triceps. This is still a stage that most people will need to go through, but should not lock into, if they wish to progress.

Don't worry about grasping all of this now. We will cover everything carefully throughout the DVD program.

## THE BUILDING BLOCKS FOR SKIING

Physical conditioning, mental preparation and equipment are important variables affecting the outcome of any skiing experience.

Proper technique is just as vital, and is the subject of this DVD. We also consider the influence that physical attributes, such as speed and power, have on the application of technique.

Skill development starts with an early emphasis on balance, proper form, structure, weight shift, gross-motor coordination and timing, in the basic movements. It is important to develop a solid structural base and to grasp some fundamental movements before progressing to more complex techniques, difficult terrain and situations.

Technique requires that the skier to take most efficient line between a finite number of optimum positions, which are adapted to the terrain and conditions in a predicable manner.

If skiing is analogous to the notion of learning a language, then the fundamentals are the alphabet, words, and grammar from which someone can build sentences. Too often, skiing is taught like memorizing common phrases from a tourist guide for given situations. Similarly, people use big words and long sentences when little ones work better.

The DVD streamlines the learning process using smart progressions and drills that are guided with clear demonstrations of the interim stages of development, leading to most experts' view of what constitutes ideal technique.

Just a cautionary note: Drills are an excellent means of isolating components from a full skiing motion. However, they should not become the focus of your skiing. Often drills come with their own idiosyncrasies and over-emphases.

Drills are useful when they can decompose complex technique into easier to grasp constituent movements, isolate an aspect of a given technique for training, or to facilitate clear progressions. Drills are less useful when they are more complex than the actual skiing techniques, grossly overemphasize or change the correct skiing movements, or introduce additional errors. Every drill tends to be

an exaggeration, deviates from correct technique and has an anti-drill pair to balance out the induced errors. In other words, every drill brings with it, its own baggage. Remember, the purpose of skiing is to ski down the trail most efficiently, and not necessarily to gain proficiency in a plethora of drills. For this reason, the only drills we use are perfect techniques in their own right. They are: double poling, free-skating, diagonal-skate and marathon skate.

It is preferable that a skier take to the trail, empowered with simple technical solutions that can be readily applied and relied upon, over-and-over-again, in every situation, rather than to be burdened with sorting through overly complex prescriptions for all contingencies.

It is possible to decompose nordic skiing technique into a manageable number of fundamentals from which more compound moves are built. Sophistication comes with mastering the basics rather than adding complexity to a movement.

## OBSERVING SKIING

Skiing is a matter of carrying your center-of-momentum down the trail with the least amount of energy, the most control, as quickly as you wish, given your present level of conditioning.

Viewers are cautioned about coming to conclusions of proper technique based solely on observations of skiers on video or in real life. It is equally important to identify with the skier by listening to what they are trying to do, and how it should feel.

For example, someone can observe that there is always some degree of angle or edge associated with the ski in skating. However, it would be an error to deduce that the idea behind skating is to always ski on edges. On the contrary, the skier attempts to ride a flat ski and only conceded as much edge is necessary to brace back-slip resulting from a decisive forward weight transfer.

Similarly, it is difficult to determine what muscles are stretched and which ones are contracted in a movement purely by watching, without the benefit of an expert skier telling you.

We will endeavor to point out common observational errors as skills are



demonstrated throughout the presentation. Explanations will describe what it feels like to do correct technique. However, less adept skiers may have to overdo a motion to feel it.

## PARADOXES IN SKIING

Paradoxes exist within the technique of any sport. There is always a balance between opposing actions or concepts. In skiing, there exists both push and glide, edge and flat, stretching and contraction, straight line motion and angulation. Weight shift is accomplished by both positioning your body over top of your ski and as well as placing your ski under your center-of-gravity - it is a bit of both. You can not approach nordic ski technique with black-or-white thinking.

If there is a perfect way of doing something, there are an infinite number of ways of doing it wrong; half of which are a matter of too-little and the other half, perhaps too-much.

The key to harmonizing seemingly contradictory approaches is to apply the appropriate mix, given the immediate circumstances. The application of technique for the situation, remains one of the most significant factors contributing towards efficient skiing. Using offset technique when conditions are too fast, like a downhill, is an example of the perfect technique applied to the wrong circumstance.

The majority of instruction focuses on textbook technique. But, in the real world, circumstances are never ideal. So, there needs to be adequate adaptation of fundamental biomechanical principles.

## APPLIED BIOMECHANICS

Proper skiing technique is simply a matter of applied biomechanics. Good biomechanics is universal; regardless of the sport.

Properly applied biomechanics is largely a matter of optimization. Technique training and skills development, for an elite skier is a departure from pure theoretical academic study into the field and applied biomechanics. Laboratories staffed by non-skiing researchers have never been able to adequately interpret real-world situations, nor capture the body of knowledge, intuition and kinesthetic perceptions of an elite athlete. It is just not something you can bottle, nor can we talk people into becoming good skiers. Skiers develop skills best when they are shown, through a mentored process that permits imprinting of good form and timing.

Skiers must concede some force in directions other than strictly where they want to go, in order to get friction or leverage - it is a necessary evil. A proportion of the reactive force set onto the ski is applied to the intended direction of travel.

The purpose of life, the universe and everything for a skier is to create efficient and sustainable propulsive forces and velocities that are translated through skis and poles to the snow.

You do not need wild motions to generate this skiing energy. The truth is that there are limited positions in good skiing. Elite skiers move between fundamental positions by the most efficacious path. Whereas, neophytes tend to make exaggerated movements, along indirect paths, to inconsistent and awkward positions.

## THE FUNDAMENTAL TECHNIQUES

You should now have a good understanding of where this DVD fits into the xczone.tv product line, the nordic skiing project, and the science of nordic skiing series. You should know whether you fall within the target audience and be able to manage your own expectations. We have presented the background for the evolution of modern nordic skiing, who we are, and the progressive nordic skiing method. With the building blocks for skill development, an explanation of the importance of applied biomechanics, we encourage you to train your eye to observing good technique in a critical fashion.

Keep the concepts that we have discussed in the back of your mind, as we now want to explain in detail how to execute each one of the fundamental techniques of Nordic Skiing.

At this point, you should have at least a rudimentary skiing ability, or have studied the "Learning to Nordic Ski" DVD series, because, from now on, we want to introduce you to a fresh approach to skiing and lead you towards an expert level.

The next chapters cover: Classic, Skating and Downhill Skills as well and an introduction to highly advanced moves.

Let's start with the common skill of: Double Poling and the Classic Skills of: Diagonal Stride, Step Double Pole, and Herringbone.

## DOUBLE POLE

Double poling is one of the fundamental techniques used in classic and skate skiing.

Keep in mind that, the propulsion in the double pole is achieved by applying your weight onto the poles, initiating with a pull and transitioning to a push.

Sport specific technique studies undertaken by the IOC medical council emphasizes that: a stretch and shortening cycle of leg and arm muscles enhances both kick and poling power in all techniques.

Too often, skiers start by pushing their body up with tense arms, thus arresting the movement and preventing adequate weight transfer.

Double poling is often used on flats and slight hills, or in a drill designed to isolate upper body coordination or build ski specific strength. Double poling is the fundamental upper body motion used in ski skating.

The components or phases within double poll are: the Planting of the poles, the weight assisted pull, a trunk and shoulder rotation, a final push, follow-through and the recovery.

Begin at the ready or upright position, with a slight lean forward. The hips must be pressed forward and locked into position. The hips and abdominals lead the motion from the core. The arms should be shoulder width apart and are bent 90 to 120 degrees. The poles are near vertical and the tips will naturally fall beside, or slightly ahead of the ski bindings; depending upon the terrain. The hands remain relaxed on the pole grip.

Movement is initiated from the hips with the force of the abdominals, which bring the poles down to the snow.

The arms and shoulder joints remain locked through the first phase of the motion.

Apply your body weight onto the poles, using first your stomach then back muscles to drive the pulling motion.

Do not collapse the arms.

Rotate forward and down at the mid-section keeping your legs nearly straight or with a relaxed nominal bend at the knee.

Respect and maintain the proper angle of your arms through the first phase of the pull. You should feel as though your lat muscles are being stretched as you hang on the poles.

The abdominal muscles contract and you should feel the power come from the core and radiate from the larger muscles in the upper body to the stomach, back, shoulders and arms respectively. Keeping the hand grip relaxed, will help focus the power coming from the core, assisted by your body weight.

You can gain measurable power from the arms and back when they switch from being stretched by the force of weight on the poles, to being forcefully contracted midway through the poling motion.

The pulling component fades and the push component increases as it becomes no longer practical to apply your body weight directly on the poles. The poles take the most direct and simple line, along the body and will end up passing beside the knees. Drive down and back with your elbows by rotating at the shoulder, only when your torso has completed the majority of the work. The arms extend and the poles go straight back; nearly parallel to the skis and snow surface. Your back may also be approaching parallel to the ground but no further. Typically, in skating, your upper body will not go down so far.

Finish the movement by extending and relaxing the arms, hands, and the fingers. The duration of the glide and tempo may vary depending on snow conditions.

At high speeds, such as sprinting, emphasis may be given to rotating the shoulders powerfully, rather than completing the arm extension at the elbow. In the interest of high-tempo, the triceps may add little force compared with a more frequent turnover using bigger muscles.

The timing is such that the upper body finishes its downward arc just as the arms have extended. The body starts and finishes one cycle of movement; from one position, to another, as one unit. Motion should be continuous and well timed.

Again, all motion originates from the center and progresses outwards; from big joints to smaller joints; starting with big muscles and finishing with smaller ones. All upper body movement in skiing follows this rule.

To recover, you reverse the order of the movements, in a smooth and direct motion. The hips drive forward and the body begins to extend near upright to make room for the hips. At the same time, the arms bend back to approximately 100 degrees and the elbows drive forward directly with little to no swing. Envision the whole phase as a linear motion forward rather than swinging upright.

You should now be in a ready position slightly leaning forward, hips engaged, arms bent and set for another pole phase.

One of the most significant errors in the double pole is to grip the handle tightly and lead the whole motion with only the arms without bearing weight onto the poles. So, remember to keep the hands and arms relaxed in the first phase of the poling motion. In particular, use the torso to bring the poles down to the snow. Lock the position and angle of your arms and use your body weight to drive the poles down. Pushing with the arms too early has the effect of arresting the whole motion by pushing you back up when you want to go down.

By fighting yourself isometrically you may get a workout, but you won't go very far.

In double poling it is most important in that the hips drive or press forward through all positions.

The legs remain fairly straight on pole plant without locking the knees. There will be a much more pronounced bend in the knees and ankles during acceleration or climbing. In either case, a "fall forward" upper body attitude is adopted, to easily apply body weight onto the poles. The hips, stomach, back, shoulders, elbows, arms and wrists work respectively to complete the double poling motion.

The arms should remain bent at 100 degrees on the pole plant for flats and as sharp as 90 degrees during acceleration or climbs. Whatever the optimum angle for the terrain, it needs to be respected throughout the first half of the poling motion. Novice skiers often collapse or straighten the arms prematurely.

The upper body bends to approach a parallel position with the snow on flat terrain. The difference between upright and down on a hill may only be a few degrees driven by a stomach crunch.



## DIAGONAL STRIDE

Diagonal stride is unique to classic or traditional technique and is used on the greatest variety of single track terrain.

The basic mechanics at the early stages can look a lot like walking with a glide, aided by poles for balance. This allows pretty much anyone an entry into nordic skiing regardless of coordination or fitness level. However, the diagonal stride technique is easy to do poorly.

The movement of diagonal stride involves a leg push from one ski, weight transfer and glide onto the other ski. The motion is assisted by opposite arm poling. This poling action is similar to double poling except the arms work individually and alternately with the legs; simplistically like the natural motion of walking or running.

Balance and weight shift are priorities for diagonal stride. The skier should be committed onto only one weighted foot at a time.

The middle of hips is over the toes in the transitional moment between strides. A useful adage is to "fall forward tall," where the trunk should be reasonably upright and not crumpled over. Avoid bending at the waist. The hips should drive forward on the glide ski during the push, without over-twisting the upper body. Notwithstanding, there is a slight twisting of the hips that is the result of a natural athletic motion. The hips move further ahead as the steepness of hill increases. The hips should be pressed or locked forward to provide the best core position. Often bobbing occurs when the hips drop in and out of position. The foot can sneak ahead of the shin on the glide ski, which lines up under the chest. The skier glides with the foot under the shin, the toes under the point of the knee, and most importantly, the heel just under the front of the hips. The hips maintain a forward position at all times. The angles at the ankle, knee and waist are all similar.

The returning ski is placed flat on the snow and is weighted when the recovery foot is in front of gliding foot. The heel presses down onto the ski when the recovering foot is ahead of the gliding foot. The weighted ski is generally not edged in diagonal stride except during sharp turns. The recovery foot should line up under the chest to have a good grip for the push-off. A full extension of leg at the end of push is also important. At this position, a straight line can be drawn through the upper body and leg. There should be no slapping of the skis when

returning the leg onto the snow.

The returning foot must drive through past the kicking foot and is placed just ahead of the kicking foot, but not too far ahead, or the skier's weight and the hips will fall back.

The motion of the push-off and glide of each leg should be balanced in timing, force and stride length. A preload of weight occurs at the beginning of the push. The height should be the same on either side in the end of the push position.

Hips should be over the foot when you are transitioning to kick, and forward during kick phase. Keep this forward hip pressure. The leg push should not be held too long, or occur too late past the center of gravity, so as to cause the hips to sit back or fall behind.

If positions and form are correct, the pole should plant near the ski binding and angled slightly backwards.

The shoulder reaches forward as the weight is committed on the pole plant and the hand is kept relaxed below shoulder height. The arm is bent slightly on plant. The arm pendulum motion is shorter on steeper terrain.

While maintaining this ideal 90-120 degree angle in the elbow, the shoulder rotates to bring the arm under the chest, before the tricep muscles first engage to straighten and extend the arm. The pole is released by the hand in a full extension.

As in all poling, the core and body weight shift first, followed in order, by large back muscles and secondly the triceps. Avoid too much twisting, dipping or rotating of the shoulders. Just use a natural reach and athletic movement.

The arm recovers by the most direct means forward returning to a bent ready position. Brush your body with your elbow to help you learn to take the shortest line forward.

The arm must pendulum forward with the hand passing the thigh in a direction forward down the track. The drive helps to set the wax and generate momentum down the trail.

The components of the diagonal stride are the Push, the Weight shift, the Glide and the Leg Recovery.

The kick referred to in diagonal stride is not a kick in the strictest sense of the word. In skiing you want to momentarily compress your ski onto the snow by bending at the knee and ankle and the ski passes underneath the center of gravity. So that you get sufficient grip to move your body forward of that position by pulling back with your ski. The skier feels the weight and compression on the heel and rolls to the ball of the foot during the push. The maximum compression occurs when the ski passes underneath your hips. By the time, the weight is on the ball of the foot, the kick is over. Pushing off the toes is often too late and results in back-slip. This is sometimes referred to as late kick.

You will want the snow to remain on the ground and your body to glide over it. Think about moving yourself forward, rather than pushing one leg back. The “kick” is like a little “pop-step” forward from one foot to the other.

The kick and opposite arm poling actions occur together. It is important to use as much upper body weight as practical and not to rely on the arm muscles to do all the work. The arms travel front to back and return by the most direct means.

As the hip aligns over the glide ski, the pushing-ski-side rotates towards the trajectory of the glide ski, such that the hips have a slight flexibility or athletic twist, while striding and orientated predominantly in direction of travel. The power comes from the hips and facilitates a full weight transfer. All movement is forward but some twisting can result.

The, now trailing leg, can extend when the weight-shift onto the new glide leg has taken place. While one leg is gliding and carrying all the body weight, the other leg extends back and relaxes momentarily.

There should not be any break in the motion. The trailing leg recovers forward at the moment that the front glide leg begins to compress down onto the snow and pull back.

Skating is up to 25 per cent faster than classic.

## STEP DOUBLE POLE

The kick double-pole fills in the gap between double poling and diagonal stride. A skier can also use step double-pole as change from double poling or extend it into a steeper hill. Step-double-pole can also substitute for diagonal stride on many hills. Doing step-double-pole a skier can extend their reach past that which they could get in a double poll technique because they are counterbalanced by their extended trailing leg.

Step-double-pole, generally, cannot match tempo of double poling.

The timing of this technique starts with a double pole. As you recover from the double pole, perform a leg push. As the poles and arms extended forward in preparation for the double pole plant one leg will have extended. Meanwhile the other glide-leg, extends to the forward position.

The rear-leg recovers forward, and the legs come back together as you begin to commit your weight onto the double-poling-pull. The leg-push and pole recovery, occur in one clean motion.

The foot of the leg that pushes, can start the pull slightly ahead of the other foot. The hips should feel forward to bring the center-of-gravity over the ski but the glide foot is a little in front of the hips.

It is not just a matter of letting a leg fall back. There is a very active “kick” involved in this technique. The kick is timed with the forward swing of the arms that follow from the double pole.

## HERRINGBONE

As the hill steepens, the skier may have to widen the “V” made by the skis and edge them more and more to prevent back slip. At a certain point there is little glide left in the technique and it is all about climbing. Note: it is not legal to glide while herringboning in a classic race.

Place one step at a time, keeping the weight mostly on the mid-foot or roll to the balls of the feet at higher tempos. The power in herringbone comes mostly from the legs but the poles assist the motion. The baskets are placed beside and behind the bindings.

We have shown you the common skill of: Double Poling and the Classic Skills of: Diagonal Stride, Step Double Pole, and Herringbone. Now let's move on to skating. You'll see that many of the concepts are exactly the same.

## SKI SKATING TECHNIQUE

In this chapter we will cover skating skills and techniques including the:

Free Skate;  
Marathon Skate;  
1 Skate;  
2 Skate;  
Diagonal-V;  
Offset;  
Skating Turns; and  
Skating Progressions.

The fundamental positions and movements of all ski skating techniques are essentially the same. Where they differ, is in timing and the preferred application to terrain. Skiing techniques are akin to the cross-over points seen between walking and running.

In the past, there has been an over-emphasis, by some, on always getting the nose, head, and knee over the tip of the weighted ski while twisting the upper body entirely to orientate in the direction of that ski and away from the intended direction of travel. Early attempts at skating technique in racing, enforced side-to-side rocking to propel weight-shift.

Although this is a very useful, and often necessary, drill in forcing novice skiers to apply their weight over the ski, the side effect is often excessive twisting motion and overemphasis on head initiated weight-shift rather than core or hip established movement. Eventually, as a skier progresses, the instructor must try a moderate excessive twisting or rocking motions.

There will always remain some twisting and rocking to assist weight shift but it should not dominate the movement in advanced skiers. Emphasis here should be on precise position and movement of the core.

Current thinking in progressive skating methods, as articulated by elite skiers, exhibits minimal twisting, rocking and edging - optimized or limited to only that which is strictly necessary.

This practical experience of elite skiers is corroborated in recent biomechanical studies. The biomechanics of the top 20 cross-country skiers for all the World Cup Races in the last five years were analyzed to determine the degree to which they rotate towards the weighted ski, in the initial setup of the skating stride. As expected, the greatest rotation was exhibited on the steepest climbs during long races.

Imagine that the rotational measurement of zero per cent represents a body position orientated straight down the track, and a figure of 100 per cent indicates a complete rotation of the nose-head-shoulders-hips and knees in the direction of the ski.

The research shows clearly that, the maximum average rotation of elite skiers on steep hills on the World Cup Circuit of the last five years is 62 per cent for men and 75 per cent for women, to within 2 per cent error, 19 out of 20 times. It is important to note that this rotation only occurs in the first three-tenths of a second after the pole plant before moderating to zero percent for the majority of the skating cycle.

Furthermore, the maximum average rotation of elite skiers on the flats is 8 per cent for men and 14 per cent for women, in the first three-tenths of a second before moderating to the center.

During high speed sprints, the absolute rotation never deviated more than 2 per cent from a straight-ahead orientation, for all finalists.

This definitive measurement of rotation amongst elite skiers, by independent biomechanical laboratories, validates the position published by the US Ski Association, Cross-Country Canada doctrine, the National Coaching Certification Program, and the research promulgated by the Federation Internationale de Ski and the International Olympic Committee in the most recent report of Sports Medicine and Science of Cross-Country Skiing.

This IOC and FIS medical report on skiing biomechanics discusses the toe, knee, nose alignment in skating as a guideline used by coaches to help skiers position themselves over the ski and to enhance weight shift. Concluding that, "the analysis of body positioning of highly skilled skiers on the World Cup shows unequivocally that they do not align toe, knee, nose. The result of too much

rotation is greater side to side motion that decreases skating tempo, stride frequency, length, and has negative impact on skiing speed."

Progressive ski skating methods emphasize more direct, simple and efficient motions, based upon key skiing fundamentals of: body unity, symmetric form, coordinated timing; blended pull, push and glide phases. Propulsion comes from a decisive weight transfer onto a flat glide ski, that is assisted by the first phase of the double-poling motion and an unweighting push of the free leg; edged only so much as is necessary to transfer power without slipping. The weight is on the heel to mid-foot.

The horizontal relative force can be propulsive when the ski is angled with respect to forward direction.

The timing varies depending on the steepness of the hill or the skier's speed. The transition from a flat ski to an edge can be gradual or abrupt, depending upon conditions. A skier's orientation is predominately in the intended direction of travel while conceding some twisting to assist weight-transfer, in the initial stages of the cycle. Think load and explode. Weight-shift from ski-to-ski is accomplished more through movements of the lower body, core and hip.

In the first phase of the arm movement, the weight is applied onto both poles to the snow at the same time. The arm pull is driven by force of weight, abdominal and back muscles, pulling with the arms.

The hips and shoulders should be level while allowing the lower body to rock subtly from side-to-side in gathering momentum.

Ski Skating can be decomposed into free skating, using: legs-only and double poling. These drills are the fundamental building blocks for the more advanced skating techniques.



## LEGS ONLY (FREE SKATE)

Free-skating, using legs-only, is employed where conditions are too fast for poling, but still not fast enough to go into a tuck. It can also be used as a strength and coordination drill.

Propulsion in the legs comes from a decisive weight transfer onto a flat gliding ski while driving down and to the side with the heel to mid-foot.

The most recent FIS and IOC technique studies also emphasize this push through heel to prevent the skier from stepping forward off ski the toes and interfering with performance. Pushing backwards will only serve to decrease relative ski speed.

The unweighting push assists the motion. This push should not overwhelm the force of the preceding weight transfer.

The weighted glide-ski transitions to an edged pushing ski, once the force of the weight transfer has been taken up in momentum on that ski. Use the weight-shift in the push phase to develop momentum forward and onto the other ski.

Typically, skiers either persist on gliding too long, without pushing, or as is more often the case, they throw themselves onto an edge and push aggressively, like a hockey player; before weight has been transferred onto a flat glide ski.

Immediately rolling to an edge and pushing too early, or pushing more vigorously than the effort you put into your weight transfer, will arrest forward motion. Like a car spinning its tires in the snow.

FIS and IOC bio-medical research emphasize that, in the matter of edging, a flat ski glides faster and that it is reasonable to expect snow drag forces to be greater on an edged ski owing to deeper snow penetration, high pressures and poor surface area.

It is further observed amongst Olympic level skiers, that the ski is placed flat and gradually roles to just enough edge to facilitate the leg push but never more than 10 degrees in elite skiers. Even here, the snow is pushed up into wedge or berm and the ski rides effectively near flat relative to the forces on the snow.

A flat ski will glide longer but it is best not to pause on the ski because this will delay tempo. Rather it is important to balance glide with turn-over in order to maintain an optimal velocity.

The force of the push must be consistent with the force of your weight transfer. The timing is weight transfer first and then push, a split second later.

To begin, step forward onto the centerline with the ski, and glide forward. Project your hips forward maintaining the same height, and place your heel corresponding to the glide ski, just underneath and in line with the front of your hips. Here, the skier may need to emphasize a slightly forward pressure to maintain this position and to complete the weight transfer onto the new ski.

You may also wish to envision stepping on an outside edge to coax the ski flat. We do not normally step on an outside edge, but the imagery helps to start the glide on a flat ski. The foot should not fall behind the hips before weighting the ski. So, maintain your position over the ski with the weight on the whole foot, and in faster conditions position the weight more on the heel.

Often skiers intend to place their foot under their hips, but by the time they have completed the weight-transfer, they have let their foot travel behind their hips; dragged back by the friction of the snow.

The knee can be seen at a most-forward position when the heel is lined up under the front of the hips. This is more evident when the skier has an aggressive lowered center-of-gravity at higher tempo, acceleration or climbing. Absence of leading knee and bend are likely indicators of underlying technique issues. Thinking about leading with the knee works when you also have a good forward hip projection and the heel of the weighted ski begins at a position, under and in line, with the front of the hips.

At the early stages of learning to skate ski, rotating to align the upper body towards the direction of the weighted ski is a useful means of facilitating weight shift. It makes the business of weight transfer, glide and skiing that much easier. A rotational emphasis towards ski alignment is a great learning progression, popular with recreational skiers or those wishing to tackle terrain with less effort.

However, the benefits of a deliberate rotation to a head-knee-toes-ski alignment, tend to diminish at higher speed and tempo. The rotation begins to act as an inhibitor when the angular momentum interferes with the linear speed down the track, causes the poles to take a circular path and slows turnover. It introduces torque in the body core that needs to be mitigated and unlimited momentum vectors in directions other than down the trail. This is why many ski racers have adopted a more squared position down the track in their training and application. Rotation may remain easier but a predominantly square position can be faster in high tempo scenarios, provided the skier already has good weight transfer and balance.

At the moment your weight is committed to the front glide leg, raise your trailing ski a minimal distance over the snow surface and recover it forward directly, along the center line. Remember to keep the front weighted glide ski pressing forward – do not let it slip behind. Feel the acceleration of the ski as the weight is transferred onto the ski through the heels. The recovered ski is moved underneath and is placed in line with the front of your hips along the direction of travel. The hips must be engaged or pressed forward at all time. Do not reach too far forward with your foot, or your buttocks will have a tendency to drop back. Similarly, do not pretend to get a larger stride by deliberately dropping your hips back. A forward bent knee can be used as an indicator of correct alignment, provided the hips and the foot are also held in check.

Repeat the cycle while maintaining a balance between left and right legs in timing, effort and stride length.

The motion with the legs should always take the shortest path. Often novice skiers lift their skis too high off the snow and pause the motion. Allowing the leg to swing freely helps relax the muscles between strokes and aids recovery.

As the hill gets steeper, lower your center of gravity to achieve greater stride length. Climbing also requires more forward body lean, this is done while maintaining a forward hip position. Maintain a consistent height over the surface. This concept of a deeper position for hills and acceleration is valid for all techniques and situations.

Disengage the foot from the snow as soon as the weight is transferred to new glide leg, recover the free trailing leg forward by the most direct route.

Do not persist in weighting a ski, if it has passed well behind your center of gravity. This late-push in skating will yank the back-leg further behind and pull the hip open. The result is an introduced twisting that reduces stride length and causes stalling out on hills.

The majority of the work done by the legs is done with the skis under the center-of-momentum. The initial foot placement is aligned with the front of the hips. Because the ground is moving underneath the skier, in the opposite direction, the skier must think about maintaining a gentle forward pressure with the foot to counteract resistance. It is too easy for the skis to get pulled behind the hips if the skier does not actively respect proper form. The skier should be able to see his feet and skis throughout the cycle. The legs do all the pushing from underneath the body to the side, with pressure on the whole foot and the heel.

Think about pushing the ski in the direction that it is pointing and not to the side. The true direction is often more forward than a skier perceives. In contrast, if you only push to the side, the inside edge of the ski will grab snow and end up dragging the ski back and widening your stance.

The movement is part push and part weight transfer or unloading the ski forward and away from the weighted ski. The analogy is: canoeists place the paddle in the water and move the boat, rather than, push water back.

## MARATHON SKATE

The marathon skate is a good starting point for instruction.

Marathon skate is essentially a double poling action; coordinated with a single skate-push, on one side. The glide-ski remains the same and is usually positioned in the tracks.

Marathon skate is a practical technique to use when the classic track is faster, or passing on narrow skating trails.

As a drill, the marathon skating technique re-enforces correct weight transfer and follow-through with the leg push. It also introduces upper body double poling motion into a coordinated skating technique.

To start, the poles do a double-poling motion, while one ski presses forward in the direction of the ski. Most of the weight is committed on the mid-foot to the heel. Meanwhile, the glide-ski remains in the track. The hips project forward to remain square with the primary direction of travel. You will feel some internal tension or torque away from the pushing leg in order to square your hips and shoulders down the track. The tension is imperceptible to an observer, but important to the skier.

The weight is transferred back to the track gliding ski by the end of the push phase, and the pushing ski is fully extended to the side.

During the recovery, the poles return just like in double poling, and the leg recovers just forward of the binding of the weighted glide ski ready for the next step and push.

## 1 SKATE double pole

In 1-skate, the skier performs a double pole and recovery, first on one weighted glide-leg, then performs a double pole and recovery on the other ski. Propulsion comes from a decisive weight transfer or preload onto a flat glide-ski; assisted by the first phase of the double poling motion and an unweighting push of the free-leg in the direction of that ski, as it transitions to an edge.

The second propulsive phase occurs when the hips, arms and trailing free-leg recover forward to the body-center together.

1-skate is great for accelerating, sprinting, cruising the flats and for climbing moderate uphill. The technique requires good balance and upper body effort.

In 1-Skate, the poles plant simultaneously beside, and just ahead of the bindings, as the weighted leg preloads or compresses at the hip, knee and ankle, and then pushes off onto the other ski, which is now moving forward. The weight is immediately transferred to the new glide-leg. The skier should feel "on top" of the glide-ski in a perfectly dynamically balanced position. According to studies conducted by the IOC medical council, poling contributes to more than half of forces generated in skiing.

The path of the glide ski should start at the centerline and continue as close to the intended direction of travel as possible. In slower conditions, or on steeper terrain, you may concede a wider stance, in which case, the skis will have to track more to the outside. The head, shoulders and hips are predominantly squared off with the intended direction of travel, while the center-of-momentum at the hips is over the weighted ski as if it were attached to the ski, so that the whole body tracks with the glide-ski together. This does not mean necessarily that the shoulders and hips need to be twisted excessively to the outside. Nevertheless, in all ski skating techniques, there is some athletic rotation.

With the hips locked forward in place, the whole body will track with the glide ski as one unit. If the hips fall back out of a fixed joint then the leg will move independently of the body. The knee is bent and forward, with the heel of the foot under and in line with the front of the hips.

The weight is transferred dynamically to the new ski as the arms pass the waist. The flat weighted glide-ski begins to unweight and transitions to push that is braced by just enough edge. Again, the ski feels flat to the skier as it is directly under the hip during initial glide. In reality, the ski will appear to ride on an edge as the hill steepens.

Again, the weight is committed forcefully onto the new glide-ski. Thus, creating forward momentum that is encouraged by a double poling action.

The upper body motion within 1-skate, is similar to double poling - although, the skier will rarely dip the upper body as low. Your weight drives the poles through the motion with the stomach, back, shoulder and arm muscles progressively. The movement of the arms and legs are snappy and forceful, carrying through with a full extension.

To catch the correct timing of the next cycle, recover both the arms and the trailing leg forward, back to the center, together. The foot of the unweighted free leg should recover to a point just ahead of the binding of the glide ski, on its way to the snow.

There should not necessarily be a forced pause within the cycle, nor an unassisted glide phase for racing applications.

The pole plant occurs, as momentum is committed towards the new ski. Often this occurs when the legs are the closest. On fast terrain, the feet may come together momentarily.

With the lower body, the skier should minimize the angle of the "v", made by the skis to what is strictly necessary. Although there will always be some twisting, rocking and lateral movement in ski skating - more is not better, if you are interested in speed-efficiency. Avoid over-twisting and skiing from one side of the trail to the other. Overall movement becomes natural if the body is allowed to swing in a relaxed pendulum style. Just enough, but no more, rotation facilitates an efficient push to the next ski.

The leg push starts with a flexed knee and ankle and pushes in the direction of that ski, not to the back. Because the ground is resisting this movement in the opposite direction, the skier may have to think of pushing the ski more forward, so

that in the end it remains beside them. The skier must always present some forward pressure onto the ski to maintain its proper position relative to the body. Otherwise, the snow has a way of sweeping it away. Weight shift onto the forward glide ski must be firmly initiated through a dynamic shift in momentum; first, before committing effort into a push. Otherwise a skier may incorrectly leave too much of their weight onto the edged trailing ski. It may falsely give the skier the feeling that their push is powerful, where in fact, weighting a pushing ski, digs the edges in, arrests weight shift forward and inhibits forceful muscular contraction of the leg.

Think about moving way from the push as much as the effort you put into the push. The point after all, is to move your body forward and not to push snow back. As the ski is pushed off it remains parallel to the snow. Again, a relaxed swing of this leg aids in recovery.

The gliding ski is placed flat on the snow and the recovery knee and hip are aligned forward over the glide ski that is accelerated forward as the body weight transfers to the ski.

Avoid leading the planting motion with arms; it is the torso that brings the poles down to the snow, and leads through.

The poles are planted close to the skis with the tip of the pole near the binding. The poles will plant in the correct position provided your form is correct. Focus on good upper body position first rather than becoming memorized by the position of your equipment. Although a misalignment of the poles can indicate errors in position, the converse is not valid. You can have the poles in the right place but your body can be messed up.

The whole body gently rocks in unity to gather necessary momentum, but keep the shoulders and hips balanced. Do not dip one or the other of your shoulders or hips.

The 'v' presented by the skis while skating can be reoriented to permit the weighted glide-ski a straighter path down the trail, but still benefit from the power generated from the 'V' in skating.





## 2-SKATE

Visually, two-skate combines free-skating equally with double poling. Each double pole plant will coincide with the dynamic transfer of weight onto the same ski on that side - for example, with every right step, in the case of two-skate right. To an observer, 2 Skate can look like a double pole plant with every other leg push. Alternatively, you can think of it simplistically as the upper body going down over one leg and coming up over the other.

This technique is often used at high speed on flats, gradual up hills and down hills.

The initial propulsion, again, comes from a decisive weight transfer or preload onto a flat glide ski assisted by the first phase of the double poling motion, and a unweighting push of the free leg. This first part is the same as 1-skate.

The second propulsive phase occurs when the hips, arms and trailing free leg recover completely forward together to center and complete the weight transfer onto the new ski. This is where it differs from 1-skate. Your weight is shifted onto the new ski as it continues past your hips and forward onto the snow to become the new glide leg. During this moment, the old glide leg transitions smoothly to the push leg; braced by just enough edge. In this process, flat glide skis transition smoothly to edged pushing skis.

The skier uses the pole recovery in a dynamic way along with a flexion of the glide leg. In 2-skate, the recovery can be nearly as powerful as the initial poling motion because the force of the recovering arm and leg are braced and assisted by the opposite pushing leg; similar to the force developed by a high jumper, but in a different vector.

The upper body motion within 2-skate is similar to double poling, except the bending compression at the waist is not normally as deep.

The biomechanics of the leg action in 2-skate are the same as those described in legs-only or free-skating technique.

The weight is shifted from ski-to-ski to generate propulsion and is frequently enough to maintain momentum. Any slowing in this motion can only occur when there is sufficient speed gliding over a flat ski. A second more obvious pre-load is

often used to re-invigorate motion after a prolonged glide phase. The movement of the arms and legs are snappy and forceful with full extension. There should not be an unassisted glide phase, or pause, in racing applications.

With the lower body, the position of the skis should be controlled to minimize the angle of the "v", made by the skis. You want the skis pointed generally where you want to go and should only concede as much side to side motion as is necessary to assist propulsion. In slow conditions, or when climbing, a skier may need to take a wider stance or angle with the skis.

## DIAGONAL-V

Diagonal-V can best be described as herringbone with a glide. This technique can be used as a drill to balance left-right leg movement before fully integrating a double poling action, or when negotiating very steep terrain.

As with herringbone, the skier steps up the hill onto a flat ski that feels flat because it is presented under the hip, but is already slightly edged owing to the angle of hill and transitions onto more of an edge to brace slippage.

Weight is applied to the heel of the lead ski, which is then used to pull and push the body up the slope. The trailing leg disengages from the snow and steps under the center-of-momentum. It is important to maintain a forward leg and hip position to generate glide, but not at the expense of sitting or leaning back. Unlike, other skating techniques which use a double pole, an alternating poling action is used to assist the climb for diagonal V.

## OFF-SET

The offset technique is a low gear in skiing and is used on steeper terrain or slow conditions. The emphasis here is on climbing with legs with the upper body providing as much propulsion as possible without fatiguing the skier or stalling the legs. Feeling “light” poling motions that keep the ski gliding is an excellent image to ensure just enough poling power. The upper body assists in maintaining momentum through a complete cycle of steps. There is very little delay between positions in offset.

The first position starts with a three-point plant involving both poles and the front leg. Step forward and up the hill along the centerline onto a moderately flat ski. The heel of the front leg should be in-line with the front of the hips and the knee should be bent. Use the front weighted ski as a platform or step. As you commit weight onto the heel of the lead ski, immediately disengage the trailing leg from the snow and move it forward and allow it to swing under the body. Use the front leg pull and push to move you up the hill. As it does, the ski will naturally edge to brace the force before transitioning to a push to the side. Do not persist on pushing after the body has moved past the weighted leg, leaving it in a trailing position. As soon as the free leg steps forward onto the snow, the weighted pushing leg must disengage.

The poles are planted at nearly the same time, and are weighted as evenly as is practical. Many skiers have a slight syncopation as the weak-side pole hits the snow slightly before the strong-side one. While the goal is to apply power as equally as possible, this is not always possible owing to the offset nature of the poling motion and a simple matter of geometry. However, the skier should not deliberately apply less force to either pole. The natural positions of the poles will provide more than sufficient “offset” positioning. The arms bearing your body weight, pull down to complete their extension together as in a double poling action. A wider stance may have to be conceded but all efforts should be made to keep this at a minimum.

The upper body remains lowered until the arms, upper body and trailing leg recovers. The upper body rises as it moves to the opposite ski and then lowers as the skater goes into the three-point landing - adding the force of gravity to the poling motion and creating a fluid skating motion. The cycle will begin again when the body comes up to do the three-point plant again, in the first position.

Movement between these positions is by the most direct and efficient path. It is key that the upper-body and arms go down, and recover up together.

It is also important for the upper body to continue the poling for both legs to step, and for the trailing leg to release from the snow as soon as possible. In the end position, the weight is supported on the opposite leg, the arms are extended to the rear and the upper body is the lowest it will be in the cycle. This occurs just before skate-off to the opposite ski. Too often skiers rush the poling.

Keep your hips pressed forward, up and onto hill without leaning back. The head, shoulders and hips should feel nearly square with the direction of travel for the majority of the cycle. Although, the skier may orientate the hips, shoulders and head slightly towards the direction of the ski on the initial pole plant and step to assist weight transfer, they will square off towards the intended direction of travel momentarily. However, the novice may have to exaggerate weight shift and even consciously twist if they straddle the track with too little weight transfer. The majority of the time spent in all ski skating techniques is spent with shoulders and hips level and squared predominantly towards the direction of travel; while conceding only as much rotation as is necessary to assist weight shift. Avoid over-twisting or rotation, especially in the torso. Alternatively, do not completely suppress all natural athletic rotation.

As with all techniques, the steeper the hill, the more climbing and less glide. Maintaining a lower center of gravity or deeper knee bend will facilitate stepping up the hill provided your hips and foot position are correct. Naturally, you will have to take up a wider position in both your arms and legs so as not to get entangled. As the hill moderates, you should try and adopt a narrower position in both arms and legs.

The most common errors in offset are:

There is not enough weight transfer or an inability to glide with balance on one ski.

The poling is weak with little stomach or lat involvement and insufficient weight on the poles at initial pole plant;

The skier lets the upper body and arms move in opposite directions;

The skier fails to lower center of gravity, bend the knee and step forward onto a heel aligned with the hips;

The poling action finishes prematurely;

One arm or side dominates the technique;

Over rotation occurs;

Hips are down and back;

The legs are too far behind;

Failing to reach up the hill or planting your poles behind you;

Not getting the weight over ski;

Standing up too much;

There is a major emphasis on hang arm and cross-body push arm;

Pushing off a back leg;

There is skewed or unbalanced climbing by legs; and

The skier relies too much on the arms to power the technique.

Try to relax the force of the arm-pull if you run into timing problems. Often, incorrect use of the arms, do more to arrest movement than help. Practicing legs-only in a climb will help a skier use both legs equally in offset.

The offset differs from the 2 skate in that the trailing leg recovers immediately and fully forward during the double poling by the upper body. In the 2 skate, the trailing leg would remain back longer until it recovered together with the arms. The offset truncates necessary leg motions to permit more lower-body-leg-work relative to upper-body work. The emphasis of upper body motions in offset should be to

assist climbing by the legs.

In offset, the weight-shift occurs dynamically halfway through arm extension by rocking the lower body under the center-of-momentum. As the weight is shifted quickly from ski-to-ski, it is essential to keep your feet moving so you do not "bog down." The movement of the arms and legs should be balanced in force and timing. There ought not to be a deliberate dominant nor recessive side. Any differences in power output are the result of natural pole positions caused by the offset nature of this skate. The notion of a hang-arm and severely-angled-cross-body swing or push arm only weakens the poling motion.

As the hill steepens, the core or center of gravity is lowered with a bent knee to permit greater reach or stepping. The leg joints naturally bend more. The converse is not true; a skier can have all the right angles in the knee and ankle, but be totally messed up. Correct angles must be coupled with correct positions of the foot relative to the hips. Movements by the legs should be equally balanced in force, stride length and timing.

As the steepness of the hill increases it becomes more important to concentrate on reaching forward up the hill with the shoulders while having correctly bent arms on the pole plant. There is a natural tendency for skiers to choke-up or collapse the arm angle on the poles when presented with a steep hill.

## GREAT LEARNING PROGRESSION FOR SKATING

A great drill to re-enforce the ski skating fundamentals is to use a progression of: free-skating, and double poling and a full skating technique such as: 1-skate, 2-skate or offset.

The secret is to alternate between free skating, a full skating technique, double poling and back to a full skating technique.

These drills help to isolate basics and in so doing identify errors, achieve proper timing, balance and biomechanics with legs or arms, before incorporating them into a full ski skating technique. With time, the skier actually transfers the skills from a more basic technique, to a more complex one.



We have covered a number of ski skating techniques in detail. You should now understand the:

Free Skate;

Marathon Skate;

1 Skate;

2 Skate;

Diagonal-V;

Offset; and

Skating Progressions.

It is time to start the process of mastering downhill technique.

## NORDIC DOWNHILL SKIING

The goal of this chapter is to help you with the intricacies of downhill technique for nordic skiers through clear demonstrations and explanation:

We will start by showing you how to survive falls before teaching the Ready Position, Tuck and Straight Running. Then it's right on to demonstrating Parallel and Slalom Turns, Pole Planting, Hop Christies, and Telemark technique. By the end, you will be more familiar with Stance, Balance, Edge Control, Carving, Transitions and lead changes.

The goal for every Nordic ski racer should be to descend hills as quickly as possible under control.

## FALLING

Controlled uphill falls are harmless when you can lay down to one side and slide.

Conversely, the following high-speed face-first downhill falls are bad. Here are some examples of what not to do.

You may wish to remove hands from pole straps for long difficult downhills, other than in a race situation.

## READY POSITION

A skier's momentum on a descent is largely fed by gravity and their actions are mostly responsive to the terrain, conditions or change of direction.

Downhill technique emphasizes the ability to establish and actively maintain a stable position in dynamic balance.

Start with your arms waist high and clearly in front of your body. Your head, hands, shoulders, hips and knees should point where you want to go – that is downhill, unless you are traversing.

Your legs should be bent athletically, so that you present an angle at the knees

and ankles. This will help absorb the bumps and provide the best position from which you can generate turning power and control. Your hips should be pressed forward without leaning back. In fact, an athletic forward lean down the slope will greatly aid stability.

The key to downhills is to attack them aggressively in order to stay in control.

As you descent, remember to keep your arms, knees and hips in check. That is forward and pointing where you want to go.

Do not let your arms drop out of sight. The worst position you can put yourself in is hips back, arms trailing, straight legs, head leading forward and knees locked up in a snow plough. This is a recipe for disaster.

## TUCK & AERODYNAMICS

A good aerodynamic position is the easiest means of maintaining speed in skiing.

The skier crouches in an egg like position. The back is parallel to the ground. The poles are tucked under the arms and are also held parallel with the snow surface. Your hands should be in front of your face. Skis are parallel and the weight is held on the heels.

In a full aerodynamic tuck, the elbows are placed on the front the knees.

In a more relaxed tuck the elbows may rest on the knees.

A high tuck is used in transition just before or after you are running out of gravity to do your work for you.

Keeping the hands in front at all times is essential, they are your guide and keep your direction in check.

The skier can use a wider stance for stability, if there are no set tracks.

Look at a downhill expert, and study the tuck position, how it may open up or tighten while reacting to variations in the terrain. Feel your skis on the snow and let them ride flat, unless you are edging for a turn. The knees absorb the contours

and variations of terrain.

From the ready position, tuck the poles underneath your arms. Bend more at your knees, ankles and waist, as you flatten your back to a position nearly horizontal with the terrain. This is a much more aerodynamic position for free skating at higher speeds and eventually closing into a high tuck.

Sink into a low tuck as you feel the force of the wind striking your face and your speed is too fast to skate. You should have a tight aerodynamic position with your hands in front of your face and the poles running parallel to the snow and along your thighs. The poles therefore should point straight back and not out to the sides. Similarly, keep your skis parallel and gliding flat down the track.

The elbows should be placed in front of the knees. Or, on long steady down hills, they can rest on the knees.

#### SLALOM / PARALLEL TURN

Negotiating turns at fast speed require a slalom or parallel turn, for racing applications. This is nearly the same as in alpine skiing except that you will have to weight the heel more, and compel the skis more deliberately into carving.

Some skiers are adept enough to complete their turn in the unweighting phase of the parallel turn, which minimizes skidding. The inside ski must be lifted and placed in parallel with the edged and weighted downhill ski. The position of the two skis can be manipulated to provide an artificial side-cut in aid of turning.

Learning this technique is best done on a wide-open hill free of distractions.

Edge the outside ski to initiate the turn and transfer the majority of your weight onto it. Lower your center of gravity and bend your knees. Project with your arms and hips around the turn, looking where you want to go. Continue to weigh the downhill ski. That is one that is the lower on the hill. Skis should be held close together in parallel or shoulder width apart.

Approaching a turn, start wide and high, cut the apex of the turn and carve around. To help initiate the turn unweight the skis by raising your center of gravity.

Skiers frequently, start the turn too much on the inside, cut in prematurely and skid wide into the bushes.

Common mistakes in turning on downhills include:

Adopting too wide of a stance;

Not weighting edge of the downhill ski;

Unparalleled skis;

Dropping arms; and

Having straight legs, hips back, face first posture.

To learn, you can start with a snowplow and gradually reduce the angle. Slide or lift and unweight the inside ski on the turn, bringing it parallel to the downhill ski and carve around.

Let's decompose the parallel turn to understand the underpinning concepts.

The principles of downhill skiing can be understood as a relationship between motion and balance. Balance is not a static position but constant adjustment to forces. The factors influencing this relationship include: the center of mass, a base of support formed by the skis, the fall line vectoring the pull of gravity, friction that induces drag on the skis, and centrifugal forces taken up in the flexion of legs, during a controlled change in direction.

Planes of balance

Inclination – changing the line of inclination effectively places the center of mass inside the radius and base of support of the new turn

Angulation – drive hips into center of turn but angles upper body upright increases pressure directly onto edges instead of shearing down the fall line

Rotation –

Forward Lean –

Extention –

Flexion –

The phases of a parallel turn are characterized by:

A completion to a neutral state by releasing the edges from the turning arc.

Transitioning from a neutral state towards the fall line and onto a straight-run platform to reconstitute the base of support with the center of mass

Steering across the fall line to completion, with a progressive increase in edge pressure through angulation and inclination. Consequently, the turn radius tightens the steering angle increases.

While form is rooted by stance and balance, motion involves pivoting, edge control and smooth pressure. Correct timing and coordination is based upon good anticipation and reaction.

Now that we have a grasp of the principles affecting the parallel turn, let's recompose the technique and talk you through it chronologically:

Start from a traverse, flex and preload your knees. Plant the downhill pole on the fall line, beside and ahead of your boot. Rise up by quickly extending your legs. The edge change and weight transfer occurs during the up extension. Roll the outside ski to an inside edge. Pivot the skis to the fall line. Build pressure onto the ski edges throughout the turn by driving forward and around the arc with your knees. The skis remain parallel with the feet close together. The two skis thus act as one unit rather than two opposing platforms. The inside boot and ski may be slightly ahead of the outside boot to facilitate the turn. This in effect, creates an artificial side cut to help turn faster and more smoothly. The inside knee should also lead around the turn to give room for the outside weight-bearing knee and ski to continue to carve unimpeded. The outside arm guides the turn while the inside arm must remain checked in front. Often the basket of the inside pole can drag to help control the pivot.

The angle of the edges and the pressure on the skis is controlled by the flexion in the knees and ankles.

The weight on Nordic race skis must be on the heels.

Remember to complete the turn. Keep your weight forward and maintain the pressure using flexion at the knees.

Let's consider the parallel turn in a bit more depth...

The shoulders should face down the fall line in short radius turns. However, the shoulders will rotate back in the same direction of the skis during larger radius carving turns that traverse a hill. Generally speaking, the shoulders face the line of travel.

Flex the knees and take up pressure on the edges, to prevent skidding around turns. However, applying too much force too soon in the turn may cause the skier to skid out of control.

The unweighting motion is key to turning on Nordic racing skis that are designed to go straight. This initiation to the turn is either an up-extension-down-flexion of the knees and ankles, or by quickly withdrawing your feet underneath you hips without pushing down first.

The withdraw method, sometimes called prejump or avalement is similar to a dynamic preload in ski skating. By unweighting the legs, this permits pivoting and initiates weight transfer forward onto the new line of travel.

Unweighting can be accomplished by flexing the knees and dropping your weight or by abruptly halting a rising or extending motion in the legs at the moment of the turn.

You must be over your ski in the critical part of the turn and the hips must be inside the turn for all the other joints to work effectively.

Use upper and lower body separation to draw your momentum back to the intended line of travel. Steering with the skis naturally creates this separation. The steering angle is defined as the deviation from the intended line of travel.

Exert more effort with the outside arm on counter slopes and keep the legs parallel together to avoid railing with the inside ski.

For a deliberate impulse turn or cramponage, you can let the uphill ski begin to rail, transfer the weight to the uphill ski and punch forward with the uphill arm. Then, pivot into the new turn, release the downhill ski and place it next to the outside ski.

## POLE PLANTING

The poles can be used for initiating a slalom or hop-Christie turn. Keep your arms ahead of your body and bring the inside pole basket forward with a wrist action. The pole should be planted just ahead and beside your boot and on the fall line. Sink with the knees and plant the basket firmly into the snow. This will start the turn by creating a pivot point and unweighting of the skis about the turn.

## MAJOR POINTS OF GOOD PARALLEL TURN

Create positive edging by rolling the knees into turn and placing the skis on edge.

The knees are together.

The weight is on the downhill and outside ski.

Weight the skis from the mid-foot and exit turn through the heels.

The body has both inclination and angulation.

Complete the turn by extending and then drive heels forward and around turn.

Torque the body and coil so the hips, shoulders, arms and hands, all face the fall line.

Extend at the legs and unload to enable the turn.

Compress throughout the turn and release smoothly.

Plant the pole at the moment of maximum compression.

## HOP CHRISTIE

Begin in a traverse. Make a downward flexion with the knees, a pole plant and rise up quickly, lift the skis off the snow and pivot them down the fall line. Smoothly but decisively roll to an inside edge and keep the knees driving forward.

## TELEMARK



The telemark technique works because it creates the effect of one big long ski that forms a natural carving shape to aid in turning.

## TELEMARK TURN

The telemark turn is an exceptionally smooth means of turning particularly in deep snow.

A good telemark turn begins with the stance. Knees should be relaxed, lowered center of gravity, arms facing downhill and hips projecting around the turn.

The telemark distinguishes itself with the lowered rear leg position. One effect of this position is to create one long ski and the angle of the two skis creates a variable side-cut, making it possible to truly carve a turn on cross-country skis.

The best way to learn the telemark turn is to build from the ground up. So, in the next section, we will cover:

the telemark stance;  
dynamic balance;  
edge control;  
the lead change; and  
pole plants.

## THE STANCE

Adopt an athletic stance for telemark; with the knees bent, shoulders low and the hands in front of body.

Your front knee should be directly above the toes of your front foot and both ankles and knees should be bent. The heel on the back boot should be directly below your butt.

The back foot is bent at the toe with the heel lifted off the back ski with equal pressure on the ball of the foot. Keep the heel as low as possible with the knees together.

Maintain a position above your skis, with the skis weighted equally and centered

fore and aft.

The back foot is often a problem in telemark turns - to control it, keep it weighed and underneath you.

With this initial position, rotate the eyes, shoulders and hands downhill. Hold the hands at chest height and reach ahead; down the hill.

## BALANCE

Balance is very important with free-heel downhill skiing. Maintain your center of momentum over the stable ski base. The tendency for many beginners is to lean up the hill, and drop their weight off the back.

## EDGE CONTROL

Roll the skis uphill to put skis on edge while using both ankles, both knees and the hips.

## TRANSITION AND LEAD CHANGE

The edge transition and lead change is the most challenging maneuver in telemark, and the one technique that we will devote the most time to.

Just as motion in downhill skiing is gravity fed, telemark focuses on fall line turns. The upper body and hips are facing the fall line and your focus should be downhill.

Precipitate the turn by lowering into a tele position. Point the upper body down hill and put both skis on edge by rolling both knees down the fall line and then into hill. Rise up and slide the back foot forward, almost like a kick, then sink back down without pausing. This transition needs to be deliberate and smooth.

Now, as you complete the turn, think of progressively applying your weight from the tip of the lead ski to the tail of the back ski as you carve the turn. The turn finishes with the front leg downhill.

Now for some details about the telemark turn:

For many people the V shape made by the skis gets too wide, during transitions, or lead changes while trying to turn across the fall line. Often this causes the back ski to drag away.

Keep your skis together and tuck your knee behind the front leg. You can learn to keep a tight stance by imagining squishing something between your knees during telemark transitions or lead changes.

On nordic racing skis, you will need to lift your back or inside ski up and deliberately place it beside the other ski.

Press your leg forward in the boot so that you feel the tongue of your boot on your shin, unless you are in nordic racing gear, in which case you will need keep the weight at the mid foot to heel.

Let's work on polishing up the turning transitions...

Extend your legs and un-weight the skis to begin the transition or turn. Change leads, roll from edge to edge, then lower and compress your weight onto the skis equally. As you commit into the turn, squish the big toe of your lead ski and the small toe of the trailing ski to engage the edges more decisively. Remember to weight the back ski equally with the lead ski, to keep both skis under control. As you complete the turn, shift the weight a bit more onto back ski.

Sliding the back foot forward in the lead change helps to weight the back ski and promotes a more aggressive skiing style. Whereas, sliding the front ski backward, to complete a lead change, allows for faster transitions on bumps and steeps.

Now we need to get the poles working for you...

The poles act like probes that help you to anticipate the terrain, to establish each turn, keeps you leaning down the fall-line and sets the pace of your turns and transitions.

Start by keeping arms in position. Then, using a strong wrist motion with the palm facing outward, reach downhill to trigger a transition.

Time the pole plant when you are at the lowest point in the compression. After you plant the pole, begin to ski around it. Your leg does not come forward into a lead change until the pole plants. Disengage the pole from the snow as you pass it, and move the pole forward so both hands stay in front. You can plan the next pole plant as you rise up.

Do not leave the pole anchored in the snow. Skiing too far past your pole will leave it uphill and arrest the turn. So avoid uphill pole plants.

Do not forget about your upper body form. Keep the arms bent and positioned in front during the turn. Punch downhill with the uphill hand across the body so that both hands are facing downhill. The hands need to stay in position to be set for the next action. Now, torque the body away from the ski direction - coiled for action.

O.K., it is time to work on that carve...

Specifically, let's address:

edge control

rotation

hands weighting

Push those knees forward around turn and apply the edges with gradually deeper commitment and stronger pressure. In the telemark turn, weight the inside edge of the front ski and outside edge of the back ski. Similarly, progressively release the edges to complete the turn. Finish your turn by cleanly exiting and unloading from the back of the skis. Edge control should be committed, strong but smooth.

The stance in a carving turn needs obvious angulation and inclination; forming a 'C' shape to the fall line, and putting pressure directly down onto the edges.

You will need more weight over ski edges, if you experience chatter. Often, skiers lean too far uphill, releasing the edges. Consequently, their skis skid out from underneath them.

Good posture is also important. The idea is to lead with the chin and head high,

rather than looking down at your feet. Keep a quiet upper body by twisting inside the turn to keep yourself orientated down the fall line. Look where you want to go.

There is more twisting required in telemark turns than parallel turns because the uphill ski is further back in a telemark stance.

Breathe in on the transition and out on the compression of the turn. Stay relaxed to absorb terrain. Listen to the rhythm and sound of your turns; aim for consistency and smoothness.

Much the same principles apply for quick turns, with more zest and commitment.

Initiate the next turn, in the moment that you cross the fall line. Punch out the lead change. The transition will require much faster loading and release than wide carving turns. The quicker you load the skis, the more they will rebound and unweight. However, too sudden a push and you will blow out your edge. Conversely, too weak an edge will induce a skid or chatter.

To perform a jump-turn, extend the pole plant down hill, down-weight the skis hard and jump off on two feet. Bring your legs, up and forward. The transition and lead change occur in the air and by dropping the lead foot back. Compress into the turn with deep angulation, inclination, positive edge control and strong rotation. Keep constant and fluid motion to maintain momentum from the turns.

Skiing moguls and trees demand that you look ahead and visualize your line. Maintain a quiet upper body and a closed-controlled-form, achieve fluid motion and the ability to absorb terrain. Avoid double-pole plants on down hills.

Presented with deep snow, you'll need to lean back a bit and pressure the back ski to prevent the skis from diving under the snow. In powder, think that the front ski carves and rear ski rudders. Let the skis float to surface before initiating lead change and turning.

Skiing at higher speeds requires strength and concentration. Everything happens much faster. You will have to be aggressive and committed, at the same time relaxed. Adopt a lower stance and check your hands clearly in front of your body.

Make good vision and line choices by planning well ahead. Project downhill. The edge change in the turn must come from hips and knees - not just the ankles. Most importantly, you have to ski fast to get used to speed and steep pitches.

By now you should have a better appreciation for falling and feel comfortable practicing the Ready Position, Tuck and Straight Running. We have discussed Parallel and Slalom Turns, Pole Planting, Hop Christies, and Telemark technique and we have covered the concepts of Stance, Balance, Edge Control, Carving, Transitions and Lead changes.

If you are adventurous, try our advanced moves...

## INTRODUCTION TO ADVANCED MOVES

If you want to take your skiing to the next level then we recommend, Volume 4 of the Science of Nordic Skiing - Advanced Moves, which covers the most elite technical maneuvers used in Nordix sprint events and stunt work, including:

- maximum speed sprinting;
- the double-push;
- power climbing;
- close pack tactics;
- double black diamond descents;
- ice, powder and crud;
- high speed turns;
- arial moves;
- style tricks; and
- stunt skiing.

## CONCLUSION

Thank you for watching the Science of Nordic Skiing Volume 1 - Technique. In conclusion, you should be aware that this DVD fits into a larger xczone.tv product line, including the nordic skiing project, and the science of nordic skiing series.

We hope that you will more fully appreciate the evolution of modern nordic skiing, and can more richly engage the progressive nordic skiing method; absorbing the concept of important building blocks for skill development; having observed good technique, and applied biomechanics through fundamental techniques in the classic, skating and downhill chapters.

Additional volumes in the Science of Nordic Skiing Series include:

Volume 2 - Training;

Volume 3 - Equipment; and

Volume 4 - Advanced Moves.

The nordic skiing project also contains excellent motivational products including:

The Art of Nordic Skiing; and

The History of Nordic Skiing.

Visit our web site at [www.xczone.tv](http://www.xczone.tv) for complete information on our products.

All of us at [xczone.tv](http://xczone.tv) wish you the best success and enjoyment with clean oxygen fed sport.