THE SKILLS FRAMEWORK

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Introduction

The Skills Framework is one component of the CSIA technical concepts model. The Physics of Skiing precedes it and the Performance model follows.

Following on from motion and the forces in skiing presented in the Physics of Skiing, the Skills Framework defines the interaction between the snow, the skis and us. We explore how the skis affect speed control, direction, and balance and how we affect them through our body's movement options.

The Skills Framework is a technical model defining a common set of fundamentals. It simplifies the complexity of skiing and distils it into functional components and explains the relationships between those components. It provides a thorough understanding of the ski's actions and movements to facilitate education.

At its core are the three skills of rotational control, edging control and pressure control; these skills are present in every turn and in all terrain. The framework is broad enough so all outcomes can be described through the combination of those skills.

The Skills Framework provides a way to define WHAT a skier does with their skis and HOW they must move in order to do it. Use the Skills Framework as a guide for assessing and developing skiers, designing tasks and lessons plans for your learners and improving your own performance and understanding of skiing.

Skiing is complex but deterministic; specific actions will produce a specific outcome. Breaking down the sport of skiing into simple elements provides clarity and understanding.

Frames of Reference and Components

We will first explore the concepts and components of the framework and the relationships between them that are essential in understanding the material as a whole. These concepts and components provide substance, meaning and context within the framework.

The laws of Newtonian mechanics elegantly govern motion – the snow pushes on us! Direction, speed, and momentum are subservient to these laws. Manipulating the interaction between our skis and the snow enables us to harness the forces presented by motion.

The Framework encompasses both the skis and the movements with which we can affect the skis.

The Skis

Our boots and skis are the tools we use to manipulate the forces presented by motion to obtain desired outcomes. The snow pushes on us. By specifically managing the interaction between our skis and the snow, we can control our motion.

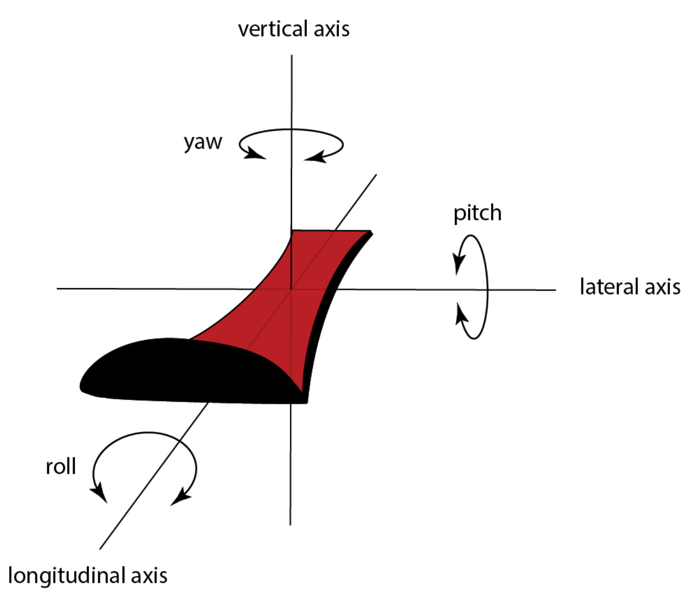
The skis are the control vehicle, providing us with the means to go where we want, at the speed we desire.

Discerning how the actions of the skis on the snow determines outcomes provides a powerful mechanism to assess and evaluate technique. Comprehending and articulating the function and benefit of the skis is of great importance in understanding the Skills Framework and skiing overall.

We manipulate the skis through twisting, tipping and pressure. The combination of these actions determines where the skis point and how much they grip.

We define the ski's relationship with the snow along its longitudinal, lateral, and vertical axes. We influence this relationship primarily through the ski control actions of steering angle, edge angle and platform angle.

Figure 1. Ski axes



Control Movements

The skis are only half of this cause and effect equation. The other half is comprised of the movements we employ to control and manage the skis.

Control movements refer to the alignment of our body and our movements. The skis are our base of support (BOS). Combining alignment and movement enables us to control the relationship between our base of support (BOS) and our center of mass (COM): our balance.

The ski's relationship with the snow comprises the 'effect' and our movements are the 'cause'. Take the time to reflect on the above paragraph – these concepts are at the heart of the Skills Framework.

The Control movements fall into four categories: rotational movements, fore aft movement, lateral movements and vertical movements.

The Skills

The Skills are comprised of the three essential building blocks of skiing: rotational, edge and pressure control.

Each of the Skills requires the action of the skis and the movements to create that action. It is important to understand the distinction of and relationship between these cause and effect components. Every aspect of ski technique can ultimately be evaluated by how it affects the ski's interaction with the snow.

Rotational control actions:

- The rotation of the skis around their vertical axis (skis)
- Applying a turning or twisting force to the skis (movement)

Edging control actions:

- The rotation of the skis around their longitudinal axis (skis)
- Edging, tipping, or tilting the skis in relationship to the snow surface (movement)

Pressure control actions:

- An overarching term for manipulating the forces fore/aft, from ski to ski, and vertically.

Blending of the Skills

The mechanistic approach above provides a framework for technical understanding. In practice, we use a combination or blending of these rotational, edging and pressure control skills in every turn. Various combinations and proportional application of the skills give us incredible control over the performance outcome of our skiing.

- The desired OBJECTIVE determines the ski-to-snow interaction.
- The ski-to-snow interaction determines the blending proportions of the skills.
- The skill blend determines our movements.

Think: what do I want to happen, what does the ski need to do to accomplish that, and how do I make the ski do it.

Ski Performance

As a skier develops skills and blending competency, ski performance and overall ability increases.

Our chosen descriptors - Drifted, Steered and Carved - define points along a continuum of increasing performance outcomes concerning the ski path and interaction with the snow.

The performance spectrum covers all stages from the most drifted to no drifting at all (carving – limited versatility but exhilarating). The turning action mechanism for a drifted turn is oversteering, where the ski tail slips more/faster than the tip as the ski moves forward.

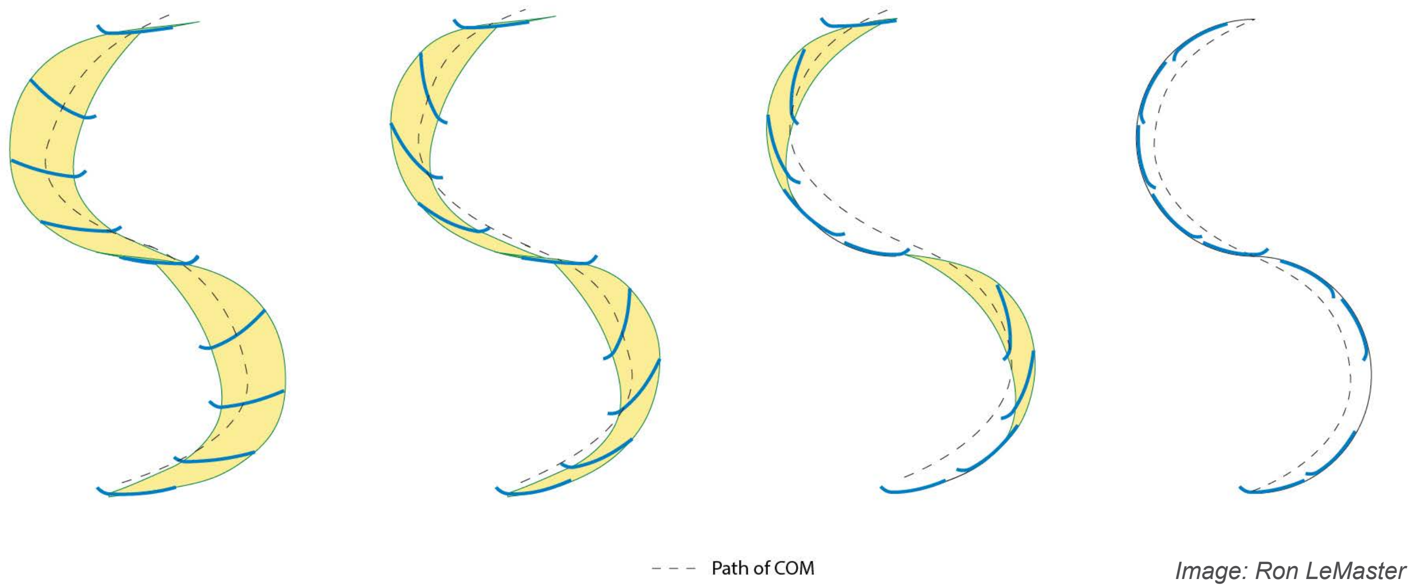
Novice skiers will have considerable drift in their turns; as their skills increase, the drift component diminishes.

Drifted or skidded: Most drift. Defined by Z-shaped turns, with little control of turn shape.

Steered: Less drifted. Producing a rounder "arc" to the turn shape.

Carved: No drift. The ski tail follows the tip and leaves a definitive arc in the snow.

Figure 2. Turn types: drifted, steered, and carved.



We will often intentionally slip the skis in a turn. The ability to slip and grip the ski within a turn provides the versatility to control turn outcomes.

Different turn sizes, shapes, speed, and performance outcomes will require a different blend of the skills to achieve the desired results.

Ski performance and turn types are discussed in detail in the Performance Model.

Timing and coordination

Timing and coordination are integral to achieving desired outcomes. Timing refers to when, for how long, and how intensely a movement is applied. The combination of timing with movements is coordination.

The timing of movements (mechanics – the action of the skis AND body movements) is addressed in the Performance Model.

Stance and Alignment

Stance (relative body position) and alignment (relative position between body segments) determine the positioning of the body for the most efficient and effective ski control and movement actions (rotational, edging and pressure). As referenced in many sports, an ‘athletic stance’ is ideal. In skiing, too low a stance is overly strenuous on the legs whereas adopting too tall a stance is unstable and ill-suited to managing variations in terrain.

Balance

Simply stated, balance is the outcome of a favorable base of support and centre of mass relationship. When the forces acting on our center of mass pass through our base of support, we feel stable.

Dynamic balance is achieved when all forces on our centre of mass are in a state of equilibrium.

Within the Skills Framework, balance is an outcome of manipulating the ski-to-snow interface (the BOS) in order to direct forces through the centre of mass (COM).

Base of support (BOS)

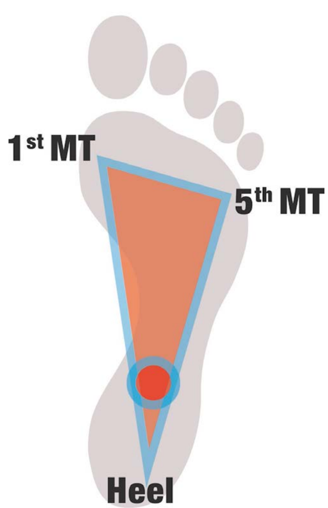
The Base of support is the location of a skier's weight on the snow: the skis.

Figure 3. Base of support - feet and pole

Figure 4. Base of support - outside ski

Within the BOS, under each foot, is the centre of pressure (COP). Efficient skiing requires us to place the COP within a triangle defined by the three arches of the foot: the anterior transverse arch, the lateral longitudinal arch, and the medial longitudinal arch.

Figure 5. Foot arches triangle.



Centre of mass (COM)

The Centre of mass is a specific point in the body where we consider the mass of the skier and equipment to be concentrated. It is generally located just below the navel but moves as we change our body position.

Figure 6. COM location A

Figure 7. COM location B.

Balance line

It is impossible to discuss the topic of balance in skiing without referencing the balance line. The Balance line is a frame of reference to help us define where a skier is spatially and where they are in relation to a dynamically stable position as defined above. This reference frame, or axis, is what we call the balance line.

The balance line runs through the COM and its trajectory is the resultant of gravity and centrifugal force acting on our COM (Figures 8,9). Understanding the distinction between the balance line and gravity is of critical importance. They are not the same thing and they are rarely aligned. This concept is discussed in detail in the Physics of Skiing (page 11, section 3.6 and page 17, section 4.5).

Figure 8. Balance Line

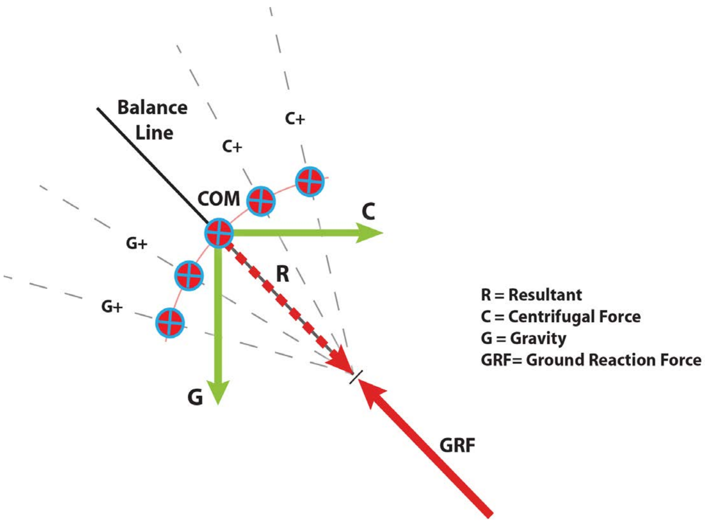


Figure 9. Balance Line - Lateral.

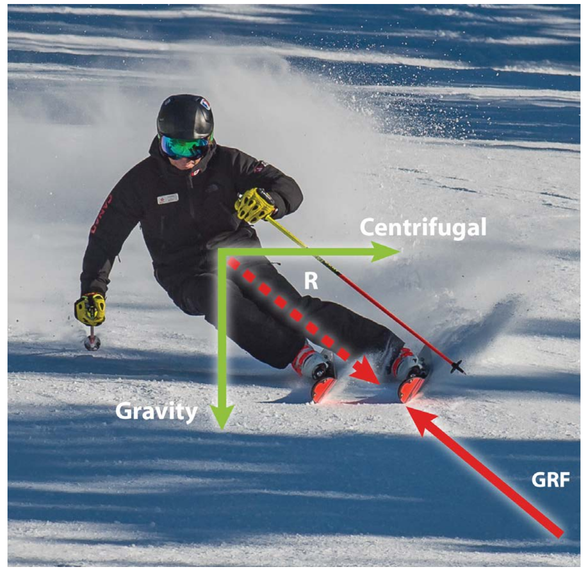


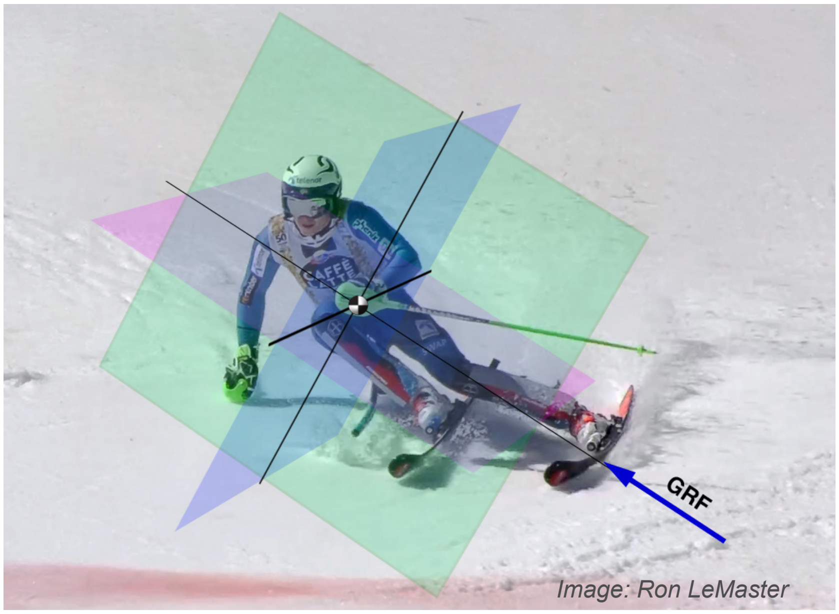
Figure 10. Balance line, Fore-aft and Lateral Plane

Optimal Balance

The balance line represents the position of the skier at a specific moment, which is not necessarily a balanced or stable position. A skier is in balance when the balance line is perfectly aligned with the ground reaction force. Said another way, a skier is in a stable position when the trajectory of the reaction force from the snow (the GRF trajectory) passes through the BOS, and the centre of mass (COM). When a skier is in this state, the muscles are typically doing the least amount of work to keep the skier upright.

As discussed in detail in the Physics of Skiing, (page 20, section 4.9 Intentional Imbalance), it should be noted that we as skiers often intentionally misalign the balance line and the force from the snow to achieve specific objectives, i.e. moving further inside the turn or propelling ourselves into a new turn.

Figure 11. Optimal balance.

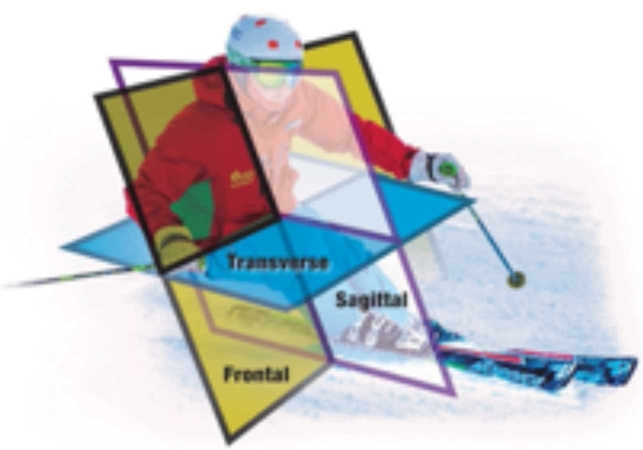


Movement

Stance, or posture, is how we refer to a skier's position at any moment in time. The movements a skier uses to obtain, maintain, or change a particular position require a greater vocabulary and understanding. All movement options can be grouped into four categories: Vertical, Fore-aft, Lateral and Rotational.

Figure 12. Biomechanical descriptions of human motion are often defined from a frontal, sagittal and transvers frame of reference and can be used to specifically describe movement. The terms are typically used in the following manner: "as viewed from the <frontal, sagittal, transverse> plane, <state a certain type of movement or action>"

Example: As viewed in the sagittal plane, the extension of the hips moved the skier's COM forward (a fore aft movement).



Vertical movement – Sagittal plane

Vertical movements are comprised of flexion and extension along the balance line. These movements control snow contact and the magnitude of pressure on the base of the ski and the distance between the BOS and COM.

Minimal vertical range is required in the beginner stages of skiing but the demand increases with situational skiing and higher performance piste skiing. Our stance must accommodate a range of movement in order to control the magnitude of the reaction force coming from the snow. Just like the suspension of a car, we use flexion and extension movements along the balance line to give the upper body as smooth a ride as possible (pressure control actions).

To control the magnitude of the snow's reaction force, we must change the distance vertically along the balance line between our ski's base of support (BOS) and our centre of mass (COM). An athletic stance supports this vertical movement.

The body does not have a specific joint to facilitate pure vertical motion. Vertical movements along the balance line are achieved through coordinated rotations of multiple joints. Articulation of a single joint will move our COM forward or backwards.

Working to improve the range of pure vertical movement while in ski boots is beneficial. Our bodies are accustomed to having a far greater range of ankle freedom in day to day life.

Figure 13. Vertical movement.

Ski boots restrictively encapsulate the ankle and set the angle of the lower leg. This angle is critical and one that deserves attention to ensure the correct setup based on individual anatomy and equipment.

Ideally, one should be able to squat down (femurs to horizontal) and not fall backwards when not clicked into skis. If necessary, the forward lean of the boot can be adjusted. Finding the optimal range of movement will enable the legs to manage forces, negotiate changing terrain, and maintain snow contact.

Figure 14. Boot - Squat to horizontal

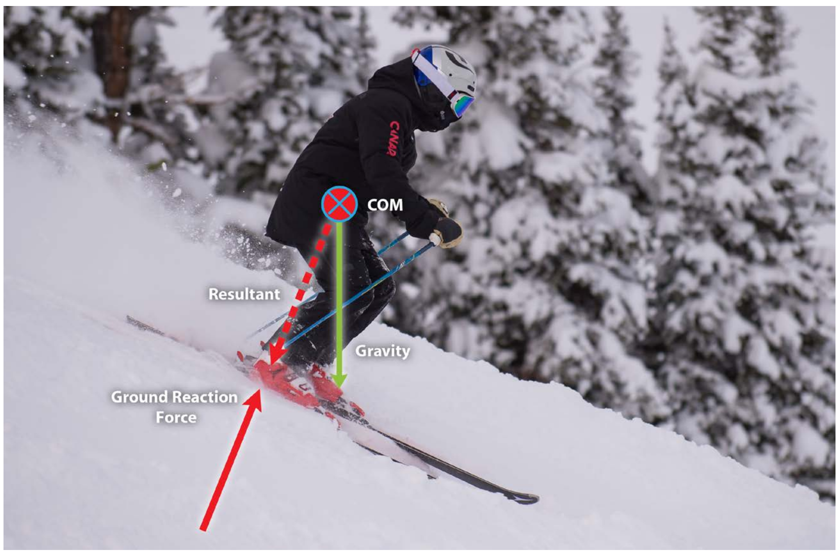
Fore Aft movement – Sagittal plane

Fore aft movements control the balance line along the length of the skis and the pressure distribution front to back along them.

As viewed from the sagittal plane, parts of the body are in front of the balance line and others are behind it. Starting from the snow up, the ankle joint sets the tone for everything else to follow. Knees will be in front of the balance line, hips behind, shoulders and head in front. The ankle joint can greatly control pressure distribution along the length of the ski. As it is the first joint in the kinetic chain, even a small movement of this joint can have a considerable impact on our COM position in the fore-aft plane.

As skiing is conducted on a slope, fore aft movements are utilized to maintain stability and keep the balance line perpendicular to the surface of the snow. We must anticipate the ever-changing pitch of the slope as we turn upon it – the pitch becomes steeper as we turn into the fall line and less steep as we come out of it.

Figure 15. Perpendicular aspect to the slope - fore aft.



Lateral Movement – Frontal plane

Lateral movements are any side to side movements across the skis that control and manipulate the edge angle of the skis and our inclination, angulation, and toppling.

Viewed from the frontal plane, the ski is rarely flat on the surface of the snow; we tip the ski over on edge every time we turn. The majority of our weight balances against the inside edge of the outside ski for most applications, so the outside ski platform is between the snow turning forces and our COM.

Figure 16. Lateral plane - outside ski relationship with COM.

Rotational movements – Transverse plane

Rotational movements turn the skis and also describe the rotational relationship between the upper and lower body segments.

From a rotational perspective, our legs lead the turning effort. We are considered successful in this regard when our hips and torso face more to the outside of the turn than our skis and legs. This separation, or independence, of the lower and upper body is referred to as counter. Just the right amount of counter is dependent on individual body types; it’s easy to have too much or not enough.

Sufficient counter facilitates a greater range of angulation at the hip. It enables a body alignment where the upper body can bend towards the outside of the turn, giving us the range of movement to adjust our balance against the outside ski.

By creating correct posture through counter, we have the ability to move the balance line laterally towards the outside ski.

Figure 17. Counter facilitating torso movement towards outside ski

The Skills – rotational, edge and pressure control

At the core of the Skills Framework are the three skills of rotational control, edge control and pressure control. These skills are present in every turn and in all terrain. A technical assessment and description can be made for any turn through evaluating the combination of these three components.

Below, we examine each of the three Skills, independently discussing the action of the skis and the movement options associated with each skill.

Rotational control

We ski with our legs and our upper body balances upon them. This fact highlights a separation in body segment roles. Independent movements of the lower and upper body around the balance line provide this fundamental action.

Ski Actions - rotational control

Rotational ski control refers to the rotation of the skis around their vertical axis, as viewed from the transverse plane. More simply, the direction the skis point.

- Pivoting (or yaw) refers to rotation around the vertical axis of the skis, flat to the snow surface.
- Turning refers to rotation around the vertical axis of the skis with edge engagement of the snow surface.
- Steering implies more active engagement of the edges.

Steering angle

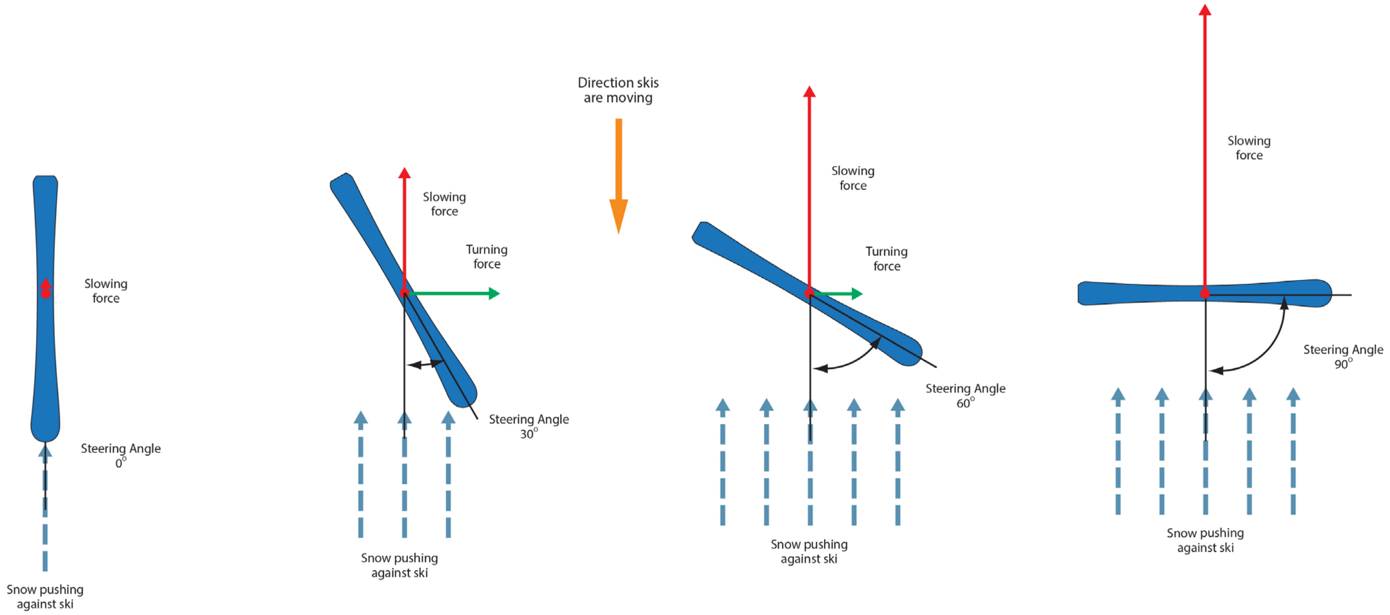
The ski's steering angle is the angle between the line of travel and the direction the skis point.

A sideways force (turning force) on the ski must be present in order to change direction (turn). This turning force is created by placing the skis at an angle to the direction of travel (a steering angle or angle of attack), tilted to the snow surface, while the center of mass is located inside the outside ski. The turning force presses against the ski bases, including the edges, and both slows the skis down and pushes them sideways.

Varying the steering angle alters the proportions of the slowing and turning components - the greater the steering angle, the greater the magnitude of the slowing component.

It is important to understand that the ski turns first, directed across the trajectory of our COM (direction of travel) before we actually turn.

Figure 18. Steering angles



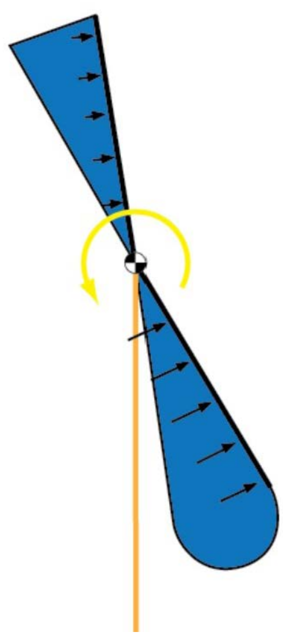
Desired turn shape, pitch and objective have a considerable effect on steering angle. Typically, the shorter the turn or steeper the terrain, the greater the initial steering angle.

Note: even in a purely carved turn, a steering angle is a prerequisite, and is omnipresent due to ski design properties.

There are three ways the ski can provide a steering angle:

1) Rotated around its vertical axis at an angle to the direction of travel. This steering angle action is the most common, versatile, and most applicable to a rotation control discussion.

Figure 19. Steering angle - transverse plane.

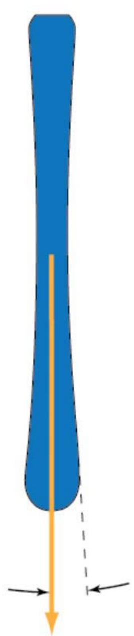


2) Flexing along its longitudinal axis to provide an angle across the direction of travel (ski bent into reverse camber).

Figure 20. Steering angle - longitudinal axis flex

3) The steering angle is provided by the sidecut geometry of the ski.

Figure 21. Steering angle - sidecut induced



Movements - Rotational control

Rotational movements occur when the body or parts of the body move in a circular trajectory around an axis. The body can make a number of such movements to provide rotational input to the skis.

Within a drifted turn, with the exception of external forces, these rotational actions, in combination with edging the ski, are the only way we can change direction.

Leg Rotation

Leg rotation is a turning force generated from the legs that changes the direction of the skis.

Internal and external rotation of the legs from the hip socket down (femoral rotation and tibial rotation) can be further segregated into upper and lower leg rotational actions. These movements are controlled by the rotator muscles of the hip and the leg adductor muscles.

When the leg is extended, the rotator muscles of the hip play a larger role. As the leg is flexed, the adductor muscles become more accessible and provide greater strength in the rotational plane.

A flexed leg can twist the skis more powerfully due to the creation of a moment arm at the knee.

Figure 22. Leg rotation.

Leg rotation is an economical movement pattern and has a direct influence on the ski. The movement provides the most effective control over the rotational axis of the skis in most applications, as rate and intensity can be manipulated quickly. Favourable pelvis and femur relationship/positioning enable effective hip angulation. The upper body remains quiet and stable, promoting good balance.

Note: the paragraph below referencing external force is of particular relevance to leg rotation.

Note: leg rotation has little effect when the ski is on a high edge angle.

Pelvis (hip) and upper body rotation

Hip and upper body rotation initiates a twisting movement to drive the legs and skis in the same direction. The action creates a rotational response at the skis via a transmitted torsional force generated from the upper body mass.

In comparison with using leg rotation to turn the skis, the movement is typically inefficient and often used by inexperienced skiers as a force to turn the skis. However, it can be an effective tactic and source of rotational input in certain conditions (ex. powder, crud, or wind affected snow).

Hip rotation also has the potential to be a powerful source of rotational input if mastered through body segment independence and discipline, by arresting hip rotation in the control phase of the turn.

Figure 23. Upper body rotation

Figure 24. Ted Ligety: using hip rotation to help start the turn (frame 6).

Image: Ron LeMaster

In a more specialized application, doing a 360 (helicopter) jump also uses the principle of generating torque from an upper body input in the rotational plane.

Common problems associated with hip and body rotation:

- Balance issues due to the centre of mass disruption.
- Difficulty in maintaining pressure/grip on the outside ski, particularly in the lower portion of the turn where forces are greatest.
- The movement can become a habit or crutch for generating the turning force.
- Often a sign that fore and aft alignment is making it difficult to steer the skis with the lower body.

Counter Rotation

Counter rotation refers to the upper body and lower body twisting in opposite rotational planes and is often generated by a quick and intense rotational muscular effort.

The movement directs an aggressive and quick rotational force to the skis and is effective in short turns or when the skis are off the snow and offer very little resistance. Applying an outside force, such as a pole plant or dragging the inside pole, can enhance the efficacy.

Counter rotation can also be effective as a recovery manoeuvre and a sick twister-daffy!

Figure 25. Counter rotation (frame 3)

Figure 26. Old school twister jump

External force

An external force is required to both create and apply active rotational input via leg rotation. Understanding and exploiting this fact can be a great advantage, particularly in situational skiing environments where the skis are more difficult to twist: power, crud, wind pack and slush.

Skis have self-turning properties but they must first be positioned with a steering angle to gain from the effect. It is often necessary to enhance the amount of turning contributed by the skis alone, by directing them with the legs through leg rotation. To initiate the turning of the legs and continue to turn them, an outside force is required.

In the case of leg rotation, we create a point of contact with the planet to supply a force against which to turn the legs.

In skiing, it is a rotational force of the legs that turns the skis in the desired direction. This required outside force can be created in several ways, often utilized in combination.

External force options

External force options are as follows:

- Inside pole contact with the snow (pole drag) - the most effective way to provide a continuous external force.
- Pole plant - provides a short/quick blocking impetus of the upper body against which to turn the lower body.
- Counter rotation (as an external force for the legs - internal to the body as a complete system).

Pole plant

The pole plant is not technically a movement around a rotational axis but should be considered a rotational control action.

A pole plant, when executed correctly, allows the snow to push on the hand through the pole. This pressure creates torque around the balance line, which provides a turning force. Through muscular tension of the hand, wrist, arm, shoulder, and core, we can control the magnitude and - to a limited extent - the duration, of this push from the snow.

Short turns and situational skiing in particular benefit from the stability provided to the upper body by the torque generated from a well-executed pole plant.

Figure 27. Pole plant

Figure 28. Pole Plant - Torque forces

Active and Passive rotational plane actions

Active rotational actions:

Robust leg actions direct the skis. This action is most apparent in short turns.

Passive rotational actions:

A stable pelvis coupled with efficient edging produces a ski geometry type turn (carved turn). This action is most apparent in expert carved long turns. The femur still turns in the hip socket but this movement is predominantly a result of the skis arcing under the body. The turning effort is led by the ski design.

Rotational independence (separation)

The ability of the upper and lower body to rotate independently is critical for efficient skiing. This movement is referred to as separation. The legs rotate more than the upper body, predominantly at the hip joint. Rotational independence is accessible throughout the kinetic chain.

Using a countered position at the completion phase of a short turn as an example, visualize the following body segments positioned around the balance line:

The legs will be rotated the most, pointing in the direction of the skis. The pelvis will be less rotated than the legs, the lower spine less rotated than the pelvis, the upper spine less than the lower spine, and the neck less than the upper spine.

Internal muscular tension throughout the core and pelvis greatly influences independent rotational efficiency. The use of a pole plant and/or dragging the inside pole creates an additional point of contact from which we can derive rotational leverage and stability, by tapping into an external force.

Edge control

Edge control is the ability to control the ski's lateral relationship with the snow. Command of this ability allows gripping and slipping of the ski and snow interaction. Additionally, edge control is the primary skill to invoke ski design features.

Ski actions – Edge control

Edge control or lateral ski control refers to the tipping action of the skis along their longitudinal axis, as viewed from the frontal plane (roll). The application affects the ski to snow angle, aka edge angle, which affects how much the ski bends along its length.

Figure 29. Lateral ski control. Platform angle is also a relevant term which is discussed later in this document

Side Slipping

Side slipping is the lateral or sideways movement of the ski across the surface of the snow. There is equal displacement of the tip and tail of the ski. Increasing the edge angle increases friction (plowing effect) and reduces sideways slipping.

Figure 30. Side slipping

Drifting

Drifting is a blend of side slipping and forward sliding of the ski. The ski tails laterally displace more/faster than the ski tip as the ski moves forward.

The sideways travel is reduced as turns become more carved. Rudimentary parallel turns are often very drifted, producing a Z-shape, indicating a lack of control of the turn shape.

Figure 31. Drifting

Steering

A steered turn is a less drifted turn but not yet a carved turn. The track in the snow is narrower than a drifted turn as it has more active steering actions present but wider than a carved turn, producing a rounder arc to the turn shape.

Carving

In a carved turn, there is no sideways drift to the ski path; it is very much a turn shape of ski geometry. The ski tail follows the tip and leaves a definitive arc in the snow.

Figure 32. Carving

Image: Ron LeMaster

Self-steering

Tipping a ski on edge invokes several design features - sidecut, longitudinal flex and complimented by a longer ski forebody than tail - that provide a self-turning function to the skis. A torque is produced that turns the ski as it moves forward. Self-steering properties of the skis are discussed in detail in the Performance Model.

Platform angle

The platform angle represents the direction of force the skier applies to the ski and the platform the ski cuts in the snow.

The platform angle determines whether or not a ski slips sideways as it travels forward, assuming the ski edge penetrates the snow and that the snow surface has enough integrity to hold the skier. The platform the ski's edge cuts into the snow provides the surface that supports the weight of the skier. The snow pushes on the ski perpendicular to this platform. If the push from the snow is aligned with the weight of the skier, the ski will not slip.

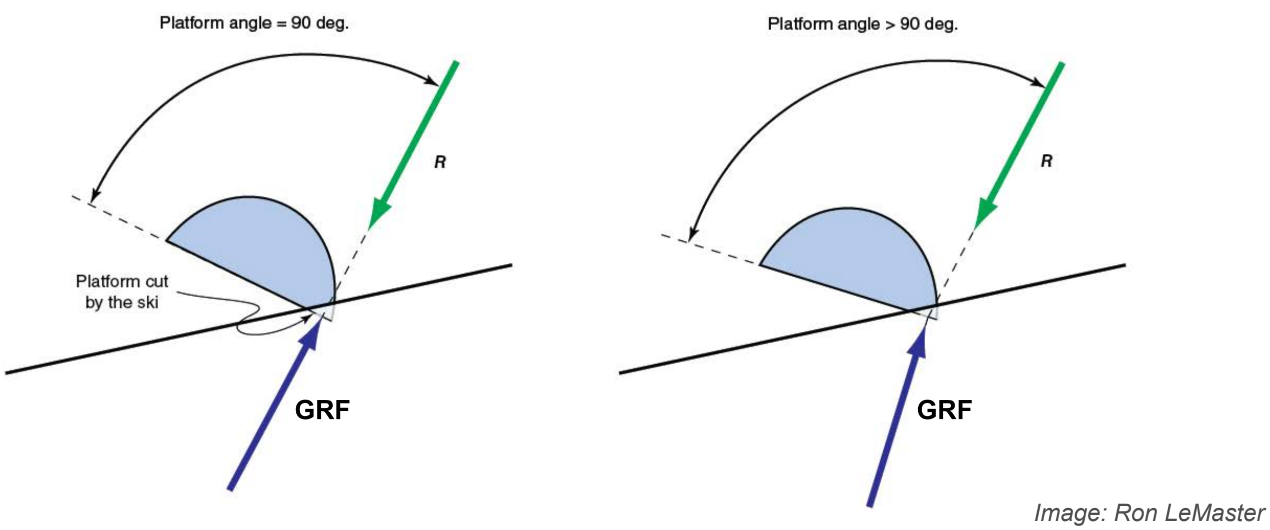
If the ski is edged (tipped) less than the inclination of the skier, the ski will slip.

When the ski is edged more or equal to the inclination of the skier, the ski will not slip.

The platform angle varies along the length of the ski. The middle of the ski provides more grip than at the ski extremities, the tip and tail always flex more in torsion than the middle of the ski. All skis have torsional flex, how much depends on the torsional rigidity of the construction.

Achieving a platform underfoot that aligns the forces does not mean that is the case at front and tail of the skis.

Figure 33. Platform angle



Ski width

The width of the ski waist has a direct effect on the difficulty of holding an edge. The force from the snow pushes on the inside edge of the outside ski. The wider the waist of the ski, the greater the distance from the centre of the ankle to the weight supporting platform. The greater the distance, the greater the force (torque) acting to flatten the ski (reduce edge angle).

Snowpack density greatly influences this situation. On hard snow, the ski edges cut a smaller platform and the distance from the centre of the ankle to the force from the snow is greater. In softer snow, the ski edges cut a larger platform, reducing the distance.

Skiing on hard snow with a wide ski places more force on the knee than would a narrower ski. Using wide skis on hard snow creates strain and fatigue potential on the knee joint due to the muscular effort of edging and holding an edge against the opposing torque working to flatten the ski.

Figure 34. Ski width - knee torque

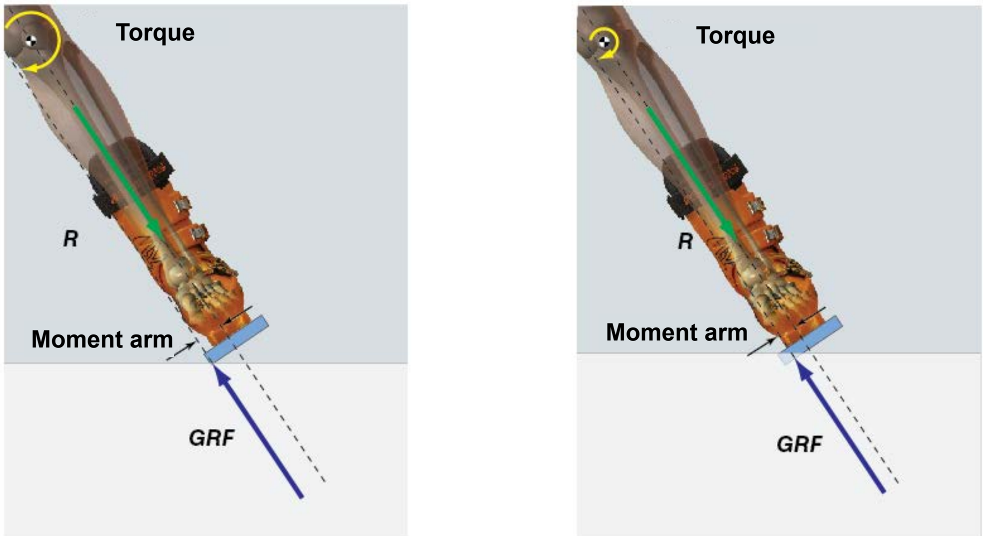


Image: Ron LeMaster

Angulation provides a mechanism for some adjustment of the force from the snow, closer to the longitudinal axis of the ski. Angulation reduces the length of the moment arm, which in turn, reduces the amount of torque.

Movements - Edge control

Lateral movement occurs across the base of support - from side to side. The movement can be viewed either from the body moving laterally across the BOS or the BOS moving away/sideways from the body.

Edging is achieved by a specific movement or a combination of movements, depending on the desired objective.

To turn, the COM must be inside the arc. The parts of the body moved towards the inside or outside of the arc (lateral movements across the skis) are considered edging movements. A variety of movements can provide edging input to the skis.

Ankle control/tension

Ankle control and tension directs force towards the inside or outside of the foot (pronation or supination) and changes the platform angle.

The ankle joint can manipulate edge angle the fastest, exerting a strong influence on early edging outcomes and enabling the angulation between the foot and the tibia.

Knee

An angle is created at the knee joint, as viewed from the frontal plane.

The knee joint has little capacity for lateral movement; perceived knee angulation is a combination of internal leg rotation, knee flexion and ankle eversion.

There is greater apparent utilization of the knee in short turns comparative to longer turns, as there is less use of the hip. Angulation of the knee is fast and reactive but weaker than hip angulation.

Figure 35. Knee angulation

Hip

Creating an angle at the junction of the pelvis and hip joint - leg and upper body independence.

Accompanied by rotational independence (separation) between the legs and pelvis, a hip hinge motion allows the body to bend laterally. The upper body moves towards the outside of the turn as the hip moves further inside the turn, creating an angle at the junction of the pelvis and hip joint.

The lateral tilt of the pelvis is effective but only a small amount of tilt is accessible without some counter position of the pelvis.

Figure 36. Hip angulation

Hip angulation allows the legs to tilt the skis more quickly than using the whole body to do so. The movement is strong and powerful but generates slower edging control compared with knee and ankle angulation; it is most suited towards higher speeds where greater forces are encountered. The hip enables angulation between the legs and pelvis and is the only joint in the skiing kinetic chain that offers circumduction movement ability.

Blending edging movements

A blend of the above movements is most common when skiing.

Desired outcomes and situations dictate the combination and extent of edging inputs, with speed and radius being the main influences.

Inclination

Inclination is the degree of lean relative to the line of gravity. It also represents the balance line as viewed from the frontal plane.

The line from the BOS (supporting foot/feet) through the COM that describes the angle (lateral movement) of the COM towards the inside of a turn.

Every turn has inclination, allowing the COM to balance against the turn forces.

Figure 37. Inclination with BOS and platform angle

Angulation

Angulation describes several movements which create discreet angles between the ankle, knee, hip and through the spine – lateral independence. Angulation allows a greater edge angle relative to our speed and radius than inclination alone.

Hip angulation, for example, creates an angle between the upper leg and pelvis. The lower body parts are angled towards the inside of the turn and the upper body parts angled to the outside of the turn.

Angulation is present in all well-executed turns. It allows lateral adjustments of the balance line towards the outside ski. When used in conjunction with counter (upper and lower body independence/separation), the range of movement is greater.

Figure 38. Angulation

Continuous/progressive edging

In a drifted turn, the steering effort must be continued to produce a round turn.

Turning forces increase as the turn progresses due to the pull of gravity downslope. If the turning effort is not maintained, the turn shape will elongate (radius will increase). This elongated turn shape is prevalent in novice skiers, as they lack the ability to create and resist the turning forces after crossing the fall line.

In a carved turn, the COM must progressively move further inside the turn as the forces build.

The largest edge angles are created during the transition between the end of the control phase and the start of the completion phase of the turn where the forces are at their greatest.

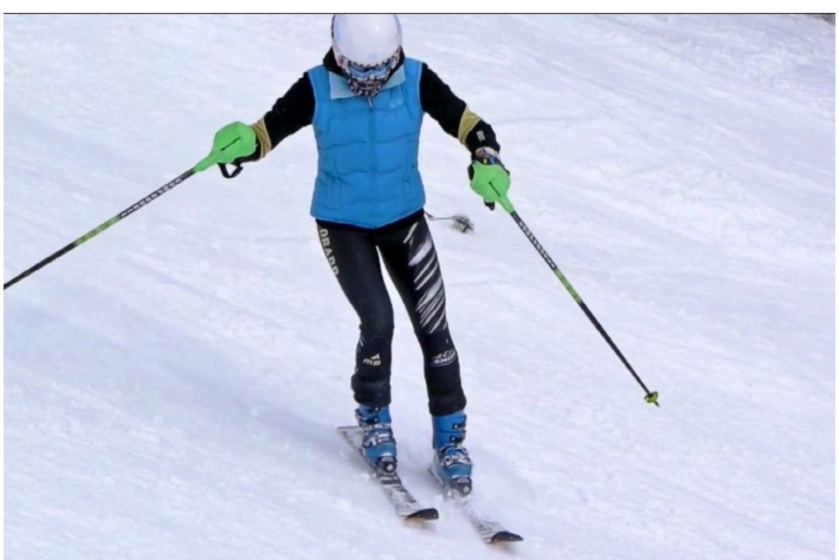
Figure 39. Progressive edge angle

De-edging

De-edging refers to reducing edge angle of the skis in a predictable and controllable manner. The ability to dynamically adjust the edge and platform angles to intentionally slip and feather the edge is of great utility.

Edging ability involves controlling the ski grip, applying it more, or less as required. Training the movements that reduce ski grip develops the versatility and adaptability needed to control many situations and turn outcomes. This aspect of edging is often overlooked. Competency is developed over time by understanding the concept and through dedicated practice.

Figure 40. De-edging



Turning force

Centripetal force (a centre-seeking force) is the sideways force making us go around a turn. Whenever centripetal force is present, the COM must move inside the turn. The greater the force, the more the COM needs to move inside the turn.

Every turn has inclination due to this force. The degree of inclination depends on the magnitude of the force.

Pressure control

Pressure control is a blanket term for managing forces in skiing.

There is artistry in mastering pressure control. Exceptional skiers are described as having a unique ‘feel’ for the snow. Pressure is simply a force divided over the distributed area (P=F/A). That statement is extremely accurate when you consider skiing is controlling forces distributed over the instruments we call skis.

Forces in skiing come from two main sources:

- Actions or movements created by the skier
- Variations in terrain and snow surface/conditions

Forces at the skis

Fore aft: distribution of pressure along the length of the ski around its lateral axis (pitch).

Ski to ski: distribution of pressure from ski to ski (as viewed in the frontal plane).

Vertical: magnitude of force acting on the ski base, including the edge of the ski.

Fore-aft distribution of pressure along the ski length effects the self-steering function of the skis by manipulating torque. Moving pressure forward increases the self-steering function, whereas moving pressure rearward decreases it.

Pressure Control movements

Fore/Aft

Fore/aft stability is constantly challenged when skiing.

Terrain features and the changing gradient of the slope require continuous fore aft adjustments between the BOS and the COM to stay in an optimal balance state.

As the skier’s location in the turn changes, the gradient of the slope relative to the direction the skier is facing also continuously changes. As a turn is initiated, the incline of the slope becomes increasingly steeper through the fall line and then rapidly decreases through completion of the turn. Snow conditions (ice/powder) and terrain also have a considerable effect on the resultant force trajectory and required fore-aft pressure adjustments.

Manipulation of pressure forwards at the start of a turn has balance and turn initiation advantages. Aft pressure distribution enables more effective grip through the middle and turn completion phases.

Relationship between the BOS and COM

The pull and push of the feet moving the BOS fore-aft under the COM is typically quicker than moving the COM fore-aft. Refinement of muscular tension and foot/ankle/lower leg proprioception has a significant influence on fore-aft pressure control at the expert level.

Subtle manipulation of pivot point changes fore-aft along the ski can be achieved. Pressure/force distribution towards the toe or heel piece of the binding also influences ski performance characteristics.

Directing increased pressure/force towards the front of the ski enables easier turn initiation and aids in a forward, perpendicular to the slope, BOS/COM relationship. Directing such pressure/force toward the tail of the ski in the middle and turn completion phases creates grip.

Joint Movement in Isolation:

The below movements have the following effects:

- Hip Flexion - Moves COM forward
- Hip Extension - Moves COM backwards
- Knee Flexion - Moves COM backwards
- Knee Extension - Moves COM forward
- Ankle Flexion - Moves COM forward
- Ankle Extension - Moves COM backwards

Figure 41. Joint articulations

The Ankle

The ankle is deserving of special mention in the context of advanced pressure control. Being the joint closest to the ski to snow interface and the first joint in the kinetic chain, the ankle can influence rapid pressure distribution on the ski both fore-aft and laterally.

Expert edging and pressure control refinement requires mastery over the movements of this joint. Small increments of articulation at the ankle produce a significant influence on balance and ski performance.

Dorsiflexion and plantar flexion, combined with hip flexor and glute activation, facilitate expert level fore-aft pressure/ weight distribution.

Ski to Ski

As we predominantly ski on the outside ski, the transition of weight/pressure from ski to ski is required.

Reasons for skiing on the outside ski:

- We constantly fall inside during a turn in order to continue to turn. The inside leg can catch us if we fall too far, too quickly, by controlling inclination.
- The outside leg is more extended and, therefore, stronger in the vertical plane (perpendicular to the ski base).
- The outside leg is biomechanically stronger, with more effective alignment to control turn forces.
- Maximizes grip. Greater edge angle and more pressure is produced on the outside ski.

As our legs can manipulate the vertical distance between hip socket to ski independently, we have the ability to rapidly transfer weight from ski to ski through flexion/extension movements of the ankle, knee and hip joints and a small amount of pelvic tilt. This leg action independence substantially controls the path of the COM from turn to turn (Toppling).

Figure 42. Ski to ski

Weight transfer can also be achieved through gross movements of the upper body but these movements are considerably slower and less effective. Different combinations and timing of these faculties provide numerous techniques to obtain weight/pressure transfer between skis.

Vertical movements

Vertical movements describe the movement of the COM closer to or further away from the BOS, vertically along the balance line.

The BOS/COM relationship is controlled predominately through flexion and extension movements of the ankle, knee, and hip joints; the spine and trunk also play a role. These movements occur along the balance line, as the push from the snow (pressure) acts perpendicular to the base of the ski.

Vertical movements are continuously adjusted to regulate the pressure through the base of the ski and control ski to snow contact. Regulating pressure as terrain and turning forces change allows the COM to stay quiet and stable, providing a predictable upper body mass against which to turn the legs.

Vertical movements to moderate pressure are most apparent at the expert level. Expert situational skiing environments often demand a full range of vertical movements to successfully manage variations in terrain.

Example: Expert short turns

Rapid pressure buildup demands absorption of pressure between turns to maintain snow contact and initiate the next turn successfully and elegantly. Vertical movements (flexion) along the balance line manage the magnitude of force through the bottom of the skis to enable this performance level of skiing.

Figure 43. Absorption - short turns

Example: High impact expert bumps

By anticipating the trajectory of the snow pushing on us upon impact, we rapidly extend and place our feet between the impeding impact and our COM. Controlled, resistive flexion movements through the full range of the vertical axis arrest the large forces encountered in these situations.

Figure 44. Absorption - bumps

Unweighting reduces forces (pressure) at the ski-to-snow interface.

Unweighting

Unweighting is a term used to describe increasing and decreasing the pressure (force) between the snow and the skier. We use unweighting to manipulate and manage the magnitude of pressure acting on our skis.

We typically refer to two forms of unweighting, up-unweighting, and down-unweighting. In its simplest form, we use unweighting to reduce the amount of pressure on the skis, making it easier to direct them.

Unweighting is achieved by accelerations and decelerations between the COM and the snow.

Up-unweighting

In up-unweighting, an extension of the legs momentarily increases pressure, but at the top of the action actually reduces pressure on the skis, making them lighter. It is easier to twist the skis when there is less weight on them (reduced pressure).

The speed and duration of this movement provides options for specific tactics and objectives.

Figure 45. Up unweighting

Image: Ron LeMaster

Down-unweighting

Down-unweighting is a quick flexion movement of the joints that creates an unweighting (reduction of force) on the skis at the start of the movement. The speed and specifics of this movement - actively pulling feet up or dropping COM down - provides options for specific tactics and outcomes.

The COM will still predominantly rise in a down-unweighted manoeuvre but it will rise less than the feet, as the feet are absorbing/taking away force (pressure).

An example is bump skiing: flexion movements occur during edge change, but the COM path still rises as the skier moves over the bump.

Figure 46. Absorption - bumps

Concept understanding note. Think: is the reduction of force derived through an extension (up-unweighting) or flexion (down unweighting) movement?

Longer transitions between turns favor an up-unweighting approach whereas a short transition favors a down-unweighting approach.

Here we conclude the Skills Framework. The Performance Model is the next document in the series.