



***Kinematics errors leading to Ski Injuries (2015)***

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# Alpine Ski

- Practice of skiing : 5000 years ago when early hunters and fisherman used animal tusks to traverse snow.
- Nordic skiing comprised the only skiing event in first Winter Olympic Games in 1928 (St Moris, Switzerland), but **Alpine ski** did not gain popularity until after 1932 Lake Placid Winter Olympics.



# Snowboard

- Snowboarding :new winter sport (1920s)
- The increasing popularity of snowboarding over the past 20 years has continued to increase the number of ski goers.
- In 1998 : Olympic event at the Nagano Olympics



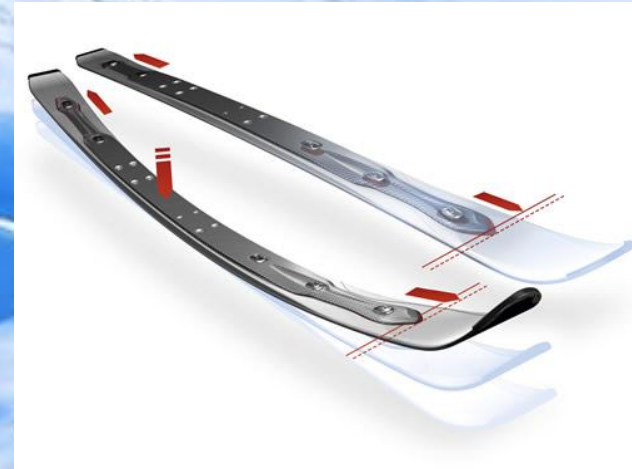
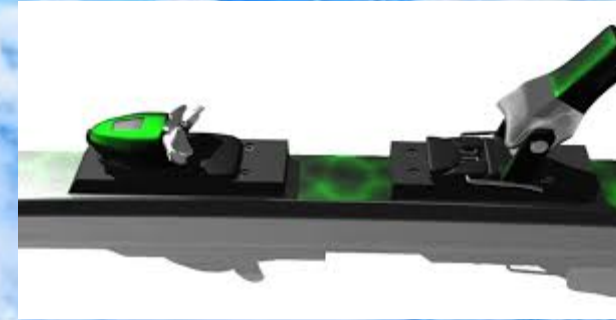
# Prevalence of injuries

- Alpine **skiers** : 2-3 injuries per 1000 skier days which has decreased due to advancement of equipment.

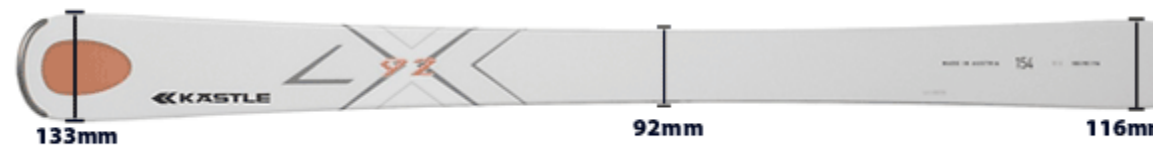


# *Biomechanical aspects of new techniques in alpine skiing and ski-jumping*

Over the past few years, dramatic changes have taken place in alpine skiing and ski-jumping. In alpine skiing, the skis have become much shorter, their side-cut has increased in size and also stiffness of ski is changed. These changes have affected the risk of sustaining an injury.

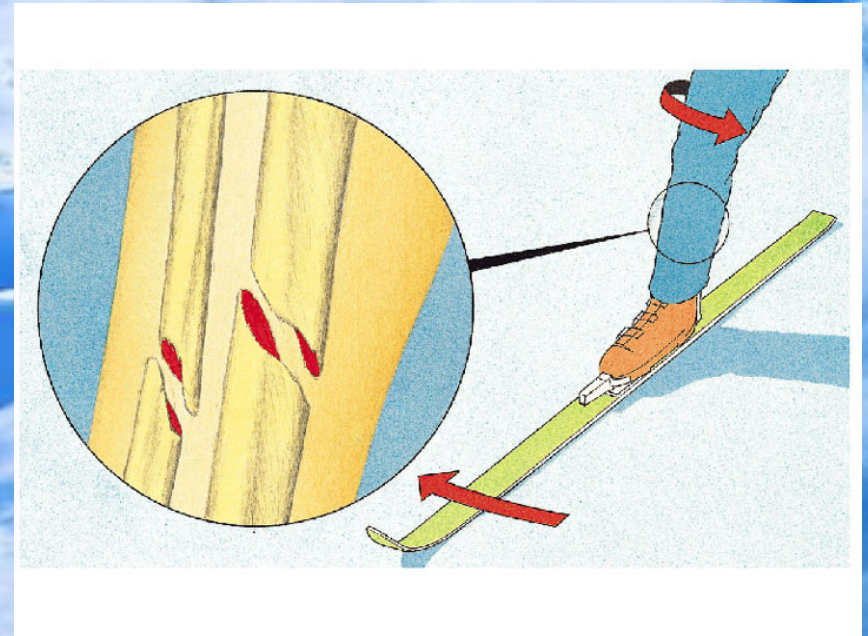


## **SIDECUT DIMENSIONS**



# Skiing injury

- Overall, the most common injuries that occur in skiing are
  1. Knee(30%),
  2. Head ( 12-20%),
  3. Ulnar collateral ligament of the thumb (8%)
  4. Shoulder (4-11%).
- Mechanism of injuries
- Torsional injuries are common in skier, as opposed to impact against the slope, which is more likely mechanism of injury in snowboarders.



# Upper Extremity injuries

- Snowboarders :
  - upper extremity
  - arms outstretched for balance.
  - speed control and to aid with terrain park maneuvers.
  - wrist is the most common upper extremity site injured in snowboarders.





# Technique

- **Initial level**
- Generally there are two main forms of turns used in downhill skiing.
- The oldest, and still common, is the concept of "stemming", pushing the front ("tips") or rear ("tails") of the skis sideways from the body so they form an angle to the direction of travel.
- The two skis are angled in opposite directions, forming a V-shape.



# How to turn?

- To turn, pressure against one of the skis (downhill or left ski) is relaxed , thereby allowing the other ski( uphill or right ski) to dominate and their weight shifted onto this ski.
- Therefore, turn the skier will occur.
- The technique is simple and powerful.
- But is very difficult to use in higher speeds.



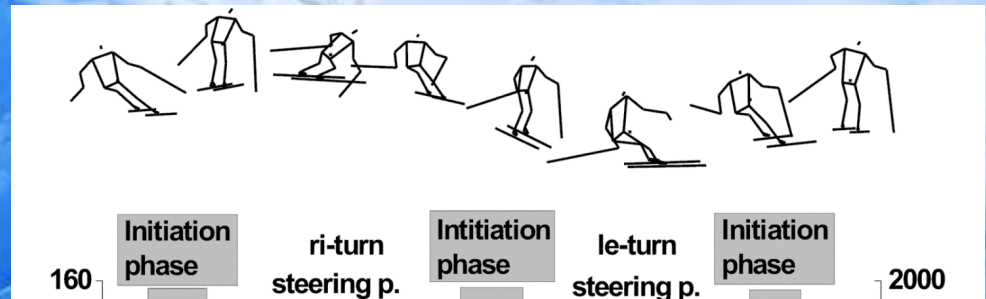
# Stem Christie

- The skis are pointed parallel between turns and the drag force is only generated during turns
- Results in higher speed and brings good feeling.



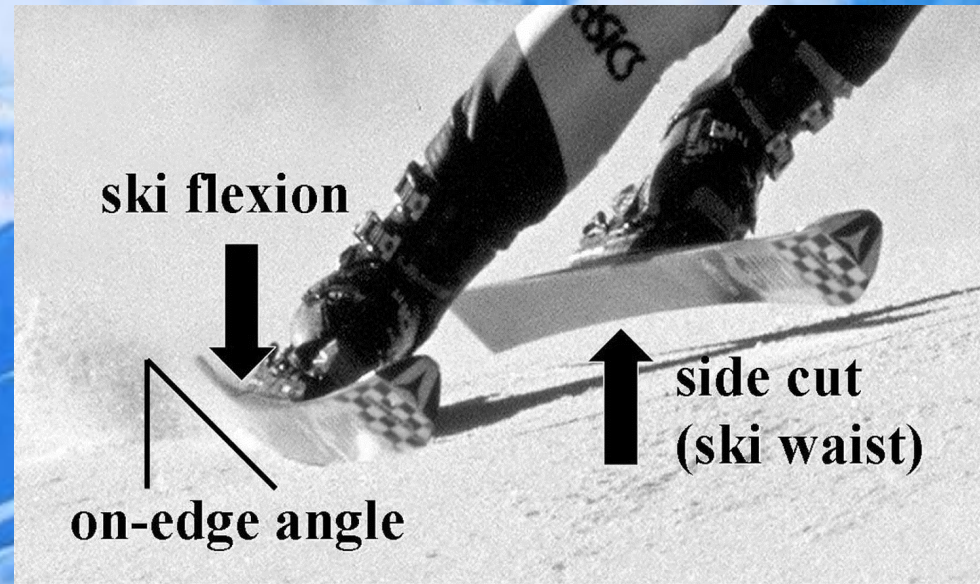
## How the skier turn?

- The initiation phases are characterized by a **load change from the outer to the inner ski**
- relatively intensive increase in load on the inner ski.



## Carving

- A different form of turn is the "carve"
- Is based on the shape of the ski itself
- carving, the 'curved turn' is important
- The curve radius during carved turns is a function of the following variables: ski waist, on-edge angle and ski flexion



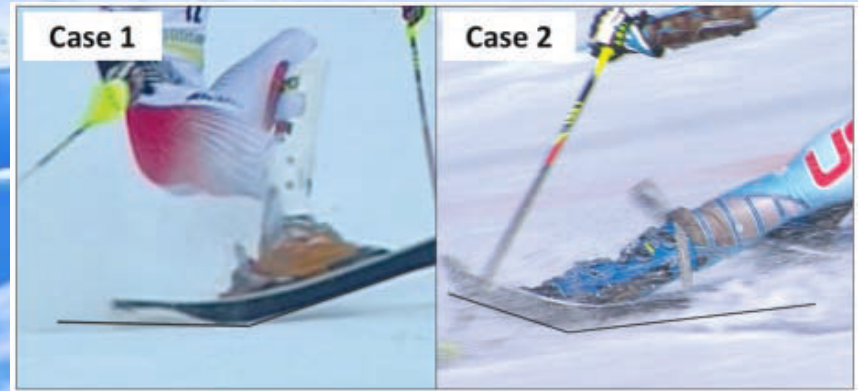
# Carving

- Starting a carved turn **simply requires the ski to be rotated onto its edge**, which can be completed through small movements of the hips and knees.
- It is faster, safer, more efficient and brings good feelings than when using classical technique.
- **Modern downhill technique is generally a combination of carving and skidding**



# Do you remember carving?

- During carving, when a load is applied on the **inside edge of the ski**, ski will rotate inward because of the ski's self-steering effect
- But when the load is applied behind the projection of the tibial axis,
- and the skier is out of balance,
- unable to adjust to the rotary motion
- **this can generate an internal tibial torque**



# Snowboarding

- In snowboarding, **both feet are strapped onto the same board and always point the same direction.**



# How snowboarders ride ?

- **Initial level**

At this stage they'll find out

1. How they feel when their both feet fastened
2. train how they control their balance
3. How they stop, control their speed and movement direction.



# Intermediate level

- working on making good turns
- ride powder
- make small jump



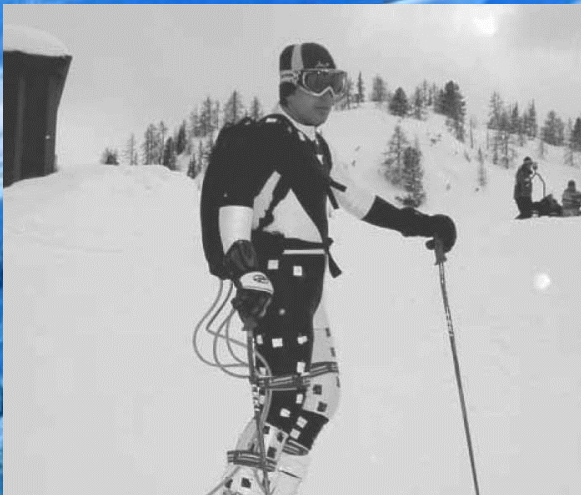
# Expert level

- They're starting to understand how to make good turns anywhere on the mountain but might still unintentionally make skidded turns.
- Expert Mountain Snowboarders make razor thin turns
- Have good form and are in complete control of their boards when it comes to edge to edge transitioning



Skier with tight-fitting stretch suit, ski boots and skies, and all markers attached

- In recent years, some studies were done based on a systematic analysis of video recording.
- It can provide a detailed description of the events leading to injury.



# Injuries in Alpine Skiing?



# Biomechanics of skiing

- As a rule: **All skier should lean a bit forward to control their balance and stability.**
- When they lose their balance, they lean backward unintentionally and change their COG
- which can increase uncontrolled speed and results in injuries.



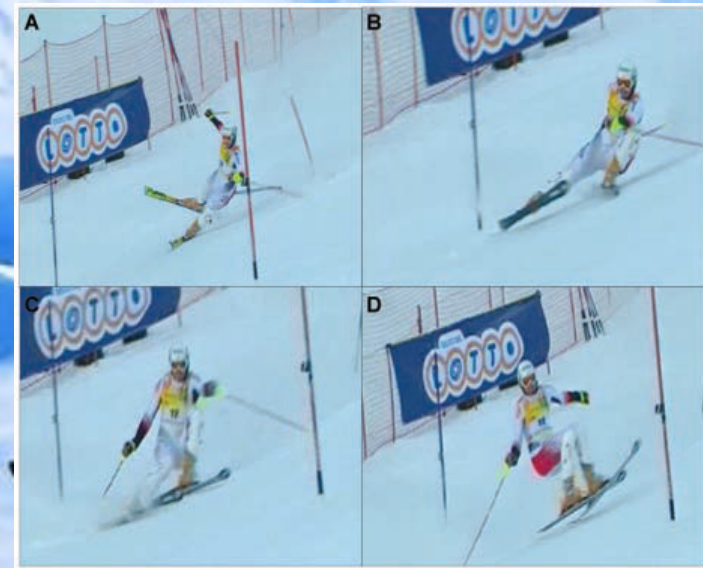
# Events leading to slip catch mechanism ACL injury to the left knee

- Factors related to the skiing techniques and strategy were different based on systematic video analysis ,
- They are divided into
  1. Slip-catch (inside edge of ski was cached in snow)
  2. Landing back-weighted
  3. Dynamic snowplow



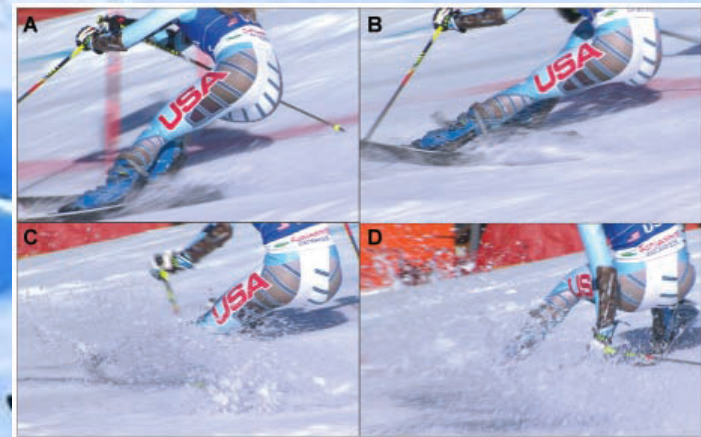
# Kinematics of Anterior Cruciate Ligament Ruptures in World Cup Alpine Skiing

- The **main mechanism**, termed the “**slip-catch**” mechanism,
- is characterized by a pattern in which the skier is **out of balance backward and/or inward while turning**
- The skier **loses pressure on the outer ski**, which then **drifts away from the body’s center of mass**.
- While trying to **re-establish grip with the outer ski**, the skier extends his or her leg
- The **inside edge of the outer ski abruptly catches the snow surface**, forcing the nearly straight knee into flexion/ compression, valgus, and tibial internal rotation



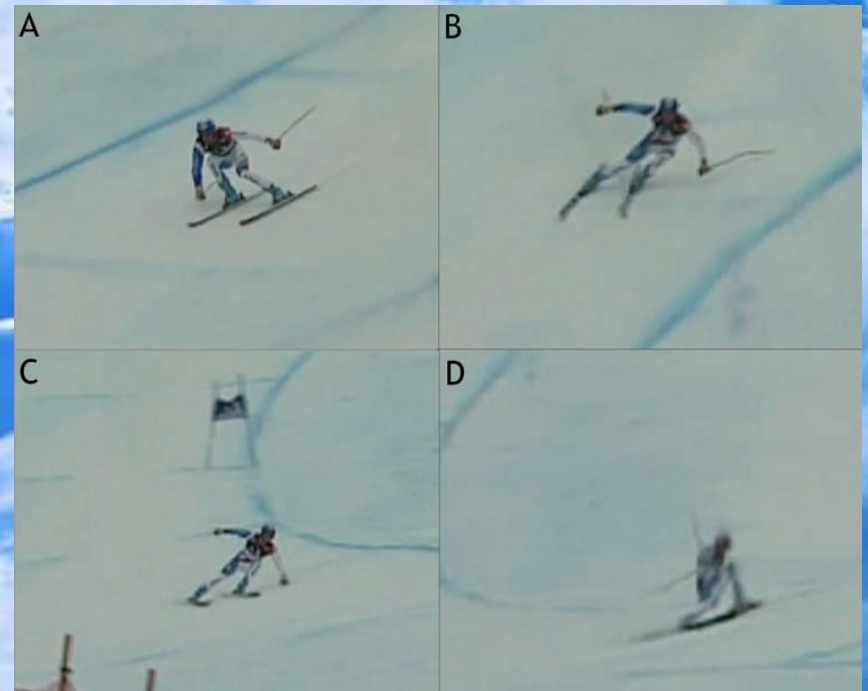
# Case 2: slip-catch situation (anterior cruciate ligament injury to the left knee)

- (A) At -300 milliseconds, the skier is out of balance **backward and inward in a right-hand turn.**
- (B) At -160 milliseconds, she **loses pressure on the outer ski**, which drifts away from the body's center of mass.
- (C) In the index frame, the outer **ski catches the inside edge abruptly.**
- (D) At 1140 milliseconds, **the skier falls backward to her left.**



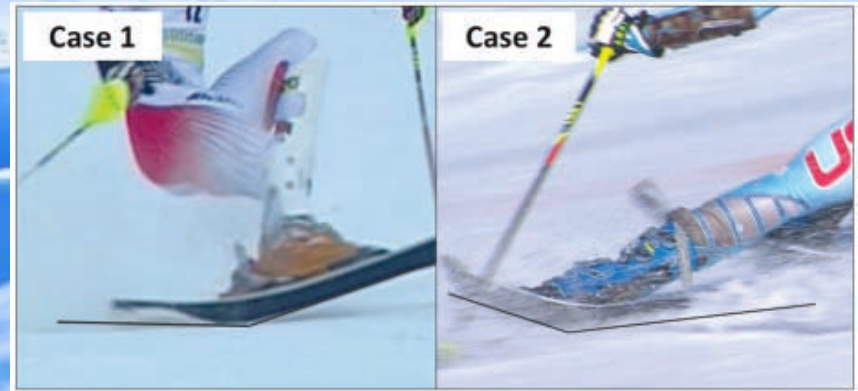
# Events leading to slip-catch mechanism (ACL injury to the right knee)

- A. Is late in on line & not balanced position
- B. Goes too directly into the next gate and **leans too much inside initiating the turn.** He is late timing his movements during the turn, **skiing passively.**
- C. goes in an unbalanced position backward/inward & **loses pressure on the outer ski,** unable to absorb the transition.
- D. The outer ski catches the inside edge abruptly, forcing the right knee into the valgus and internal rotation.



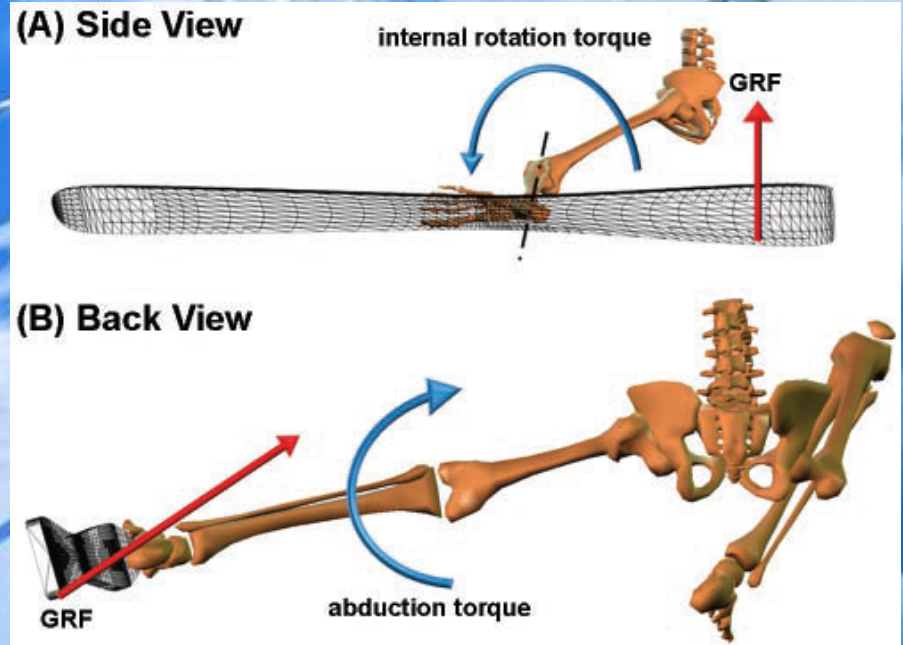
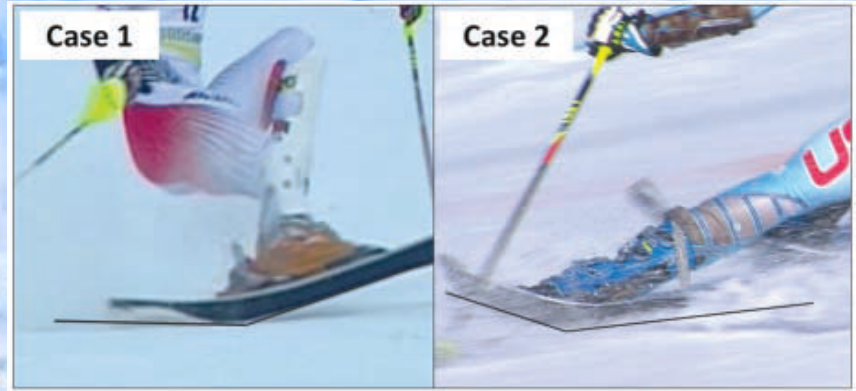
# Slip-catch situation

- In carving ski internal tibial torque is occurred by 2 mechanisms.
- 1. As a rule, a carving ski will rotate inward because of the ski's self-steering effect.  
In a balanced position, it is appropriate for the skier to follow the path of the ski by using technical approaches



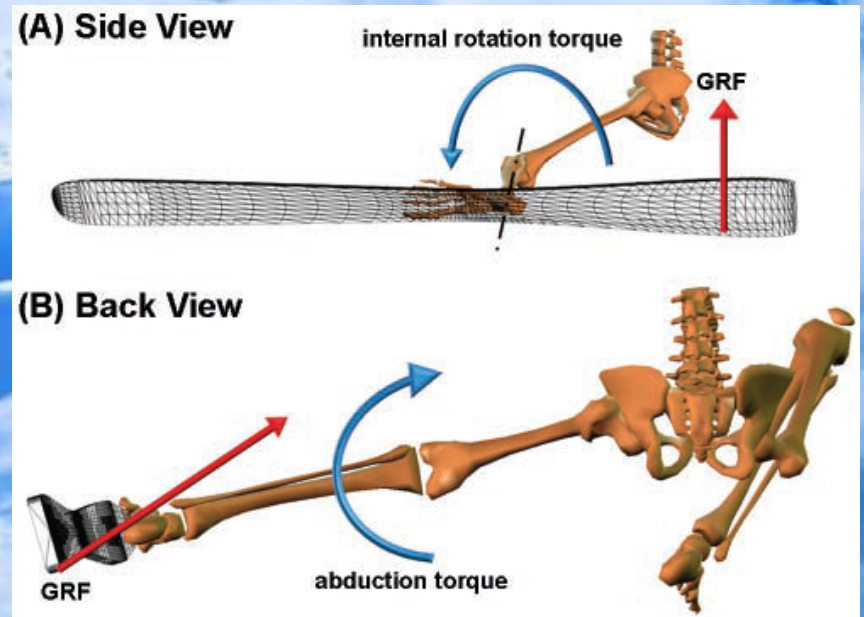
# Slip catch situation

- But when the skier is out of balance, he or she may be unable to adjust to the rotary motion.
- Therefore, the self-steering effect of the ski can generate an internal tibial torque by forcing the ski to carve inward



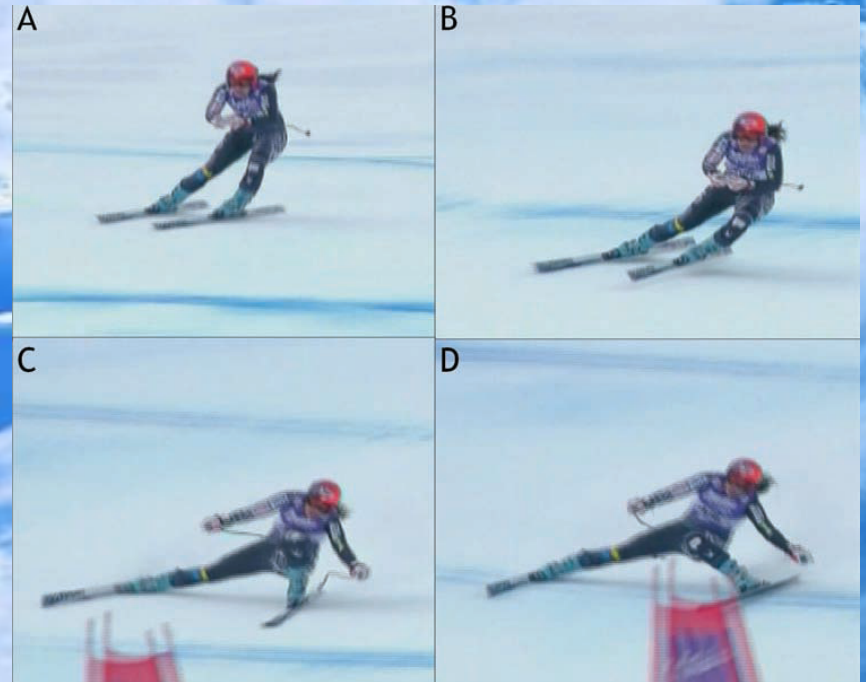
# Slip catch situation

- Second, when a lateral load is applied behind the projection of the tibial axis, the ski will act as a lever to generate internal tibial torque.
- More backward lean will give a longer moment arm to the tibial axis and thus a larger internal rotation torque



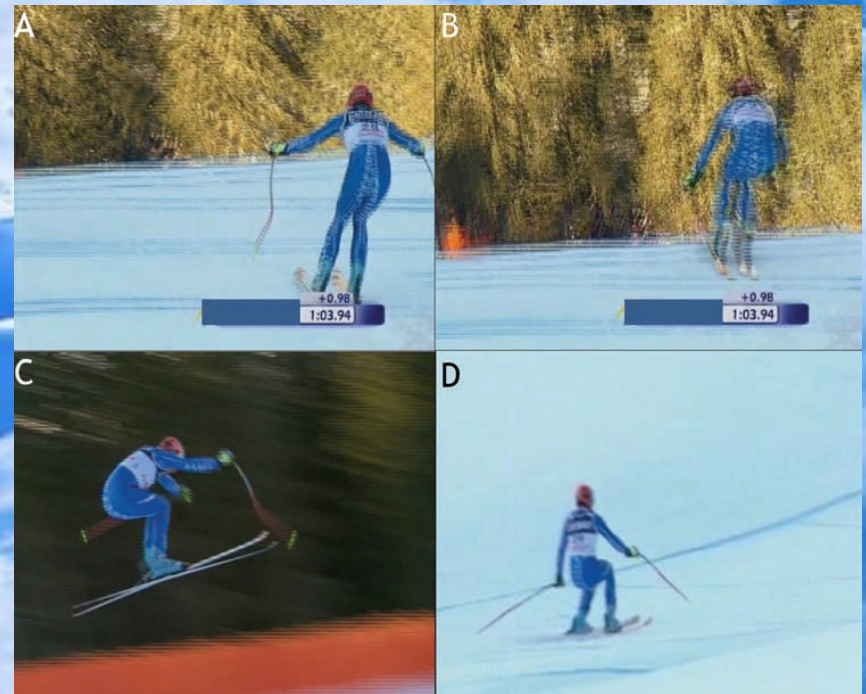
# Events leading to dynamic snowplow mechanism (ACL injury to the left knee)

- A. The racer **initiates a left hand turn** too early with too inside lean
- B. Loses pressure on the ski, and in an unbalanced standing position backward/inwards,
- C. Due to inappropriate weight distribution and ski edging angle, the **inner ski rolls from inside edge to outside edge**
- D. Ends up in snow pole position forcing the left knee into internal rotation and valgus.



# Events leading to landing back- weighted ( ACL injury to the left knee)

- A. Is **late in timing of movements** into the jump and **timed his take off** badly.
- B. In **Backward leaning position** at take off.
- C. **Uncontrolled flight** due to a poor jumping technique & incorrect tactical decision
- D. Tries to **recover from backward leaning position after landing on the ski tail with almost straight knee.**
- E. It is a very bad position because in this situation knee extends and creates an anterior drawer of the tibia relative to the femur => can causes ACL injuries





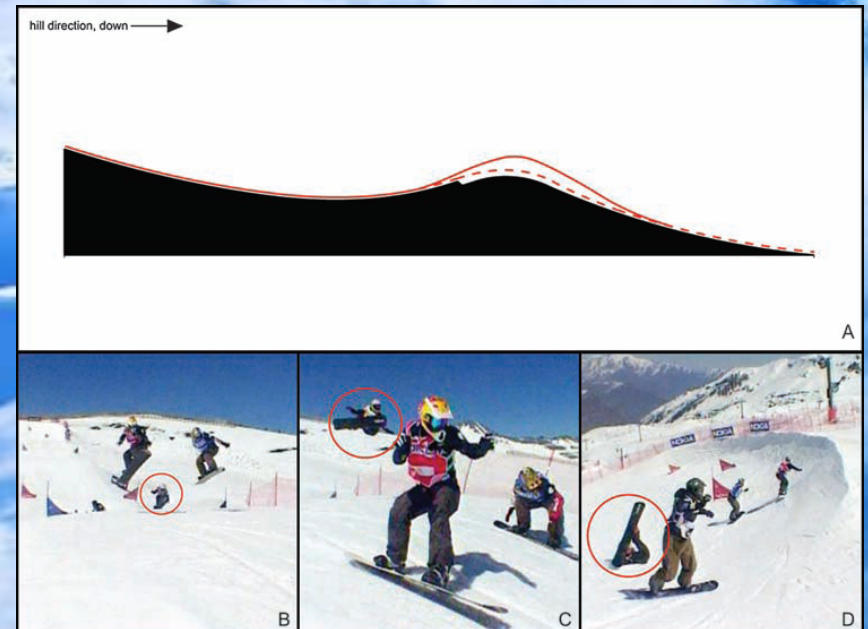
# Mechanisms of injuries in World Cup **Snowboard** Cross: a systematic video analysis of 19 cases.

- little is known about the injury mechanisms in SBX.
- The primary cause of the injuries -based on the systematic analysis- was a **technical error at take-off** resulting in a **too high jump** and **subsequent flat-landing**.
- The rider was then unable to recover leading to fall at the time of injury.



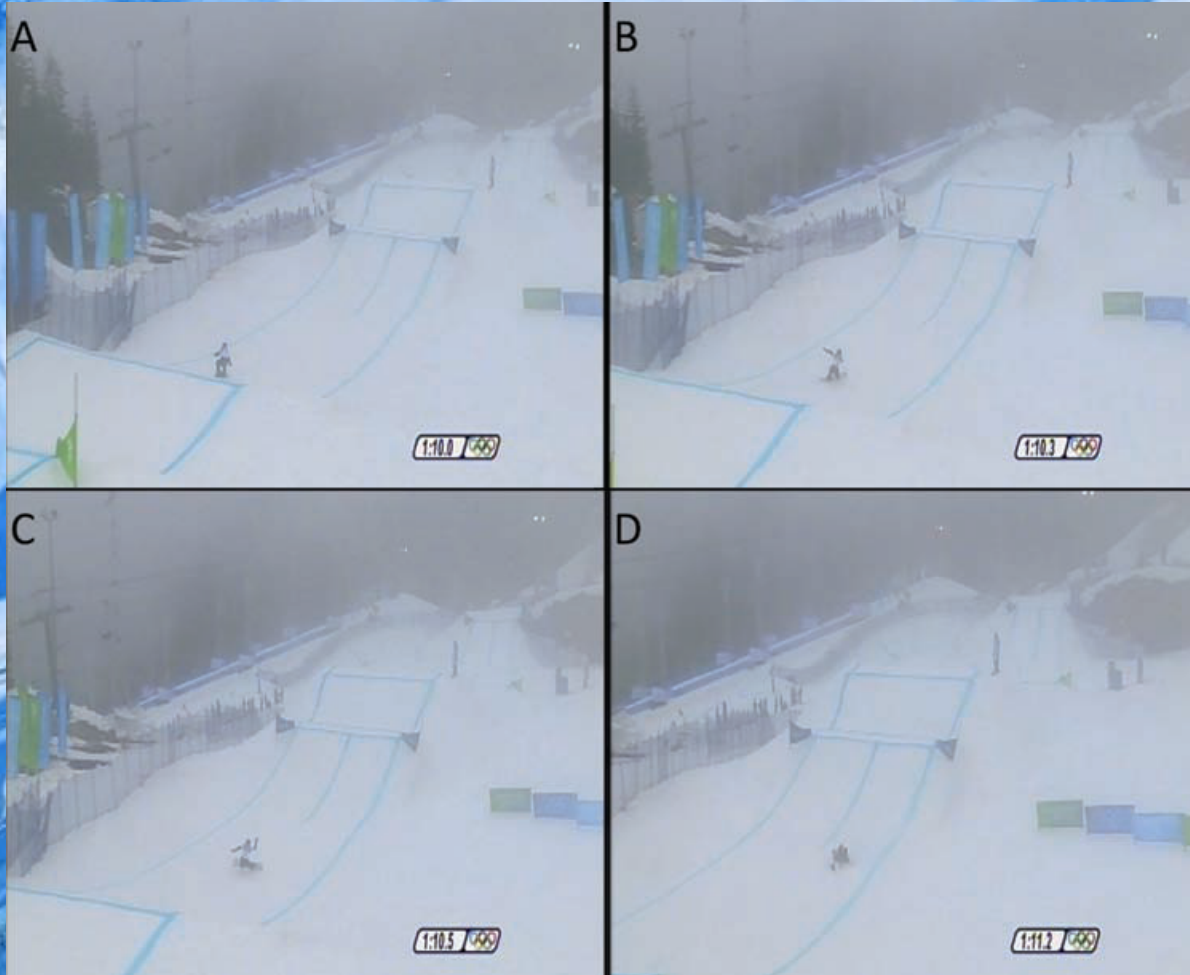
# Technical error at take off

- A. Sectional view of the jump showing the trajectory taken by injured rider (continuous line is injured rider, broken line is assumed optimal line).
- B. The rider (circled) loses control at take off
- C. Leads to uncontrolled flight with a high speed trajectory.
- D. The injured rider lands flat, outside the piste with a head fall (concussion).



### *Technical error at landing*

Lands out at balanced backwards, Tries to recover with a heel turn , Catches the edge , Falls backwards



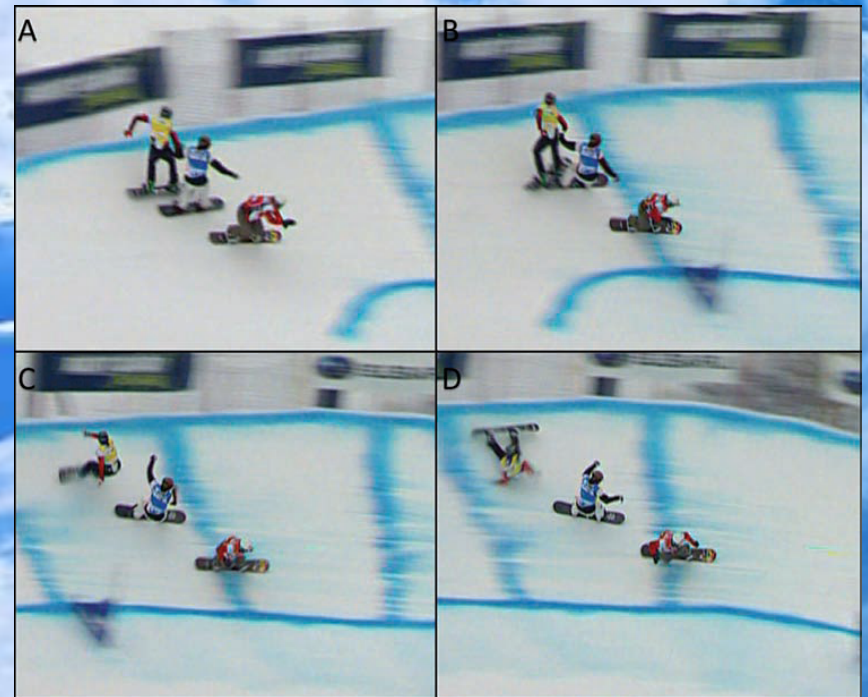
# Mechanism of injury in World Cup Snowboard Cross: a systematic video analysis of 19 cases

- Injuries were occurred at bank turn (rider should start turning)
  - characterized by a pattern where the rider in a balanced position lost control due to unintentional contact with another rider.
- It is **more common** for riders to contact as **they compete for the front position**
- These potential external risk factors, combined with high speed, may contribute to injury.



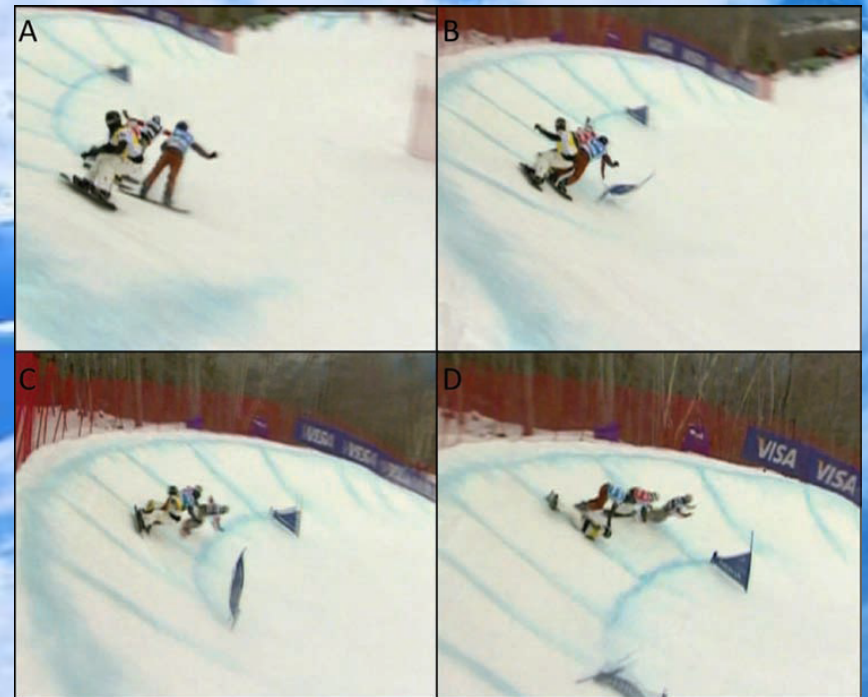
# Bank turn injury, contact

- A. The rider in the red jersey has the inner position in the initial phase of a bank turn.
- B. Red jersey forces the blue rider to change position from inner to outer, riding into the course line of the injured rider( yellow jersey).
- C. Causes contact by catching the board to the injured rider.
- D. As a result, the injured rider loses balance and falls onto his outstretched hand and sustain a fracture of forearm.



# Bank turn injury, contact

- A. Blue jersey in an inner position at initial phase of bank turn.
- B. The other rider changes position from inner to outer position riding into course line of the injured rider (yellow jersey).
- C. Causing contact by catching the board of the injured rider.
- D. As a result the injured rider loses his balance and falls onto the shoulder.



# In conclusion

- Based on video analysis, skier errors dominated as the main contributors
  - a. Snowboarding: Technical error at take-off , injuries in bank turning
  - b. Alpine skiing: Slip-catch (inside edge of ski was cached in snow), Landing back-weighted , Dynamic snowplow are main mechanism of injuries.
- Identifying the factors seems to play a part in the occurrence of injury is an important step to generate hypotheses and ideas for injury prevention.



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