RESPONSE OF BIATHLETE ORGANISM TO TRAINING LOAD IN ATC 2011/2012

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Abstract
In the paper, we have, by monitoring ANT cardiac rate shift and ANT speed, determined the relationship between volume and intensity of training. T.H. always after completion of at least one-week training at the aerobic intensity in conjunction with training above ANT, which he usually performed as a complex training, has recorded increase in performance. This assumption is based on the results, which he had achieved at an international race. On the contrary, at the pace of middle intensity a decrease in performance occurred, especially in shorter races. The training methods recommended to T.H. – excluding the middle training zone – have been confirmed. We recommend including the utilization of the medium intensity into the preparation only within complex training.

Key words: *biathlon, sports preparation, sports training, training load, lactate curve.*

INTRODUCTION

In professional sport there is a constant increase in performance, which necessarily requires gradual qualitative and quantitative changes in the training process. However, these changes cannot be applied without the use of scientific research findings from practice. Biathlon belongs to sports where performance is closely related to aerobic endurance of athletes. The cardiac rate and blood lactate levels are two simple values with which it is possible to manage and control the training process. Based on various functional tests, either field or laboratory, we can, based on the lactate levels and the cardiac rate determine the most appropriate form and intensity of a workout.

The goal of a training process evaluation is to relate completed training load, changes in trainability, and changes in performance. Subsequently, based on the results, draw conclusions about the effectiveness of the training process. The evaluation requires data recorded in athletes' as well as in coaches' training logs. Consequently, one can determine what methods were used to carry out the training activities, the intensity-volume ratio, and more. The purpose of the evaluation, not only the yearly one but also of the ongoing training process, is to implement measures in time, if the reality differs significantly from the plan (Ilavský, 2005; Peric et al., 2010). According to Neumann et al. (2005) the evaluation of a training process and the feedback is the alpha and omega of success and growth as well as it is the prerequisite of making sound conclusions throughout all levels of training management. The quality of such feedback depends on how one combines the diagnostics results and the training analysis, which afterwards have to be interpreted correctly. Only then, may the finest ways of improvement for the upcoming practice be presented. In biathlon, the diagnosis primarily focuses on two main areas to analyze – power and endurance capabilities. Diagnosis of strength is used during the training periods, and phases during the controlling of trainability and evaluation of the effectiveness of training in terms of the given objectives and tasks. Such analysis helps to determine the adequacy of the training tools and methods. The problem is that adaptive changes may take few weeks to appear. When diagnosing endurance, the level of endurance cannot be measured directly. However, based on the measured parameters can be assumed a shift of endurance skills, either improvement or degradation. To measure such parameters, there are primarily field means of measurement used, which are complemented by further laboratory tests. In field testing, we focus on:

- Average locomotion speed ($m.s^{-1}$) until interruption caused by fatigue, when evaluating the distance passed
- Specified time limit of locomotion, based on passed distance and average speed
- Specified track length, evaluating the lap time, and the average speed

In laboratory testing, we focus on cardiac rate, oxygen consumption up to the maximum consumption, O_2 consumption in respect to body weight, lactate levels (achievement at the aerobic and anaerobic threshold and the maximum lactate level after the exercise) (Lehnert et al., 2010).

Based on the objectives of this paper, we used the lactate curve to diagnose the current performance by which we determined the value of ANT. Generally, ANT is considered to be the lactate concentration of 4 mmol l -1 (Pupiš, 2005). Loužecký (1985) argues that the blood lactate values in biathlon range from 7 to 10 $mmol^{-1}$. In endurance biathlon the value equals to 7.4 $mmol^{-1}$, although Astrand (In Ilavský, 2005) notes that the level of lactate drops as the length of the race track increases. In the finish, after a 10 km race the lactate value of 11 - 15 $mmol^{-1}$ was measured. Bunc (1995) suggests the value of 10 $mmol^{-1}$, which however, may fluctuate during a race and may reach as high as 15 $mmol^{-1}$ or even more at the end of the race.

Lactic curve is basically a mathematical model that helps us to better understand each metabolic zone and its importance in endurance sports. For a clear identification of the curve in the plane, it is necessary to know at least three different points which the curve will pass through. In order to find this dependency we have to construct a test for the athlete in which each sector would differ in progressively increasing intensity. If we want a more accurate evaluation, it is better to set four different load levels, where the first step should be purely in the aerobic zone, second and third level should be somewhere within the mixed zone, and the fourth step in the anaerobic zone or around the critical speed corresponding to the level of $VO_{2\,max}$. From such a curve it is then possible to determine the load that is equal to aerobic or anaerobic threshold (Pupiš, 2012), thus help monitor the response of the body to the load. We think that the values of $VO_{2\,max}$ in men doing biathlon range between 75-90 $ml.kg^{-1}.min^{-1}$ and in women 65-70 $ml.kg^{-1}.min^{-1}$. Loužecký (1985) argues that the superior performance in biathlon is ensured by $VO_{2\,max}$ levels above 80 $ml.kg^{-1}.min^{-1}$.
In biathlon we use a stress test - lactic curve - to determine individual load intensity and anaerobic threshold (ANT). This test is implemented through athletic running or roller skis, which is specific for the given sport type (Murínová, 2008).

Pisařík & Liška (1985) argue that rough forms of training load with short, intense segments with short breaks may in fact cause a disturbance of the internal environment. An athlete must overcome fatigue, which peaks in about ľ of the distance. Then, acute shortage of the rapidly available energy in muscles occurs and the quality of neuromuscular transmission progressively decreases. In this state, the biathlete has to apply tactical thinking and decision making and has to essentially shoot, which requires high sensorimotor coordination. Biathlon generally sets great demands on kinesthetic, statokinetic, and visual analyzer, while using the central and peripheral vision. Thus, the success of shooting is much affected by the lactate level and VO2 max. Bunc (1995) argues that to achieve successful shooting, it is advisable that the cardiac rate is at the time of the shooting at or below the ANT.

The high performance level in today's sports requires an individual approach in examining the training and its impact on athletes. The works of authors Socha & Zaporožanov (1997), Šachlina (1997), Prusik (1999), Zeličenok, Nikituškin & Guba, (2000), Jančoková (2000), Kompán (2000), Vanderka & Kampmiller (2002), Pupiš & Korčok (2004), Kubaščík & Paugschová (2005), Čillík (2006), Korčok & Pupiš (2006) and others, contribute to the solution of the current theoretical and practical problem.
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The aim of this paper is, based on the analysis of the level of trainability in an annual training cycle in 2011/2012, to assess the impact of completed training load for the increase in trainability of a professional biathlete.
To meet the goal we set the following tasks:

1. Athlete diagnosis with the exercise test
2. Interpretation of the results and formulation of conclusions

METHODS

The proband was the Slovak representative in Biathlon - T.H., height 183 cm, weight 80 kg. He has been dedicated to sports since 1998 under the leadership of several coaches. From the beginning of his athletic career he has been representing the Biathlon Club Valaská-Osrblie. One of the greatest successes is considered the 10th place in endurance race at the World Championship in the junior category in 2010 in Torsby, Sweden and 17th place in sprint race at the open race of the European Championship in the men category under 26 years-old in the season 2011/12 in Osrblie. T.H. is also a European double vice-champion in summer biathlon in the junior category (speed race in 2010, held in Osrblie, and in sprint race in 2011, held in Marttel, Italy). At the same time, he is a double overall winner of the European Cup in the summer biathlon among juniors in the season 2010/11 and 2011/12. Since the season of 2011/12 he has been a member of the men's biathlon national team.
Basic data on the proband are presented in Table 1.

Table 1 *Spiroergometric examination of the proband*

Date	Weight (kg)	VO_{2max} (mml.l^{-1})	VO_2 (kg) (mml.l^{-1})	HR_{ae} (no. per min)	HR_{at} (no. per min)	HR_{max} (no. per min)
22.5.2011	80	5582	69,775	150	172	189
20.8.2011	77	5766	74,883	152	180	187

Legend: $VO_{2\ max}$ - maximum oxygen consumption; VO_2 (kg) - maximum oxygen consumption per kilogram of body weight; HRae - cardiac rate at aerobic threshold; HRAT - cardiac rate at anaerobic threshold, HR_{max} - maximum cardiac rate

Due to the fact that T.H. represented the Slovak Republic in competitions abroad, it was necessary to allow traveling and regeneration in order to give him the opportunity to attend the test well rested. We also planned that T.H. would have at least 6 hours of sleep. We conducted the testing in intervals from 11:00 a.m. to 2:00 p.m. considering his biorhythm - at this time his vast majority of races start.

The diagnosis was conducted in a sports complex with a tartan surface (400m) ASC Dukla in Banská Bystrica. We chose a repeated test run on an athletic track 5 x 1 km, which was carried out on a four-week basis. The sections were completed at a gradual pace with a 2 min break in between the laps. After each section, T.H. had 20μl of capillary blood withdrawn from his fingertip. The concentration of LA in the blood was analyzed with the use of Accutrend Lactate Pro lactate measuring device.

Dates of testing were as follows:
1. Testing – 15. September 2011
2. Testing – 3. October 2011
3. Testing – 2. November 2011
4. Testing – 30. November 2011
5. Testing – 11. January 2012
6. Testing – 21. February 2012

Recorded data:
- Time in minutes and seconds
- HR, using devices such as Polar RS400
- Lactate levels in the blood measured with
- Accutrend Laktate Pro

Before each test, every athlete warmed him/herself up at pace up to 130 HR for 10 minutes. Afterwards, the first measured run of one kilometer was executed, during which the speed was set to 10 km per hour. After the finish, blood collection followed. After a pause of two minutes the second kilometer-run started at the speed of 12.5 km per hour with additional blood sampling in the second minute after the finish. Then, the third kilometer-run started at the speed of 15 km per hour. This way we continued up to the speed of 17.5 km per hour, followed by running at maximum intensity. Upon the clearance of the last section, blood sampling in the first minute, third, eighth, and in the eleventh minute followed. In order to achieve maximum athletic performance, we need to bear in mind not only the quantity but also the quality of the completed training loads, if you like, the completed race.

RESULTS AND DISCUSSION

Based on the spiroergometric analysis, prior to the diagnosis (Table 1), we note a decrease in the body weight, which was caused by an increase in $VO_{2\ max}$ and VO_2 per kilogram of body weight to the level of 74.883 ml.kg^{-1}.min^{-1}. The increase in HR_{ae} is in our opinion negligible, if it is caused by a low intensity workout after the volume load. The increase in the HR_{at} level is considered a "steady" zone just below the ANT. HR values from 172 to 180 ml.kg^{-1}.min^{-1} can be considered an exemplary rise as a body response to a training load in a given training period. We assume that T.H. had completed high quality training since May 2011, which focused on overall, or rather general endurance with a phased training to develop speed abilities. From Table 1, we assume that the training load was an appropriate mix towards the autumn-period of the diagnosed HRATC. The important figure HR_{at} (difference of 8 pulses) illustrates, in our view, a very good tolerance of the body to lactate. Based on that, we may conclude a high level of endurance in athlete's abilities. On the other hand, we observed a little difference between the ANT and HR_{max}. We think that in practical terms, the organism has no room to "work" during a race or training. Even if the athlete's pulse rises only by 2 to 3 pulses, which could be caused by the athlete's greater effort to optimize performance, the lactate levels would increase, thus he would no longer be able to put out high level of performance because the body becomes "hyperacid".

First testing – 09/15/2011

The first testing was conducted after the break period of the autumn preparation afterward the World Championship in roller skiing (Figure 1).

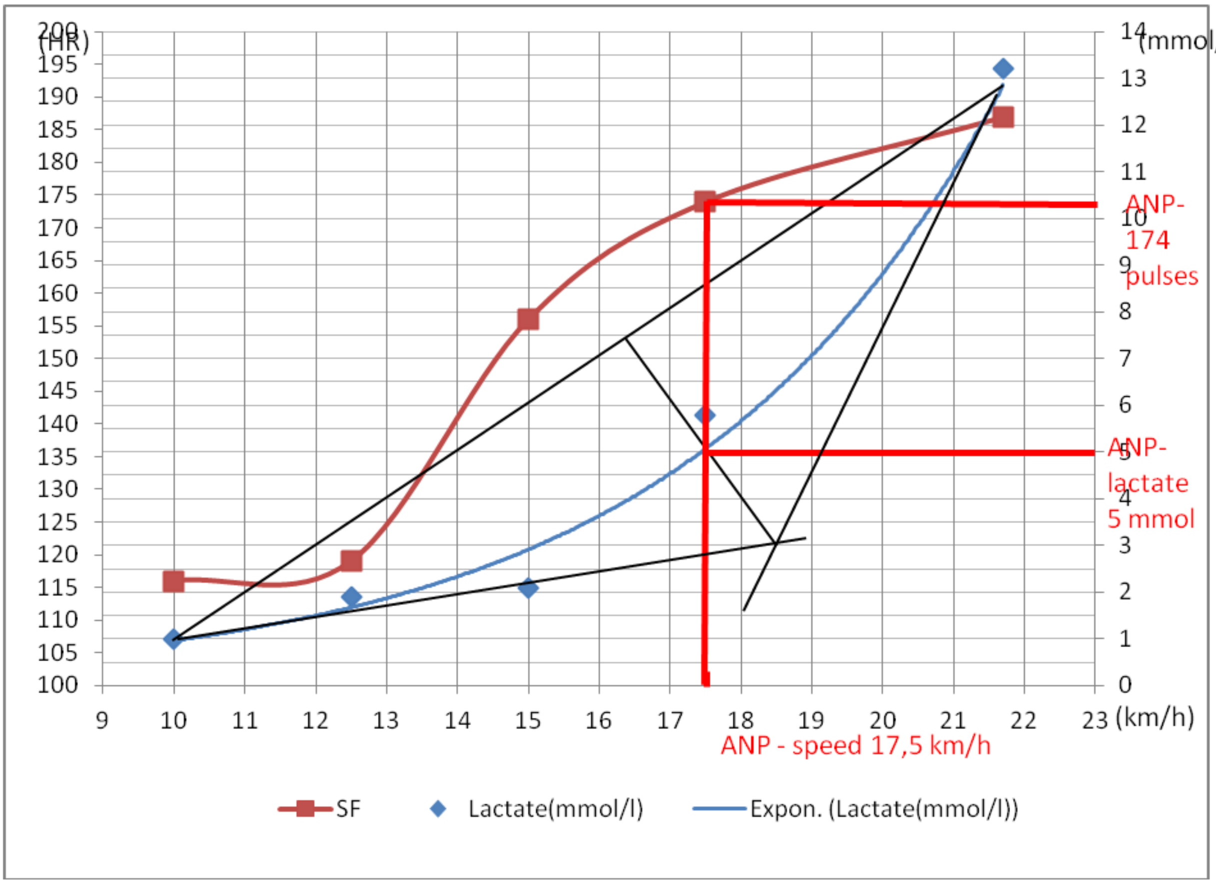

Figure 1 *Testing data from 09/15/2011*

In the first testing, we found that the athlete's anaerobic threshold is located around the level of 5.0 mmol.l^{-1} of lactate in the blood, with a cardiac rate of 174 beats per minute. The running speed in ANT was 17.5 km.h^{-1}, and on that basis, we calculated the pace of 1 km - 3:25.71 min (Table 2).

Table 2 *ANT values for each testing of T.H.*

Indicator	Results					
Date	*09/15/2011*	*10/03/2011*	*11/02/2011*	*11/30/2011*	*01/11/2012*	*02/21/2012*
HR ANT (Bpm)	174	173	163	164	161	159
Lactate ANT (mmol.l^{-1})	5,0	4,9	2,9	2,7	3,2	2,5
Tempo ANT (min/km)	3:25,71	3:25,71	3:36,86	03:39,51	3:30,52	03:38,19
Speed ANT (km.h^{-1})	17,5	17,5	16,6	16,4	17,1	16,5

During the period between the first and the second test, the main aim of the preparation was T.H.'s regeneration and general training with the focus on body recovery after a difficult summer season, during which he completed 25 competitions in the summer biathlon. T.H. used during the preparation the widest possible number of training means of intensity I, only the complex training was conducted at high load at least once a week in order to maintain the speed and improve the shooting capabilities after a high load. The training methods in the complex workout rotated, most of them were the interval method, and the mostly used training tools were roller skis and imitative running.

Second testing – 10/03/2011

The second test T.H. passed one week before the end of the special autumn training and before the departure to a training at a glacier. The test results confirmed that he was able to maintain his speed capabilities, whereas he improved his maximum speed by 3 seconds per km. Therefore, we can conclude that the results confirm the suitability of the training model in maintaining his performance (Table 2).

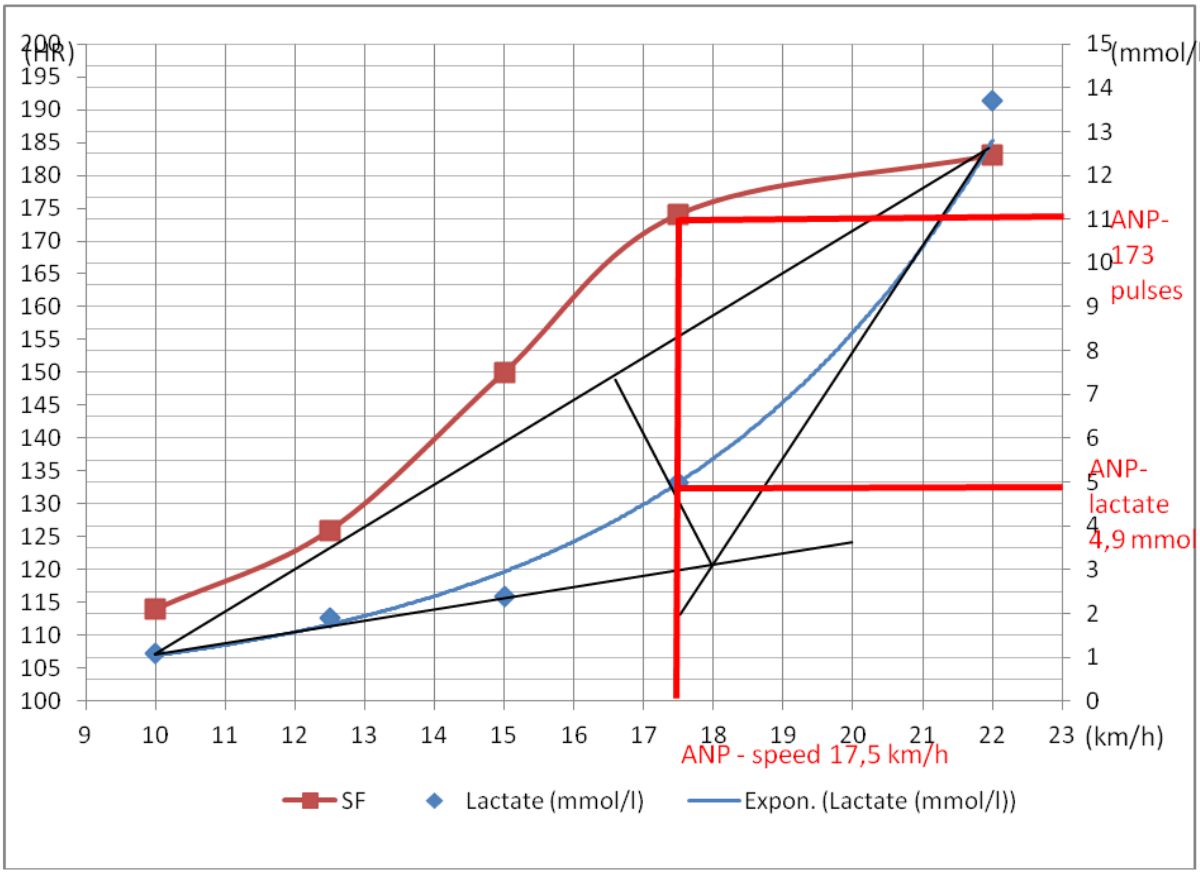

Figure 2 *Testing data from 10/03/2011*

In the next period (between the second and the third testing) the training focused on volume training in an alpine environment. T.H. completed three-week training at the Dachstein glacier in Austria. The training focused mainly on the development of aerobic ability by focusing on the development of balancing endurance, therefore the morning phase consisted of ski training on the glacier at around 2600 +- 50 MASL. The training efforts aimed to improve the cross country skiing techniques at the intensity of I. The afternoon training consisted mostly of complex roller ski exercises or imitation running, at which the load intensity would increase up to the mixed zone or even to the ANT level because of the adaptive capacity of shooting after5 an exercise. Strength workouts were more specialized and were performed in the afternoon. The overall ratio of the general and special strength in the strength training changed compared to the previous period from 40%:60% to 20%:80%. As it turned out, even in our pro band, contradictory conclusions regarding training and its effectiveness at high altitude were confirmed; mainly because of the limited options of more intensive training and because of a significant slowdown in recovery processes (Friedmann & Bartsch, 1997). Generally, high-altitude training leads to reduced immunity. Vasankari et al. (1997) suggest an increased risk of respiratory and digestive tract infections, which was also the case of T.H. In some athletes, psychological problems may occur as well.

Third testing – 11/02/2011

The third testing was conducted after the return of T.H. from the high-altitude training. The results showed that the three-week training in low and medium intensity, omitting the training of speed and dynamic ability development resulted in a decrease of anaerobic threshold of ten beats per minute and ANT speed of 0.9 km.h^{-1}, as well as the maximum speed (Figure 3, table 2).

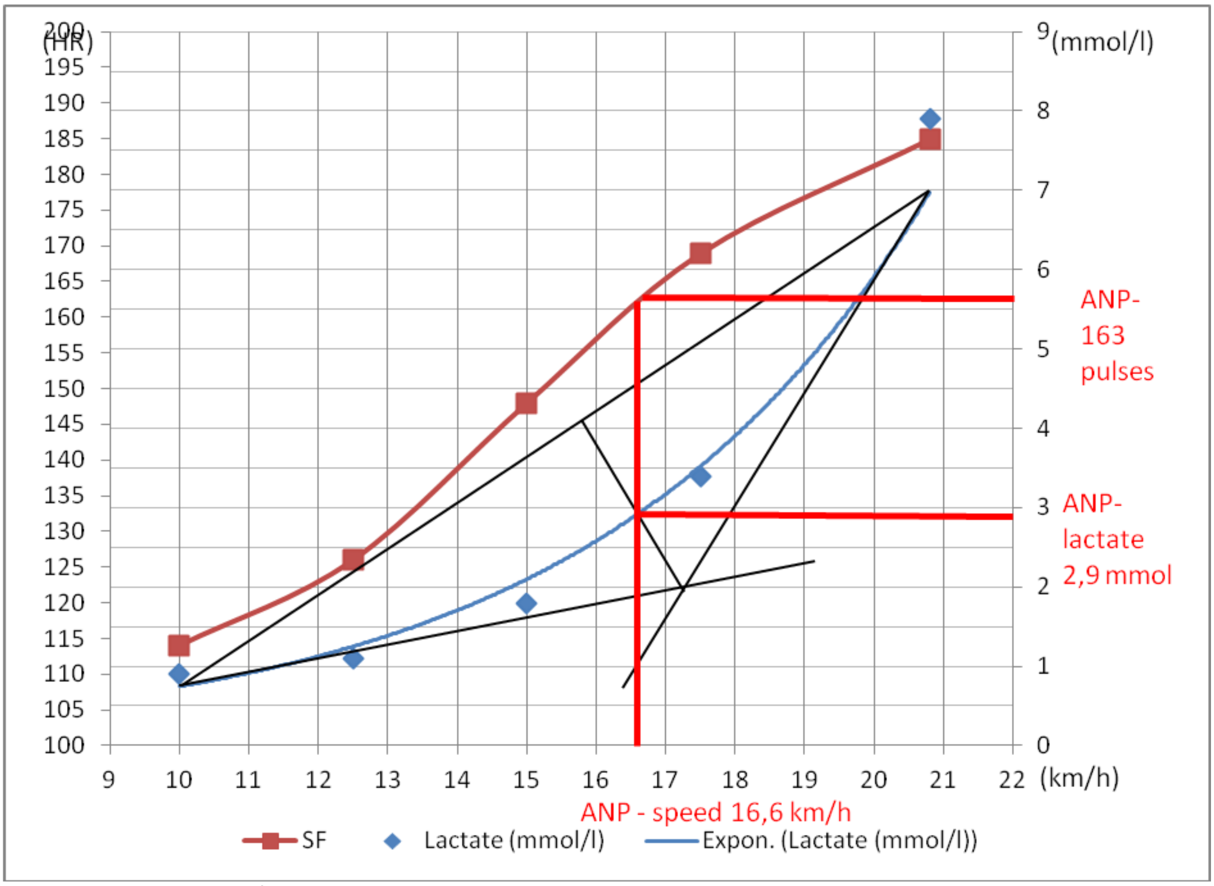

Figure 3 T*esting data from 11/02/2011*

In the following period (between the third and fourth testing) T.H. continued in the preparation with the male SR representation. However, T.H. suffered from a viral disease after his arrival from the glacier. A few days after returning to training process he left for the preparation on snow, first on artificial snow in the Torsby tunnel, and then on natural snow in Ramundsbergene and Östersunde, where he completed the first winter race at the European Cup. However, the disease had left some consequences at the weakened immune system, and since he experienced sinus problems in the first week on snow, it became impossible for him to train at the full potential. The preparation had been focused from the beginning mainly on complex training, whereas the main tool used were skis. In addition, the proportion of complex training increased, in comparison to the previous period, by 480 minutes of load at various intensities. Roller skis and running were used to supplement and enrich the dull training process. Since the training process aimed to increase the volume load, T.H. noticed a decline in speed capabilities – already the third measured section was slower.

Fourth testing – 11/30/2011

The fourth testing was conducted after T.H. returned from the special training on snow. As the results of the testing analysis indicated, we recorded a further decline in performance. We concluded that the causes were the effects of the disease from the beginning of the previous period as well as the problems with the implementation of the training activities in the first few weeks of the special training on snow. The testing showed an additional decline in ANT speed of 0.2 $km.h^{-1}$, as well as a decrease in lactate levels of 0.2 $mmol.l^{-1}$. The only improvement was an increase in cardiac rate of one beat per minute (Table 2).

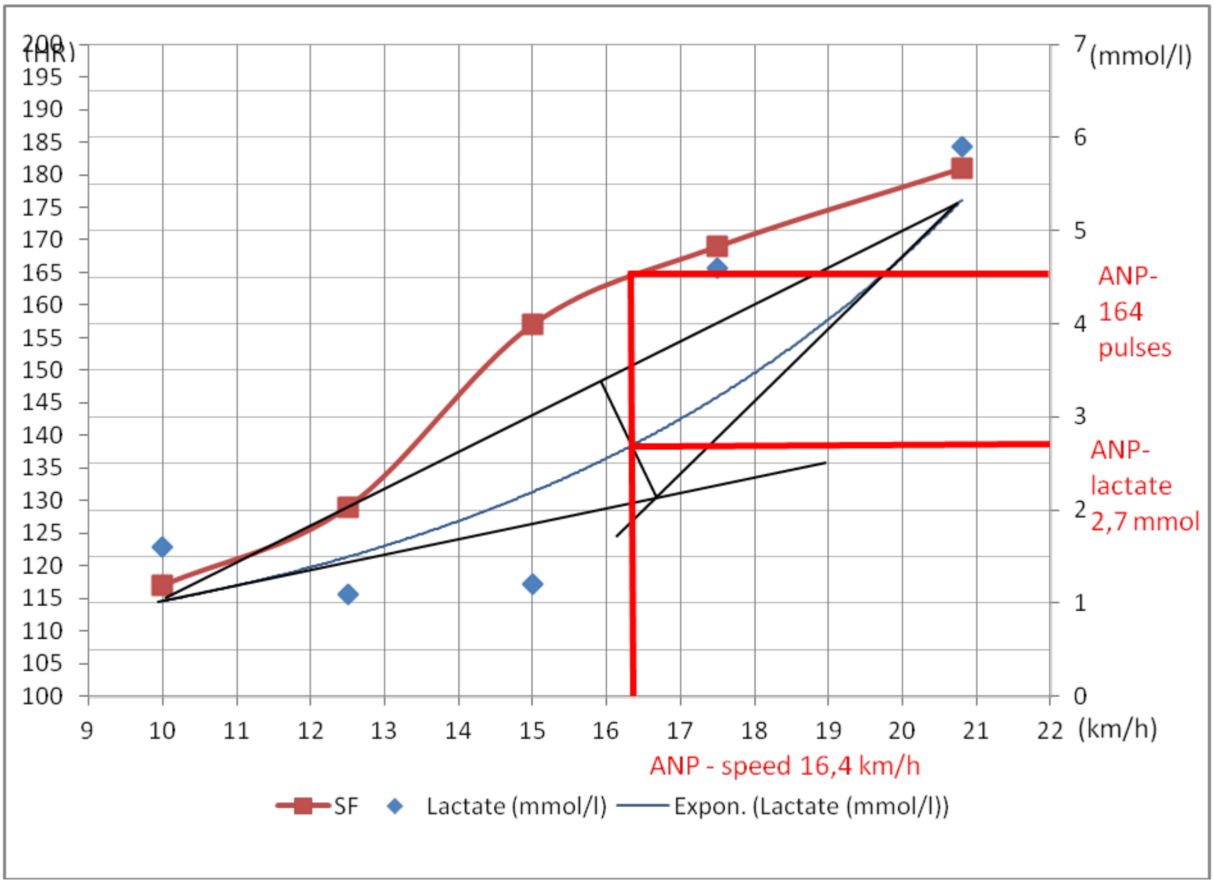

Figure 4 *Testing data from 11/30/2011*

The period between the fourth and fifth testing included the transition from the special winter preparation to the main training period and modeling to achieve the desired athletic condition. During this period, already as a representative in the men's category, he completed six events at the European Cup and four domestic races as a preparation for the peak season, which was the European Championship of under 26 years-old in Osrblie. In the training process, ski as training means dominated, as their total volume increased by 1,240 min. Similarly, the complex training increased, as its volume increased by 100 min. The initial phase of this period, T.H. completed a training at Obertilliach in Austria, where the training still focused on increasing the volume load, but there was already an increase in output intensity mainly above the ANT zones. The strength training was supposed to maintain the high degree of specialization the overall strength to special strength ratio of 10%:90%. The total load had been constant since the third cycle ATC - 400 minutes per mesocycle. We believe that even at this stage of athletic training the training efforts should have been aimed to develop, or rather to maintain the speed abilities.

Fifth testing – 01/11/2012

Test results showed a further decrease in cardiac rate at the ANT, but the positive included the increase of speed at ANT of 0.7 km.h^{-1}, and also a shift in ANT lactate of 0.5 mmol.l^{-1}.

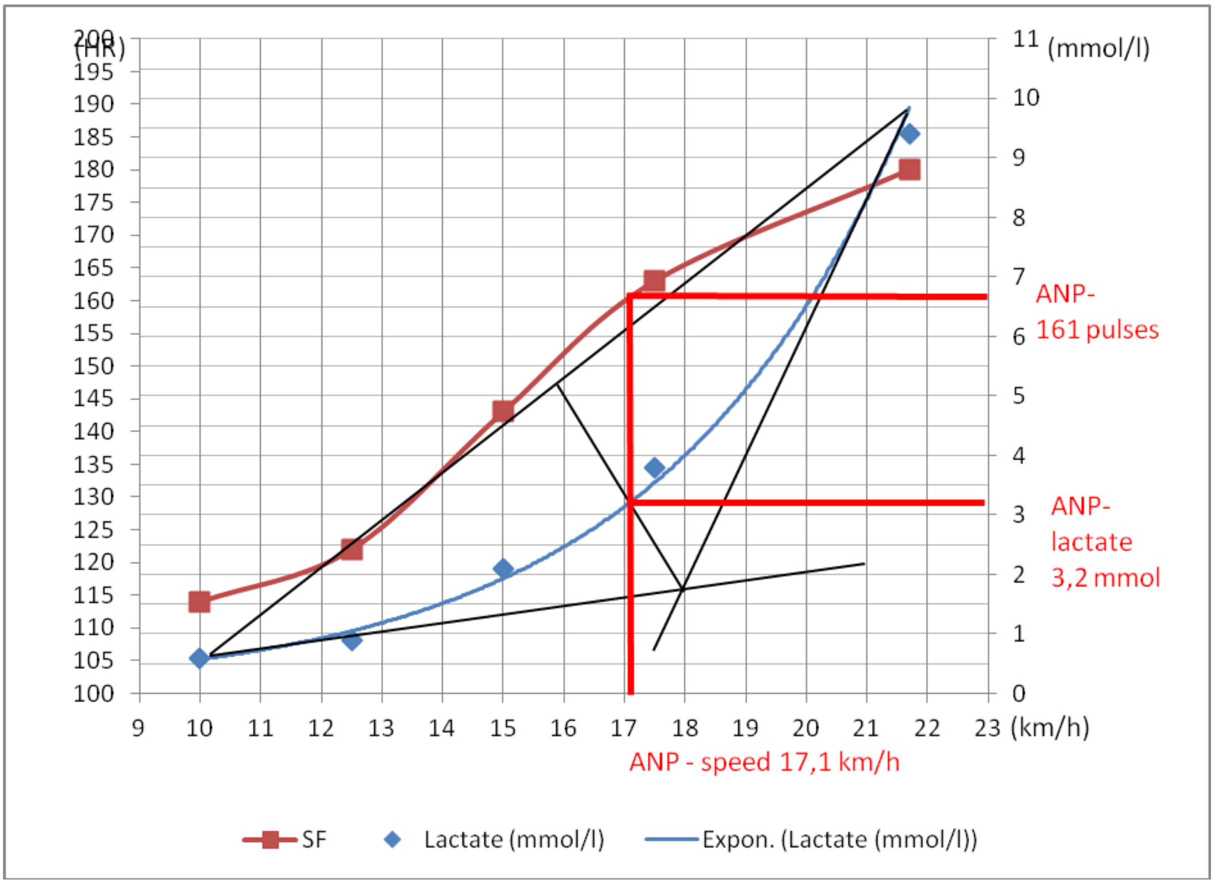

Figure 5 *Testing data from 01/11/2012*

The last testing period was two weeks before the training season for the top event; ATC 2011/2012. The preparation was done in Osrblie, and was led by J. M. Within two weeks, he reduced the training volume to 60%, whereas the training load intensity, especially intensive workouts, remained unchanged. In strength training he, almost exclusively, headed towards specialization. After the completion of the European Championship under 26 years-old, T.H. had a light week with recovery training up to 60% HR, followed by the continuation of the race season. Despite a decline in intensity in the first period, T.H. ended up with the maximum number of minutes of load on skis (2680 minutes in total). This was due to the type of preparation for the following competitions at the end of ATC 2011/2012. Running was at that time used only as a mean of regeneration and was implemented at levels of about 60% HR.

Sixth testing - 02/21/2012

The last testing was completed after the completion of the Slovak Cup. However, T.H. with his training load again leaned towards performance growth for the last European Cup and completed the testing after a full training load, which was also reflected in his results. Again, ANT cardiac rate and ANT speed decreased (Figure 6). His cardiac rate reached the lowest value recorded - 159 beats per minute, similarly, lactate reached the lowest recorded value as well - 2.5 mmol.l^{-1} (Table 1).

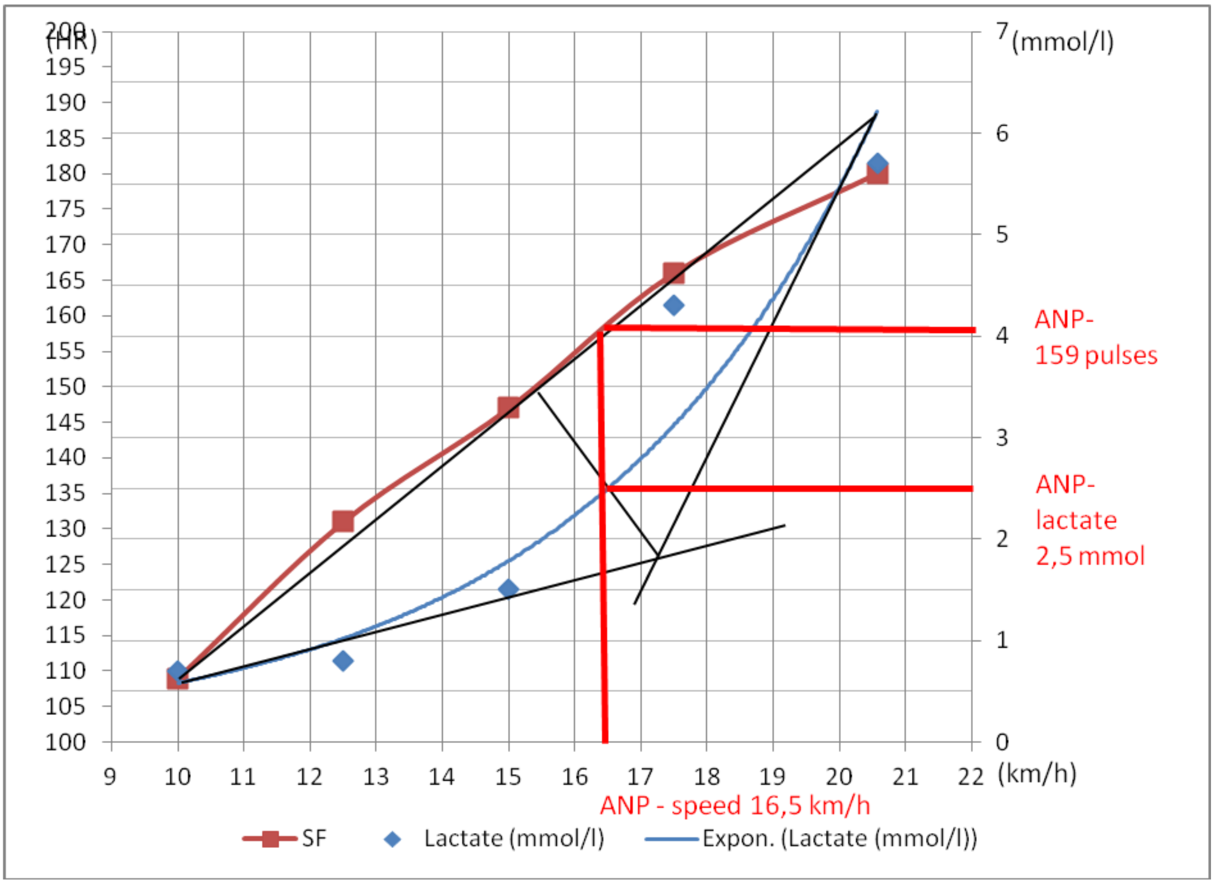

Figure 6 *Testing data from 02/21/2012*

Based on the results in Table 2, we conclude that the first test results are greater than the results of the last test. However, the fifth test is especially interesting because there was measured an increase in the ANT speed as well as an increase in ANT lactate levels. The reason for the decrease in running speed in ANT, we consider to be that in winter running is only used as regeneration training, compared to summer when it is used not only for recovery, but also for functional development with the use of all intensities.

The cause for the decline in blood lactate levels we consider to be caused by the high number of races T.H. had completed in a short period, which lead to body exhaustion. The organism has adapted to the load so that it did not produce a large amount of lactic acid at maximum performance, thereby reducing the negative impact of acidification of the body on the aerobic and anaerobic abilities of the athlete. On this basis, we suggest T.H. the next season to factor into the training process, training units resembling by their intensity and volume, the races he will attend in winter. However, at the same time he has to follow the rules of super compensation and follow the individual requirements for regeneration of his body after such an intense workload and thereby prevent fluctuations in the functional abilities during the race period. He would gain, already during the preparation, sufficient information on his body's abilities to respond to such intense workload.

In Figure 7 we present the relations of measured ANT cardiac rate values, volume, and the intensity of training loads in the periods between the testing. The periods in between the testing were not of equal length, so we cannot take the volume as an explanatory variable. However, the intensity of the practiced volume we can compare as the ratio of individual intensities. We note that in the period of the greatest decline in ANT cardiac rate was workout at intensity II in relation to workout at intensity III six times greater. However, when there was a change and the portion of workout at intensity III increased, the cardiac rate at ANT increased as well. In the fourth testing period, we once again noticed an increase in training load proportion in the middle zone, which resulted in the second largest change in the ANT cardiac rate and a decrease again.

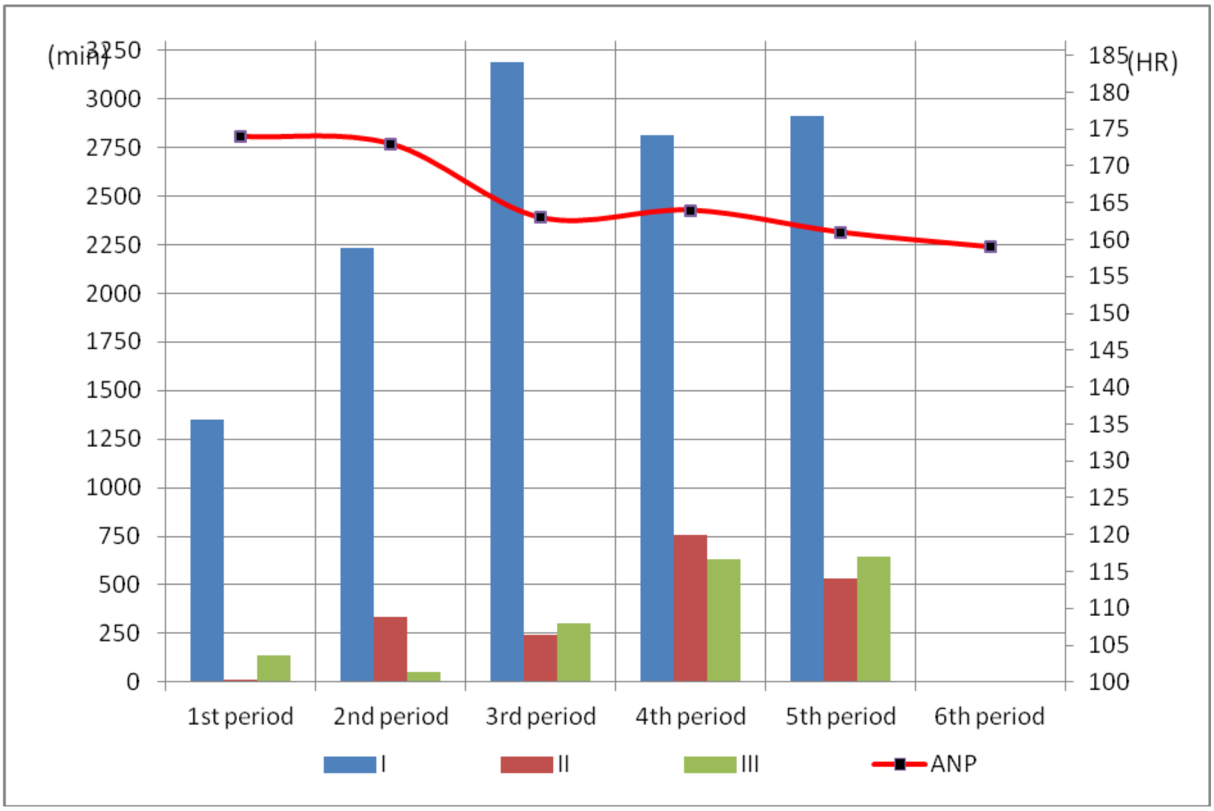

Figure 7 *Comparison of the relationship between intensity and volume of training with our ANT values measured in different periods*

CONCLUSION

As mentioned above, training of a professional athlete is a complex process, which is subject to many factors. Therefore, an increase in ATC running performance depends on the used training methods and means, thus training is very individual.

After the second testing, T.H. was not able to achieve the same level of speed capabilities at ANT. Similarly, the cardiac rate values were declining, which can be justified by the fact that during winter training, running was only used as a means of recovery training. As the main reasons behind this (T.H.'s) trend we would particularly point out that his summer training was led by a personal trainer, whereas during the autumn and winter special training, he attended training events with the male representation, which conducted the training in a different way. The main difference was that T.H. during the summer training omitted workload training at intensity II, however, at the training events of representatives were the workouts designed in that way; to develop the speed abilities. Another reason of the decrease in performance we consider that only by respecting the fundamental laws of body adaptation to training, its functional development is possible. In this respect, the problem was the number of races that T.H. completed within a short period of time. During a high intensity load, which lasts more than 10 min in Biathlon, there is an increase in lactate levels to high levels. Acidic environment with pH around 7.0, acts unfavorably to enzymes, which provide enough energy during an aerobic load. The high acidity of the internal environment blocks this system, resulting in a total aerobic capacity reduction of the body. Such a block may last even a few days and if the body does not have enough time to recover, there is a decrease in aerobic capacity (Soumar et al. 2000). The arguments are justified by the fact that T.H. after returning from training in Torsby – Ramundberget – Öestersund had one of the worst results of the testing. Subsequently however, after three weeks of training by the model he was trained by from the beginning of the season, he once again achieved sati HRactory results in the senior category at the European Cups, but also at the home races. Then, after the period of competitions, his performance has fallen again, but after a two-week training he again managed to get the performance capabilities at a high level, based on which we express the assumption that the proband should from the beginning of the next season either change the training model and increase the proportion of training at intensity II or continue training throughout the year with omitting this band. It is clearly visible that during the monitored period he did not reach a stable athletic shape. The only indication was the period from 12/11/2011, which was planned to ascent to the peak of the season, but already by the end of the month T.H. experienced a decrease in running performance. We see the cause in the insufficient preparation for the high volume load and intensity, which is difficult to achieve because T.H. is only 21 years old so his endurance and speed capabilities are not adapted to such a load. The only way to stop the decreasing performance was the compensation of a great volume at high intensity by aerobic training to develop his functional skills. The solution also had a final effect, which can be noticed in the fifth testing, but in the short period we only managed to retain the downward trend and after the top races of the season, T.H. again experienced a decline in running performance, which was observed during the sixth testing. Another recommendation for T.H. is to consider the fact that his ANT is at the level of 180 pulses in spirometry examination, but the maximum HR is at 187. We conclude that he is not able to work under anaerobic conditions, which may negatively affect his shooting and running performance (if in discomfort). Based on the results we suggest T.H. not to switch various training models in the next season, but remain only with one, which could have a positive impact on the formation and maintenance of a stable skiing performance in the season 2012/13. The results convinced us that in order to increase the effectiveness of training it is important to make use of current knowledge, especially in exercise physiology.

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