Blood Lactate Level Responses and Comparison with Submaximal Running and Roller Skiing in Cross-Country Skiers

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A B S T R A C T

The purpose of this study is to examine the effect of 30-minute duration submaximal running and roller skiing exercises, which are among the most important aerobic exercise models in cross-country skiers, on lactic acid levels. The study group comprised 6 female and 4 male athletes (age: 16.87±1.87years, body height: 168.35±5.66 cm, body weight: 56.83±7.1kg) who competed in cross-country skiing at national and international level. All athletes participated in the study voluntarily. Measurements were performed three times as basal (1st measurement), immediately after exercise (2nd measurement) and 5 minutes after finishing exercise (3rd measurement).Statistical analysis was conducted using SPSS (version 11.5). A significant increase (P<0.01) in lactic acid levels was found for both 30-minute submaximal exercise types; however, this effect did not differ statistically between groups. Running exercises caused greater fatigue than skiing exercises, according to percentage values, but the difference in fatigue levels between exercise types was not statistically significant.

Key words: *rollers, lactic acid level, running, cross-country skiers*

Introduction

Cross-country skiers use different exercise methods along with winter exercises in order to maximize their performances[1]. Exercises on snow are most effective in increasing the performance of cross-country skiers. For this reason, world-class skiers conduct snow exercises on icecaps even during summer months[2]. However, this is a method which can be used limitedly and cannot be carried out by skiers at all levels. Cross-country skiers continue their exercise programs during spring and summer months and apply various exercise models in order to reach the highest performance for winter races. These methods may be ranked by importance as: roller skiing, running, ice-skating, in-line skating, hill running with ski poles, rowing, climbing, cycling, swimming and tennis[1,3,4] Examining the necessary factors for the best race performance while preparing exercise programs for cross-country skiers, it is seen that the most distinctive factors are maximal oxygen consumption (VO_{2max}) and lactic acid level, mostly known as anaerobic threshold (AT)[5]. Although VO_{2max} is an important criterion in determining performance in endurance training, when individuals with the same VO_{2max} values are compared, there is a weak correlation between VO_{2max} and endurance performance[6,7]. Therefore, individual differences in endurance performance and AT, is more important than VO_{2max}[8,9]. Recent studies show that the most appropriate exercise intensity can be better determined with blood lactate concentration measurements[4]. In endurance training programs, athletes firstly increase the volume and then the intensity[10]. An exercise program that is of sub-optimal intensity will not develop aerobic performance; on the other hand, a high intensity exercise program can cause overtraining. Thus, observing exercise intensity is considerably important for trainers and athletes[11]. Running exercises are the most common method used in improving aerobic capacity[12]. In addition, one of the most important performance benchmarks for cross-country skiers is the endurance of their upper body muscles. This can be achieved by means of exercise methods such as skiing and roller skiing. For this reason, roller

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skiing has an important role in exercise programs, especially in seasons in which there is not any snow[2,13,16]. High intensity, low tempo and long-term exercises are planned while preparing exercise programs applied in summer months by cross-country skiers, whose main purpose is to improve their endurance. Sub maximal roller skiing and running exercises are commonly used by both males and females to increase maximal oxygen consumption[17] and also for cool down. Thus, the objective of this study is to examine the effect of 30-minute sub maximal roller ski and running exercises which are using different workout between upper and lower body on lactic acid levels in cross-country skiers.

Material and Method

The study consisted of 10 elite cross-country skiers (6 male and 4 female) who had participated at a national level and exercising for at least 6 years. All of the study participants were volunteers and all gave written, informed consent prior to the study.

The study was carried out individually in both exercise models by applying the same protocol and on the condition that 2-day long intervals should be given between exercises. The measurements were conducted immediately following the race season, when cross-country skiers carried out running, strength and roller skiing exercises required by their exercise programs. The day before starting the exercise protocol, the heights and weights of each athlete were measured using a stadiometer and calibrated scale. In the skiing exercise, subjects used double poling technique with The Rabbit Skate XT is the XC-Training Model of the Eagle Sport roller-skis with 100 mm wheel diameter with and their own ski boots, ski poles and helmets, which they had used previously in training and races. The racetrack used for roller skiing was a 1 km long plain area, while the running exercise was conducted on a standard running track with a length of 400 m. The Karvonen method was used to calculate the 75% intensity exercise level for each athlete. A 15--minute warm-up period was provided to the athletes before the exercise started. The measurements were evaluated with an Accutrend Roche diagnostics, Germany portable lactate analyzer with blood taken from the athletes' fingertips. Three series of samples were taken: basal (1st measurement), right after exercise (2nd measurement) and 5 minutes after finishing exercise (3rd measurement) in order to determine recovery tendency. During sub maximal exercises, athletes covered an average distance of 9018±625 m during the roller skiing exercise and an average distance of 6765±669 m during the running exercise.

Statistical analysis was carried out using the SPSS program (version 11.5). Repeated measures of ANOVA using Bonferroni post hoc analysis was used for determination of changes in lactate levels between the three measurements; Paired sample t-test was applied in comparison between the exercise modes. Level of significance was set at $\alpha<0.05$.

Findings

The statistical analysis determined that there were significant differences ($p<0.01$) between 1st and 2nd measurements, 1st and 3rd measurements and 2nd and 3rd measurements for blood lactate in both running and roller-skiing. There was no significant difference between the two exercise modes ($p>0.05$). Considering percentage differences in lactic acid levels between the sampling sites, there was an increase of 293% in the running exercise and an increase of 268% in roller skiing exercise between the 1st and 2nd measurements. Between the 2nd and 3rd measurements, there was a decrease of 15.5% in running exercise and a decrease of 18.0% in roller skiing exercise.

Results and Discussion

The study examined the effects of submaximal roller skiing and running exercises, common aerobic exercise models among cross-country skiers, on lactic acid levels. While there were significant differences in both exercises at a level of $p<0.01$ between 1st and 2nd and also the 2nd and 3rd measurement, there was no significant difference between exercise types ($p>0.05$).

During exercise, CO_2 increases depending on increase in O_2 consumption, lactic acid increase speeds depend on intensity and length of the exercise and H^+ concentra-

TABLE 1
LACTATE LEVELS AND STATISTICAL ANALYSIS FOR ROLLER SKIING AND RUNNING AT REST, AT THE END AND AFTER FIVE MINUTES OF EXERCISE

Exercise	Running (X±SD)	%	ANOVA	Roller Skiing (X±SD)	%	ANOVA	t-test
Resting	1.89±0.57	1–2		1.89±0.57	1–2		NS
(LA mmol/L^{-1})		292.59	1–2**		268.25	1–2**	
End of Exercise	7.42±1.40			6.96±1.48			NS
(LA mmol/L^{-1})			1–3**			1–3**	
5 min After Ex.	6.27±1.51	2–3		5.71±1.79	2–3		NS
(LA mmol/L^{-1})		–15.49	2–3**		–17.95	2–3**	

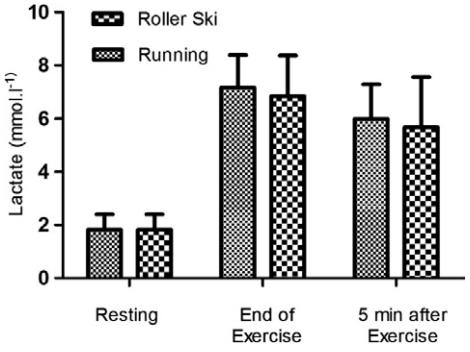

Fig 1. Lactate levels in roller skiing and running at rest, at the end and after five minutes of exercise.

tion increases in paralleled to this. The increase in lactic acid production as a response to exercise is related to the increase in H+ ions providing the change of pH in cells. Generally, pH balance in skeletal muscles is the balance between accumulation and removal of H^+ ions. Removal of lactic acid is carried out by composed lactic acid diffusion or facilitated transport across the sarcolemma[18]. The transportation of lactic acid in skeletal muscles is facilitated by two (MCT1 and MCT4) monocarboxylate carriers. The increase in MCT1 and MCT4 proteins is effective in removal of lactic acid and minimizing pH in cells[19]. In this perspective, Bonen et al. determined that MCT1 carriers increased during short-term endurance training[19].

Previous studies reported that athletes' tolerance of lactic acid increased as a result of regular exercises and anaerobic threshold increased. As a result of this adaptation that occurs due to exercise, athletes can complete the same exercise for much longer periods with less lactic acid formation. Because of these effects, it is seen that lactic acid accumulation is considerably important, especially in endurance exercises.

As in all endurance sports, it is emphasized that the relationship between blood lactate level and heart rate is very important in exercise programs prepared for cross-country skiers[3]. It is determined that cross-country races are carried out in two branches, distance and sprint, and one of the most important physiological factors which can affect the result in distance races is lactic acid level. It is determined that, in cross-country exercises, other than exercises carried out on snow, there are distance exercises in different exercise models which are done at low intensity in order to develop aerobic capacity.

In cross-country races, maximum oxygen consumption is the most important criterion that affects the result. As this proportion decreases, lactic acid production increases at the same proportion and fatigue becomes inevitable. Therefore, prevention or delay of this fatigue in exercises is the most distinctive objective[2]. Lactate production and lactate removal proportion can vary according to the type of exercise or muscle groups used in the exercise. This can result from the use of much smaller muscle masses, the increase in muscle fiber type working with anaerobic metabolism or lactate production. Other possible explanations include the increase in aerobic capacity and large release of adrenalin because fibrils, which contract fast during upper body exercises, are much more intensive or slow contracting muscle fiber proportion is dense in legs[20,21,22].

A great part of energy during low intensity muscle activity is provided from the oxygenated system, and as the intensity increases, much of the energy is provided from the lactic acid system. Lactic acid, which occurs when energy is produced by anaerobic activity, is used as fuel in muscles in energy system with oxygen. However, if the amount of lactic acid exceeds that used as fuel, it accumulates in muscle and starts to pass to the blood[23,7]. Although the blood lactic acid level in submaximal exercise is not higher than the starting level, it differs[23]. The present study measured lactic acid levels at baseline, right after exercise and 5 minutes after exercise in order to determine recovery tendency following 30 minutes submaximal roller skiing and running. The changes observed in lactic acid levels in this study were similar to those reported in the literature.

Lactic acid increased 296.59% in the running group between the 1st and 2nd measurements, compared with an increase of 268.25% in the roller skiing group. The main reason for this difference between the exercises is that the workload is a higher in running exercise in comparison to roller skiing[23]. This is because the whole motion consists of two stages in roller skiing; the first stage involves pushing, which works the body, and the second stage involves the use of skis[4]. Another important reason is that upper body muscles are used intensively in roller skiing activity. One of the most important criteria affecting the race performance of cross-country skiers is to increase oxidative capacity of upper body muscles. The literature shows there was a decrease in lactate accumulation, especially among athletes who trained their upper body, compared with people who had never done exercise. In addition, exercise adaptations such as high capillary density, increase in oxidative enzymes and the size and distribution of muscle fibers in athletes who trained their upper body can increase the potential for lactate removal[21,24,25]. The results obtained in the present study reflect those in the literature.

A previous study that compared roller skiing and double poling and running exercises found that besides low heart rate proportion lactic acid accumulation during roller skiing exercise was also lower in comparison to running exercise[3]. The 3rd measurement, taken 5 minutes after exercise, showed a 15.49% decrease in lactic acid level in running exercise and a 17.95% decrease in roller skiing; the difference between the two groups was not statistically significant. This decrease in lactic acid level immediately after exercise can be interpreted as indicating greater physical fatigue in running exercises compared to roller skiing exercise. The most distinctive difference between roller skiing and running exercises results from the use of different muscle groups[25]. The first mechanism for removing lactate is the oxidative

mechanism. This provides the opportunity for lactic acid to convert into energy and to be used during exercise[22]. This potential lactate removal mechanism can be increased to a higher degree with combined upper and lower body exercises[25].

Consequently, it was determined that 30-minute duration sub maximal running and roller skiing exercises had an effect on lactic acid levels; however, this effect was not statistically different between two exercises. Examination of fatigue levels associated with distance exercises in cross-country skiing training, it was determined, although there was no statistically significant difference between the two exercise types, running exercises caused more fatigue than roller skiing exercises. This criterion should be taken into consideration by trainers while selecting double poling exercise models that form part of cool down.

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RAZINA LAKTATA U KRVI I USPOREDBA S SUBMAKSIMALNIM TRČANJEM I SKIJANJEM U SKIJAŠA

SAŽETAK

Svrha ovog istraživanja bila je ispitati učinak 30-minutnog submaksimalnog trčanja i roller-ski vježbi, a koje su među najvažnijim aerobnim vježbama cross-country skijaša, na razinu mliječne kiseline u krvi. Istraživanu skupinu čine šest djevojčica i četiri sportaša (dob: 16,87 ± 1,87 godina, tjelesne visine: 168,35 ± 5,66 cm, tjelesna težina: 56,83 ± 7,1kg) koji su se natjecali u cross-country skijanju na nacionalnoj i međunarodnoj razini. Svi sportaši sudjelovali su dobrovoljno u istraživanju. Mjerenja su provedena tri puta za bazalno stanje (1. mjerenje), neposredno nakon vježbe (2. mjerenje) i 5 minuta nakon završetka vježbe (3. mjerenje). Statistička analiza provedena je pomoću SPSSa (verzija 11.5). Značajno povećanje ($P < 0,01$) razine laktata ustanovljeno je za obje 30-minutne tipove submaksimalnih vježbi, međutim, taj se učinak nije statistički razlikovao između skupina. Vježbe trčanja uzrokuju veći umor od vježbi skijanja, ali razlika u razinama umora između vrstama vježbanja nije bila statistički značajna.