Please use this information to design and understand training programs. Theory and ideas are always changing take from it what you can. We publish this info to help raise the level of ski racing in America. As a side note, the graphs on the original document didn't convert over to the PDF.

USSA Cross-Country - Definitions of training

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Introduction

Many different descriptors of training sessions are used throughout different coaching bodies, physiological literature and between countries. The following is not an attempt to re-write what is currently understood but to try to bring together some of the differences in terminology in order to accurately describe the current training sessions being used by the USSA Cross-Country team. Such descriptions are also aimed at making it easier for the coach to identify the different sessions, their main goals and the effects they will have on their athletes' bodies. An overview in the form of a table is given below. Following this is a description, main goal, some example sessions, pro's and con's of the different sessions as well as a brief review of the physiological effects you can expect from them and what these effects will look like if you have access to any kind of physical testing.

Table showing the different "types" of training sessions listed in order of intensity

Training type	Session "Descriptor"	Lactate (mmol/L)	Main goal(s)	Energy system(s) (Approximate)	Breathing ref.	Velocity ref. (Continuous effort)	HR range % Max	HR range % LT
Distance / Recovery	Level 1 Easy A1 (Aerobic-1)	< 1	Inc. aerobic efficiency	90-98% Aerobic 2-10% Anaerobic	Very easy to talk	Slow	60 - 70	65 - 75
Distance / Technique	Level 2 Moderate A2 (Aerobic-2)	1 – 3	Inc. aerobic efficiency *Note: only a small contributor to the volume of distance training – see pro's and con's below	80 - 90% Aerobic 10-20% Anaerobic	Easy to talk	Medium	70 - 80	75 - 90
Threshold / steady state	Level 3 Steady LT	3 - 5	Inc. work capacity at LT Improve lactate metabolism	60-80% Aerobic 20-40% Anaerobic	Hard to talk	50 Km race pace	80 - 90	90 - 100
VO_2 max	Level 4 Hard Max Aerobic	5 - 10	Inc. maximal aerobic capacity	40-60% Aerobic 40-60% Anaerobic	Very hard to talk	5 Km race pace	90 - 100	100 - 110
Tolerance & Peak Lactate	Level 5 Very Hard Supra-Maximal	> 10	Inc. anaerobic capacity	10-20% Aerobic 60-90% Anaerobic	Cannot talk	Prologue race pace	N/A	N/A
Speed	Level 6 Pace / Max velocity Resisted speed	N/A	Inc. time or biomechanical efficiency at a specific velocity	2-10% Aerobic 90-98% Anaerobic	N/A	N/A	N/A	N/A
Over-speed	Level7 Assisted speed	N/A	Inc. Max Velocity	2-10% Aerobic 90-98% Anaerobic	N/A	N/A	N/A	N/A

Abbreviations: [LSD-Long Slow Distance; LT-Lactate Threshold; Inc.-Increase; ID-Identified; VO_2 max-Maximal aerobic capacity; N/A-Not Applicable]

Aerobic Training

- Level 1 – Distance / Recovery
- Level 2 – Distance / Technique
- Level 3 – Threshold / Steady State
- Level 4 – VO_2 max

Level 1 - Distance / Recovery

Description

Distance training – this involves medium to long workouts generally at a fairly constant pace. The athletes should get tired from the length of the session NOT the intensity. If heart rate zones are unknown and lactate checks impractical then breathing is an excellent way to monitor and control the intensity of these sessions. Breathing should be relaxed and rhythmical and it should be very easy to talk.

Main goals

Increased endurance
Increased cardiovascular and respiratory efficiency
Decreased reliance on anaerobic metabolism at low intensity
Active recovery (when volume is controlled)
Learn/ingrain proper technique

Physiological changes:

These include long-term structural changes to the heart, lungs and muscle:

- Increased cardiac efficiency, which is caused, by increases in size, elasticity, and contractility of the heart tissue. These changes in heart structure lead to a greater stroke volume and cardiac output resulting in the typical decrease in heart rate both at rest and at any given work load below LT (see graph below)
- Increased blood volume (mainly plasma though with some increase in the total red blood cell count)
- Increased capillarisation of muscle and lung tissue
- Increased respiratory efficiency (increased tidal volume and oxygen transfer rates)
- Increased oxygen uptake capacity of muscle cells (increased myoglobin content)
- Improved mitochondrial[ξ] size, number and function (increase in oxidative enzyme concentration)
- Increased muscle fuel storage: glycogen (carbohydrate) & triglycerides (fat)
- Increased efficiency of fat relative to carbohydrate metabolism (glycogen sparing) also resulting in the secondary effect of decreased subcutaneous fat storage if calories are in deficit.

Long-term neuromuscular adaptations resulting in habitual technique changes

Special notes:

Pro: The extremely low intensity and therefore velocity of level 1 aerobic training makes it ideal for high volume work. Maximizing long term structural changes in the cardio-respiratory and muscular systems whilst minimizing the impact caused by residual muscular fatigue on other training sessions.

Con: The biomechanics of the activity needs to be carefully considered to minimize the transfer of "poor" mechanics. For example, roller skiing at level 1 requires the use of slightly different mechanical patterning to on-snow skiing. Due to the high volume of repetition of this movement pattern it has been associated with the translation of poor mechanics into on-snow skiing. The patterning is close enough to on-snow to create reinforcement of "poor quality technique". Skiers training too slowly can ingrain poor technique. It should be every skier's aim to use proper technique (i.e.: proper body position, mechanics, application of power, and tempo) while training – especially while training in level 1. While the aim is to train all distance sessions in level 1, some athletes will need to hit level 2 at times (in difficult terrain) in order to maintain proper technique. When this is the case the volume of each ski/roller ski session will have to be shorter to allow for the higher intensity. Non-ski-specific workouts, such as running, hiking, biking can be done in level 1 with less concern for proper technique – even here though one should use snappy motions and avoid "moving in slow motion".

[ξ] Note mitochondria are small specialized organelles found inside muscle cells which perform the oxidative process.

Example session(s)

Intent: Aerobic training: Level 1: Distance / Recovery. Lactate < 1 mmol/L

Session Aims:

Increased aerobic endurance and efficiency

Gradually increase training volume – and base for building higher intensity aerobic and anaerobic sessions

PROGRESSION 1	SET
Warm-up Some light stretches after the first 5 mins	45min–3hr continuous

Special notes:

Skiers should be able to comfortably handle the volume of training they do. To ensure this, raise the volume of training as gradually as is necessary within the year and from year-to-year.

Gradual cycles of increased loading and recovery need to be followed.

Train to improve, not to accumulate training hours.

Altitude will increase the intensity of the session, it is super important to stick to identified heart rate levels whenever possible as breathing can be misleading. Recording spot lactates occasionally if possible can be extremely helpful especially during the first week or so of adaptation. Easier is better during the acute acclimatization phase of 4-8 days.

This type of training for distance skiers is done year-round, and makes up about 80% of a skiers total training volume for the year. The volume of this type of training for sprint skiers is more variable based on their specific needs and is more often used as a recovery tool.

Level 2 – Distance /Technique training

Description

Distance training – as with level 1, this involves medium to long workouts generally at a fairly constant pace, though some introduction of carefully controlled intervals often in the form of a "fartlek" session are also common. The athletes once more get tired as a function of volume NOT the intensity of the session. A lactate level of 2 (or the heart rate tested to correspond with this value) is optimal for determining training intensity, however breathing is also a good guide – once more it should be relaxed and rhythmical and easy to talk. To maximize physiological changes athletes should aim to train predominantly in Level 1 for all distance training. Here within USSA Cross-Country we like to say that "Level 2 happens." Level 2 "happens" mostly when athletes need to train faster to ingrain proper technique. Elite skiers should be able to train in Level 1 using good technique. Level 2 also "happens" in difficult terrain and during shorter distance sessions, as well as in warm-up and warm-downs for intervals and racing.

Main goals

As given for Level 1.

As a part of distance sessions where technique is a focus (ski and roller ski sessions).

As a part of a warm-up and/or warm-down for intervals and races.

Physiological changes:

As given for Level 1:

Special notes:

Pro: Level 2 allows for better biomechanics with a rhythm closer to that used on snow. However due to the increase in intensity great care needs to be taken in the volume selected and its potential to have a greater negative impact on other training sessions due to residual fatigue.

Con: Care needs to be taken with the volume of this type of workout – with the relative intensity being twice that of a level 1 session. It is very easy to overload an athlete with too high a volume of this level of workout. Additionally due to the added intensity these sessions are more likely to cause residual fatigue, which may impact the quality of subsequent training sessions.

Example session(s)

PROGRESSION 1	SET	COOLDOWN	SUMMARY
Warm-up 5 mins of light (HR< Level 1) activity, plus warm-up stretches.	As the terrain and technique demands dictates in distance training.	5 mins of light (HR< Level 1) activity, plus warm-up stretches.	Focus on technique – not on training in level 2. *Note Level 2 "happens".

Level 3 – Threshold / Steady state

Description

Threshold sessions are designed as sessions, which can span across a wide variety of sets and reps. Level 3 intervals are executed at or below the anaerobic threshold (75-90 % of max heart rate). One is not supposed to accumulate lactic acid. One should feel like one could go faster and longer for every interval. Therefore, they have built in to them sufficient rest or slow work to allow complete recovery between reps or sets. This design format ensures that there is no accumulated fatigue between sets or reps allowing maintenance of quality rather than a reduction in performance caused by fatigue.

Main goals

The aim of these sessions is to get the body used to working intermittently above threshold and practice recovering after each effort. Gradually this type of training stimulates improved efficiency and increased recovery rates around threshold allowing the body to gradually increase the work it can do without accumulating progressive amounts of lactate.
Ingrain proper technique from repetitive correct biomechanical patterning.

Physiological changes:

The major goals of these sessions are to improve aerobic efficiency and aerobic capacity. This is achieved by a combination of:
Increasing cardiac efficiency and oxygen transport both from the lungs and into the muscle cells. This leads to an increased aerobic efficiency "around" threshold and an increase in aerobic work capacity at threshold (level 3)

- Increasing cardiac output (both by increased cardiac efficiency and maximal capacity)
- Decrease reliance on anaerobic metabolism at gradually increasing workloads.

Example session(s)

They span the continuum between continuous to short interval sessions: Brief descriptions and session details are given below:

Intent: Continuous work at threshold (Steady state sessions)
Training progressions are achieved by increasing the length of time at this load.
For example: 30-60 minutes non-stop skating or running. Lactates around 4 mmol/L the whole time.

Intent: Longer intervals with controlled intensity (Level 3), and moderate rest.
For example: 3x10 minutes, 4x8 minutes, 3x15 minutes, ladder of long intervals. Rest 1-3 minutes.
Lactate at the end of each interval should be around 3-5 mmol/L.

Intent: Shorter intervals also with controlled intensity, with very short rest.
For example: 2x12x200 meters with 20-30 seconds rest, or 2x8x400 meters with 20 - 60 seconds rest.
\Lactate around 3-5 mmol/L at the end of the workout.
This sort of workout is important to learning a new speed while still keeping the overall intensity of the session at Level 3.

Level 4 – VO_2 Max training

Description

Level 4 intervals are executed at or above the anaerobic threshold, which is typically between 85%-95% of max heart rate. (Note: these heart rate values can vary a lot with training the amount and direction varies with the athletes' history as well as the volume and intensity base of their training schedule). The reps and sets of these types of sessions are designed in such a way that during each interval and during the workout there will be an accumulation of lactic acid often between 5-10 mmol/L by the end of the session.

Main goals

The main goal however is to maximally challenge the aerobic as opposed to the anaerobic system. To do this, the distance or time governing each rep needs to be a minimum of 3 minutes and the athlete must be able to perform each rep at the same velocity and with the same technique throughout the session. To control the overall intensity of the session rest is usually equal to the length of the interval or determined by how long it takes for the athletes' heart rate to fall below their A1 heart rate (HR at 1 mmol/L lactate from testing).
Ingrain proper technique.

Physiological changes:

The major physiological goals of these sessions are to improve VO2 max and maximal aerobic work capacity. This is achieved by a combination of:

- Increased cardiac output (both by increased stroke volume and the efficiency of cardiac output under maximal load)
- Increased maximal tidal volume of the lungs
- Increased maximal O2 transfer rates both from the lungs to the blood and from the blood to the muscles.

Example session(s)

The level 4 intervals will typically use 4 to 5 reps of 3-6 minutes, although the rep length can be extended as far as 10-15 minutes with fewer rep numbers – more often these are categorized as time trials.

5 – 15 Km Time trials

Out of season races

Anearobic Training

- Level 5 – Tolerance & Peak Lactate

Think first!

Does your athlete need this energy system yet to compete?

These sessions result in residual fatigue, which will affect subsequent training sessions especially those requiring skill acquisition or strength

They need to be planned carefully with proper respect and a purposeful goal to be effective in an athlete's overall development.

These sessions when combined with a sound aerobic base have the potential to further stimulate maximum aerobic capacity BUT can reduce cardiac efficiency.

Level 5 - Tolerance

Description

Anaerobic tolerance sessions can span a wide variety of reps and sets. They are however, unlike the threshold sessions designed in such a way that there is significant accumulated lactate and fatigue during the work out so that the quality of each repetition reduces as the reps and sets progress. (Sometimes longer recoveries are given to maintain 2-4 sets of equal quality, with fatigue occurring from rep to rep within each set). Anaerobic intervals are of either such high intensity, or with such a short recovery time that the rate of production of lactate is higher than the removal of lactate leading to its accumulation in the muscles and a corresponding drop in pH. It is this drop in pH, which eventually causes the muscle cells to stop contracting. Hence a well-planned progression of reps and sets will challenge the dynamics of the lactate production and removal mechanisms as well as pH control. Proper technique should be maintained at all times.

Main goals:

A progressive accumulation of lactate which will result in a substantial improvement in enzymes responsible for lactate metabolism – both it's production and removal rate.

Increased maximal anaerobic capacity

Improved capacity for physiologically coping with changes in terrain and velocity during a race

Improved efficiency of movement both at higher velocities and under fatigue

Improved rate of recovery following an anaerobic challenge

Physiological changes:

Increased anaerobic fuel storage (ATP, CP, glucose and glycogen)

Increased glycolytic enzymes (those responsible for anaerobic metabolism)

Increased pH buffering capacity

Improved lactate removal dynamics

Special notes:

The timing and utilization any anaerobic sessions as well as their specific design is very much determined both by the training experience of your athlete and their competitive goals. The anaerobic training load of sprinters will be quite different to that of endurance based skiers.

Due to the dependence of the anaerobic system entirely on carbohydrates as a fuel supply it is essential that athletes carbohydrate load and are well hydrated for a minimum of 24 hours prior to these sessions to get the training effects from them.

These sessions all have specific warm-up to maximize the effect of the sessions and reduce the risk of injury. Athletes are also educated well on food and hydration to maximize the training session and improve the rate of recovery after the session.

Example session(s)

Anaerobic tolerance work-outs are extremely eclectic in design with no one progression providing the key to the development of this system in all athletes. Part of the reason for this is that in designing a tolerance session you have four main variables available as tools for you to alter the overall load of the session:

1) Number of reps & sets
2) Recovery between those reps and sets (long enough to maintain "reasonable" technique, short enough to ensure loading the anaerobic system in preference to the aerobic system)
3) Velocity of each rep
4) Duration of each rep (<180 secs)

These four variables allow for not only a huge variety of initial session designs, but also many ways in which to develop appropriate progressions of load on the anaerobic system.

All athletes have a different make-up of fast to slow twitch muscle fibers as well as different potential for the "trainability" of the systems involved in the limits of this system, in addition to their different racing goals. Hence, it is important to understand your athlete's background and the goals of your session in this area in so much as whether they are biased toward developing better lactate recovery dynamics, better biomechanics at race pace for longer, or better maximal anaerobic capacity as these things will guide you as to the length of reps and number of sets to use in training.

Example warm-up:

15-20 mins of light (HR<level 1) activity, plus warm-up stretches.
2 -5 mins steady (HR Level 2)
(15s hard: 1 min easy 15s hard) x 2
5-10 mins easy:
6 x 6s (short rhythm efforts)

Intent: Anaerobic Tolerance (short duration)

Session Aims:

- Gradually increase number of reps at controlled velocity usually selected based on movement patterns / race pace development

PROG	SET	RECOVERY-REPS	RECOVERY-SETS
1	2 x 6 x 30s	40s recovery between reps.	Heart rate must drop below level 1 before you start the next set. However a minimum recovery between sets is 10 minutes.
2	1 x 10 x 30 s	As above	N/A
3	3 x 5 x 30 s	As above	As above
4	1 x 12 x 30 s	As above	N/A
5	3 x 6 x 30 s	As above	As above
6	2 x 8 x 30 s	As above	As above
7	1 x 15 x 30 s	As above	N/A
8	2 x 10 x 30 s	As above	As above

Intent: Anaerobic Tolerance (short -moderate duration)
Session Aims:
- Gradually increase length of each rep
- Use 90 – 100% velocity for each rep
- Maintain overall quality of session by controlling recovery between reps

PROG	SET	RECOVERY-REPS	RECOVERY-SETS
1	3 x (2 x 30s HARD)	2 mins recovery between reps. (HR after 2 mins should be less than threshold!)	Heart rate must drop below level 1 before you start the next set. However a minimum recovery between sets is 10 minutes.
2	2 x (3 x 30s HARD)	As above	
3	6 x 30s HARD	As above	
4	6 x 40s HARD	3 mins recovery between 40s reps.	
5	2 x (3 x 50s HARD)	4 mins recovery between 50s reps.	
6	6 x 50s HARD	4 mins recovery between 50s reps.	
7	2 x (3 x 60s HARD)	5 mins recovery between 50s reps.	
8	6 x 60s HARD	5 mins recovery between 50s reps.	

Intent: Anaerobic Tolerance (moderate - long duration)
Session Aims: Specific control of velocity in each repetition

Example given for mixed terrain using classic skiing (elite athletes)

PROG	SET	RECOVERY-REPS	RECOVERY-SETS
1	3 x 1k in 3:30 mins	15 mins recovery between reps. HR after 2 mins should be less than threshold!	Heart rate must drop below level 1 before you start the next set. However a minimum recovery between sets is 10 minutes.
2	4 x 1k in 3:25 mins	As above	
3	4 x 1k in 3:20 mins	As above	
4	4 x 1k in 3:15 mins	As above	

* Times and progressions are variable based on technique, terrain and conditions

Level 5 - Peak Lactate

Description
Peak lactate training sessions are a very specialized tool for elite sprint athletes who already have a well developed aerobic base (needed for recovery from this type of session), as well as a well-trained anaerobic system. It is specifically designed to produce maximal lactate production and accumulation, which will in turn produce a maximal pH drop. This pH drop is caused by the release of H^+ ions as a result of formation of lactate. The rate of pH fall during maximal anaerobic work is determined by the buffering capacity (control of pH) the athletes' body. Improved buffering capacity is attained by improving the release and availability of predominantly bicarbonate ion (HCO_3^-). As dropping pH is the main cause of muscle dysfunction during anaerobic activities, improving the buffering capacity of an athlete can quickly and effectively slow pH drop and the increase both the amount of lactate which can be accumulated and therefore the work capacity able to be performed.

Main goals
Stimulate a maximal drop in pH
Improve the bicarbonate availability and release
Improve maximal production and tolerance of peak lactate
Improve maximal anaerobic work capacity

Physiological changes:
*****Increase bicarbonate storage and release in response to an acute pH drop
*****Increased pH buffering capacity
Increased anaerobic fuel storage (ATP, CP, glucose and glycogen)
Increased glycolytic enzymes (those responsible for anaerobic metabolism)
Improved lactate removal dynamics

Note: only the changes marked with a * are major – the other anaerobic adaptations are better attained using specific tolerance sessions

Example session(s)
Intent: Maximal lactate accumulation and pH drop

Session Aims:

- Improve buffering capacity of the anaerobic system to get a rapid response and improvement in maximal anaerobic lactate production and work capacity.

SET	RECOVERY-SETS	SPECIFIC SESSION COMMENTS
40s HARD – 100% 30s static 30s HARD – 100%	FULL 20 MIN RECOVERY (See details on anaerobic recovery sessions)	The 40-30-30 session is run once or twice in training session depending on the athletes anaerobic response. If one is doing 2 sets then we will use a minimum set break of 20 minutes.

Special notes:

This session should be done roller skiing or skiing to facilitate technical adaptation and maximal localized response in the muscles specific to skiing

A long specific warm-up building intensity and load similar to that described for the tolerance sessions is essential

The key to this session is an ALL out effort

This session is extremely fatiguing and it is imperative that athletes performing this training session glycogen load before AND after it – to optimize the session – (produce maximum lactate) as well as optimize recovery from it – otherwise it will limit their training for an extended period of time.

Speed Training

- Level 6 – Speed
- Level 7 - Over speed

Level 6 - Speed

Description

Speed sessions are designed as sessions, which can span across a variety of techniques, which can be used to improve maximum velocity. All of which require the athlete to be fresh and able to perform "perfect biomechanics". All of these sessions are performed as either roller skiing or on-snow skiing in order to practice and improve biomechanical efficiency and facilitate maximal power application from both the lower and upper body in the generation of forward propulsion.

Main goals

Increase maximal velocity
Improve efficiency at sub-maximal and maximal velocity

Physiological changes:

Improved pattern of neuromuscular firing
Improved muscular recruitment
Improved ATP/CP storage and replacement rates

Example session(s)

General warm-up (10 – 20 mins – aerobic based, movement specific)
Movement specific warm-up and basic movement pattern based drills (5 mins)
Explosive flexibility (5 mins)
Drills based on achieving loaded range of motion at controlled intensity (5mins)
Progressive intensity build with optimal technique patterning / drills or controlled velocity short repetitions (5 mins)

Intent: Technique – learning acquisition
Session: 5–10 x 8–10 secs at 90 – 95% max velocity

Intent: learning adaptation repeated performance
Session: 8 -10 x 8–10 secs at max velocity

Intent: Resisted speed: Loaded technique – learning adaptation: Learning how to bio-mechanically and neuro-muscularly move close to max velocity with a load (95 – 99% max velocity) - eg pulley, weighted vest, up-hill, slower roller-skis.)
Session: 8 -10 x 8–10 secs resisted
Note: sets and reps vary with technique and terrain – alter load based on maintenance of perfect technique)

Special notes:

The key to this session is the quality of each repetition –speed work is essentially repetitive neuromuscular patterning – your body and mind must be FRESH. This means at the start and before EVERY repetition there needs to be plenty of recovery in order to get the maximum gains and neuromuscular adaptations.

Level 7 - Over speed

Description

Assisted technique – learning acquisition (101 – 105% max velocity) using various pulling techniques (pulley / snow mobile. This type of speed training needs to be performed at velocities very close to the skiers own max velocity. The session is designed to facilitate neuromuscular learning giving the skier the biomechanical "know-how" and neural wiring to generate a higher self propelled max skiing velocity.

Main goals

The major goals of these sessions are progressive improvements in speed biomechanics and neuromuscular recruitment, culminating in faster skiing. Since max velocity is reached within 6-8 seconds, these speed drills use 4-5 reps of 6-10 seconds, with 3-4 minutes rest between reps. The main focus here is on building velocity and technique, not the number of repetitions. The athlete will stop the speed workout when he/she is not able to maintain the velocity.

Physiological changes:

Neuromuscular learning
Improved muscular recruitment
Improved max velocity biomechanics and efficiency

Example session(s)

Yet to be developed based on experience with on-snow pulley work and athletes responses.
A minimum 40 mins drill work – technique based reps – of progressive intensity aimed at preparing the body both physically and biomechanically for supra-maximal velocities.
Develop a progression of loaded and unloaded work based on athletes' learning response and video feedback of biomechanical adaptation.