Aerobic Training

OF THE FEMALE ATHLETE

CROSS COUNTRY
SKI
DE FOND

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Thanks to all the individuals who generously provided photos for the pamphlet.

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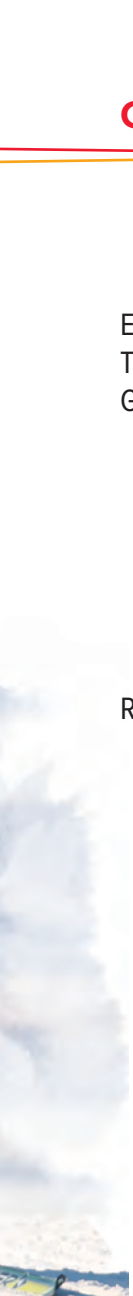


Why is Aerobic Training Important for Nordic Skiers?

Skiers train and race at distances that exceed the activity level of average Canadian life. This movement is continuous over extended periods of time which requires that the body is trained to efficiently supply the muscles with fuel partly derived from the oxygen we breathe in. Effective aerobic training will enhance the body's efficiency for both dryland activities and for skiing long distances, and optimize the level of performance for the athletes. Enhancing this training will help our Canadian women become very competitive in distance races at the international level.

Energy Systems

During exercise, muscles are fuelled by phosphates, oxygen and lactate. Exercise duration and intensity determine which energy system is used. There is substantial overlap between the three systems. If the energy demand is greater than the supply, then other systems will be activated (See Graph -Coach.org).

A. **Anaerobic Alactic – Phosphate System**
   Does not need oxygen and does not produce lactic acid. Adenosine Triphosphate (ATP) and Creatine Phosphate (CP) stores are used. Supplies energy for only 6-8 seconds. ATP and CP are completely replenished 3-5 minutes after activity is finished.

B. **Anaerobic Lactic – Lactate System**
   As the intensity of exercise increases, the anaerobic or lactate system produces lactic acid.

C. **Aerobic System – Oxygen System**
   Burns nutrients from food. Long-lasting – uses mainly carbohydrates and fats, with oxygen. Energy from fats is virtually unlimited while carbohydrates provide limited energy and are stored as glycogen. Glycogen usually lasts for about 60-90 min during submaximal exercise.

Contribution of energy systems to time of movement

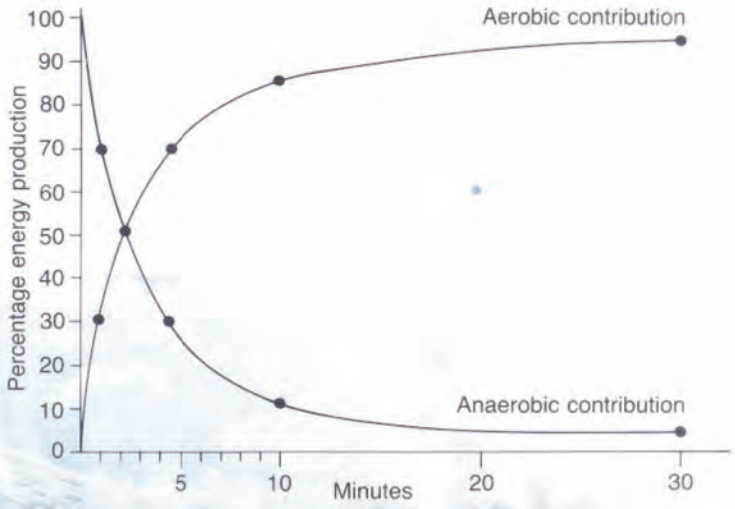


Table 1 illustrates the percentage of each energy system that is used during races of different durations.

Table 1.0 Percentage Share in Total Energy Supply in Endurancet Events (Janssen 2001)

Distance	Duration	Phosphate system	Anaerobic capacity	Aerobic capacity: oxygen system
42 km	130-180 min	0	5	95
10 km	28-50 min	5	15	80
5 km	14-26 min	10	20	70
3 km	9-16 min	20	40	40
1.5 km	4-6 min	20	55	25
800 m	2-3 min	30	65	5

Note: The relation between the duration of exercise and the percentage share of the various energy systems applies to every sport. The duration of the exercise determines the energy system that is used.

Aerobic energy accounts for approximately 85-99% of the total energy required during cross-country ski racing (Biathlon Canada, 2010). However, the anaerobic energy system is not insignificant – in fact, it may also be working at near peak rates, and may actually be the deciding factor in a race, as when the winner makes an escape from the pack.

"If all other factors are equal, anaerobic power will determine success."
Biathlon Canada, 2010

Training the Different Energy Systems

Training the Anaerobic Alactic (Phosphate) System

Importance for skiers: Supplies energy for the start of a race, up short hills and sprinting.

- Maximal intensity: Best trained by maximum speed sprints 6-8 seconds long, with 3-5 minutes rest, depending on the athlete's fitness level. Many repetitions.
- Recovery is complete. The recovery phase between repetitions must be long enough to allow re-synthesis of high-energy phosphates (ATP & CP); otherwise the lactate system will be activated.
- Increased high-energy phosphates increase the athlete's capacity to succeed in activities that last about 10 seconds.
- Endurance training (ie. running 3 times a week for 7 months) increases ATP & CP stores by up to 50%; sprint training increases the enzymes that break down and rebuild ATP (Janssen 2001).

Training the Anaerobic Lactic (Lactate) System

Importance for skiers: Supplies energy during increases of pace, as in surges, climbing, escapes and finishing sprints. Also used at the beginning of any exercise, as it takes 2-3 minutes before the aerobic system fully functions.

- Many different ways to train this system; best trained with interval workouts. Intense intervals lasting 1-3 minutes will exhaust this system the most. Recovery period between intervals should be 30 seconds to a few minutes, depending on fitness; not too long, or blood lactate levels will decrease too much (Janssen 2001).

- This system may be best trained by racing, as long as adequate recovery is allowed between races.
- The shorter the event, the higher the lactate levels that can be tolerated. In running, the highest lactate levels occur in 400 to 800 meter races.
- Lactate is removed more quickly from the blood and muscles with active recovery (cool down). At rest, it takes about 75 minutes to remove 95% of the lactate (Janssen 2001).
- Acidosis occurs when oxygen system cannot neutralize the lactic acid formed. This limits the ability to maintain the same level of intensity. It may take days to recover and regain aerobic capacity after acidosis damage, which means workouts should be chosen appropriately after acidosis occurs.
- Repeated intensive exercise without proper recovery decreases aerobic endurance capacity.
- High lactate values affect coordination. Thus, technique training should never be performed with lactate values greater than 6-8 mmol/L.
- High lactate values also decrease the amount of fat burned, which endangers energy supply when glycogen reserves are depleted.

"The athlete who can delay a moment of acidosis longest will probably win the race." *(Janssen 2001).*

Training the Aerobic System:

Importance for skiers: This is probably the most important energy system to train for skiers, since most ski races are at least 3 minutes or longer.

The Aerobic System is best trained by endurance workouts, where there is no lactate accumulation. According to Dr. Peter Janssen (2001), there are 4 types of endurance workouts:

1. Intensive endurance training:
    a. Shorter intervals are 2-8 minutes long at 90% of maximum HR with 4-6 minutes recovery (5 to 8 repetitions). These are an intermediate form between aerobic and anaerobic training.
    b. Longer intervals are 8-15 minutes long at 85-90% of max HR, with 5 minutes recovery (and 4-5 reps).
2. Intermediate endurance training: Heart rate is at 80-85% of max. Duration depends on race length – generally, race distance is surpassed once a week.
3. Extensive endurance training: Long slow distance (10 km, increasing with age). HR range 70-80% of max. Often combined with intermediate endurance training workouts. Helps to train the oxidation of fats, which saves carbohydrate reserves longer so that high intensity exercise can be maintained longer (Janssen 2001).
4. The recovery workout: Very low intensity (heart rate lower than 70% of max) – aerobic capacity does not improve. Helps the recovery process.

Gender Comparisons

> "Think of VO_2 max as an athlete's aerobic potential and the lactate threshold as the marker for how much of that potential they are tapping."
> *www.sport-fitness-advisor.com*

Aerobic Capacity

The standard measure of aerobic fitness and cardiovascular endurance is VO_2 max (also called maximal oxygen uptake, or aerobic power). A high VO_2 max may be necessary for successful performance in endurance sports, but it is not always as predictive of performance as other markers, such as lactate threshold.

- The average person may increase their VO_2max by approximately 20% with training. This percentage is hereditary and varies widely between individuals.
- VO_2max decreases with increased altitudes above 1600 m.
- VO_2max also decreases with age, by approximately 1% after the age of 25 (however, this is often due to increases in percentage body fat).
- Nordic Skiers have some of the highest VO_2max values ever recorded for both males and females (Wilmore & Costill 2005).
- Males and females have similar VO_2max values until puberty.
- After puberty women's VO_2max values are roughly 75% that of men. This difference is related to the higher essential fat stores of women, women's lower haemoglobin content and their smaller heart size.

- Studies show that gender differences are small in elite athletes.
- Some research suggests that with age, VO_2 max decreases more rapidly for older men than it does for older women. As a result, the gender differences decrease in the later decades of life (Weiss et. al., 2006).

The **Lactate Threshold** (often used interchangeably with Anaerobic Threshold, although technically not the same thing) is the point at which blood lactate levels exceed 4.0 mmol/L (on average). It indicates the maximum level of exercise that an individual can maintain for a long period of time without accumulating lactate.

- At rest, blood lactate levels are at about 1 mmol/L. As an athlete increases his or her level of intensity, the lactate levels increase as well.
- Endurance capacity is best trained by workouts around the level of lactate threshold (where lactate values are 2-6 mmol/L).

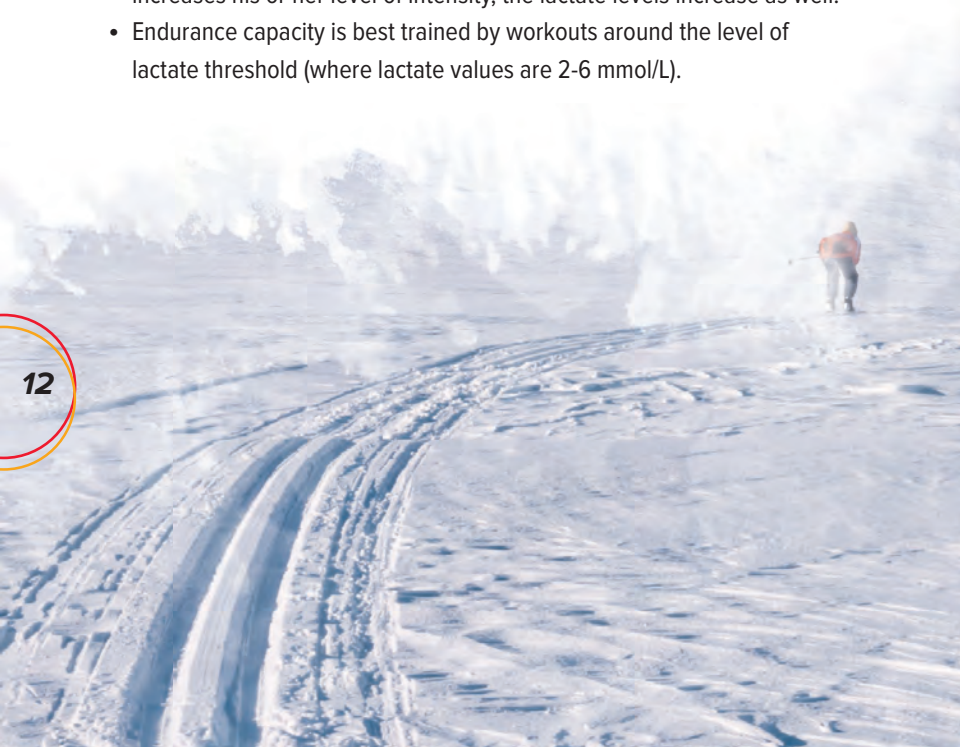


Table 2.0 Comparison of Aerobic Power Between Genders		
	Men	Women
VO_2 max value – average citizen aged 20-29 (Wilmore & Costill, 2005)	43-52 ml/kg/min	33-42 ml/kg/min
VO_2 max value – Normative data for Elite Nordic skiers ages 20-28. (Wilmore & Costill, 2005)	65-94 ml/kg/min	60-75 ml/kg/min
High VO_2 max for Gold Medlaists	96 ml/kg/min (Norwegian Bjorn Daehlie, EspenHarald Bjerke 2005)	77 ml/kg/min (by Bente Skari, Norway (Olympic Gold medalist))
Swedish National Ski Team values	85-94 ml/kg/min	70-74 ml/kg/min
Age at which peak VO_2 max is reached	17-20 years old	12-15 years old

"For good endurance athletes, the anaerobic threshold is as close as possible to the maximal oxygen uptake (VO_2max)."
Janssen 2001

Heart Rate

Heart Rate is useful for many things when monitoring training. It is a good indicator of training intensity, as there is a linear relationship between HR and intensity of exercise, and is easily observed with a heart rate monitor.

Resting Heart Rate can indicate improvements in conditioning, can help to indicate whether or not an athlete has recovered from a workout or race, and can give clues about overtraining and viral infections.

- Resting heart rate is higher for women than it is for men of the same age, (Janssen 2001).
- Resting HR should be taken consistently at the same time of day.

Maximum Heart Rate (HRmax) is not believed to be influenced by gender, and may be determined by maximal effort tests using a heart rate monitor. It is useful for determining appropriate training intensities.

- The traditional formula for estimating HRmax is 220 – Age (ie. A 20-year-old would have a max heart rate of 200 bpm). However, this is not always accurate and some researchers have found that this tends to overestimate HRmax for women (Gulati et al., 2010).
- Studies have shown that HRmax can vary significantly depending on which modality is used for testing. It is best to determine a sport-specific HRmax for use in training.
- While both genders have similar maximum heart rates, females have a smaller heart size and thus lower stroke volume compared to men; they compensate with higher heart rates at a given workload (Wilmore & Costill, 1999).
- The cardiac output for the same absolute submaximal power output is similar for male and female athletes.

Other Physiological Comparisons Between Male and Female Athletes

Some of the main issues surrounding female athletes are to do with exercise amenorrhea (cessation of menstruation) or oligomenorrhea (irregular menstrual periods). Around one third of competitive female long-distance athletes (aged 12-45) have experienced one or the other at some point, in correlation to the number of kilometers run (McGlynn, 1996). Irregular menstruation is associated with lower bone density, which puts one at risk for osteoporosis.

More facts on female athletes:

- Women have a lower centre of gravity, which gives them better stability in sports that require balance (such as martial arts).
- Women have a higher percentage of body fat (approximately 19-24%, compared to 12-17% for males), which gives them more buoyancy and insulation in water sports.
- Women have less lean muscle in relation to total body weight and lower total stores of ATP, CP and glycogen.
- Female athletes have increased iron and calcium needs (McGlynn, 1996).

Long Term Athlete Development Model

The Long Term Athlete Development Model, or LTAD for Cross Country Skiing helps to identify appropriate training goals at each stage of the athlete's physical development. For more details, see www.cccski.com/dbfiles/1670.pdf.

Peak Height Velocity, or PHV, is a key component of the LTAD and refers to the point of fastest growth during puberty. It is important when considering training for sports, and helps to differentiate physiological age from chronological age. Physical characteristics such as coordination/agility, aerobic endurance and strength are best trained during certain chronological "windows".

- Females tend to reach PHV around age 12, while males reach PHV at an average age of 14.
- Most girls experience their first menstrual cycle approximately one year after PHV.
- VO_2max and strength increase significantly following PVH.
- Simple measurements (standing height, sitting height, arm span) can be used to monitor PHV, and appropriate training can be set to match the athlete's development.

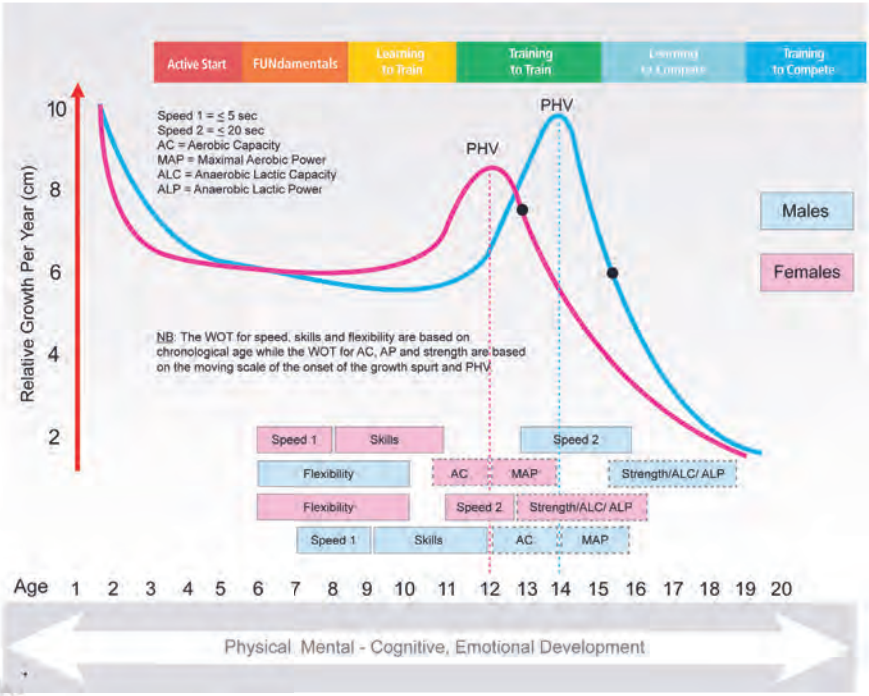
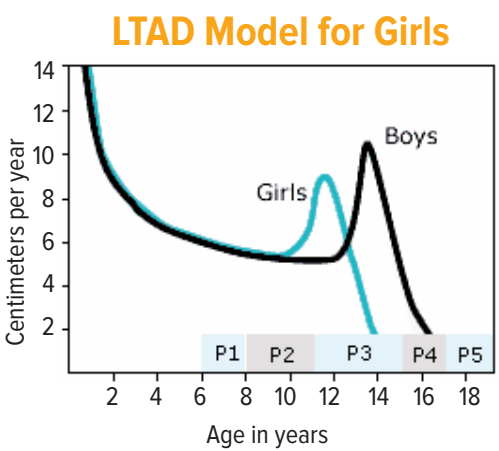


Figure 2 - Peak Height Velocity & Windows of Opportunity (Balyi et al. 2004)

Figure 3 demonstrates the average ages for various phases of the LTAD with the Late Specialization Model used in Cross Country Skiing:

- **P1** = **FUNdamentals** (Girls 6-8) – Participate in all sports; develop fundamental sports skills.
- **P2** = **Learning to Train** (Girls 8-11) – Learn all fundamental sports skills.
- **P3** = **Training to Train** (Girls 11-15) – Develop the aerobic fitness base (after the onset of PHV).
- **P4** = **Learning to Compete** (Girls 15-19) – Emphasis on fitness and sport specific skills performance.
- **P5** = **Training to Compete** (Women 19-23+) – Optimize fitness, technical and performance.
- **P6** = **Training to Win** (Women 23+) – Focus on maximizing skills and performance.



Specific Training Guidelines for Female Skiers:

1. Increase the aerobic training component earlier for female athlete than males to reflect the earlier maturity of the aerobic energy systems.
2. Encourage aerobic activities that are weight-bearing (e.g. running) to build strong bones in female athletes prior to age 30, and to sustain bone density after age 30. Weight-bearing exercise helps to maintain bone density later in life and reduces the incidence of osteoporosis in female athletes.
3. Female athletes have unique nutritional requirements and may require supplementation (in particular, iron and calcium).
4. Realize that female heart rates may be higher than male teammates' heart rates at rest, and for an equivalent work effort.
5. Monitor growth rates to determine optimal times for training different capabilities.
6. As a general guide, the volume of aerobic training should not be increased more than 10% per year, to minimize risks of injury.
7. Encourage athletes to keep a detailed training log and include resting HR, growth rates, menstrual cycles, fatigue, etc.
8. Ensure that skiers are training at the right intensity level, at the right time.
9. For men, a carbohydrate-loading diet can increase the levels of glycogen stored in muscles and improve performance in endurance competitions. Studies reveal mixed results for women, but suggest that carbohydrate loading may not be as effective for women; the menstrual cycle seems to be a factor.
10. Care must be taken when collecting anthropometric testing (ie. Body fat measurements) with female athletes. This data should be kept confidential and should not be compared with teammates' data, so as not to cause stress relating to body image.

Fun Activities for Female Skiers

Here are some ideas for keeping aerobic and anaerobic training fun and interesting for girls of all ages. These have been tested and recommended by active female racers*.

- Keep it fun and make it social!; Girls love the social aspect of sport.
- Scavenger hunts or treasure hunts.
- Destination runs and/or bike rides (to get a treat at a store & back, or to a waterfall, a lookout, or somewhere special).
- Create a playlist/mixed CD and do body-weight type single lunges and half push-ups , jumping jacks, squats, bungee cord pulls (lightweight, lots of repetition); switch exercise each time the song changes.
- Orienteering races (running or skiing). Night orienteering is even better!
- Soccer, ball hockey, ultimate Frisbee. Play tag on a jungle gym.
- Sprints in the middle of any aerobic activity (running or cycling or roller-skiing), usually using landmarks like hydro poles or sign posts.
- Fun races such as biathlon-type events (throwing darts or basketballs, shooting pucks into a net, shooting water balloons into trash cans), reverse pursuit races, hill climb races (counting only uphill sections).
- Fartlek-type intervals where you run faster between mailboxes.
- Try a workout class: aerobics, aqua jog, or spinning.
- Drumming circle (with balls, stomping, etc.).
- Try a magazine workout.
- Jump on a trampoline.
- Take a dog for a run.
- Enter a team relay in a local running race.
- Dance or gymnastics may also be positive environments in which women can improve joint mobility, hip flexion, flexibility of the spine, speed and agility.

**NOTES: Thanks to all the female Nordic skiers in Thunder Bay who provided suggestions for activities.*

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