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The impact of endurance exercise on the cardiovascular capacity of a male amateur cross country skier. Pilot study

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ABSTRACT

The purpose of physical training is to achieve the maximum capacity of the body. These changes are caused by numerous adaptive mechanisms taking place in the circulatory-respiratory, muscular, nervous, hormonal, and immunological systems, as well as in the mass and composition of the body. They are most visible in athletes of endurance disciplines such as cross-country skiing, skiing, long-distance running, roller skiing, triathlon or cycling. These disciplines are characterized by long-term effort and the highest intensity. This applies to both athletes and amateurs. The aim of the study was to assess the impact of physical activity during the period of main preparations on the circulatory and respiratory parameters of amateurs practicing cross-country skiing. This study was a pilot, and show the results of the assessment of the case. The purpose of this retrospective case study was to describe changes in cardiovascular endurance within three months of a male amateur cross country skier. This study was based on the analysis of training registration, ergospirometry test (treadmill test) results and body composition measurements. The results showed an increase in maximum oxygen uptake, a shift of the lactate threshold towards higher loads and a reduction in body weight. This parameter was lower than the performance of highly qualified competitors, but the individual changes between the first measurement and the second were similar. Monitoring and evaluation of these changes are mandatory in the training process, also in amateur sport. It helps to counteract states of fatigue, overtraining and designing pro-health training loads. In addition, they can provide protection for the health of those who make the marathon and ultra- marathon efforts. The

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popularity of ski marathons is growing. Assessment of participants' exercise capacity can be used to plan training and comparison with professionals.

***Keywords*:** marathons, cross-country skiing amateur, cardiovascular capacity, performance

1. INTRODUCTION

The implementation of the assumed training plan requires the body to work at a certain intensity level (expressed in HR-heart rate or P-power). This level depends on many variables such as age, sex, health or training goal. Other loads and intensity of training will be used to burn body fat, and another to adapt to start loads. In all cases, in order to determine the most effective training parameters, it is important to examine the cardiorespiratory capacity of the body [1]. The capacity of the organism is understood as the potential for the ability to perform intensive and long-lasting performance. During this process large muscle groups are involved (based on the energy potential of aerobic, mixed or anaerobic) with small fatigue changes and fast and effective rest [2]. It is connected with an efficient course of recovery.

Long-distance cross-country skiing is a competition in which amateurs compete with professional athletes. Often these are competitors who once competed in the highest-ranking competitions, such as the World Cup and the Olympic Games. They are also those who have not been able to enter to this level. The most prestigious cycle is currently the Visma Ski Classics cycle, consisting of over 10 stages. The competition is broadcast on several television stations. Some of these gears are in parallel in the Worldloppet calendar, an organization associating 20 events, taking place among others in Norway, Sweden, Italy and Poland, as well as in countries such as Iceland, Argentina and New Zealand.

The most famous and longest run in both cycles is the Vasa Race (Vasaloppet 90 km). Most races take place on flat profile routes. However, there are also gears with more diversed shape. This type is the most popular in the third in terms of popularity of the cycle - Euroloppet. They take place only in Europe. The distances of the main competitions are from 40 to 90 km. The ones dominated by the classic technique.

These efforts are characterized by a long duration of time and intensity between the third and the fourth zone. These are strenuous-strength efforts. They require not only high efficiency, but also technique. Cross-country skiing is one of the most demanding sports in the world [3]. Apart from the high energy demand, the specificity of the effort is also relevant. Cross-country skiing involves almost all the muscles in the body, for instance in marathons especially the upper parts of body muscles. This sport is also ideal for the elderly and obese. Both the body and the hands are an important factor of success [4]. Therefore, ercoline training is also important. Ski marathons require additional sport preparation [5].

Cross-country skiing have a pro-health impact. However, without an individual, thoughtful and professional plan, it can cause health problems due to overloads, injuries and i.e. heart muscle diseases which may be irreversible. Therefore, it is so important to be aware of your body and control the impact of exercise on the body. An additional advantage of monitoring is better adjustment of the training plan and counteracting fatigue and overtraining. The monitoring process should apply to both athletes and amateurs. Both groups perform submaximal and maximum effort during the competition. Professional athletes have a coaching staff that checks for negative changes in their body.

Amateur must take care of it themselves, both in the aspect of physiotherapy, physiological monitoring, biochemistry, diet, supplementation, training loads and monitoring of progress [6]. Their work and private life also have a significant impact on these changes. The impact of physical exercise on performance is well understood in the group of professional athletes. However, it remains unknown in the group of ski runners training amateur and marathoners. This has become an impulse for conducting pilot studies, which in the future are to include a representative group. The study aimed to determine the cardiovascular capacity of the group and assess the impact of the three-month training.

2. MATERIAL AND METHODS

2. 1. Participant

The man was 35 years old. He was in amateur training and start-up internship lasted ten years. He was trained for the last four years by a cross-country ski trainer. His training plan was tailored to individual capabilities and goals in the season. The competitor worked professionally in a big city and could spend up to 90 minutes a day for physical training.

The guidelines for the study included the completion of at least three ski marathons in the season preceding the tests, a minimum of five years training, physical activity at least 4 times a week, and physical performance above 50 Vo2max (ml / kg / min). The competitor met these requirements.

2. 2. Ergospirometric test

To assess the aerobic capacity expressed by the level of maximum oxygen uptake (VO2max) was used an ergospirometric test with gradually increasing intensity, performed on a mechanical treadmill. This test was performed on a treadmill using HP COSMOS CPET equipment and ergospirometr Cosmed Quark/k4B2 two times. The first took place in May, at the beginning of the preparation period and after the inter-season break. The second one was carried out in September, after the main preparations and before the winter season.

It started at a speed of 8 km / h and a 0% treadmill inclination. Then every 3 minutes, the speed was increased by 1 km / h, and the inclination by 0.5%. The test was continued until the subjective feeling of exhaustion by the competitor (up to refuse).

During exercise the following parameters was measured: speed (km / h), the load on the threshold of anaerobic AT (km / h), volume oxygen uptake - VO2 (L / min), maximal minute oxygen uptake - VO2max (ml / kg / min), minute oxygen uptake on the lactate threshold - VO2 AT (ml / kg / min), the percentage of maximal minute oxygen uptake on the threshold of change oxygen -% VO2max on the threshold AT, the maximum minute ventilation – VE MAX (l / min). ratio respiratory exchange – RER max (VCO 2 / VO 2), maximum heart rate - HRmax (thigh / min), the heart rate at the threshold of alternating aerobic - HR AT (ud / min), stroke volume - O2 / HR (ml), changes in the acidification maximum - LA max (mmol / l), lactate concentration change ΔLA (mmol / l) and a change of acidity after 12 minutes after the end of exercise ΔLA res 12 '.

The anaerobic threshold (AT) was determined based on the dynamics of changes in the respiratory system parameters and changes in the concentration of lactic acid in the blood.

2. 3. Weight and body composition

Body weight and the weight measured by Tanita Body Composition Analyzer BODY IN 220 consisting of an 8-point touch electrode system. The test was carried out just before the ergospirometric tests began. The following were determined: body weight, water content, minerals, vitamins, fat content in the body (% and kg) and slim mass muscle (muscle mass in % and kg), WHR (waist to hip ratio) and BMI (body mass index). This article contains body mass, BMI and fat content in the body. Body weight and body composition are important in endurance sports. They have a significantly impact on the level of maximum oxygen uptake, which is the best measure of the ability of endurance athletes (especially content of adipose tissue and slim muscle). Changes in the direction of lower values of body fat are characteristic of a healthy influence of endurance training.

2. 4. Training loads

This period of a cross-country skier (between May and September) was characterized by the largest training volume of moderate intensity in a macrocycle. The purpose of this was to train exercise capacity. For this purposed comprehensive training (running, cycling, swimming, walking in the mountains), targeted (roller skiing, double-pooling, exercises on the ercoline, imitations) and specialized forms (cross-country skiing rarely used in the summer due to the specificity of discipline and available infrastructure). The last one was not excluded. There are year-round cross-country ski trails in Europe, which are located on glaciers and in ski tunnels, available all year round. This tracks are position of for example at the Dachstein glacier in Austria or the ski tunnel in Oberhof in Germany. However, the researcher did not use this forms of training. Separately counted resistance training. Circuit training was used in July and August (like cross-fit). It increased the body's efficiency. Maximum strength training was introduced in September. The purpose of this was to increase the strength capabilities.

The effort was carried out in six zones:

SR (static recovery) - static relaxation zone, e.g. stretching, stabilization training,

AR (active recovery) - zone of active rest - accelerates rest processes after intensive efforts such as swimming, yoga,

LI (low intensity) - low intensity zone - the work performed increases the ability to perform long-term efforts in conditions of moderate fatigue typical for e. g. cycling, training on the ercoline training. This tree zones basic on use free fatty acid to produce energy,

MI (middle intensity) - medium intensity zone - the work done in it is in favor the task to increase the ability to perform aerobic efforts (aerobic) -continued for a long period of time intensifies combustion adipose tissue e. g. running or roller skating used mixed substrates,

HI (high intensity) - high intensity zone - the work performed is conducive adaptation to the efforts of a significant share of anaerobic metabolism typical of e.g. competition. Substrates for energy was: phosphocreatine, glucose in the blood, glycogen in the muscle and in the liver and ATP (adenosine triphosphate),

VHI (very high intensity) - very high intensity zone - performed in it work favors adaptation to short-term efforts with maximum intensity up to 60 seconds, typical for individual and

team games, combat sports, accelerations, spurts, etc. basic on phosphocreatine substrates and ATP.

Table 1. An exemplary weekly training plan (basic microcycle) in July.

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Running 30 minutes + multi-jumps 15 x 10 jumps + imitation cl 50 min (intensity third zone) + 20-30 minutes run (second zone) + stabilization 10 x 30 s	Running or roller skiing 90 min (w tym double pooling 30 min) intensity: 2-3 II Training Running, intensity: 2, 15 minutes, warm up 10 '+ resistance training 40 stations (4 circuits with 10 stations) type: MAXYMAL + stabilization	Cycling 100 min (second zone) + 30 min ercoline	Before work: ercoline 20 min + stabilization After work: Roller skiing 30 min (zones 2-3), 30 min double pooling (zone 2), 20 min no poles (zone 2) 30 min roller skiing	Roller skiing 120 min + 20 min Running (2-3 zones) +stretching Running intensity 2, 15 ', warm-up 10' + resistance training 40 stations (4 circuits with 8 stations), + stabilization 10x 30 "	Cycling 180 min intensity 2 II Training Running 30 min imitative exercises + stabilization + sauna, jacuzzi	**Free of workout**

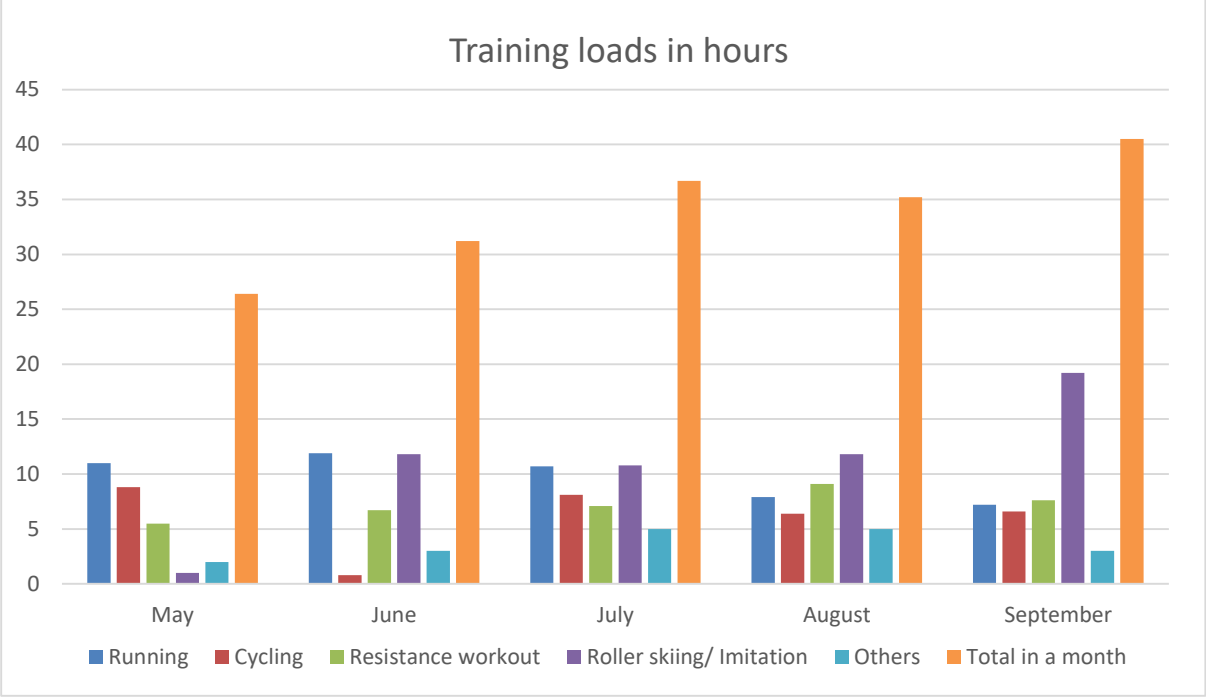

Figure 1. Type of workout in the studied months in hours.

Summaries of training loads in hours of efforts in months are presented on the charts. They describe trainings made between May and September. In the annual preparation of ski runners (macrocycle) it is mesocycle of the main preparations (Table 1 and Figure 1).

3. RESULTS

3. 1. First treadmill test

The first ergospirometric test took place on the ninth of May 2016. The competitor continued his effort for 22 minutes 10 seconds and carried out an exercise test at 15 km / h for 1 min. The maximum ventilation was 155.5 l / min. It was obtained at a tidal volume of 2.38 l (best 2.4 l) and breathing rate at 55.6 breaths / min. The incidence of cardiac contractions at the time of discontinuation of the exercise test was 195 ud / min (HR max).

3. 2. The second ergospirometric test

The second ergospirometric test took place on the twenty-ninth of September 2016. The subject continued his effort for 24 minutes and 15s, reaching a maximum speed of 15 km / h . Maximum ventilation was 147 l / min. It was obtained at a tidal volume of 2.41 liters and respiratory rate 61 breaths / min. The rate of heart contractions at the time of stopping the exercise test was 192 beats / min. The anaerobic threshold (AT) tested after 19 min of effort, at a speed of 13.5 km / h. The oxygen uptake at the anaerobic threshold was 49 ml / kg / min. The threshold of oxygen transformation (LT) was obtained at a power of 11.5 km / h and Hr 164 beats / min. Maximum VO2 oxygen uptake at the aerobic threshold reached the value of 42 ml / min / kg (Figure 2).

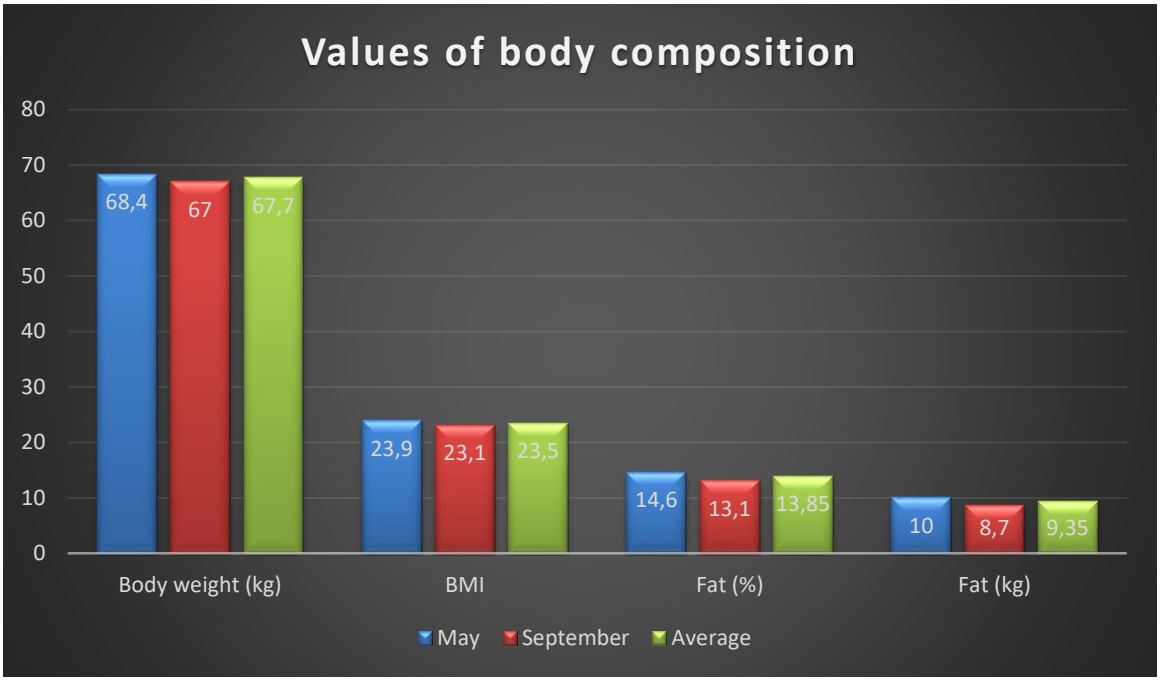

Figure 2. Values of body composition and anthropometric indices.

3. 3. Changes in mesocycle

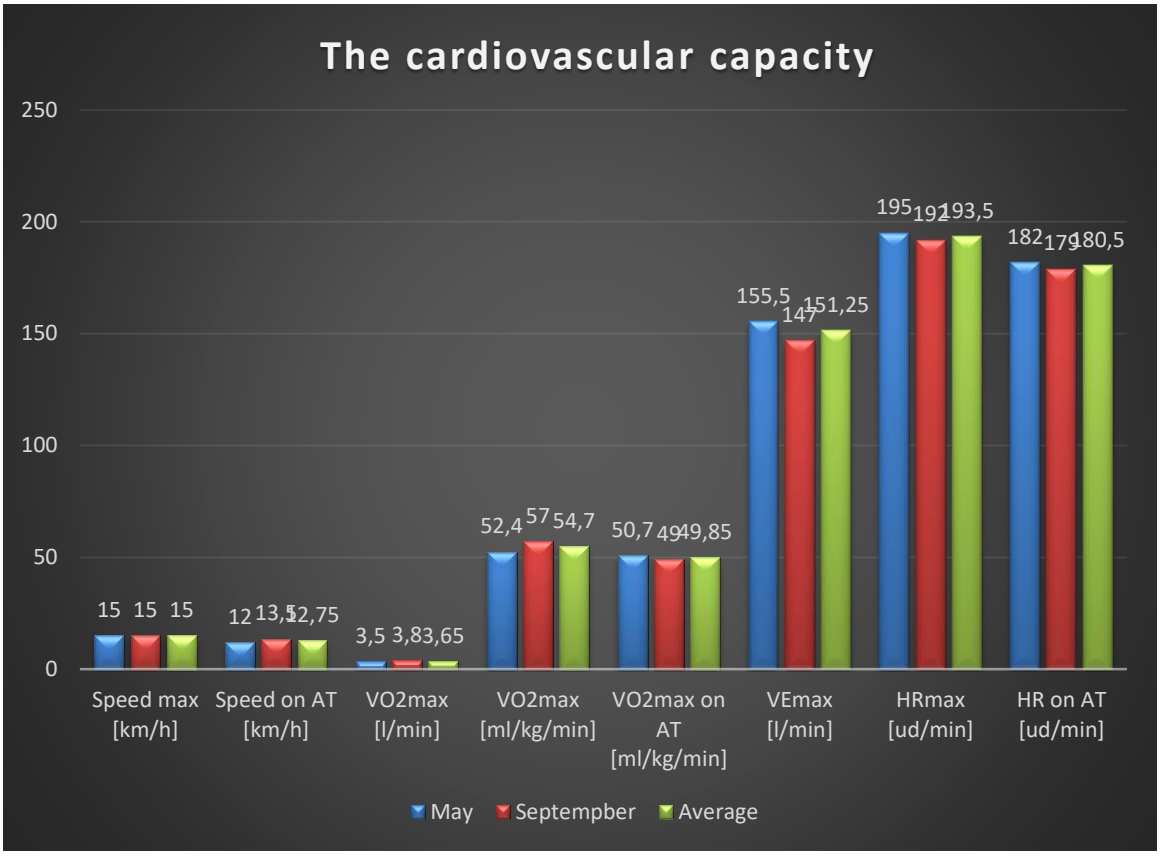

Figure 3. The cardiovascular capacity parameters.

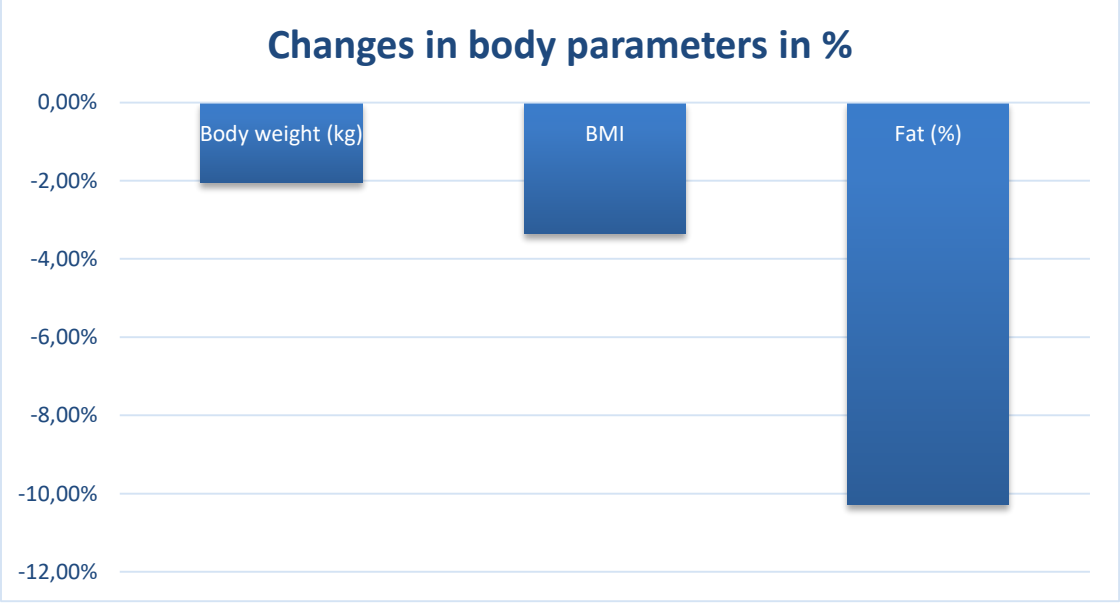

Figure 4. Changes in body parameters in %.

The largest percentage changes in the body was of adipose tissue (average 10%) (Figure 3 and 4). An incline in parameters was recorded during this period in maximal speed, speed on anaerobic threshold and maximal oxygen uptake. A decline was registered during this period in: a maximal minute ventilation, maximum heart rate, heart rate on anaerobic threshold and maximal oxygen uptake on anaerobic threshold (Figure 5). Individual exercise zones are shown in the table (Table 2).

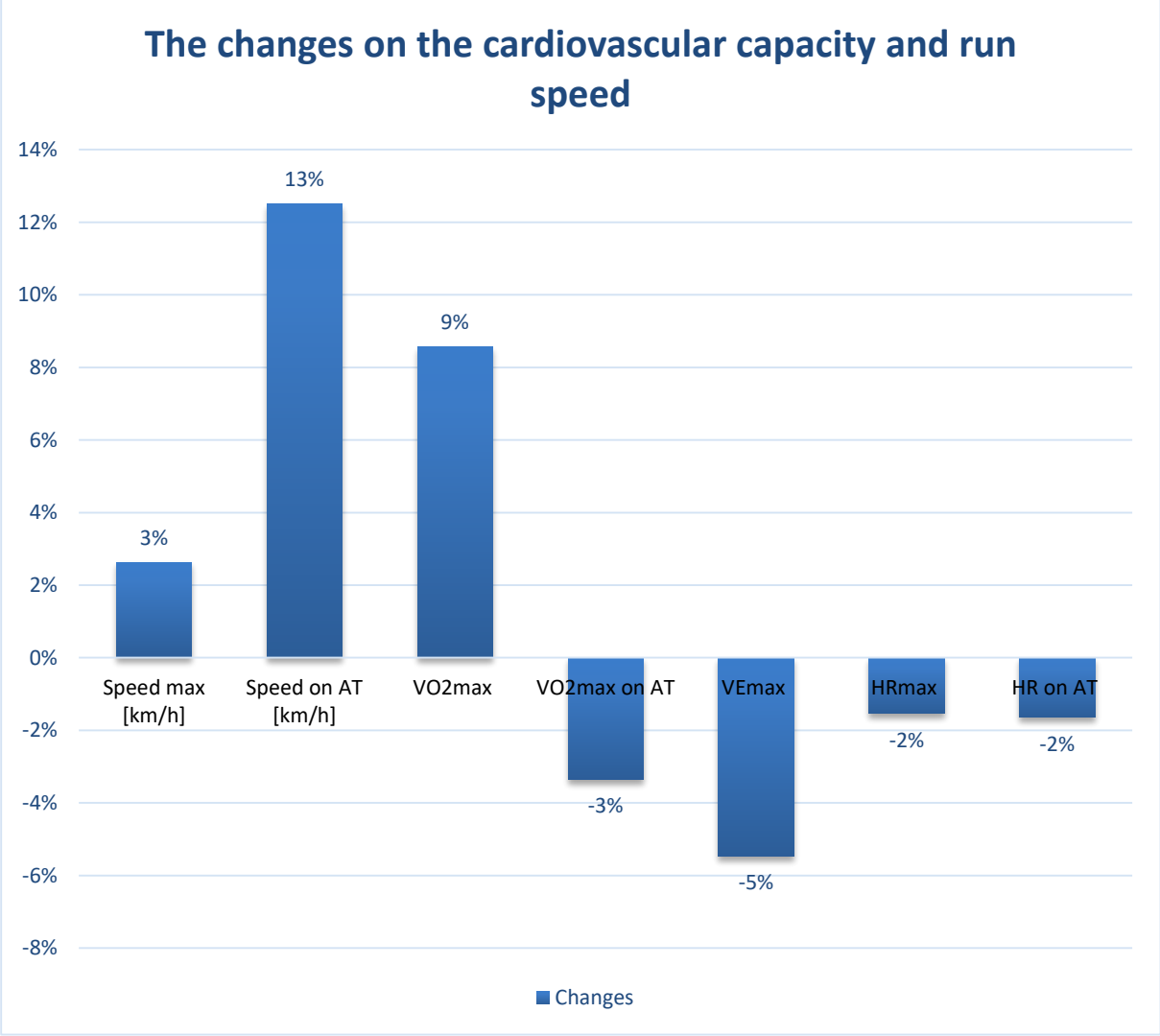

Figure 5. The changes on the cardiovascular capacity and run speed.

VO2max - maximal oxygen uptake, VeMAX a maximal minute ventilation, HRmax - maximum heart rate, HR on AT- heart rate on AT

Table 2. Individual exercise zones.

The effort zone	**Heart rate per minute 1st test**	**Running Speer 1st test Km/h**	**Heart rate per minute second test**	**Running Speer second test Km/h**
AR **Active recovery**	Below 145	Below 10	Below 9	Below 9
LI **Low intensity**	146-166	10-12	145 - 164	9 – 11,5
	167-174	12-13	165 – 172	11,5 – 12,5
MI **Middle intensity**	175-184	13-14	173 – 179	12,5 – 13,5
HI **High intensity**	185-195	14-15	180 – 186	14– 15
VHI **Very high intensity**	More than 195	More than 15	More than 187	15

4. DISCUSSION

The VO2max value was approximately 54.7 ml /min /kg. These values are rated as very good and desirable in the amateur group [7]. This indicates a relatively large capacity of oxygen metabolism. VO2 max is heavily genetically conditioned, but it showed that the right training and diet can increase its parameters (from 52,4 to 54,7 ml/ kg/ min) but it was significantly lower than those within the best professional athletes, where average Vo2max reaches 71.5±6.4 ml/ min/ kg [8]. The elite cross-country skiers exhibit extensive aerobic capacity, both absolute (L / min) and relative (ml / kg / min) [9]. The highest values were recorded at one of the Norwegian ski runners. They were 7.48 liters per minute, which was 94 ml per kilogram of body weight [10]. Similar results were recorded in cyclists and runners (marathoners). Few contestants won medals in the World Championships and Olympic Games with VO2max values below 6 l / min. or ~ 80-90 ml / kg / min [11]. In these studies the following parameters were lower with the averaged mean values as 3.65 l / min and 54.6 ml / kg / min. However, they were the best one so it is difficult to compare with this group. WHO guidelines on pro-health activities indicate the desired level of Vo2max as 35 ml / kg / min. In this case, the athlete substantially complies with these guidelines. The high level of maximum oxygen uptake supports the circulatory-respiratory system, quality of life and health protection. This is particularly important in older people who have sarcopenia and the

problem of overweight and obesity. It is estimated that every year the level of maximum oxygen uptake decreases about 0.5-0.6 ml / kg / min. In active people it is significantly smaller. Adaptations also provide training around the threshold and adaptive to starter speeds (intervals, starts). The first test was not done to the physiological maximum. The cause could be biochemical conditions and the lack of adaptation of the muscles to such an effort. In the test the athlete noted a 9% increase in Vo2max. Norwegian researchers give the opportunity to 8% VO2max value changes in time so the results are similar [12]. Maximum ventilation (VE), which is one of the indicators of respiratory capacity, was approximately 151,25 l/ min. It decreases in this period. It could be a result of illness or accumulation of mucus in the lungs. The maximum heart rate (HRmax) was 195 tpm. Endurance effort should reduce this value. It this research results decreases on 2%, as well as in T. Losnegard study [13].

The reference range of the adipose tissue content ranges from 8.0 to 20.0%. Elite athletes have a much lower score, even below 3%. The studies showed that the average value of 13.85% and reduction in body fat in response to endurance efforts by - 1.3 kg (- 10%). Sperlich and Stoogl [14] noted decrease in body weight in endurance sportsman 3.7% +/- 3%, during the 9-week workout (with VO2max at 62.6 ± 7.1 ml/kg/min) so it was significantly smaller. The difference can be caused by the presented output level (competitors and amateurs). Despite of it, this changes had an impact, among others increase in maximum oxygen uptake during this period. The decrease is desired. Responding body composition guarantees the possibility of high circulatory-respiratory capacity, but also protection against diseases of this system like obesity and overweight [15]. This result confirms the pro-health impact of endurance exercise as well as in the study of T.Stellingwerf [16]. Exercise loads at which metabolic thresholds have occurred should be assessed as good. The anaerobic threshold (AT), however, occurred at a speed of 13.5 km / h and 3% inclination. The cardiovascular system responded steadily to the given load, which was manifested in a linear increase in heart rate. The respiratory system in turn is moderately adapted to the effort, as evidenced by the maximal ventilation. This confirms the effectiveness of the training plan and the positive effect of endurance exercise on the organism [17].

5. CONCLUSIONS

Ski marathons are one of the most demanding sports disciplines. The test results indicate a high level of maximum oxygen uptake in the study group compared to the population. Endurance training also has a significant impact on increasing exercise capacity during the main preparations. It also differentiates composition and body mass. These results may be guidelines to assess an amateur ski marathons group, but they need confirmation in subsequent studies. In addition, they can be used as a guide to prevent obesity and overweight.

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