Development of Ski Fitness and Strength for Cross Country Skiing

Foreword

These are my thoughts for the short, introductory presentation on the title subject required for the SE L2 On-Snow Instructor Course held at Obertilliach 2025. Treat them as an introduction to the subject and a bit rough around the edges!

Alistair (March 2025)

Warning

I'm not medically trained or qualified in physical exercise/education. Exercise and fitness training can result in serious injury or death[1]. Get appropriate advice from a professional before trying to copy Klæbo's or Diggin's training programme.

What Is Fitness?

Physical fitness can be thought of as the engine for our skiing.

Why Are We Worried About Fitness?

For a given skiing ability, fitness determines how far and how fast we can ski. Whatever your level of skiing technique and balance at the moment, suitably improving your fitness and strength should allow you to ski further or faster.

A way to break this down is, fitness consists of Endurance and Strength.

- Endurance is the engine. How well your body converts energy (from food/drink) into useful motion and disposes of the by-products (e.g CO_2, lactate) from that conversion.
- Strength is the gearing that determines the force that that endurance can provide.

Endurance Training

Cross-country skiing is an endurance sport (even sprint races are over 1km long) so endurance training is a particularly important aspect.

There are two measures used when defining the amount of endurance training:

- Intensity: Amount of effort (i.e heart rate)
- Duration: Length of time or distance covered

For a given endurance capacity:

- As you increase the intensity of a session/drill you'll achieve less duration, or
- As you increase duration, you'll have to reduce the intensity to complete.

[1] As can eating a meal or crossing the road, to keep some perspective.

Aim

With endurance training you are trying to increase the duration you can achieve at an intensity or vice versa.

Heart Rate Monitoring

The easiest way to measure intensity is measuring heart rate[2] (HR). There are other measures like breathing effort scales[3] e.g can you chat easily, only say a word per breath or wonder what you're doing with your life/ think you're going to die!

As a cross-country skier I'd suggest a chest strap HR monitor rather than wrist-based HR monitor is still the only sensible option.

Wrist based HR monitors:

- Do not respond well to rapid HR changes. For example, required for intervals.
- Have to be touching to skin to work. Not practical with jumpers, gloves etc if you want to be able to read them easily.

Heart Rate Training Zones

There are 3 basic HR ranges of relevance to this introduction[4]. These are:

Name	HR Range	Percentage of Training
Low (Aerobic)	(50)60-70% Max HR	80%
Tempo/Threshold	80-90% Max HR[5]	15%
High	90-100% Max HR	5%

Note On HR Zones

In my experience the only reliable way to get your max HR is to measure it. For example, the age calculation (220-age) is meaningless.

When measuring maximum HR, creep up on it. If you just sprint 'out of the blocks' your top effort will be limited by lactate buildup before you hit maximum HR. Building up speed over 2-3km with sprint at end is a far better test.

Whilst the ranges in table are given as Max HR my suggestion is to use the Karvonen Formula that uses working HR range rather than just Max HR to calculate HR ranges.

Karvonen HR Formula

$$HR_{\%} = \% \times (HR_{max} - HR_{rest}) + HR_{rest}$$

This also requires you to know your resting HR (HR_{rest}). This is easier to measure than max HR, relax for 5 minutes lying or just measure it in your sleep.

[2] Usually measured in beats per minute (bpm).
[3] See Miles' Endurance Training Session article in MCCSC website Library.
[4] You might see 5 or 6 defined in some books. Sport's scientists seem to have too much time to justify. Until you can exercise to given HR levels, why complicate things!
[5] Yes. There is intentionally a gap between Low and Tempo HR bands.

As you train, your resting HR should decrease and as you age your maximum HR may decrease. But do not over think it, for the accuracy we are using calculations for, a couple of beats per minute error does not matter.

Long Slow Distance (LSD) / Aerobic training (80%)

Builds a solid endurance base by increasing aerobic capacity and improve the efficiency of oxygen utilisation.

Consists of long duration/ distance (e.g an hour or more / 10km or more). Performed at reasonably steady effort i.e HR in aerobic range. Do not be afraid to walk up hills to keep HR down within appropriate range (staying at the lower end of range is better than being near top end of range).

Examples:

- Roller skiing (if suitable, relatively flat terrain available).

Obviously best match, both for technique and 4 limb usage. Even if available, give body a rest by mixing with other endurance exercise.

Other examples (2 limb):

- Inline skating (similar but different to roller skiing)
- Jogging (accessible)
- Hill walking
- Ski-erg
- Cycling (will need longer distances/durations because of mechanical gearing e.g factor of 2)

Other examples (4 limb)

- Rowing (indoor rowing usually more accessible for long distance, perhaps max out at 10km)
- Swimming (less distance required because of water resistance e.g 1 hour/ mile tops)

Whilst these are 4 limb activities remember your weight is being supported so not directly indicative for skiing. This could be good or bad (i.e don't kid yourself if you're a heavier skier!).

Tempo/ Threshold (15%)

Exercising just below or at the lactate threshold. Helps improve the body's ability to handle lactic acid buildup and delay fatigue.

Consists of steady efforts for 20-30minutes. Work up to doing several intervals.

Exercises same as Aerobic just faster or with more resistance. Consider using hills to increase resistance for roller skiing or running to keep speed down i.e the speed required is not limited by technique ability.

High Intensity Intervals (5%)

Help increase VO_2 max (ability for body to utilise oxygen).

Consists of short durations e.g max 4-5 minute followed by similar duration recovery (or when HR drops to certain level[6]). Sets (repeats) of 3-5.

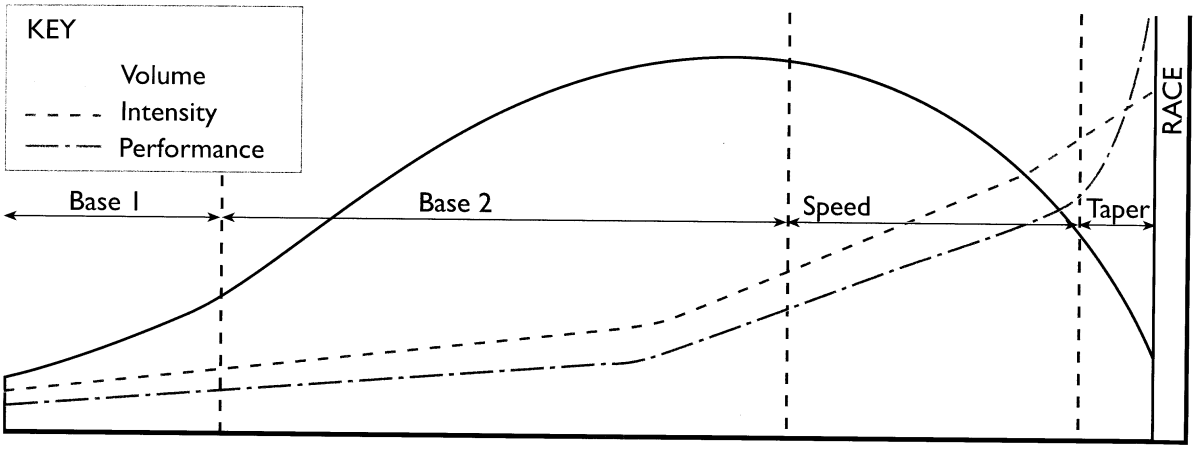
Exercises same as Tempo, again consider hills to keep speed within your skiing ability.

[6] When you start you might find longer rests are required to allow HR to recover to suitable level to perform next interval.

Build Up

To get fitter you need to be increasing the amount (or volume) of these training sessions.

Starting a 6 month period before your ski holiday/ race is a good timescale to look at.



First 4 Months (Base 1 & 2)

Initially focus on the aerobic sessions. Increasing distance/duration of longest session as well as total distance/duration per week[7].

This period:

- Improves aerobic capacity
- Prepares body for the harder Tempo & High Intensity Interval sessions.

Increasing resistance during duration sessions by:

- Slower rollers
- Single pole skiing (also helps improve technique, plus good training for lose/ break poles in race!)
- More climbs
- Higher bike gears (cycling)

Do some interval/ tempo sessions to get used to speed but not too much.

Next 1.5-2 months (Speed)

- Decrease Aerobic sessions
- Increase Tempo sessions and High Intensity Interval sessions

Last 2 weeks (Taper)

- Taper (drastically reduce aerobic and number of Tempo & High Intensity interval sessions).
- Want to stay ready for event but not exhaust body (allow it to recover).

[7] Note you would expect to work up to your event distance with longest aerobic workout not exceeding about 35km. For longer events expect to just do more duration sessions.

Strength Training

Strength is what allows us to propel ourselves along with our super-efficient, newly trained endurance (aka engine).

Cross-country skiing is a full-body activity, upper and lower body limbs are used. It also involves climbing (moving body against gravity).

Compared to normal life we need to improve our strength because most of us do not:

- Manually move large loads for long periods of time[8].
- Lift more than our body weight with our legs for more than a few flights of steps (let alone use our arms to help do that).

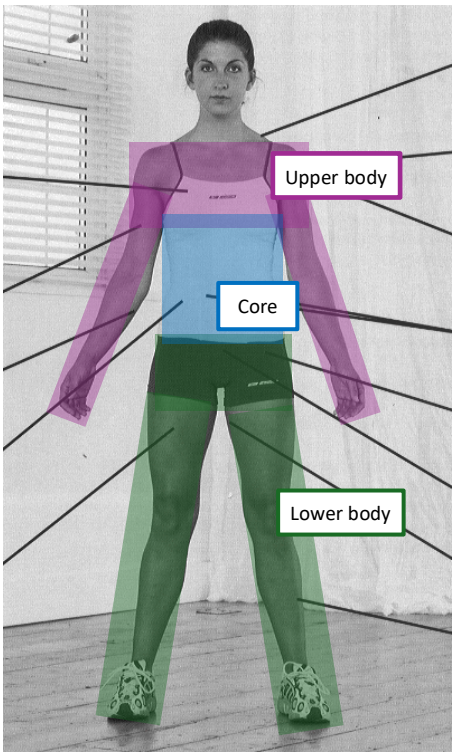
Regarding upper body strength you are lucky if you do lots of:

- Rowing
- Swimming

Relative Body Weight Strength is What Counts

When considering strength in cross-country skiing we are usually interested in strength to weight rather than absolute strength[9]. That is, it is the amount of weight you can lift[10] as a factor of your body weight that matters not the absolute amount of weight. For example, a 60kg person who can bench press 70kg is relatively stronger than a 100kg person who can bench press 100kg (pull-ups and press-ups are a real leveller!)

Muscle Groups



[11]

[8] There are exceptions, perhaps you grew up on a farm, think yourself lucky and focus on another aspect!
[9] Unless you're carrying/ dragging fixed mass e.g very large rucksack or sledge.
[10] When I say lifting, I mean moving weight with legs, arms or core.
[11] Prizes are not available for identifying all the muscles indicated by the label lines!

Broadly we divide the body into three muscle group areas:

- Upper body: Arm, shoulder and pectoral muscles.
- Lower body: Legs and pelvis muscles, e.g glutes, hip flexors, abductors (leg out) & adductors (leg in).
- Core: Connect the upper and lower body. Not just the '6-pack', but also obliques and back.

Measures for Strength Training

As with endurance training there are two measures used when defining the amount of training:

- Intensity. This is the amount of weight.
- Duration. This is number of times (repetitions aka reps) you lift (or hold) that weight.

For a given strength:

- As you increase intensity, you'll achieve less repetitions, or
- As you increase repetitions you'll have to reduce intensity.

Aim

As with endurance training, with strength training you are trying to increase the duration you can achieve at an intensity or vice versa.

Thoughts on Improving Strength

Start training with focus on improving intensity (maximum weight you can lift). Then move focus more on increasing duration.[12][13]

However, nothing wrong with starting with duration and increasing weight throughout year.

Intensity Training (Maximising weight you can lift/move)

Focus on high weight and hence, low reps (about 6 max per set)

Consider the following when deciding whether to use weights machines or free weights.

Weights Machines:

- Good: Can use on own.
- Not so good: Tend to be designed to isolate muscle. This reduces development of linked support muscles[14] (which you'll use skiing).

Free weights (particularly on bar):

- Good: Less muscle isolation.
- Not so good: Often need help with weights for final repetitions, particularly if using a bar, because you are usually under the weight. At best you'll have to drop them away from yourself.

[12] When increasing duration the initial intensity (weight) will obviously be lower than the maximum you can achieve in single lift.
[13] This was Alan Eason's suggestion many years ago for how to improve. Heavy weights over summer, more endurance focus in autumn/winter.
[14] This isolation can be useful for certain injuries because it can let you carry on doing some exercise because the injured areas aren't loaded as they would be with free weights.

Repetition Patterns

There are various approaches to how you should do reps in a set for best results. My basic conclusion is change the pattern every now and again because the body gets used to a particular pattern, so it loses its effectiveness.

Example patterns:

- Pyramids: Increasing weight and reducing reps in each set
- Drop sets: Do repetitions to muscle exhaustion then reduce weight (e.g half) and do repetitions to muscle exhaustion again. Start next set at initial weight.
- Partial reps: Only lift weight for partial limb motion e.g for bicep, fully extended arm (down) to horizontal forearm then extend. Separately, horizontal forearm to fully contracted bicep, back to horizontal.
- Eccentric focus. Do eccentric part (muscle lengthening whilst loaded) slower than contraction (muscle shortening whilst loaded) part of repetition.

Remember muscles work in pairs because they can only lift/hold load when contracting. Therefore, do not just focus on one half of pair in a session.

Duration Training (Maximising how long you can lift/move weight)

Focus on lower weight and higher reps (e.g continuous for 1 minute).

Free weights (e.g dumb bells, kettle bells, medicine balls) rather than weights machines best (and practical because lower weight than intensity training) but also body weight (possibly with additional free weights).

Classic body weight strength exercises:

- Pull ups (various grips)
- Push-up (various hand positions)
- Crunches (many various variations)
- Plank (plus variations)
- Squat thrusts (or mountain climbers, burpees)

Can do classes, for example:

- Circuits: Combine cardio with body or free weight reps. Classes vary focus between cardio and weights due to equipment available, instructor's preference, number of attendees etc[15]. Try class to find out, but either focus is good for cross-country skiing.
- Body pump: Free/ bar bell weight reps to beat (moving to a beat can be problem if you have to use large weights)
- Pilates: Body weight core exercise.

Circuit and Body pump classes can be a good introduction to using free weights. They are also good for keeping intensity up because someone else is tracking times and telling you what is next.

[15] I've done circuits in large sports halls with large numbers of attendees so lots of long shuttle runs & laps and some body weight exercises. I've also done circuits in a small school gym with wall climbing frames, lots of lifting and jumping on/off benches (plus some rope climbing!) with very short runs around school yard.

List of Exercises

I'm not listing exercises here. There are already plenty of books, websites and YouTube videos dedicated to listing hundreds of exercises and variations on exercises. If you're really stuck see Lists of 101 Exercises in References.

As a cross-country skier consider combining several exercises into a single exercise motion (duration strength), for example:

- Dumbbell thrusters (squat plus shoulder press)

- Lunge with bicep curl[16] (lunge plus bicep curl)

Some Realism

- Time. Most of us have jobs and are not being paid to ski. Find your 'Why am I doing this?'[17] and hopefully you'll be halfway to finding the time to do some training.
- Recover. Rest/sleep to let your body recover and adapt.
- Something is better than nothing. Focus firstly on doing the sessions than them being exactly the right durations or intensity. Lots of books and theory is useful but doing the training is the only thing that makes you fitter.
- Listen to your body. If you're ill, let yourself recover. Then re-start at a lower intensity/duration than you were at when you stopped!
- Be pragmatic. Don't worry if you miss a session and don't try to catch up if you do.

[16] You can also add a torso twist after bicep curl before standing up if want a real combination.
[17] Not wanting to ache halfway through the week is not a bad starting goal!

Conclusion

I have provided some background as to why fitness and strength are important for better cross-country skiing. Recognising that cross-country skiing is a full-body workout endurance sport I have outlined the areas to focus on if you want to improve your fitness and strength.

If you have done exercise for other sports or reasons this should allow you to steer your focus.

If you are new to exercise then you are probably a bit goggle eyed now. To start, improve your endurance by getting out there and gradually build up the distance/time you can ski (remember going slower is allowed). For strength, whilst there are lots of resources online, books etc I would recommend finding someone in your club to chat to or visit local gym and get in some classes or get a personal trainer to guide you until you are happier you know what you are doing.

Further Reading

Some books from my library (most probably out of print now).

Endurance

- The Complete Guide to Endurance Training – Joe Ackland (mainly focused on triathlon training).
- Fitness Cross-Country Skiing – Steven E Gaskill (see Miles' Endurance Training Session article on MCCSC website for summary)
- 80/20 Running – Matt Fitzgerald
- Maffetone (MAF) training method (https://philmaffetone.com/method/)

Strength

- Fitness for Life Manual – Matt Roberts
- 90-Day Fitness Plan – Matt Roberts

Lists of 101 Exercises

See Strength references above.

Go to Circuits & Body Pump Classes.

- Men's Health Big Book of Exercises – Adam Campbell or Women's Health Big Book of Exercises – Adam Campbell (take your pick)
- Swiss Ball for Total Fitness - James Milligan
- Core Strength Training – DK Books