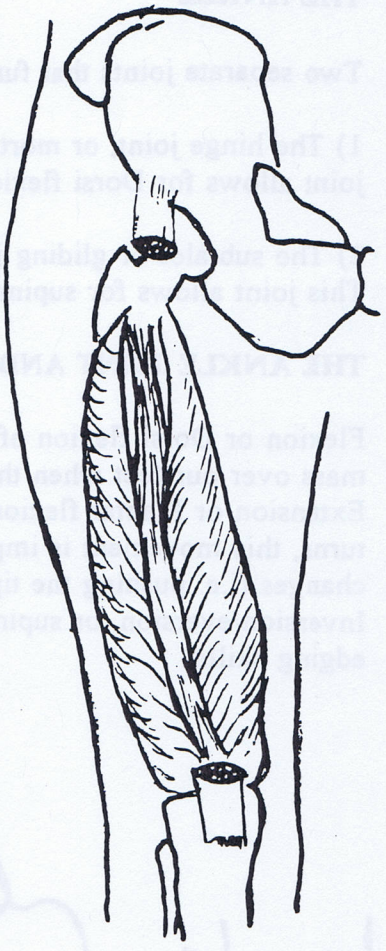
**EXTENSORS OF THE KNEE**

*Any muscle that spans the anterior aspect of the knee joint i.e. Quadriceps.



**FLEXORS OF THE KNEE**

*Any muscles that span the posterior aspect of the knee i.e. Hamstrings - 3 muscles and Gastroc Nemius (calf) - 2 muscles

## THE ANKLE

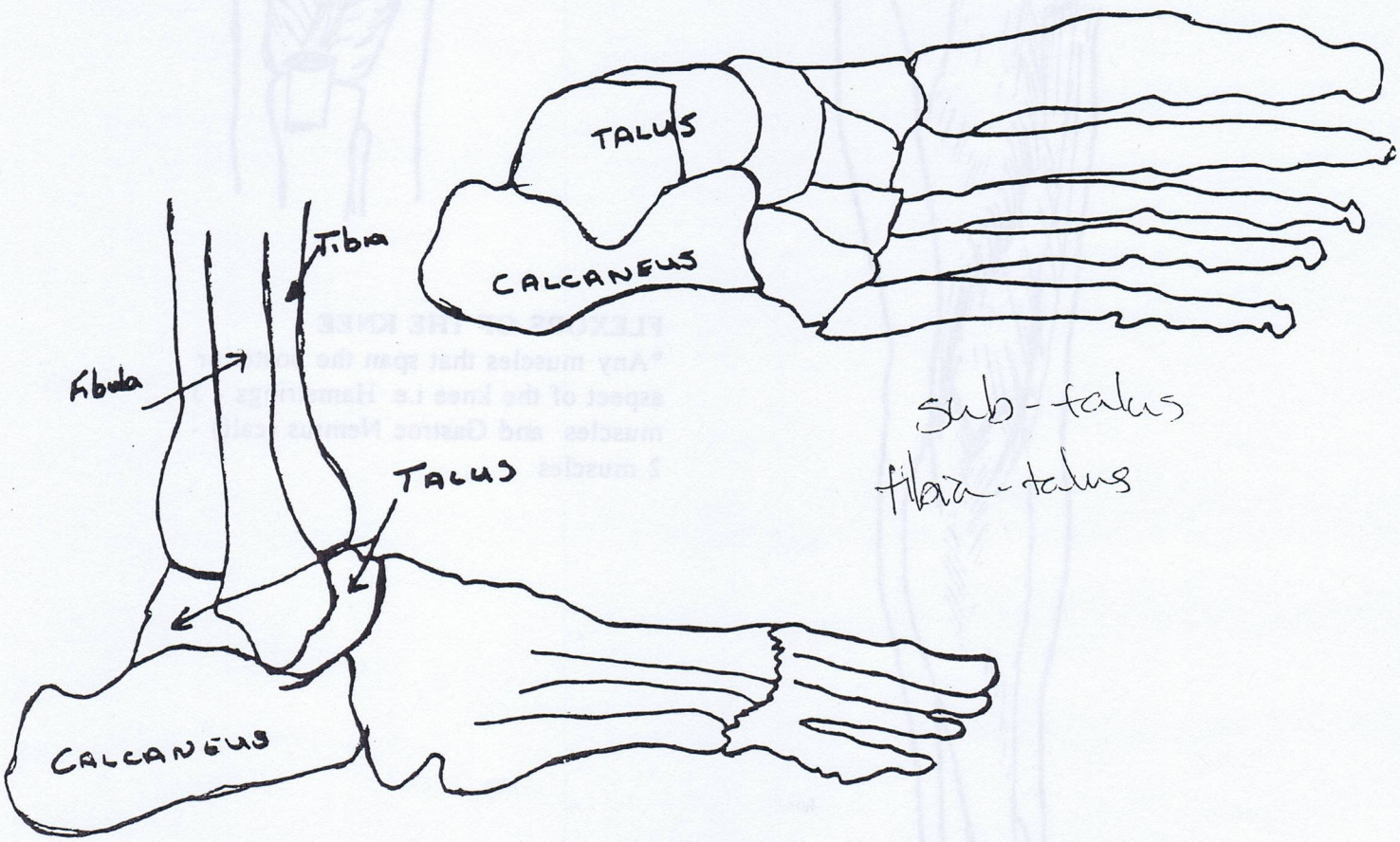
Two separate joints that functionally make up the ankle - a compound joint.

1) The hinge joint, or mortise joint, is between the tibia/fibula and the talus. This joint allows for Dorsi flexion and Plantar flexion.

2) The subtalor or gliding joint, is formed by the talus (above) and calcaneous (below). This joint allows for supination/ pronation or inversion/eversion.

## THE ANKLE JOINT AND ITS IMPORTANCE TO SKIING

Flexion or Dorsi flexion of the ankle joint (mortise joint) aids in keeping the center of mass over our feet when the knee is flexed.
Extension or Plantar flexion of the ankle joint is seen in up-unweighting and hop turns, this movement is important in maintaining ski snow contact during terrain changes (i.e. pushing the tips of the skis down from the top of a bump.)
Inversion/eversion, or supination/ pronation (subtalor joint) allows for fine control in edging skills.

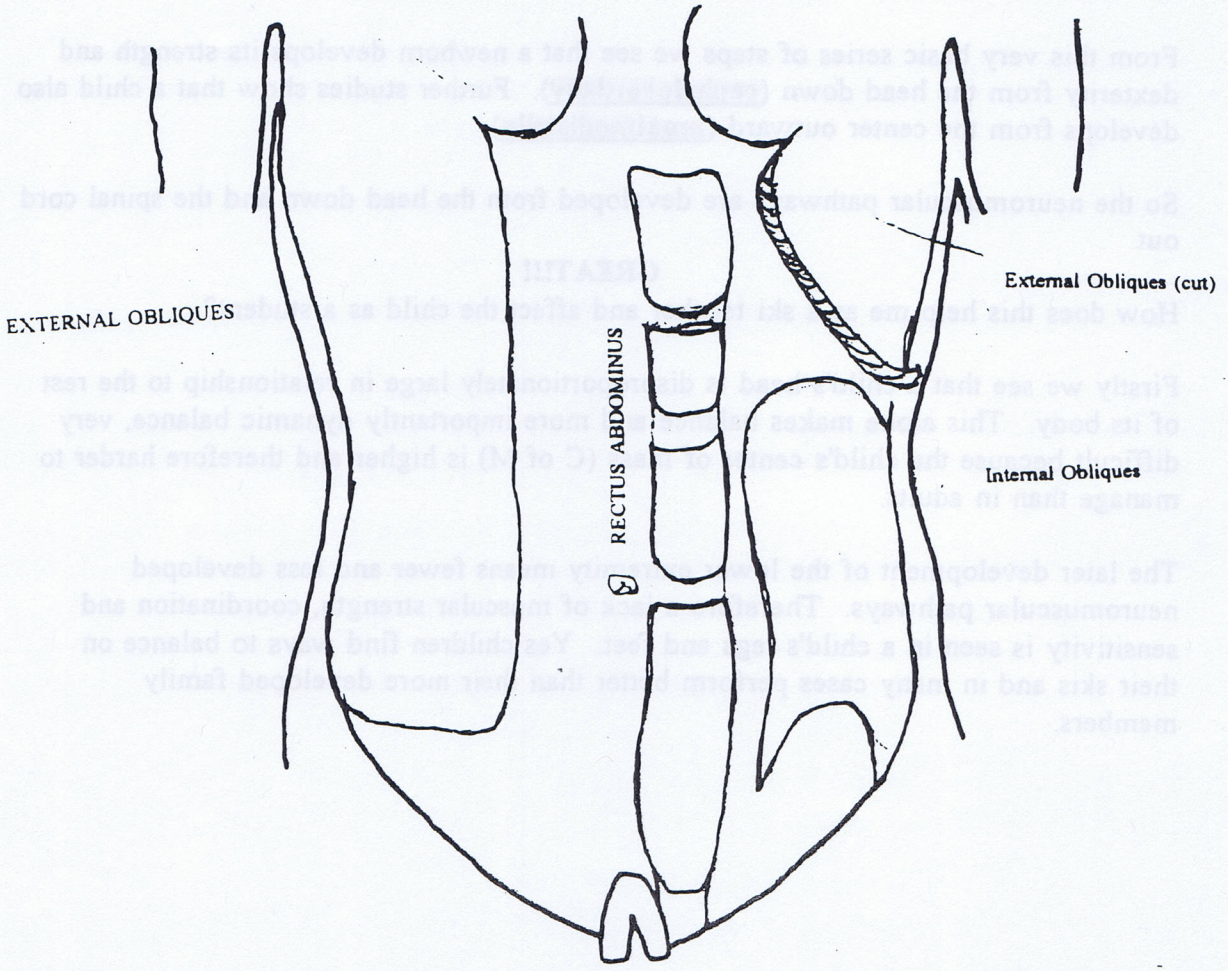


## THE TRUNK

For our purposes, the trunk is made up of the pelvis and spinal column. The pelvis serves as a stable yet movable platform for the spinal column to sit on and is really the"hub of the wheel" from which trunk movements occur. Trunk movements result from the complex interactions of many muscle groups. Of primary importance in these muscle groups are:

1) The abdominals
2) The obliques
3) The spinal extensors

One of the situations in skiing where the trunk is actively involved, is in the twisting movements associated with anticipated, short radius turns. As the upper and lower body twist in opposition to each other, the muscle, tendon and ligament tissues involved become stretched or tensioned. When the upper body is connected to the ground via the pole plant, and this tension is released at theski edges, we are able to use this potential energy as an aid to the turning power of the following turn (i.e. anticipation release).



## BIOMECHANICS FOR CHILDREN

Why do we need a separate biomechanics section for children?

As adults we have many years of activity, experiences and maturity to bring to a ski lesson. Along with this maturity, we as adults are far more developed and balanced neuromuscularly. Children on the other hand, have little experience and are still in a very developmental stage of their lives; Therefore, neuromuscularly they are not yet ready to ski the adult way. By recognizing these differences we can tailor our children's lessons to work within the child's neuromuscular parameters. This creates a far more positive environment for the child as well as the instructor; rather than trying to force the child to ski like an adult.

This section of the manual is going to address the above stated differences. It will show how the turning powers used and the stance characteristics shown by children are in fact, very appropriate for their level of development neuromuscularly.

As a newborn child develops we watch it first lift its head up to observe its environment. Next it will start to explore its environment by pulling itself around with its hands and arms, and later adding the legs and feet to crawl more efficiently. Lastly the child will stand and walk throughout its enlarged environment.

From this very basic series of steps we see that a newborn develops its strength and dexterity from the head down (**cephalocordally**). Further studies show that a child also develops from the center outward (**proximodistally**).

So the neuromuscular pathways are developed from the head down and the spinal cord out.

**GREAT!!!**

How does this help me as a ski teacher and affect the child as a student?

Firstly we see that a child's head is disproportionately large in relationship to the rest of its body. This alone makes balance and more importantly dynamic balance, very difficult because the child's center of mass (C of M) is higher and therefore harder to manage than in adults.

The later development of the lower extremity means fewer and less developed neuromuscular pathways. Therefore a lack of muscular strength, coordination and sensitivity is seen in a child's legs and feet. Yes children find ways to balance on their skis and in many cases perform better than their more developed family members.

How can this be? Lets see how they do it and why they have to do it this way.

## FOUR TO SEVEN YEAR OLDS

This age group will typically stand with a wide stance and weight even on both feet. This is their way of creating a balance platform to cope with their higher C of M.

We also see this group often bent at the waist, not only to aid in balance, but also to create a torque to turn the skis. By breaking at the waist the child has created a lever arm; that in conjunction with the larger upper body mass and a young child's tendency to turn the body as one unit; creates a very effective turning power that is highly appropriate for this age group's neuromuscular development.

As the child continues to develop, he/she will be able to balance on a narrower platform and use his upper and lower body independently. As instructors we must recognize this change in potential and tailor our lesson plans accordingly.

How does a young child deal with pressure and edging skills when the lower extremity is last to fully develop?

A young child cannot create angles underneath the body (edging), because he/she is not yet ready to balance on a flexed leg and therefore he /she finds their own way to edge the ski by pushing the downhill leg away. This straight downhill leg configuration also puts the child in a very strong position to cope with building pressures (forces) in a turn. By aligning the osseous structures of the leg (stacking the bones) and using the larger and more developed muscles in and around the hip joint, the child is able to balance its body over his/her skis.

This position of a straight downhill leg now puts the child up against the back of the ski boot, which is stiffer and more supportive than the front, so for a young child who is not ready to balance on a flexed leg, the front of the boot is seldom used. Therefore all the work in the world won't change this until he/she is neuromuscularly ready to balance in a more mature way.

As a child grows older the neuromuscular pathways become more developed and numerous. Pressure and edging movements can be refined to include more flexion and extension at the ankle and knee as well as the introduction of leg steering as opposed to whole body rotation. You may also begin to introduce upper and lower body separation. These new anatomical relationships and improved movement patterns cannot be adopted by a child until the body has developed neuromuscularly, thus allowing for these improvements in coordination and dexterity.

With this improved understanding of why children stand on their skis and show the turning powers that they do, we as instructors can better cater to the child's ability to learn and improve, and so provide a better experience for our younger guests.

## BIOMECHANICAL DIFFERENCES IN WOMEN

After many years of misconceptions and disinformation, the ski industry has finally taken the physical differences in men and women seriously. It is now possible for women to understand why they have trouble levering the tips of their skis, balancing on the whole foot, staying countered at the hips and so on.

Let's look at the differences and see how they affect women when skiing and how these differences can be compensated for and overcome.

### THE PELVIS

It is commonly discussed that a woman's pelvis is larger than a man's.

**SO WHAT!!!**

How does this affect how women ski? A woman's pelvis is on an average two inches wider, hip socket (Acetabulum) to hip socket.

This increase in width has a tendency to produce a knock kneed stance and the "A" frame position that many women show. This leads to a woman's tendency to stand on the inside of the foot (pronation) more than the whole foot. Without the use of orthotics and or canting of the ski boot, women tend to balance on an edged ski rather than a flat ski.

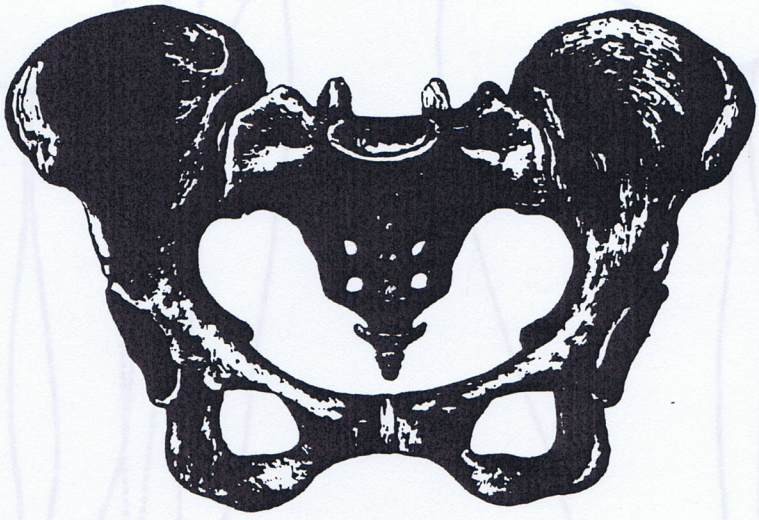
The extra width of the female pelvis also has the effect of moving her C of M lower and further back than a male's. This is why women often find it hard to balance on a ski's sweet spot, or lever the tips at the turn initiation. With skis designed with a boot center for a male, a female's boot centered this way has her positioned too far back (her C of M is lower and behind a male's), and the skis tend to wander or jet out from under her.

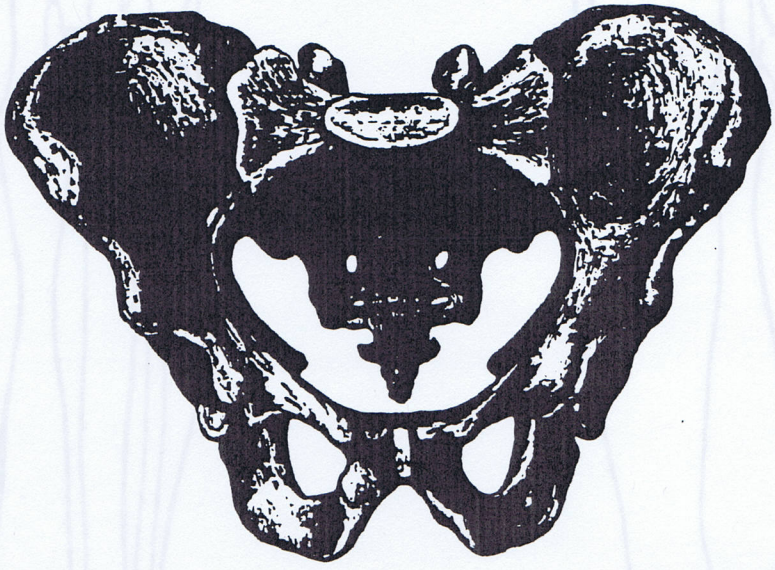
To further increase the balance problems on men's skis, women also have shorter Achilles tendons, thus decreasing their range of movement toward the front of the ski boots, therefore keeping their C of M further behind the sweet spot of the ski.

The increased pelvic width of a female changes the leverage muscles have on the hips, femur and trunk. This lack of leverage along with a female's smaller muscle bulk, makes maintaining a countered position with the hips in turns involving large forces very difficult. The most important muscle groups for a woman to develop in skiing are: The abdominals, gluteals and hip rotators for stronger countering movements. The muscles surrounding the ankle joint as well as the gastrocnemius group (calves) for improved stance and therefore balance.

With the use of heel lifts for balance and centering of the C of M on the skis, and a specific boot center mark on skis for women, in conjunction with the before mentioned orthotic devises and cant adjustments; women can adapt their anatomical differences to a male dominated equipment pool and improve and enjoy their skiing accordingly.

FEMALE

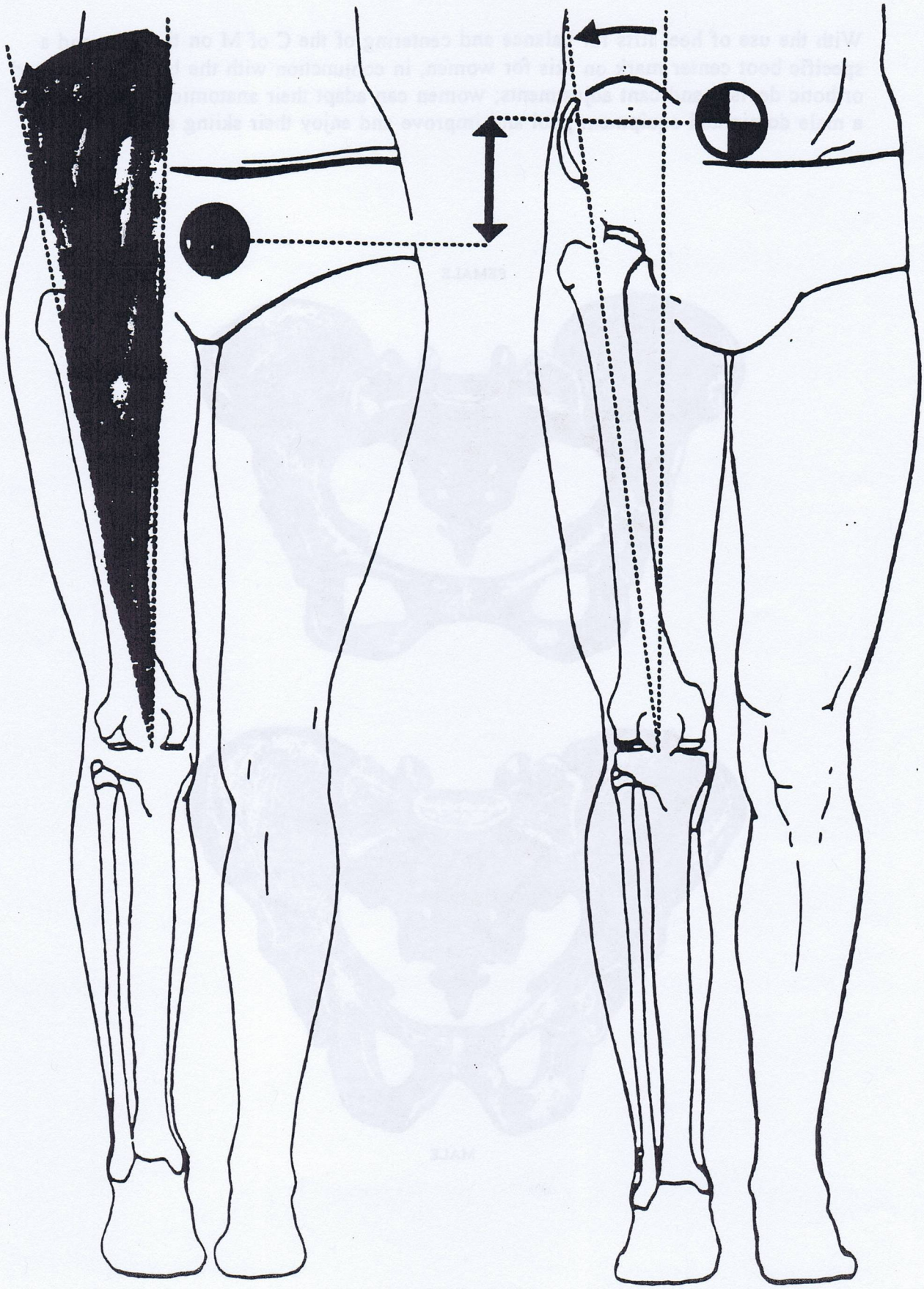




MALE

FEMALE

MALE



## SOME COMMON SITUATIONS WE SEE IN SKIING AND HOW THEY RELATE BIOMECHANICALLY

1. The stiff outside leg: Compare statically a stiff leg and try to turn the ski off the snow left and right. Now try the same exercise with the ankle, knee and hip flexed, which is easier? Try both in turns.

2. With stiff legs try to edge the skis and maintain extra pressure on downhill ski. Try this same task with ankle, knee and hips flexed, which works better?

3. Jump up and down on stiff legs, then try this on flexed ankles, knees and hips, which requires less energy and is the softest landing? Pressure control exercises.

As we see just from one stance situation we can show how the more appropriate position can enhance our ability to steer, edge and pressure our skis.

By balancing back of center we increase the tension in our quadriceps and hip flexors. The result is a decreased range and reduced ease of movement at the hip joint, with earlier onset of fatigue in these muscles.

## WHY BALANCE ON AND EDGE THE OUTSIDE SKI VERSUS THE INSIDE SKI?

As we saw earlier in the manual, the adductors and internal rotators are better aligned than the abductors and external rotators. Therefore it is stronger and more precise to create angles (edge the ski) under the body versus away from the body. Along with the medial axis of the foot being longer, stronger and more sensitive than the lateral aspect. Therefore this medial portion of the foot is better able to support the body and adapt to balance changes.

## HOW DOES THE PELVIS TIP IF WE BALANCE ON OUR LEFT LEG ONLY?

It lifts up on the right side and drops on the left side to align our C of M over our new point of balance. Wedge turns that produce an inside edge lock are often seen to be initiated from the hips. This movement leaves the inside hip behind the outside hip. From a biomechanical stand point in skiing, this stance is incorrect. The hips are not open to the fall-line, instead they are closed, weight is distributed more to the uphill side which is supported by a straight uphill leg. It is now very hard for this person to steer the inside ski, one of the common threads of skiing as seen in our skiing model.

So by understanding why we teach the four skills from a biomechanics stand point, we are better able to diagnose the cause of our students difficulties and correct them more efficiently.

## SAMPLE BIOMECHANICS QUESTIONS

1. Describe the joints of the lower body and their functions.
2. What is leverage and the use of lever arms in skiing?
3. Why ski on the outside ski?
4. How does a skier balance on the outside ski?
5. What are muscle groups?
6. How do muscle groups work?
7. What is a prime mover?
8. Explain the difference between isometric and isotonic exercises.
9. What function do ligaments have?
10. What are the quads and the hams and how many muscles in each group?
11. If I were going to train my muscles for strength rather than endurance, what changes would I make in my exercise program?
12. Explain anticipation in terms of biomechanics.
13. Talk about the joints in the body relevant to skiing, Identify them and describe their function.
14. Describe the ankle joint and its function.
15. Is there some degree of rotation in the knee joint? If so, how much and what inhibits rotation of the knee?
16. What is a neuromuscular pathway?
17. What is often referred to as "muscle memory"?
18. Can reaction time be developed?
19. What is the name of the tissue which stabilizes the knee joint against rotary displacement?
20. What is a synapse?
21. What is the difference between aerobic and anaerobic?
22. What is eccentric contraction?
23. What is concentric contraction?
24. What is co-contraction?
25. What is an abductor?
26. Name two types of muscle fibre.
27. What two things can a muscle do? — slow & fast twitch
28. What causes pelvic tilt when skiing on one foot?
29. What role do the eyes play in skiing? balance
30. Do ski poles contribute anything to balance?
31. It is often said that balance is an innate ability and that there are certain limitations placed on a person's ability to balance due to genetics. Do you think that balance can be improved upon and how?