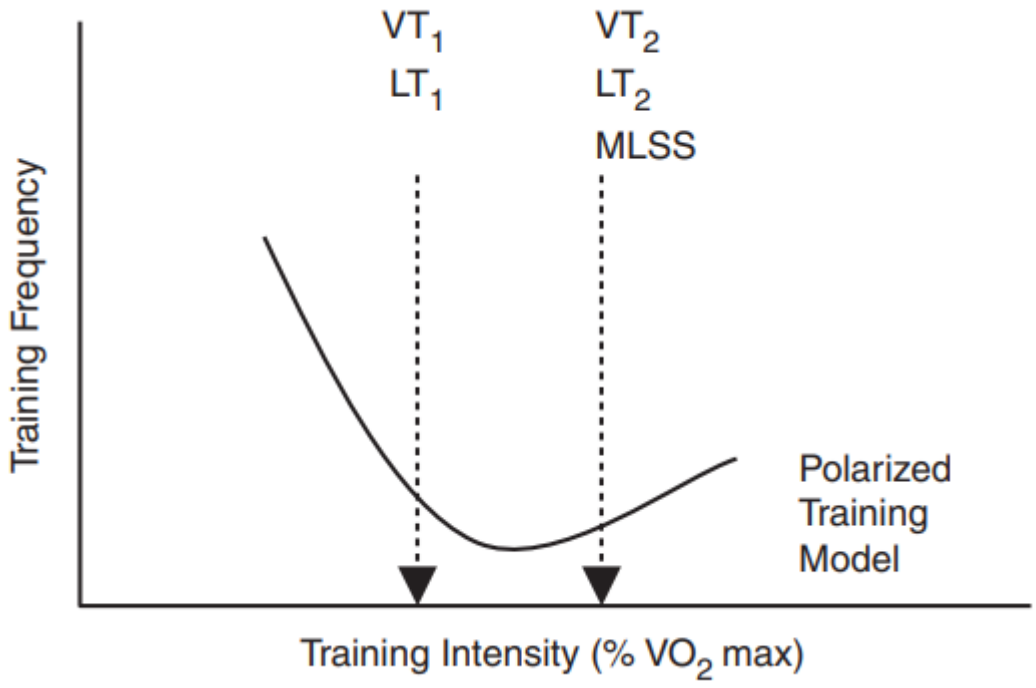
HANDOUT

Low Intensity Training in Cross-Country Skiing



(Figure: Seiler, S. & Kjerland, G.O. (2006). Quantifying training intensity distribution in elite endurance athletes: Is there evidence for an 'optimal' distribution? *Scandinavian Journal of Medicine & Science in Sports,* 16, 50.)

Table

1. Introduction

The goal of each training intervention is to maximise athlete performance and avoid overtraining, injury and illness. In endurance training there are a lot of variables which can be manipulated, each of them has different effects on the outcome of a race for example. This article aims to provide some useful information for the reader regarding one of those important variables known as long, slow distance training, aerobic endurance training or low intensity training (LIT). The goal is to support athletes and coaches with some basic knowledge regarding planning and executing LIT. Therefore, this article tries to collect different scientific studies and merge the important findings into one document.

"*When examining the intensity distribution of this large training volume, a number of studies across a broad range of sports converge on the finding that 75-90% of all endurance training time is performed as low intensity training (LIT, below the first lactate turn point) for athletes training >500h pear year"* (Tønnessen et al., 2014, p.1).

This abstract highlights the importance of low intensity training and why it is crucial to aim for sessions of high quality. All successful athletes in endurance sports and particularly in cross-country skiing spending a lot of their annual training time in this intensity zone. But currently there is minimal scientific research and no guidelines for athletes and coaches on this specific topic. A lot of studies compare training intensity distribution from elite athletes or focus on different training interventions (e.g., high intensity training, threshold training, interval training). Current scientific knowledge with regards to low intensity training has been developed from retrospective analysis of training data (i.e., training diaries). But at this moment no study has compared different intensities or approaches of LIT or has manipulated this intensity zone (no interventional study).

This article aims to provide an overview and will give some practical advice for LIT, while highlighting some examples of highly trained and successful athletes. In addition, the question of what "good quality" in low intensity training actually means is discussed and how to control the long, slow distance sessions. The studies used in this work are listed in the last segment with some additional articles the reader might find interesting.

Important to add here is, that all training zones and training prescriptions for athletes should be highly individualized with regards to intensity and duration. What is good for one skier does not mean it has to work for another. This literature research aims to help elevate the quality of LIT in cross-country skiing and is useful to athletes and coaches in their daily training.

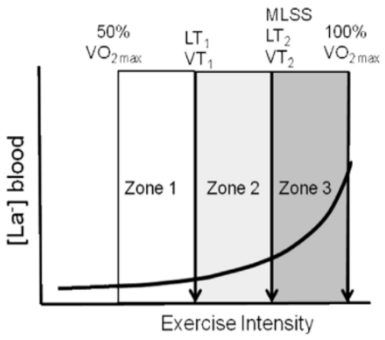
2. What is low intensity training?

In scientific research a three-intensity-zone model (based on blood lactate thresholds or ventilatory thresholds) is commonly used where low intensity training refers to zone 1 and is conducted under the first lactate threshold (i.e., the intensity at which blood lactate begins to rise above baseline levels – see Figure below). This training zone is comparable with the zone A1 used by athletes and coaches in Sweden. Be aware, that the demarcation points of this training zone are highly individual and should be measured during a performance test in the laboratory. LIT can be described as training intensity where blood lactate is stable below 2 mmol/l and training is conducted under LT1 with most of these sessions lasting between 60 -120 minutes (see Seiler, 2010).

In scientific research there are some important values which describe and define the intensity in LIT (see Seiler & Kjerland, 2006):

1) Below 2mmol of lactate (individual)
2) Below LT1/VT1
3) RPE (rate of perceived exertion): 1-4 (Foster 1-10) or 8-12 (Borg 6-20)
4) 60-75% of $V\dot{O}_{2max}$
5) Heart rate below 80% of HR_{max}
6) >55% of HR_{max} / >50% of $V\dot{O}_{2max}$ (see Seiler, 2020)

Note that LIT is an effective training zone and it is not only a recovery training zone. The stimulus for the body from that exercise is highly dependent on one's baseline "typical" low intensity training session duration that the body is adapted to and is able to cope with. This means, if a common training session lasts normally 2 hours, then a 3-to-4-hour workout is a big task for the athlete. Therefore, speed and intensity in LIT have to be matched with the duration of a training session and should be controlled (see Seiler, 2020).



- A three-intensity-zone model based on identification of ventilatory thresholds.

Figure: Three-intensity-zone model used in science (Seiler, 2010, p. 278). LIT refers to zone 1 in this model and is demarcated by the lactate threshold 1 (LT1).

3. Examples of highly trained athletes

This chapter will provide some information regarding LIT with respect to some highly trained and successful athletes in cross-country skiing and other endurance sports (running). It should help athletes and coaches with planning and conducting LIT sessions in their aerobic endurance training programs.

3.1. Example: Marit Björgen

The participant of this study by Solli, Tønnessen & Sandbakk (2017) is the most successful female cross-country skier (8 gold medals at the Olympic Games, 18 gold medals at the World Championship, 110 World Cup victories). In the following section, training data from her training diaries will be presented (5-year period).

Annual training volume was 937 ± 25h with 90.6% endurance training (the remaining volume is strength- and speed training). Endurance training consisted of 92 ± 0.3% low intensity training, 2.9 ± 0.5% medium intensity training and 4.8 ± 0.5% high intensity training. LIT sessions were conducted as warm-up (21%), sessions lasting <90min (14%) and long duration sessions >90min (65%).

The target heart rate in low intensity exercise was between 67-75% of maximum heart rate (RPE 11). Due to underperformance in the season 2008/2009, there was the decision to change the intensity in LIT. Before the athlete struggled with very unstable performances, with a lack of energy and bad recovery after training sessions. Therefore, the athlete increased the volume of LIT about 9% and the intensity decreased from 79% of HR_{max} to 73% of HR_{max}. After that change the athlete reported that she felt a lot better and the previous feeling of heavy legs was gone (see Solli, Tønnessen & Sandbakk, 2017 & 2020).

This example shows that it is important to be aware of the intensity during LIT. If an athlete tends to go too fast in every training session, it could be that there are some problems with respect to recovery and performance during high intensity sessions or competitions.

3.2. Example: Highly trained runners

In this study Seiler, Haugen and Kuffel (2007) investigated the effects of training intensity and duration on acute recovery of autonomic nervous system (ANS) balance after exercise. For

interest with regards to this paper are the values from controlled LIT sessions from 9 highly trained male runners ($V\dot{O}_{2max}$ 72 ± 5 ml/kg/min).

During this study the beforementioned athletes performed their LIT sessions (60min and 120min) at 68 ± 7% of their maximum heart rate, lactate values were stable at 1.0 ± 0.1 mmol/l and they ran at 61 ± 0.7% of their $V\dot{O}_{2max}$. The session RPE for this group of highly trained athletes was 9.7 ± 0.4 (Borg scale 6-20). It is important to note that these training sessions were performed under the ventilatory threshold and there was no difference found in physiological values or response between 60min and 120min exercises (see Seiler, Haugen & Kuffel, 2007).

This shows that highly trained athletes executed their LIT with very stable values and that they are able to keep the same intensity for 60 up to 120 minutes.

3.3. Example: Elite XC skiers and biathletes

Tønnessen and coworkers (2014) examined the training data from 11 elite cross-country skiers and biathletes (4 males & 7 females) who were Olympic and/or World Champions. This retrospective study of highly trained athletes ($V\dot{O}_{2max}$: 85 ± 5 ml/min/kg [m]; 73 ± 3ml/min/kg [fm]) highlights the importance of LIT. 91 ± 1% of the training volume was performed as endurance training (LIT <2 mmol/l lactate). Another important finding is that these athletes conducted their LIT sessions mostly in *Zone 1* (<1.2 mmol/l lactate, 54-73% of HR_{max}) 86 ± 3.4% of endurance training and only little time in *Zone 2* (1.3-2.0 mmol/l lactate, 74-83% of HR_{max}) 5.3 ± 3.0% (in a 5-zone model).

The main conclusion with regards to LIT is that elite athletes who are training around 800h per year are very cautious when they are conducting their low intensity training. Approximately 90% of their aerobic endurance training was below the first lactate threshold. This means, they are able to train a lot without disturbing their hormonal balance and therefore can cope with and recover from these sessions at a faster rate.

In addition, Sandbakk et al. (2016) found that, in the period from may until october, world class (WC) cross-country skiers trained more than national class (NC) skiers (532 ± 73h vs. 411 ± 62h) during 270 ± 26 vs. 240 ± 27 sessions. The sessions of the WC skiers were 18% longer (~2.0 vs ~1.7 h per session) than those of the NC skiers. WC skiers carried out 26% more low-intensity endurance training and almost twice as much moderate-intensity and speed training as the NC skiers. In another study, Sandbakk et al. (2011) concluded that "*WC skiers performed around 30% more total training time, mainly caused by 30% more LIT and twice as much MIT and speed*

training (…) WC skiers trained more LIT and MIT than NC skiers. (…) the present data indicate that the differences are in LIT and MIT volume, rather than in HIT" (Sandbakk, Holmberg, Leirdal & Ettema, 2011, p.e9).

This training data therefore shows that it is highly important to have a large training volume in order to have success in cross-country skiing.

4. Good Quality in LIT

In this chapter the focus is on how athletes should execute their low intensity training sessions. A good quality in training leads to an improvement in physiological values (e.g., $V\dot{O}_{2max}$, lactate threshold) or in performance, therefore athletes and coaches want to get the most out of a session. However, the more an athlete is training, the more caution is needed in the sessions to prevent illness, injury and overtraining. A good balance has to be established between a specific stimulus and the response from the athlete to that. Keep in mind that LIT is not a recovery training zone and therefore has to be well planned and prepared for.

Some key-points on good quality in LIT are listed here. They supplement the beforementioned values (see "What is LIT?"):

- LIT should feel easy! Training < LT1 – established through laboratory testing, defining individual training zones!
- Improvement in physiological values or in performance (train – evaluate & analyze – change)
- Train fast enough (stimulus – adaptation) – but not too fast (energy expenditure [carbohydrates!!]): Goal is to be able to train a lot (volume & frequency), able to train high intensity sessions with good quality!
- Control intensity & duration (e.g., heart rate, lactate, RPE)
- LIT is not a recovery training zone
- Keep a good technique & speed (downhill & flat sections)

Research has shown that training at an intensity of 65% of the athlete´s $V\dot{O}_{2max}$, *"for well-trained athletes with a high $V\dot{O}_{2max}$ (…) this "low" intensity still generates a high-oxidative flux in the working muscle (…) This magnitude of cellular energy turnover coupled with the relatively long*

duration the workloads are sustained appears sufficient to provide an effective stimulus for the induction of the various genes involved in mitochondrial biogenesis" (Seiler & Kjerland, 2006, p.55). Because cross-country skiing is performed on different terrains including a lot of uphill sections, the skier will automatically reach a higher intensity. In other words, it is a lot easier to train too hard, then to control the session properly. Some athletes tend to be too fast in their low intensity session and end up in the medium intensity zone. But the main goal in LIT is to stay under LT1, this is crucial for the development and performance of an athlete.

In addition to that Haugnes and coworkers (2019) have shown that the metabolic demand of cross-country skiing could be very high during uphill terrain, also in LIT. A practical advice would be that skiers should not be too fast in uphill sections but could train close to competition speed during flat or downhill sections.

"Overall, the practical implications of this might be that skiers should be advised to use many hours relatively close to their competition speed in flat and downhill terrains with LIT, thereby using training during this type of terrain to induce large technical improvements. By contrast, skiers need to reduce speed much below their competition speed when climbing uphill during LIT. Therefore, the uphill speed is relatively low with LIT, which means that prioritizing HIT sessions in uphill terrain may be required for training with a competition-relevant speed and technique" (Haugnes, Kocbach, Luchsinger, Ettema & Sandbakk, 2019, p.1375).

There a still a lot of questions which remain unclear, but if an athlete or a coach is planning a specific LIT session, there a more variables to think of:

- Technique/gear usage in different terrains
- Optimal ski tracks for LIT (flat vs. undulating/uphill)
- Rest periods during LIT
- Energy supply during prolonged LIT
- Weekly training structure including other types of endurance exercises (high intensity training, threshold training), strength- or speed training

5. Intensity control during LIT

There are different possibilities to control and quantify the intensity of a LIT session. Training can be measured in terms of internal work (heart rate, blood lactate, $V\dot{O}_2$), external work (power, distance, velocity) or regarding the perceived stimulus (RPE – rating of perceived exertion) (see Sylta, Tønnessen & Seiler, 2014). The most common for cross-country skiers is to use heart rate during training and to use a so-called time in zone (TIZ) method to quantify training intensity

distribution, where heart rate is registered in a software and then allocated to a defined intensity zone. A proper training diary should also include a report of the perceived exertion (RPE) during the session. It is likely, that the most difficult part for an athlete is to stay below the lactate threshold 1 because *"small differences in intensity slightly below or above LTP1/VT1 are not detected and recognized by athletes although it might be important"* (Hofmann & Tschakert, 2017, p.337).

Practical advice for intensity control (supplement training with values from laboratory testing):

- Define training zones during laboratory testing (e.g., LT1, HR_{max})
- Compare heart rate with blood lactate levels & $V\dot{O}_2$
- Compare speed and elevation with blood lactate levels
- Question during training: "Does it really feel easy?"
- Some sessions with lactate measurement, if possible/necessary

If an athlete is using heart rate as their main intensity control, they should be aware that it is very sensitive to different circumstances during training (e.g., temperature, water & food consumption, training status, sleep, stress…). Heart rate should be kept stable in LIT and should not overshoot in uphill sections. In addition, there is always an element of heart rate lag while exercising. This means, heart rate response to a certain metabolic demand is delayed. Therefore, it is good to have another type of intensity control for comparison (i.e., velocity, RPE, lactate), which athlete and coach agree on when working together.

The goal with any control during LIT should be to keep the athlete in the low intensity range. No measurement or device can provide exact details of the current physiological state during training. It is more like a guide, that helps athletes and coaches to execute LIT in the best possible way. The athlete should develop a good feeling with regards to how low intensity training should be executed and should feel.

6. Summary

Low intensity training plays a big role in the training of endurance athletes (approx. 90% of annual training time), particularly for cross-country skiers. It is a highly effective training zone and the basis for endurance performance. Examples of highly trained athletes provide some good information regarding quality and quantity of LIT and highlight the importance of this exercise zone. The common agreement is that spending numerous hours at this training intensity might be a crucial part to be successful in endurance sports.

The physiology of every athlete is different and therefore training prescriptions and defining intensity zones should be individualized. There are different ways to control the intensity in LIT, but keep in mind that also the duration of a session has a huge impact on the athlete`s fitness and on endurance development.

To summarize, low intensity training is important for cross-country skiers and should be prescribed and performed in a way that helps athletes perform at a high level, while also allowing maintenance of their health and wellbeing during their careers.

7. Fortsatt diskussion

Vi vill tacka Christof Moosbrugger, internationell internship vid Mittuniversitetet i Östersund, för denna sammanställning av forskningsläget inom lågintensiv träning. Här följer en sammanfattande diskussion av Svenska skidförbundet längds utvecklingsgrupp och docent Glenn Björklund (Centrumledare Nationellt Vintersportcentrum, Mittuniversitetet i Östersund). I diskussionen fokuserar vi på lågintensiv träning och distansträning.

I den här sammanställningen tycker vi att det är viktigt att skilja på lågintensiva pass och distanspass. Ett lågintensivt pass innehåller träning i den lågintensiva zonen, som i svensk längdskidåknings träningslära benämns som AI. Enligt Borgskalan bör ett AI – pass vara 9 – 12 (mycket lätt till ganska lätt) i upplevd ansträngning och laktatkoncentrationen under 2 mmol/l. Vi vill betona att mot slutet av ett långt eller överlångt träningspass inom AI kan den aktive känna sig utmattad, vilket i sig kan vara ett viktigt syfte. Ett distanspass är däremot ett kontinuerligt sammanhängande arbete som inte är knuten till en specifik intensitetszon. Empiriskt vet vi att framgångsrika längdskidåkare genomför distanspass där delar av passet pendlar mellan den lågintensiva zonen (AI) och den medelintensiva zonen (AII-AIII-). Vi vill mena att terrängens och underlagets variationer samt växlingar mellan olika deltekniker ibland gör det svårt att stabilt ligga under 2 mmol/l i laktatkoncentration.
I sammanställningen kan det tolkas som att 90 % av den totala träningsmängden sker i den lågintensiva zonen (AI), men frågan är om verkligheten överensstämmer med det? Här vet vi för lite om hur mycket träning som sker i de olika zonerna, eftersom vi tror att många pass som aktiva registrerat som AI innehåller en del AII och AIII-. I sammanställningen bygger den mesta av forskningen kring LIT på träningsdata insamlad i efterhand ur träningsdagböcker. Detta innebär att det är av stor vikt att denna redovisning är korrekt.
Utifrån elitaktivas träningsdagböcker kan vi konstatera att flertalet av de aktiva genomför cirka 10% högintensiv träning (AIII- till AIII+) inklusive intervaller, träningstävlingar, tävlingar med

mera (notera att AIII- räknas in i både den medelintensiva och högintensiva träningen eftersom zonerna överlappar varandra).

Förhållandet mellan lågintensiv (LIT), medelintensiv (MIT) och högintensiv träning (HIT) är individuellt och varierar utifrån ålder, träningsbakgrund och ambitionsnivå. Vid mindre träningsvolymer (t.ex. 450 timmar/år) kan det finnas ett större procentuellt utrymme för MIT och HIT än vid större träningsvolymer (t.ex. 800 timmar/år). Anledningen till det är att belastningen påverkas av träningsfrekvens, träningstid och/eller träningsintensitet.

Något som nämns i sammanställningen samt diskuteras bland tränare och aktiva är kvalité i träning. För att säkerställa kvalité i träningen bör den aktive vara medveten om syftet med varje träningspass samt utvärdera om det uppnåddes med respektive pass. LIT är den största delen av den totala träningsvolymen, därför är det viktigt att även ha ett tydligt syfte och plan med dessa träningspass som kontinuerligt utvärderas. Exempelvis kan det vara viktigt att under vissa perioder eller träningspass hålla belastningen inom AI-zonen under distanspassen. Under andra perioder eller träningspass kan det vara okej att variera belastningen mera under distanspassen. Här följer några konkreta exempel på frågor som du kan ställa dig själv i utvärderingen av LIT:

- Hade jag ett tydligt syfte och mål med träningspasset?
- Uppnåddes syftet och målet med träningspasset?
- Fokuserade jag tillräckligt mycket på syftet/uppgiften eller åkte jag och pratade med andra aktiva?
- Blev belastningen för låg eller hög eftersom jag var tvungen att anpassa mig till träningskompisen/-arna?
- Vad utvecklade jag under träningspasset?
- Genomfördes passet kontinuerligt eller hade jag långa avbrott med drickapauser, instruktioner från tränare m.m.?
- Använder jag sträcka i förhållande till tid för att definiera kvalité på ett träningspass?
- Använder jag total stigning/antalet höjdmeter för att definiera kvalité på ett träningspass?
- Upprätthöll jag en teknik och ett rörelsemönster som liknar det jag ska göra i en tävlingsprestation?
- Orkar jag ha fullt fokus och god kvalité i all träning som genomförs? Hur stor del av ett träningspass inom LIT kan jag upprätthålla fokus? Är det okej att släppa fokus?
- Fyller jag på tillräckligt med energi före, under och efter träningspassen så att jag kan upprätthålla fokus och kvalitet i träningen?

Avslutningsvis kan vi konstatera att tävlingsnära hastighet, frekvens och position i lättåkta partier går att träna och utveckla i alla intensitetszoner (LIT, MIT och HIT). Däremot vid

lågintensiv träning i tung terräng, såsom branta uppförsbackar, är det svårare att upprätthålla tävlingsnära hastighet, frekvens och position. Därför kan medel- och högintensiv träning lämpa sig bättre i tungåkta partier för att utveckla tävlingslika färdigheter. Hastighet, frekvens och position bör dock tränas i alla olika terrängavsnitt och intensitetszoner.

Vi anser att vi behöver blir bättre på att använda LIT och distansträning för kapacitetsutveckling. LIT kan lätt bli träningspass där syfte, mål och fokus inte poängteras på samma sätt som MIT och HIT. Vi anser att det är viktigt att belysa kvalitetsbegreppet när det gäller lågintensiv träning och distansträning. Mot bakgrund till det vi har skrivit i den sammanfattande diskussionen är det betydelsefullt att aktiva och tränare är noggrann när träningen registreras, till exempel om ett distanspass innehåller AII och AIII- ska det registreras i dessa zoner och inte som AI. Det är en grundläggande faktor för att få ännu mer kunskap kring vilken träning som de facto genomförs och vilken extern belastning vi utsätter kroppen för samt dess respons. Om du vill läsa mer kring alla intensitetszoner, dess syften och respons rekommenderar vi dig att ta del av *”Träningsintensitet svensk längdskidåkning”.*

Resources

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Other resources (video):

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