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PERFORMANCE AND TRAINING PROGRAM CHARACTERISTICS IN ELITE YUNIOR FEMALE ROLLER SKIER FROM 2021 SEASON: A CASE REPORT

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Abstract. *The purpose was to evaluate the training program, body mass composition, aerobic performance laboratory and field test results, blood hormone concentration in elite junior female roller skier in successful competition season. Methods. Totally 206 training sessions (278 training hours) were analysed during six months (from April till September). Athlete wight and body fat changes were monitored, laboratory tests on a treadmill and field tests were performed and concentration of hormones in the blood was detected. Results. A polarised training intensity distribution was observed. The highest volume of training workloads (70 training hours per month) was achieved in the last month before start of World cup season, this change corelated with change in blood testosterone levels. Heart rate decreased by 7.51% at the anaerobic threshold load intensity and by 10.1% at lower intensity loads. Peak oxygen uptake (VO_{2max}) of 49 ml/kg/min was reached in laboratory test. Increase of lean body mass by 2.4 kg was observed. The progress in 3000m running race time was detected from 14:30 minutes in the beginning of April to 13:16 minutes in June. Conclusion. VO_{2max} in junior elite female roller skier is low in comparison with cross-country skiers, but the training workload intensity and volume are comparable with skiers. This research shows insight in top junior level female roller-skiers physiology and training, but specific values determining the success of this athlete are still to be determined if compared to traditional cross-country skier.*

Keywords: *aerobic power, heart rate, roller-skiing, training program, workload's intensity, and volume*

Introduction

Well-trained female cross-country skiers have high maximal oxygen uptake (VO_{2max}) values: more than 70 ml/kg/min (Ingjer, 1991; Sandbakk, 2012), roller skier's average values for both genders of the elite athletes VO_{2max} values varied from 61.5 to 65.9 ml/kg/min in dependence on laboratory or field test conditions (Starczewski et al., 2019). A skating style and high VO_{2max} values have not being reached during roller skiing competitions (Losnegard & Hallén, 2014). Due to short 200m sprints and mass start races included in the roller skiing World cup

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ability of the athletes in production of high anaerobic power is crucial to achieve superior results (Sandbakk et al., 2011). There is a lack of information in scientific literature concerning the sport - specific physiological demands to the World cup female cross-country skiers and the factors that differentiate between competitors with different rankings (Sandbakk et al., 2011). Even less about female Junior roller-skiers.

There is sufficient evidence to argue that it is important to train aerobic endurance by fixturing low and high intensity workloads in the endurance athletes (Seiler & Kjerland, 2006). However, specific information about training programmes of adult or junior female roller skiers is not available in the literature.

Deeper understanding of the top-level roller skiers' performance requires analysis of training patterns and performance characteristics in such athletes.

The purpose of the study was to evaluate the training program, body mass composition, aerobic performance laboratory and field test results, hormonal concentration in the blood in elite junior female roller skier in successful competition season.

Methodology

Participant was a 19-year-old female. She was the season's overall World cup winner in junior roller skiing and bronze medallist in World championship in 2021. Written consent to participate in this study was obtained from the participant. The research was performed according to the declaration of Helsinki.

Design. The study consisted of two parts:

1) analysis of data from training sessions obtained from April to September - till end of the season.

2) Physiological, laboratory test and blood test analysis corresponding to the training regime.

Training monitoring. Totally, 206 training sessions (more than 278 training hours) were analysed which were performed during six months (from 1st of April till 30th of September 2021).

Heart rate was obtained from Polar Flow training database and exported for using in the study. Heart rate data of all training session were recorded on Polar M400 heart rate monitor using polar H10 chest strap (Polar, Kempele, Finland). Using a filet, all heart rate data were divided in five load's intensity zones: zone 1 – heart rate (HR) was lower than 120 beats per minute (bpm), zone 2 – HR was from 120 to140 bpm, zone 3 – HR was 140-160 bpm, Zone 4 - HR was 160-180 bmp and zone 5 – HR was higher than 180 bpm. These zones corresponded to the results obtained in a laboratory testing, where aerobic and anaerobic thresholds where determined.

Laboratory testing. Tests were performed in Latvian Olympic Team laboratory using a standardised testing protocol for Nordic walking with pools. A treadmill used was H/p Cosmos Saturn 300 (HaB International Ltd., Southam, UK). A gas analysis was performed using Cortex Metalyzer 3B (Cortex Biophysik GmbH, Leipzig, Germany), heart rate was measured using Polar CS400 and H7 chest strap (Polar, Kempele, Finland).

Body weight and composition was measured using Tanita Multi Frequency Segmental Body Composition Analyzer MC-980U (Tanita, Korea).

Protocol. Warm-up: Nordic walking speed was 5.5 km/h, slope of the treadmill's surface was 2,5%, duration was 20 minutes. Test: started at Nordic walking speed 6.0 km/h and treadmill' slope 2.5, %; the slope increased by 0.5% each minute till the ninth minute, then Nordic walking speed also increased till reached 7.0 km/h at the slope of 17.8% at the end of the test.

Field tests. Regular control training sessions for 60m, 400m and 3000m races running were performed in Latvian Academy of Sports Education stadium in Riga, Brivibas 333.

Competition results. Individual results and overall World cup results were obtained from FIS data bases.

Blood analyses (hormones). Testosterone and cortisol concentration changes in venous blood samples were monitored regularly every month during all the period of observation.

Results

Training sessions. In this research 206 training sessions where analysed, from 1st of April till 30th of September 2021, which include 18 competitions. More than 278 training hours, the distribution of training hours in five training zones can be seen in Figure 1.

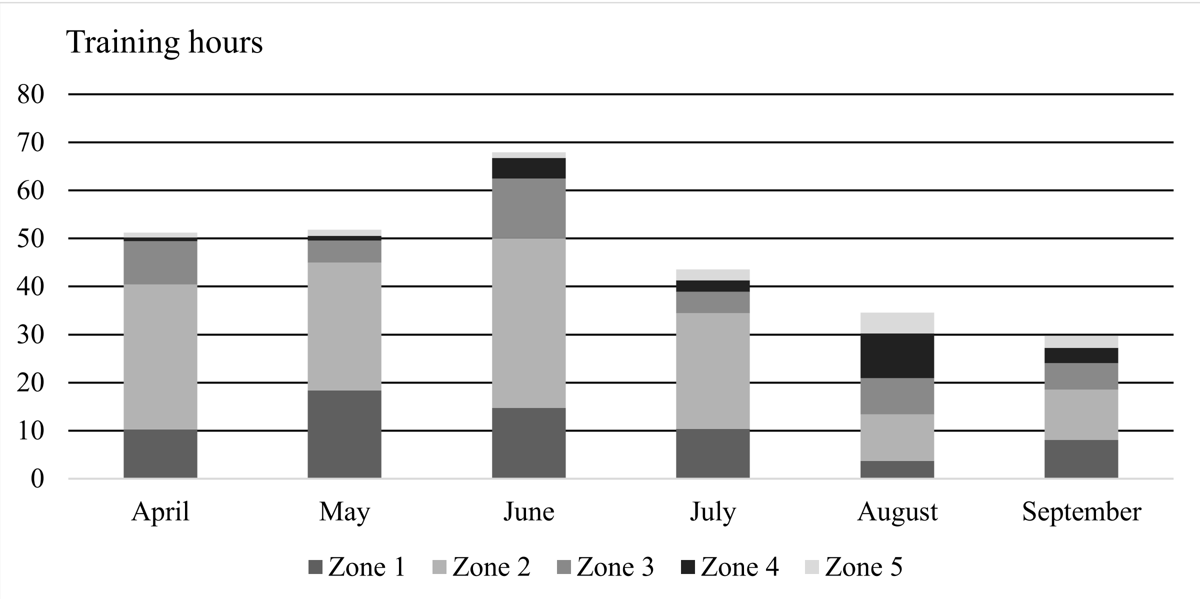

Figure 1 ***Distribution of training hours in five training zones in each month of the examined training period*** *(created by the authors)*

Total training volume was increasing in time from April, where it was 51 hours to June which had the highest volume of 67 training hours. In July, August, and September the training hours gradually decreased. These data corresponded with the start of World cup season on 23rd of July.

Success in competition. During the 2021 season the podium was reached six times in total in junior world cup (five times it was the second place and once - the third place) and one bronze medal was won in World championship. This result was sufficient to win the Overall World cup with 683 points, with the margin of 61 points. Most podiums (four) were reached in sprint competition, and one in World championship, other two where mass starts, none was reached in individual distance races.

Training cycles in different weeks from April to September. As a training process progressed, accumulative goals changed from week to week.

Workloads' intensity was lower and duration longer during training sessions in April, training sessions involved more resistance and sprint training exercises in May and June, starting from July training sessions included mostly interval training with growing duration of each session. Typical training week's plans in each of six months of April, May, June, July, August, and September were presented in Table 1 and Table 2.

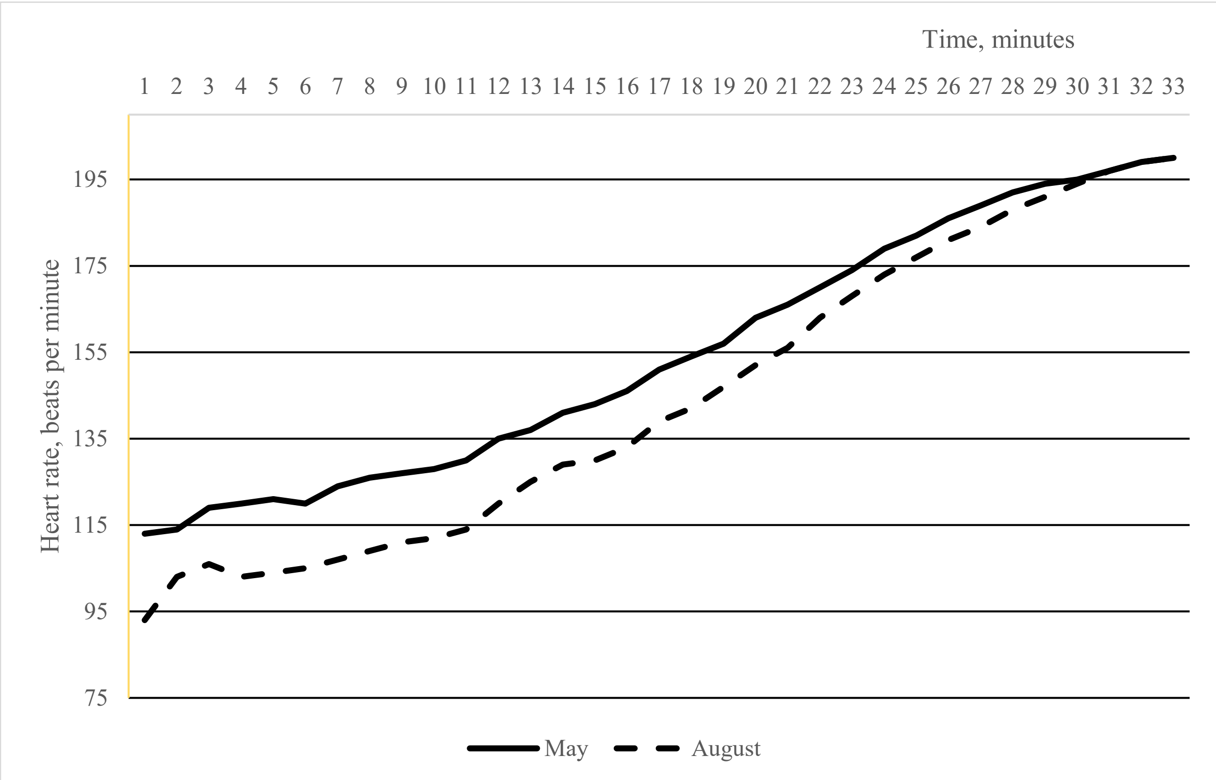

Figure 2 ***The relationship between the workload's intensity in different minutes of the Nordic walking test on the treadmill and the heart rate in May and August***
(created by the authors)

Laboratory testing. The athlete visited a sports laboratory and completed the Nordic walking stress test on a treadmill to an exhaustion twice: 1) in May when her body mass was 61.5 kg and body fat percent 18.6% and 2) in August when her body mass was 64.3 kg and body fat percent 18.3%. The relative peak oxygen uptake (relative VO_{2max}) was the same both times: 49 ml/kg/min. This means that her aerobic power increased because body mass was larger due to skeletal muscles' mass growth. This was proved by increase of the lean body mass for 2.4 kg from May to August.

Considerable changes were observed in a heart rate between both tests at the same workload up to anaerobic threshold load's intensity.

The heart rate during the laboratory test was lower in August in comparison with May: it decreased by 7.51% at the anaerobic threshold load intensity and even more in lower intensity loads – by 10.1%, Figure 2.

Table 1 ***Typical examples of workloads performed in each month during the period of three months (April, May, and June 2021)*** *(created by the authors)*

Day of the week	Training sessions 1.and 2.per day		
	April	May	June
Monday	2.30 min easy run	1. Control 60m, 400m, 3000m	1. Cycling 2h Z1-2 2.Gym strength exercises 2h
Tuesday	1.Running + walking easy intermittent 2h Z1-2 2.Roller skiing classic technique 1h 20min Z2-3	1.Cycling 1h 30min Z1-2 2.Gym strength exercises 2h	1.Roller skiing double poling 2h Z1-2 2.Roller skiing skating 4 sessions 5x15s
Wednesday	1.Cycling 1h 20 min Z1-2 2.Gym strength exercises 2h	1.Rollerskiing skate 1h 20min + 2 sessions 5x15s sprints	1. Intermittent running/walking 2h Z1-2 2.Gym strength exercises 2 h
Thursday	1.20 min warm up + 3 sessions 5x15s sprint running	1.Cycling 1h 30min Z1-2 2.Gym strength exercises 2h	1.4 sessions 5x15s sprints double poling 2.30 min recovery run
Friday	-	1.30 min light cycling	1.Gym strength exercises 2h 2. 2 sessions 5x15s sprints roller skis skate
Saturday	1.Control 60m, 400m, 3000m 2.Cycling 1h 30min Z1-2	1.Gym strength exercises 2h 2.4 sessions 5x15s sprints running	1.Training race roller skiing sprint Cl
Sunday	1.Imitation running/ walking 3h 30min Z1-2 2.Cycling 2 h Z1-2	1.Imitation 3h 30min Z1-2 2.Cycling 2h Z1-2	1.Training race roller skiing sprint F

Field control. As the part of the training process, some maximum 60m, 400m and 3000m running tests were performed in stadium during the pre-racing phase.

Clear progress in 3000m running race results was observed from 14:30 minutes in the beginning of April to 13:16 minutes in June. Using the relative peak oxygen uptake (relative VO_{2max}) calculator, the result was 42.6 ml/kg/min, which is close to the laboratory testing, considering that the laboratory test was done as Nordic walking. It is considered that the peak oxygen uptake was smaller during running than during roller skiing or Nordic walking tests due to using of arm muscles in roller skiing or Nordic walking. This gave additionally 5 - 10 ml/kg/min to the relative VO_{2max}.

Table 2 ***Typical examples of workloads performed in each month during the period of three months (July, August, and September 2021)*** *(created by the authors)*

Day of the week	Training sessions 1.and 2.per day		
	July	August	September
Monday	1.Control 60m, 400m, 3000m 2. Gym strength exercises 2 h	1. Laboratory testing 2.Roller skiing 2h Z1-2	1. Gym strength exercises 2 h
Tuesday	1.Roller skiing double poling 2h 30min Z1-2 2.Cycling 3h Z1	1.Gym strength exercises 2 h 2.4x4min Roller skiing skate intervals	1.Gym strength exercises 2 h 2.4 sessions 5x15s sprints roller skies skate
Wednesday	1.Gym strength exercises 2 h 2. 6 sessions 3x15s roller skiing skate	1.Gym strength exercises 2 h 2. 4x4min Roller skiing skate intervals	1.Gym strength exercises 2 h 2. 4x4min imitation jumping intervals
Thursday	1.Gym strength exercises 2 h 2.3 sessions 5x40 uphill cycling sprints	1.Gym strength exercises 2 h 2. 4x4min Roller skiing skate intervals	1.4x4min Roller skiing skate intervals 2. Gym strength exercises 1h 40min
Friday	1.30 min recovery run 2. 30 min recovery run	1.30 min recovery run 2. 30 min recovery run	-
Saturday	1.Gym strength exercises 2 h 2.5 sessions 5x15s imitation jumps	1. Roller skiing 2h Z1-2 2.Running 2h Z2-3	1.Gym strength exercises 1h 40min 2.5x4min imitation jumping intervals
Sunday	1.Roller skiing Classic technique 3h Z1-2 2.Cycling 2h Z1-2	1.Roller skiing control race 10km 2.Easy 30 min recovery	1.6x4min Roller skiing skate intervals 2. 4x8min imitation jumping intervals

Blood analyses (hormones). The testosterone concentration in the venous blood corresponded negatively to changes in training volume: the lowest testosterone concentration of 0.23 ng/mL was measured at the end of July, when the highest volume of training workloads was achieved. Due to decrease of total training workloads' volume in competition season, the concentration of testosterone in the blood increased to 0.51 ng/mL at the end of roller skiing season at the last week of September. The concentration of cortisol in venous blood was 490 nmol/L in the beginning of April, it increased to 638 nmol/L in July, and dropped back to the initial concentration - to 472 nmol/L by at the end of September.

Discussion

Training sessions. Analysing of the distribution of high and low intensity training workloads, it was seen the dependence on the training period. This corresponds to findings of Seller & Kjerland (2006). Larger volume of low intensity workloads and smaller volume of higher intensity work – polarised distribution was performed in the pre-season training sessions (Seller & Kjerland, 2006). The amount of monthly training hours lowered as the competition season started. The highest volume of training workloads (more than 70 training hours per month) was achieved in the last month before starting of World cup season. During the competition season the training workloads' volume dropped to less than 30 hours in September.

Laboratory and field testing. Laboratory and field testing proved an aerobic performance improvement in the athlete during pre-season training period: the heart rate was lower for 7.5 – 10.0% in dependence of the intensity of Nordic walking on the treadmill in June in comparison with May, and 3000m running race time was smaller in June (13:16 minutes) than in April (14:30 minutes). So, these results confirmed aerobic capacity improvement during pre-season training program execution of the elite athlete which leaded to high achievements in the roller skiing competitions in the examined season. The importance of heart rate monitoring in establishment of the intensity of training workloads was confirmed by Starczewski et al. (2019) who determined that the anaerobic threshold heart rate values obtained in roller skiing tests performed using the classical or skating techniques interchangeably are useful to determine roller skiing training loads.

Hoff et al. (2002) proved that maximal strength training with emphasis on neural adaptations effective enhanced muscle strength, particularly rate of force development, and improved also aerobic endurance performance by improved work economy in male cross-country skiers. We determined the lean body mass increase in our elite roller skier by 2.4 kg in the time from May to August (for four months). This gave un evidence that strength training played significant role in high results achievement in competitions in our athlete. Borve et al. (2017) determined that six weeks of upper body muscular strength endurance training increased not only muscular endurance and one repetition maximum (maximal strength) but also improved performance in double poling on a roller-skiing treadmill. Therefore, upper body muscles strength training should be a promising training model to optimize performance in well-trained cross-country skiers. This should be useful in roller skiing performance improvement.

The important role of aerobic performance to achieve high results in roller ski skating was confirmed by Seeberg et al. (2021) who determined that the most significant performance-determining variables of simulated mass-start performance in males were VO_{2max} (correlation coefficient r = 0.68) and gross efficiency (r = 0.70), enabling lower relative intensity and less accumulation of fatigue before entering the final all-out sprint. We did not investigate gross efficiency of roller skiing in the present study.

Limitations of the study: training program, aerobic and performance characteristics were investigated in only one elite participant.

Further direction of the research: larger number of qualified roller skiers training programs and performance characteristics should be investigated.

Anaerobic performance characteristics and proper roller skiing technique of movements were especially important to achieve superior results in the roller skiing, especially in short distances of 200m. This is in good agreement with the data obtained by Talsnes et al. (2021) who proved that both laboratory performance indices and field-based performance tests provided valid predictions of cross-country skiing and roller-skiing performance in a heterogeneous group of male cross-country skiers, with test values obtained in running tending to be more strongly correlated with cross-country skiing performance than those found for technique-specific modalities on roller skis. However, more sophisticated, and sport-specific testing might be required. Sandbakk et al. (2013) determined that the better ranked elite male and female cross-country and roller skiers skied more efficiently (using less metabolic energy in comparison with lower-level athletes). Therefore, further research is necessary to evaluate anaerobic performance and sport-specific technique of movements in roller skiers.

Conclusion

The relative peak oxygen uptake of 49 ml/kg/min in junior elite female roller skier is low in comparison with the female endurance athletes trained in cross-country skiing (Sandbakk, 2016). Nevertheless, the training workloads intensity and volume are comparable with skiers (Myakinchenko, 2020). The lean body mass of the participant increased by 2.4 kg in the period of four months, this should be explained with growth of muscles mass, strength, and strength endurance. Overall, improvement of aerobic performance was determined during six months of the observations which proved the role of aerobic performance and muscle strength to achieve the high results in competitions of roller skiing. Current state of scientific literature shows clear predominance of cross-country skiing research over roller-skiing research and factors determining roller-skiing results are a lot less clear comparing to cross-country skiing. This research shows insight in top junior level female roller-skiers physiology and training, but specific values determining the success of this athlete are still to be determined.

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