

# **Lactate Removal Rates in Sprint and Endurance Cross-Country Skiers**

By: Berit Dool and Dr. Derek Kivi

## Introduction

Cross-country (XC) skiing is a demanding sport that requires inherent abilities and timely technical, physiological and psychological preparation (Silletta & Scheier, 1995). Its diverse nature requires a competitive skier to possess both the aerobic and anaerobic capacities to meet the physiological demands of the sport (Hoffman, 1992). It has been observed that individuals with a high ratio of fast-twitch (FT) versus slow-twitch (ST) muscle fibers perform optimally in anaerobic sprinting activities. In contrast, individuals with a higher ratio of ST fibers perform optimally in aerobic endurance activities (Powers & Howley, 2007). Lactate accumulation occurs with increasing exercise intensity when lactate production from glycolytic oxidation exceeds the lactate removal. Although lactate has beneficial functions, it can also have an inhibiting effect on performance due to an increase in acidic hydrogen ions and a reduction in beta-oxidation. Lactate removal has been observed to be the most efficient at intensities of 30-70%  $VO_{2max}$  during active recovery (Baldari et al., 2005). A study of blood lactate recovery kinetics by Denadai and Higino (2004) found that sprinters tend to display elevated blood lactate and a delayed peak in blood lactate during recovery as compared with endurance-trained subjects. However, muscle fiber differences in the removal of lactate have not been studied in depth. The purpose of this study was to investigate the differences in lactate removal rate of sprint and endurance cross-country (XC) skiers. With knowledge muscle fiber type and rate of lactate removal, coaches and athletes can modify the type of training to increase the efficiency of lactate removal and thus increase athletic performance.

## Results

The sprint XC skiers had faster time-trial times (8:16 min) compared to the endurance skiers (8:51 min). They also averaged higher peak lactate values (9.1 mmol/L vs. 8.2 mmol/L). However, the endurance XC skiers had higher lactate removal rates (0.35mmol/L/min) than the sprint XC skiers (0.25 mmol/L/min), indicating that they are more efficient in removing lactate. Additionally, the endurance XC skiers returned closer to baseline measures after 18 min of active recovery (2.7 mmol/L) than the sprint XC skiers (4.4 mmol/L).

Table 3: Lactate data of participants (n = 6)

ID	E/S	TT (min)	Pre-exercise La	La 0min (mmol/L)	3min (mmol/L)	6min (mmol/L)	9min (mmol/L)	12min (mmol/L)	15min (mmol/L)	18min (mmol/L)	Lactate Removal Rate (mmol/L/min)
1	S	10:28	1.3	2.8	3.2	2.2	2.3	2.4	2	1.4	0.12
2	S	7:22	1.4	7.2	11.7	7.7	5.7	8.4	7.3	8.1/7.8	0.24
3	S	6:58	1.8	5.8	6	6.4	5.7	5.3	4.7	3.4	0.25
4	E	7:08	1.8	8.7	10.1	6.7	8.9	3.4	4.9	3.9	0.41
5	E	12:05	0.8	7.2	5.8	4.3	3.7	2.2	0.8	1.6	0.31
6	E	10:37	1.6	7.2	7.4	5.4	3.6	3.6	2.4	1.3	0.41

Note: E = Endurance, S = Sprint

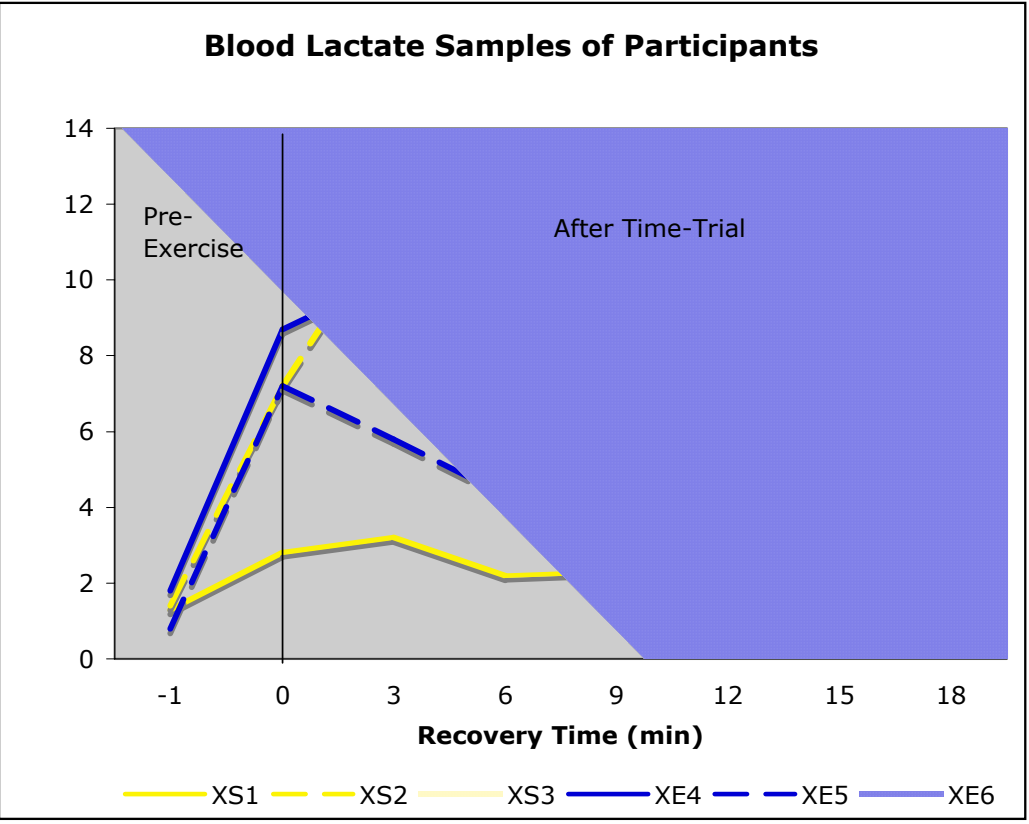


Figure 2: Blood lactate samples of participants

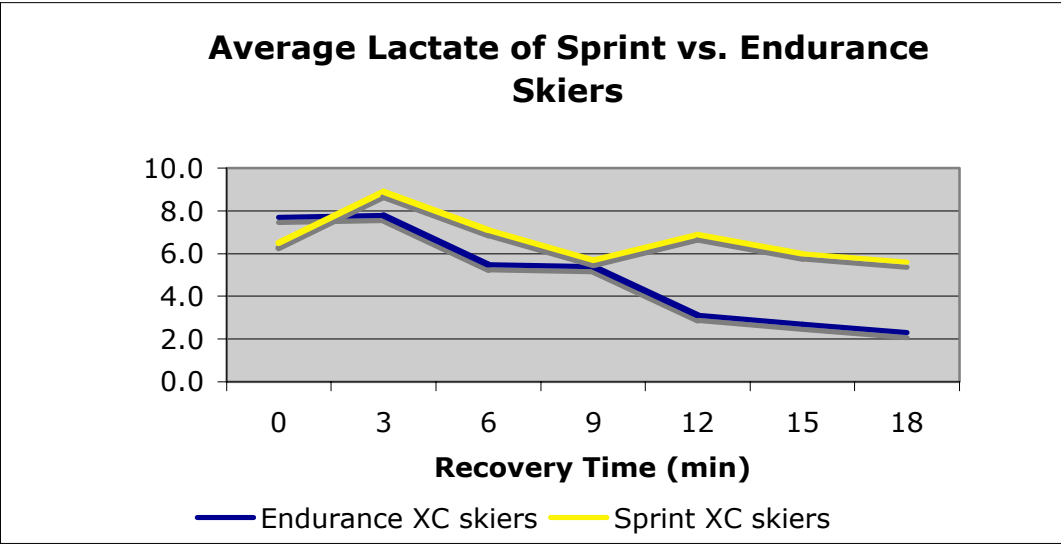
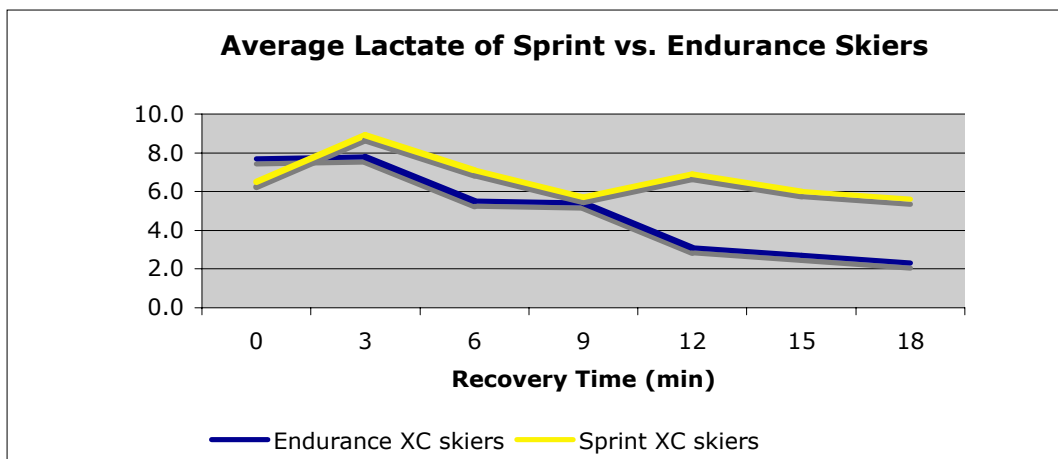


Figure 3: Average lactate removal of a sprint and endurance XC skier

## Discussion

### *Major Findings and Explanations*

Muscle biopsies have identified that sprinters have a greater percentage of high-contraction FT fibers while endurance athletes, which have a greater percentage of fatigue resistant ST fibers. It is universally accepted that differences in muscle fiber composition are important aspects of performance differences between sprint and endurance athletes. Therefore, it was expected that the sprint XC skiers would have faster ski times during a course of short duration. Additionally, although not as noteworthy of a difference, the sprint XC skiers also reached higher peak blood lactate values than the endurance skiers (9.1 vs. 8.2 mmol/L). This also may have been influenced by an imbalance of lactate producing FTx fibers compared to lactate consuming ST fibers (Donovan & Pagliassotti, 2000). Thomson & Garvie (1981) proposed that lactate concentrations should peak around four minutes post-exercise after volitional fatigue. Therefore, indirect measurements suggest that the participants



reached intensities at or near maximal effort because the lactate concentrations peaked between three and six minutes post-exercise for all participants.

In negotiation, the endurance XC skiers were more efficient at removing lactate with values averaging 0.10 mmol/L/min greater than the sprint XC skiers (0.35 vs. 0.25 mmol/L/min). Conversely as Philp et al. (2005) have suggested, this may be due to a higher percentage of ST muscle fibers, which have higher abilities to utilize lactate as a substrate for oxidative metabolism. Aply, the endurance XC skiers were also able to return closer to near-resting values after 18 minutes of active recovery. Since the sprint XC skiers produced greater amounts of lactate, it may have taken longer to remove contributing to the disparity of final lactate measures.

At a physiological level, lactate removal differences may be related to organelles or enzymes within the muscles fibers themselves rather than the muscle type. The higher concentration of mitochondria within ST fibers would theoretically increase the oxidative capacity of the muscle. Therefore, lactate disposal would be quicker than the muscle fibers with less mitochondrion.

Another influence may be the amount and type of monocarboxylate-transport (MCT) proteins within the muscle fibers. The predominant MCT proteins in human skeletal muscle are MCT1 and MCT4, both of which mediate the transport of lactate. Since ST fibers have a higher concentration of high-affinity MCT1 proteins and FT has a higher low-affinity MCT4 proteins (Powers & Howley, 2007) sprinters may want to consider finding a method of increasing their MCT1 concentration. This may be more beneficial in optimizing anaerobic performance and lactate removal than increasing the concentration of mitochondria. Since increases in mitochondrial concentrations enhance the oxidative capacity of the skeletal muscle, compromises to the anaerobic

capacities may occur. In contrast, MCT protein shifts from MCT4 to MCT1 might limit or halt any reductions in anaerobic metabolism.

Additionally, increases in lactate dehydrogenase may increase the number of reactions of the lactate to pyruvate, thus enhancing the amount of substrate available for oxidative metabolism.

### *Application of Results*

How can this information be applied to XC skiing? Competitions in XC skiing are beginning to cater toward specialization in the sprint and endurance events. Although information on lactate removal can be applied to all XC skiers, it has the most importance for sprint XC skiers due to the nature of their event. Sprint competitions are composed of a qualifying, quarterfinal, semi-final, and final rounds, in which there is limited time for recovery. During these sprints, which are roughly 1.2 km in length or 2 to 3 minutes in time, the racers accumulate high concentrations of lactate, which can be limiting to performance. Ideally, it would be best for the racer to return to baseline lactate concentrations prior to upcoming round. However, this may not be entirely possible due to the short recovery time in between rounds. Therefore, maximizing the amount of lactate removal during recovery is imperative to performing well in the upcoming race. In extreme situations, endurance XC skiers may be able to outperform the sprinters during a competition of numerous sprints within a short period of recovery because of their heightened ability to return closer to resting lactate concentrations.

Additionally, these findings support the notion of incorporating aerobic training into training programs for sprint and endurance athletes. Endurance training causes mitochondrial adaptations to improve the functioning of oxidative metabolism.

Improvements include an increase in enzymes for oxidative metabolism, smaller  $O_2$  deficits due to a more rapid increase in  $O_2$  uptake at the onset of work, an increase in fat metabolism that spares muscle glycogen and blood glucose, a reduction in lactate and  $H^+$  formation that helps to maintain the pH of the blood, and an increase in lactate removal (Powers & Howley, 2007). This will reduce the baseline lactate concentration of the athlete in subsequent races, will thus improving performance.

### *Limitations*

As with any research, uncontrolled factors may have negatively influenced the results. The most evident limitation was the uncontrolled testing environment. Testing sessions for the participants were inconsistent as they were completed over a course of three days, each with different weather and snow conditions. Cold temperatures have may negatively influenced the validity of the blood lactate analyzer and participants' performance as opposed to warmer temperatures. There is a negative correlation between temperature and snow conditions (Silletta & Scheier, 1995) as colder temperatures increase the friction of the snow, thus reducing the glide. It appeared that the lactate analyzer did not produce accurate readings on the first day of testing in minus 20 degrees Celsius weather conditions. Unfortunately, the results of two participants tested under these conditions were omitted from the results due to inaccuracy. With regards to the influence on the participants', the cold temperatures would produce slower time-trial times and perhaps lower motivation compared to the warming testing days. Additionally, although the course was identical for the participants, trail conditions (i.e. grooming) may have affected the results. However,

since the scope of the study focuses on lactate removal rate, these factors should not have influenced these results as rigorously.

Other uncontrollable factors are individual differences including genetics and physiology. These would include exercise tolerance, muscle fiber type based on athletes' preference (no biopsy performed), and interpretations of maximal effort. Unfortunately, the participants were not screened for the use of ergogenic aids, which may produced unnatural performance or physiological results. The experience levels of the researchers may have negatively impacted the accuracy of the lactate readings. Finally, recovery HR was not controlled for by the researchers, but rather relied on the reliability of the participants.

#### *Delimitations*

The scope of this study was limited to the skating technique and a short-intermediate distance. Results may have differed using the classic technique, as sport specificity is an important consideration in athletic performance. Additionally, lactate accumulation is affected by exercise intensity, which would be limited by the scope and distance of the time-trial course. Another delimitation is using an active recovery of 50 to 59% HRR, which may have been less than optimal lactate removal and excludes the principle of individuality as HR zones may be different amongst individuals. Lactate samples were halted after 18 minutes, which prematurely calculated lactate removal rates, as the results may have fluctuated after last sample is taken. Also, this study was limited to participants whose fitness was well above the general population. Therefore, these results cannot be generalized to the normal population

#### *Suggestions for further research*

Supplementary research should be completed to identify a training method of improving the lactate removal rate without decreasing anaerobic capacities, thus improving the performance of sprint XC skiers. Although endurance training increases the amount of MCT1 in FT fibers, this might reduce the anaerobic capacity of the muscles. Determining a training mode which increases lactate removal without reducing anaerobic capacity would be ideal. Additionally, other sports should be studied to observe differences in lactate removal rates. This may give guidance to XC ski coaches when creating a training program for the preparatory phase, as it is primarily non-sport specific training.

### Conclusion

Appropriate recovery is an important component to an athletes training program and performance. It was observed that endurance XC skiers are more efficient at removing lactate during an active recovery of 50 to 59% HRR than sprint XC skiers. A superior lactate removal rate for the endurance XC skiers may be an effect of a higher percentage of ST fibers. Therefore, it may be important for sprint XC skiers to incorporate training methods that would enhance their ability to remove lactate during recovery periods.

## References

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