Biomechanics of Winter Sports- Alpine and Cross Country Skiing, Snowboarding and Ski Boots

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Biomechanics of the Alpine Skier

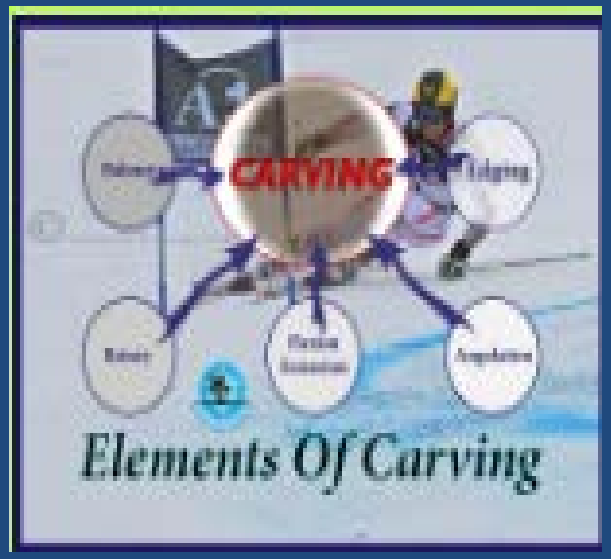
The skier can be a very challenging patient.

- Being aware of his/her numerous concerns, whether due to biomechanical imbalances leading to poor ski technique, or performance or problems related to foot or boot-fit discomfort.
- One must understand the concepts of lower extremity biomechanics related to skiing, boot design, boot fitting, as well as the relation between a ski orthotic and the boot in which it sits.

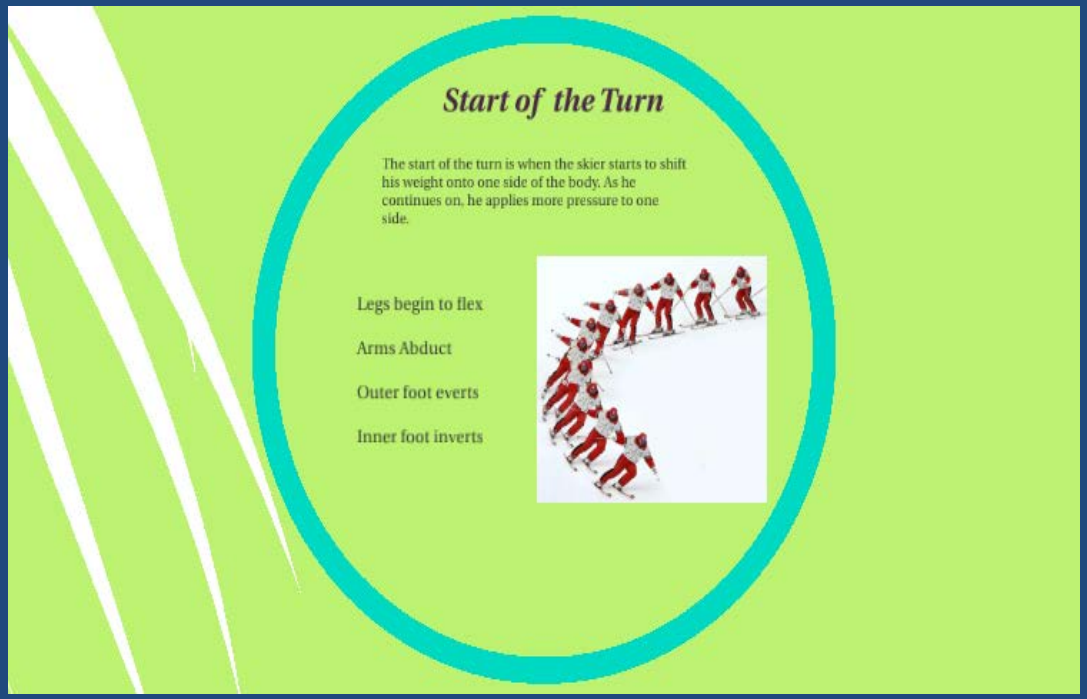
Alpine Skiing Biomechanics

- Alpine or downhill skiing is a complex skill that requires controlled pronation, setting the foot, ankle, and lower extremity on the inside edge.
- Pronation sets the inside edge of the downhill (control) ski and allows for the skier to lean inward against the ski, which holds a skid-less arc throughout the turn.
- While balanced on a beam of flexible composite (6.3 cm wide), the skier drives the shin forward against the stiff boot cuff and swings the hips to the opposite direction.
- The ski rolls onto its sharp steel edge and bites the snow, creating an arc across the hill (Ross & Subotnick,1999).

Elements of the Ski Turn



Start of the Turn



Mid-Turn

Continuing the Turn

The middle of the ski turn is the most intense part of the turn. It is when the skier's body is most compacted and is when the majority of injuries occur.

Leg Flexion continues

Outer foot everts

Inner foot inverts

Skier is in most compact position of the turn

End Of the Turn

End of the Turn

The end of the turn is when the skier starts to relax and has a few seconds to recouperate before going back and and making another turn.

Legs Extend

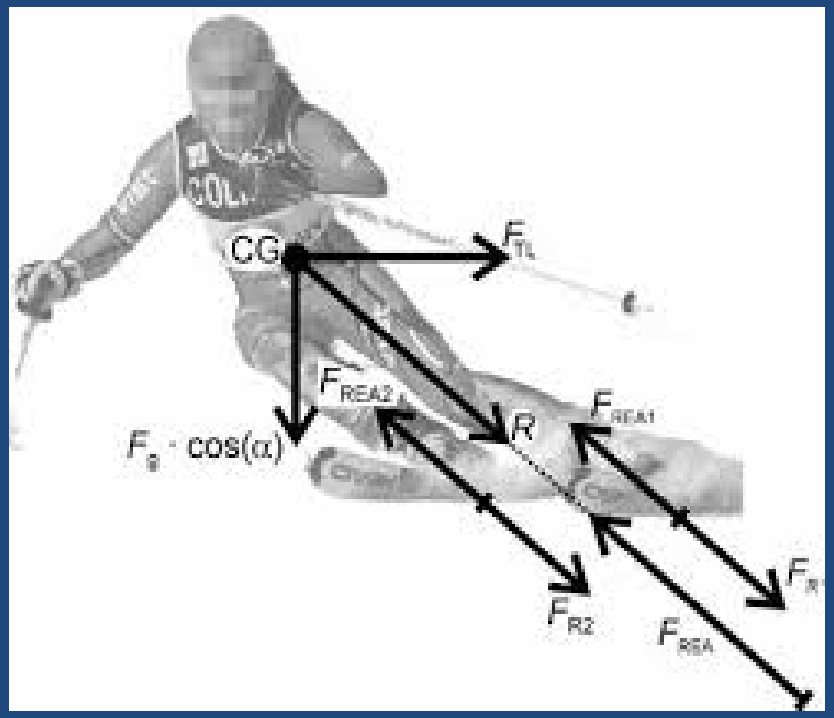
Outer foot inverts back to normal

Inner foot everts back to normal

Then the process of a ski turn starts over again.

Center of Gravity of the Turn

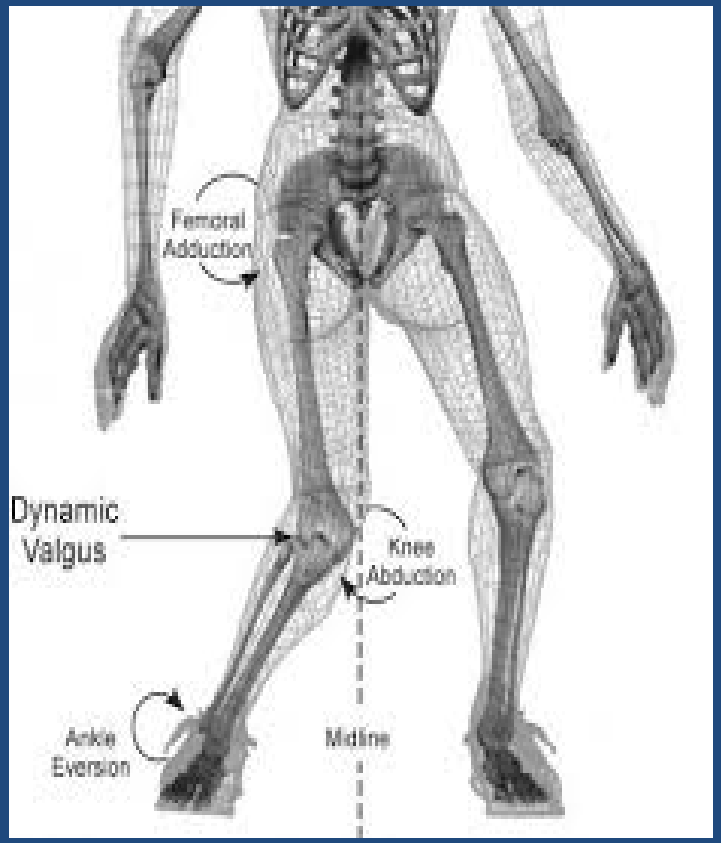
- Skiing is analogous to ballet on snow, where the skier encounters many centrifugal as well as g-forces during the turns, while simultaneously attempting to keep the center of gravity in line over the center of the ski.
- Any change in the normal biomechanical balance can alter the skier's ability to develop a controlled turn, thus predisposing the skier to injury if the abnormality is significant enough.



Ski Biomechanics

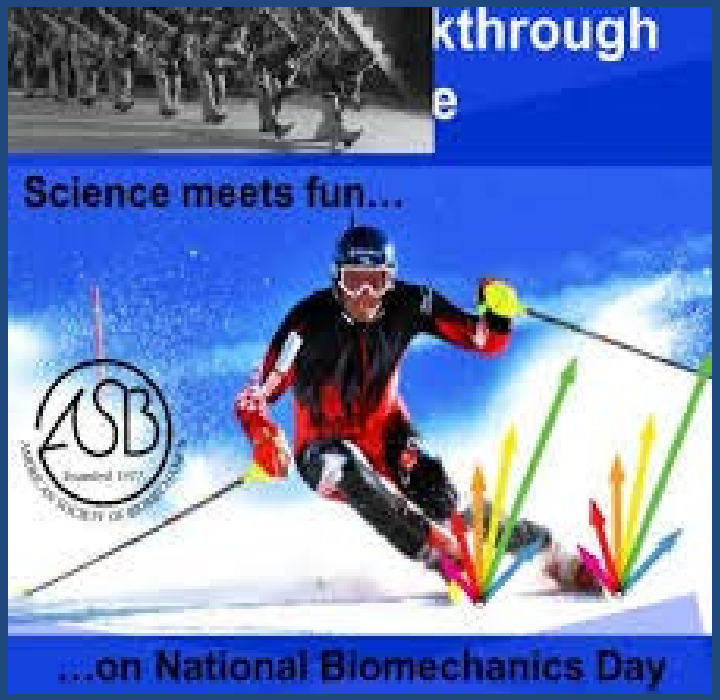
- Skiers who have biomechanical abnormalities will compensate by obtaining Pronatory forces from other joints, for example, the hips and knees, in order to ski effectively.

- Using the ElectroDynogram (EDG), Ross (1985) showed that forces are transmitted from both the forefoot and the rear foot , which the skier utilizes in up-and down-weighting, as well as in the completion of turns.



- Abnormalities which were observed included: excessive foot pronation, shortened heel contact with excessive propulsive phase on the toes, extreme forward lean of the boot, as well as asymmetry between the two feet.

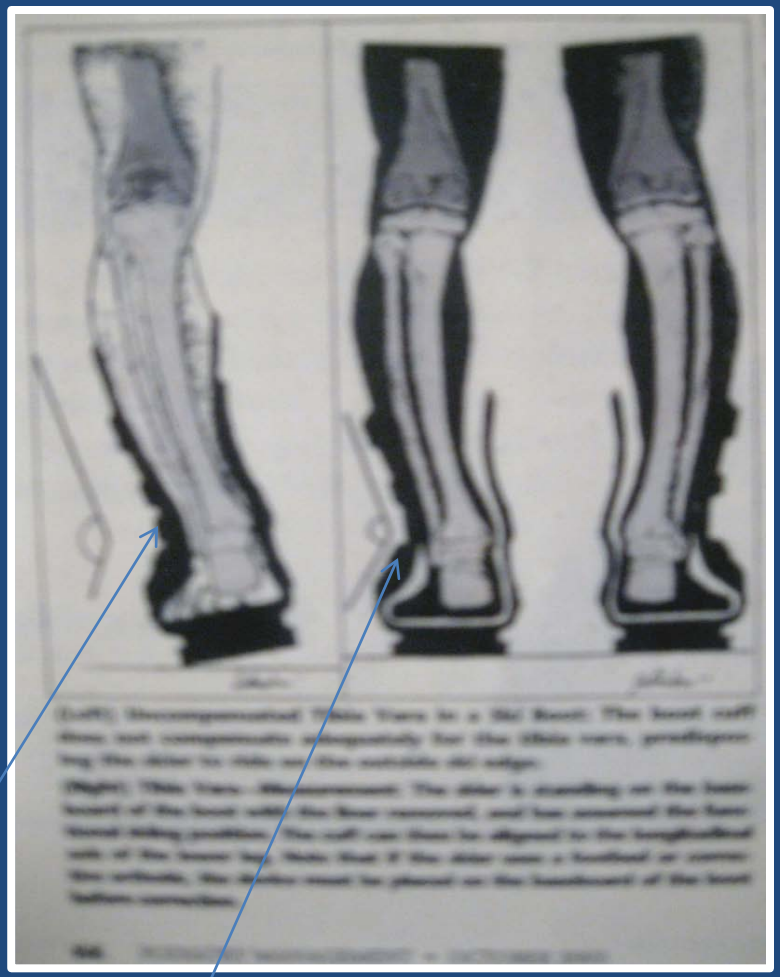
These combined affected the skier's effectiveness and overall performance. The sports medicine podiatrist can assist skiers to overcome some of these lower extremity abnormalities, including poor skiing style, poor edge control, as well as foot imbalances (e.g., rearfoot varus/valgus, forefoot varus/valgus, pronated or supinated subtalar joint) by prescribing a variety of orthotics for control in their ski boots.



Tibial Varum

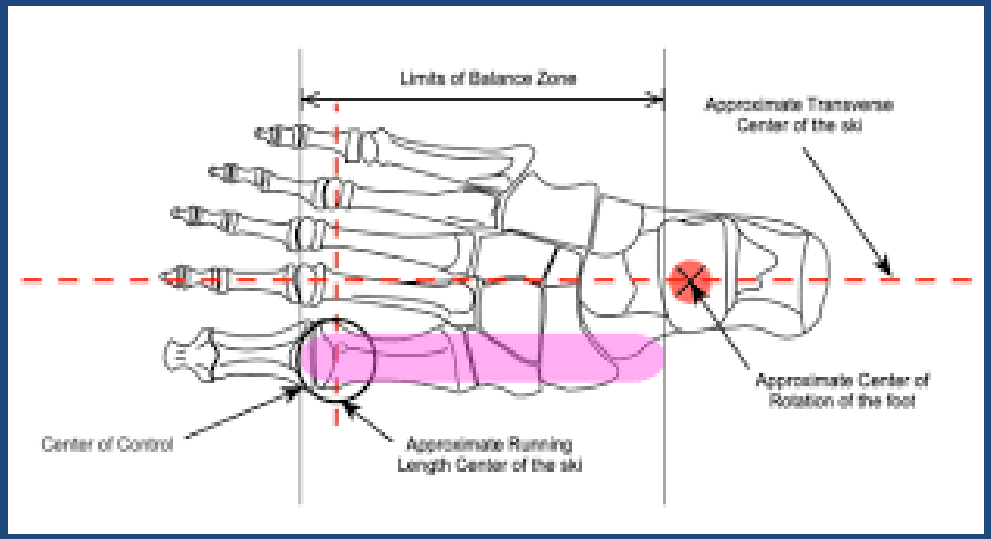
- Tibial varum is one of the more common lower extremity biomechanical abnormalities that can have a negative impact on a skier's performance.
- Tibial varum is a result of an uncompensated varus deformity of the tibia, which transmits instantaneously to the ski-snow interface, and causes the skier to ride excessively on the outside edge of the ski.

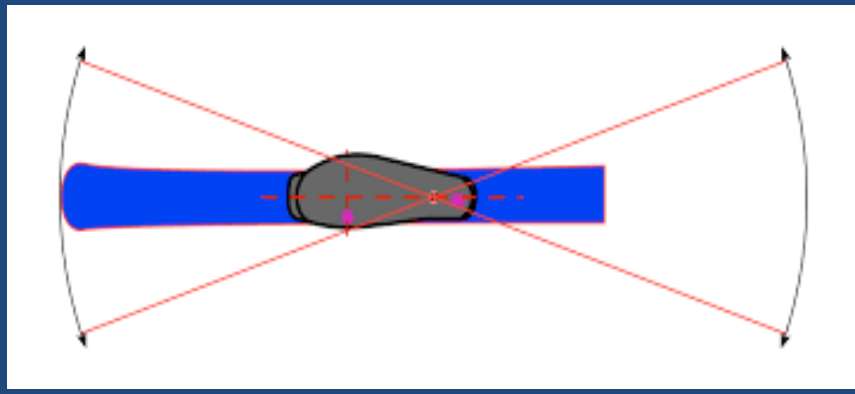
  Those skiers who have greater than 8 to 10 degrees of tibial varum will have a great deal of difficulty initiating a parallel turn without "catching" the outside edge of the ski.



Uncompensated Tibial Vara in Ski Boot

Cuff alignment to longitudinal axis


Limits of Balance Zone
Approximate Transverse Center of the ski
Approximate Center of Rotation of the foot
Center of Control
Approximate Running Length Center of the ski



Accidents

One of the most common injuries of skiing effects begginers and intermediate skiers. It is so common, almost one in every four injuries are diagnosed as this injury! Medial Collateral Ligament Strains (MCLS). This injury is caused by the skier not being in control and losing his balance. This injury is connected to ski turns because someone who is unsure of when to start the turn will most likely become inured in this way.

Prevention

Prevention of MCLS is critical for skiers ranging from first timers to professionals.

Here are some of the things you can do to prevent the injury:

Train for skiing
- Quadriceps
- Calf Muscles

Wear Comfortable And Supportive Socks for your feet

Don't Push Yourself Harder than you think you can handle

(Always wear a helmet)

Bag of Boots

- Unlike the average runner who has a small bag of running shoes, the skier who makes the trip to your office has a big bag filled with ski boots, as well as foot beds and orthotics.

  The skier's visit to your office may be because of chronic foot pain due to the boots, or his/her performance being affected by the inability to be totally comfortable in the boot while initiating and completing turns.

  Whatever the reason, you may be the skier's last hope after attempting to correct the situation

  first at the ski shop or with the boot fitter.


VISA
BEAVER CREEK


SÖLDEN

Ski Boots


LANGE
XT130


S
salomon

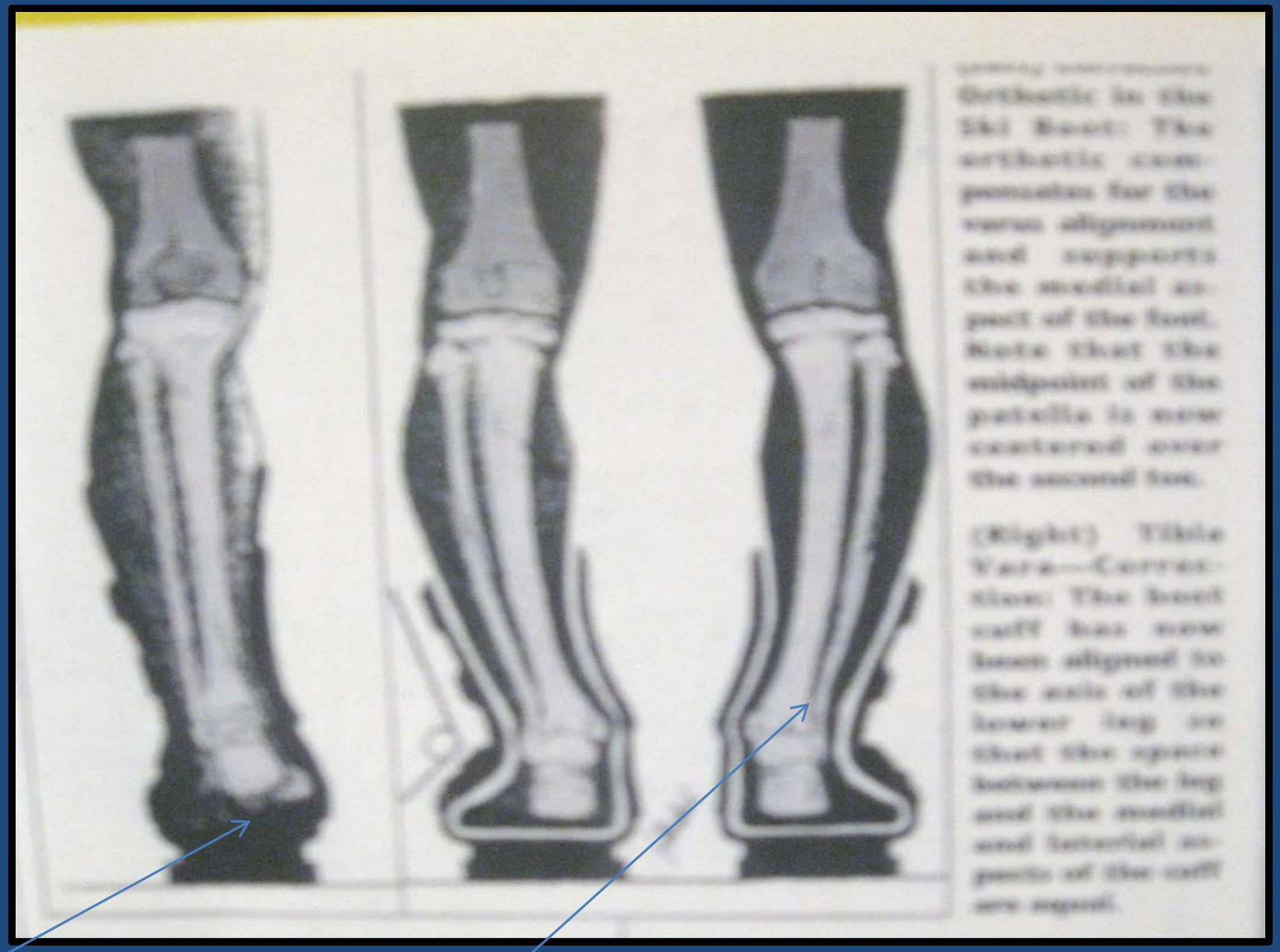

ATOMIC


BRIKO
PEAK
Red Bull


Barilla
VISA
Audi
Jack Wolfskin
LEKI

Foot Bed and Leg Alignment

Boot Canting



Orthotic in the ski boot

Tibial Vara Correction

Ski Boots and Orthotics

- The ski boot removable foot bed may be replaced with custom-made orthoses. Many of these devices are made in the ski shop with a computer imprint of the skier, or by placing the foot in a semi-weight-bearing neutral position, with a knee stabilizer apparatus built into the platform to accurately align the knee over the foot for a more complete lower leg correction.
- In the traditional method of making an in-boot cast, the skier assumes a neutral ski stance position, which will help achieve a greater degree of correction.
- It has been shown that controlling excessive pronation/supination and locking the midtarsal joint (stability) will greatly enhance edging and performance.

- The five areas of concern in the foot bed are:
- Zone one-the foot bed,
- Zone two-the tongue,
- Zone three-the hindfoot,
- Zone four-the shaft, and
- Zone five-the forefoot.

Footbeds and Orthotics for Ski Boots

- "The combination of the orthotic, the custom liner, and any changes we have to make to the shell let us achieve our goal:
- we want to let you stand comfortably in the boot with no shell impingement on your bones, which usually occurs on the inside or outside of the ankle.
- This allows the skier to be in a neutral, athletic stance without cutting off any circulation or causing discomfort." Ray Rice Surefoot

Larry Olmsted Senior Contributor *Forbes*

One foot at a time is scanned and 3-D modelled using this computer controlled footbed scanner


salomon
ATOMIC
BOOT FIT STATION
ATOMIC
salom

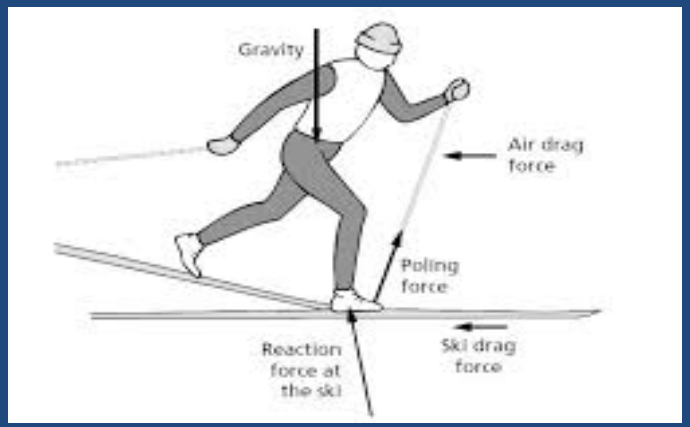

ATOMIC
MEMORYFIT
IT'S PERSONAL
SALOMON
CUSTOM
SHELL

The Boot Tech

Cross-Country Skiing

Cross-Country Skiing

- Cross-country skiing involves a heel that is repeatedly lifted within and lowered again.
- This creates a more unstable situation for the skier.
- The technique that is used in cross-country skiing is referred to as a swing kick and glide.
- Longer ski poles are used to create upper body stability and propulsion, while the heel is kicked upward to maintain forward motion with a forefoot propulsion on the ski.
- When alternating the opposite arm, this creates a diagonal stride and leg forward movement, similar to walking or running.



Cross-Country Skiing

- The difference between the alpine boot and the cross-country boot is that the trekking boot is a hybrid between the backcountry and a running racing flat in both design and support.
- In comparison, the cross-country boot has much more freedom of movement, while giving up some of the support that the alpine provides.
- In cross-country skiing, sagittal plane motion is the predominant direction of the foot and leg and it is not essential that the touring skier require stability in the shoe for exaggerated turns. Typically, the touring skier will be in a track on a course, except when skiing backcountry.

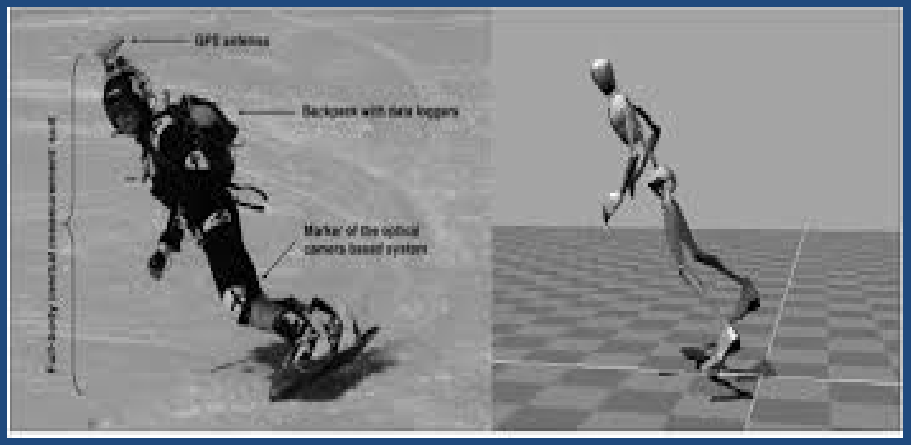
Snow Boarding

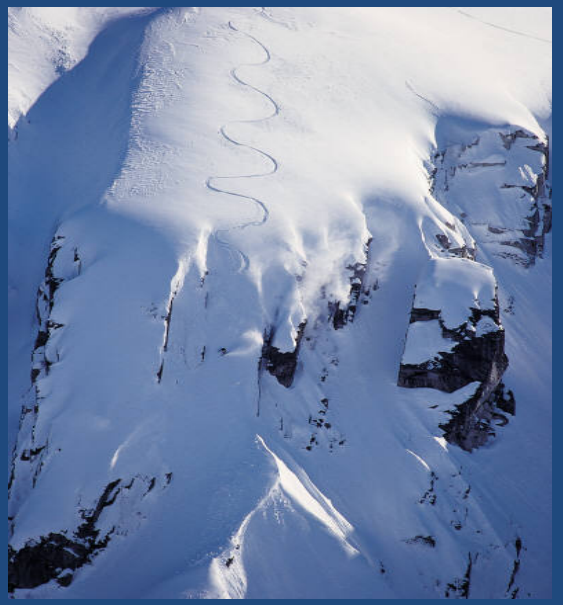
Snow Boarding

- The difference between alpine skiing and snow boarding is that the "boarder" lacks the freedom of individual leg movement, thus decreasing the chance for recovery.
- Whereas alpine skiing incorporates integration of the foot, knee, and hip motion, snowboarding focuses energy on the hip and knees, due to the nature of the short pivoting turns.
- An evolution has also taken place in boots. Earlier designs produced a soft boot with more freedom of movement, whereas more recently a full hard shell and half shell are typically worn. The softer design, allowing for more foot motion ,also resulted in more injuries than the harder designs.

Biomechanics of Snowboarding

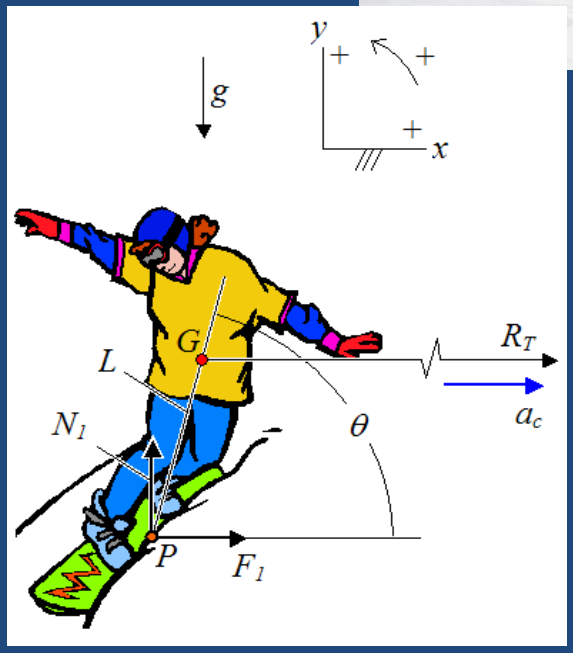
- A snowboarder typically gains speed by converting gravitational potential energy into kinetic energy of motion
- The more a snowboarder descends down a hill, the faster they goes.
- The snowboarder must prevent from going too fast and losing control. They do so by skidding the board on the snow, in a controlled zig-zag pattern .





Biomechanics of Snowboarding

- This creates frictional resistance with the snow and prevents the speed from reaching dangerously high levels.
- The snowboard is pointed in the same direction as its velocity (which is the same as the velocity of the snowboarder). This is a necessary requirement for minimizing snow resistance, and maximizing speed.



Biomechanical analysis in freestyle snowboarding: application of a full-body inertial measurement system and a bilateral insole measurement system

Andreas Kru¨ger and Ju¨rgen Edelmann-Nusser Otto-von-Guericke

Sports Technol. 2009, 2, No. 1–2, 17–23

University, Department of Sport Science, Germany

Several investigations show that 5–28% of all injuries relate to the ankle joint complex [1–4]. Furthermore, correlations between the type of equipment used and the injury were found [2,3,5,6]. Thus, the development of enhanced snowboard equipment, to reduce the risk of equipment-related injuries, is considered in literature [2,5,6,7]

Hockey and Figure Skates

Thank You!

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Conclusions

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