

## **ANAEROBIC LACTATE RESISTANCE OF A CROSS TRIATHLETE'S BODY**

***Svetlana Liparova, Mgr.***

Department of Physical Education and Sports, Faculty of Arts,  
Matej Bel University in Banska Bystrica, Slovakia

---

### **Abstract**

Monitoring of athletes and assessment of their current performance capacity is an integral part of the training as well as the whole training process. It requires an individual approach of the coach and the athletes who should know their assets as well as their limits.

Testing provides us with the opportunity to assess the current state of an athlete's body and their resistance to the load. These findings subsequently represent the basis for the evaluation of the training effect of the load, for adaptation of the training units and setting further course of the training process (Cillik & Tataruch, 2013).

In our study, we discuss the resistance of a cross triathlete's body to the load. We used a lactate test – 4x2 km with gradually increasing load. All the tests were performed in laboratory conditions at Matej Bel University in Banská Bystrica.

We were able to identify the triathlete's individual thresholds (aerobic threshold = AeT, anaerobic threshold = AT) by using the lactate test outcomes as a base. Our findings were subsequently correlated with the selected parameters from the training logs. The main research method was the regression and correlation analysis of the time series. The results obtained by mathematical statistics were subjected to the substantive analysis. The results and findings show that it is necessary to adjust the ATC and to time the increase of the AT towards the peak of the season. Training zones of various sports had different impact on the changes in the AT curve with different time lags as well as various levels of statistical significance (see the results).

The most significant positive correlations of volume indicators and speed changes in the AT appeared during the second time lag. In addition to the cycling discipline, positive correlation of volume indicators appears also five months before the ascent of the AT curve. On the contrary, negative impact of the volume indicators appeared with the lag of one mesocycle.

---

**Keywords:** Anaerobic threshold, triathlon, lactate resistance of the body

## **Introduction**

Cross triathlon is a summer sport, thus the season's peak is equally planned for summer. The preparatory phase begins in October and continues until the first race at the end of April. This is followed by the competitive phase which begins with the first duathlons. The peak of the season is represented by the World, European or Slovak Championships. Other races serve to control the level of an athlete's physical fitness and are a good training method during the ATC.

As in most endurance sports, development of basic endurance (BE) is essential also for cross triathlon and it represents 60 – 85% of the total training volume. Basic endurance zone comprises 75 – 85% of the individual maximum, i.e. aerobic metabolism. Continuous training methods are considered to be the most appropriate ones (Neumann et al., 2005).

Basic endurance zone is interconnected with the aero-anaerobic zone, i.e. special race endurance which ranges from 85% up to 95% of the individual speed maximum. It covers 10 – 25% of the training plan. To develop basic endurance, the continuous intensive and alternating methods as well as an extensive form of the interval method are used.

Special endurance is being developed by the race endurance training while the training speed represents 95 – 105% of the individual maximum. It is the control and race training method similar to the race for its distance and speed of rate. This method represents approx. 5% of the total training volume.

The race speed training at short tracks is referred to as the speed endurance development. All of these methods are intensive forms of the interval training. The energy coverage is similar to the one presented during the race. The annual volume represents 2 – 3% and the speed reaches 100 – 120% of the speed maximum.

1 – 3% of the total training volume comprises the speed and strength endurance training. This represents the endurance development in difficult conditions, i.e. with resistance.

The strength development is equally essential. It represents one of the key factors in the endurance training. One can develop the muscle groups that are the most relevant for the specific discipline and the most strained during performance by the specially designed training sessions. The training methods should be compatible with the structure of the athletic performance (Neumann et al., 2005; Mandzakova, 2012).

Formanek & Horcic (2003) determine the internal load by means of heart rate in relation to the anaerobic threshold. Using this as a base, Formanek & Horcic specified three levels of the training intensity (Table 1).

**Table 1 Characteristics of the Basic Training Zones in Triathlon (Formanek & Horcic, 2003)**

Training zone	HR level	Lactate (mmol.l <sup>-1</sup> )
Intensity I – Sub-threshold zone	75 – 95% of the HR <sub>AT</sub>	1 – 3
Intensity II – Threshold zone	95% – 102% of the HR <sub>AT</sub>	2 – 5
Intensity III – Supra-threshold zone	93 – 100% of the HR <sub>MAX</sub>	5 and more

Sub-threshold zone (Intensity I) is divided into 3 sub-categories:

- Long-term endurance III – intensity mainly affecting increase of the fat reserves as the primary source of quick release energy and is very important during the training for a long triathlon. The intensity reaches 75 up to 85% of the HR<sub>AT</sub>.
- Long-term endurance II – intensity of movement developing mainly efficiency of the systems providing their performance by burning the fat reserves as a source of quick release energy. Development of this type of endurance is particularly important for a middle distance triathlon. Intensity reaches the level of approx. 80 – 90% of the HR<sub>AT</sub>.
- Long-term endurance I – intensity of movement ensuring and developing ability to obtain energy by burning the mixture of fat and sugar. It is the basic aerobic endurance that develops aerobic capacity and is important for all the triathlon disciplines. The intensity of movement reaches approx. 85 – 95% of the HR<sub>AT</sub>.

The threshold zone (Intensity II) is a load at the AT level. By swimming or running at the HR<sub>AT</sub> speed level, we are capable of maintaining the pace at the AT level for a longer time. If the speed of our movement while swimming, cycling or running is slightly above the AT level, the speed of movement at the AT level increases.

The supra-threshold zone (Intensity III) represents the intensity of movement above the AT level. Training in this zone focuses particularly on the development of endurance in different parts of sprint and short distance triathlon (400 up to 1,500 m swim, 10 up to 40 km bike and 3 up to 10 km run). This is the level of training with maximum oxygen uptake. In addition to the special race endurance, this category includes the speed and intensity of movement which is higher than the race intensity.

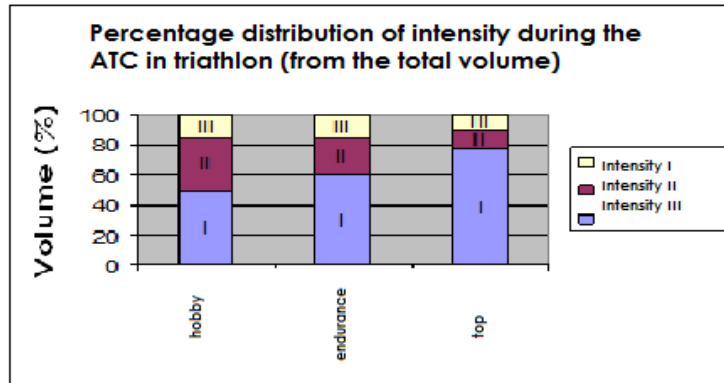


Figure 1 Percentage distribution of the intensity in the ATC from the total load volume in triathlon (Formanek & Horcic, 2003)

1. Intensity III (Supra-threshold) – share on the load volume in the ATC represents 5–10%
2. Intensity II (Threshold) – 15–30%
3. Intensity I (Sub-threshold) – 55–70%
4. REG – activation, regeneration – 5–15%

Proportion of the supra-threshold and threshold intensity in total volume of the load in ATC decreases with the increasing performance, however, in the absolute values, the volume in all zones increases with the increasing performance (Fig. 1).

As stated by many authors (Verchojansky, 1992; Mader, 1994; Reisse et al., 1994; Neumann et al., 2005), development of the special endurance is a subject to the level of the basic endurance achieved.

From the physiological point of view, there are two fundamental factors influencing performance in triathlon: the first one is ability to produce the biggest amount of energy in working muscles and the second one is ability to transform this energy as efficiently as possible resulting into the horizontal movement. A triathlete's body works mostly in aero-anaerobic regime, therefore the movement is fuelled by the aerobic breakdown of sugars and fats but, at the same time, the intensity of the movement is enhanced by the transformation of sugars into energy. Therefore, lactate is partially degraded already in the course of loading. Anaerobic component is gaining its importance particularly during the rapid changes of pace (e.g. the initial acceleration at the beginning of the swimming discipline, uphill cycling or running or in the triathlon finish).

Regarding the  $VO_2$  max during the aerobic performance, its level is often not as important as the economy of movement and the ability to work at a high percentage level of  $VO_2$  max for a long period of time.

Objective information about the current level of the AeT and the AT, as well as the  $VO_2$  max level, is one of the starting points when creating the aerobic training loads. Considering the adequate heart rate, the level of

lactate and the percentage of  $\text{VO}_2$  max use, the knowledge of possibility to manage the intra-individual endurance load becomes complete (Laczo, 2004). Appropriate application of the continuous methods (with steady, alternating or increasing intensity) as well as the discontinuous methods (extensive interval method with variable duration and intensive interval method with variable duration), enables efficient development of the aerobic endurance. Training up to 40 – 60%  $\text{VO}_2$  max has mostly an immunostimulatory effect.

However, in terms of training effect, the level of physiological body changes caused by the load of certain intensity and duration is much more important. The most important organs of the circulatory and respiratory systems respond to the muscle work, especially with a longer duration. The most appropriate parameter reflecting the level of their activation during the physical load is the heart rate (Hamar, 1989).

As stated also by Valiska (2012), all the studies and results show that adaptation to the aerobic load is the primary goal set at the very beginning of the training process. The aerobic system is a kind of “trash can” where the lactate and alactate loads are metabolised to  $\text{CO}_2$  and water in Krebs cycle. If we do not build this base strong enough, the entire system could collapse in no time.

During this adaptation, we are trying to achieve the highest  $\text{VO}_2$  max and anaerobic threshold possible, even though we realise that the inheritance rate for the  $\text{VO}_2$  max is approx. 66% up to 85%.

Running disciplines ranging from 5,000 m to half marathon or marathon depend significantly on the anaerobic capacity since the speed of running reaches approx. the level of anaerobic threshold. Elite endurance athletes do not increase their performance through the higher  $\text{VO}_2$  max but through the greater ability to use a larger fraction of  $\text{VO}_2$  max, i.e. their anaerobic threshold is shifted closer to 100% of the  $\text{VO}_2$  max.

The anaerobic threshold is the most appropriate and the simplest indicator of the performance in disciplines ranging from 5,000 m to marathon. It represents  $\text{VO}_2$  max and the economy of running.

The elite 800m runner's AT is at 83%  $\text{VO}_2$  max, a 400m runner's AT is at 84%, a marathon runner is at 86 – 88%  $\text{VO}_2$  max and an average runner (3h 30m) has the AT of 70%  $\text{VO}_2$  max. The world's best football players play 66% of the game time at 77% of their  $\text{VO}_2$  max, i.e. approx. 170 BPM.

Physiological values of triathletes in all disciplines are very similar to those of the athletes who practice only one of the triathlon disciplines, whilst they have to divide their time among three different disciplines. Physiological predispositions of triathletes are particularly similar to those of cyclists and athletes-runners thanks to the cross trainings (swimming – cycling, cycling – running), i.e. the transition training. However, it does not

affect the swimming discipline. With regards to these findings, triathletes are recommended to benefit from cross/combined trainings (Misarosova & Mandzak, 2003; Suriano & Bishop, 2007; Hruzova, 2006; Bonacci et al., 2010; Papadimitriou & Papadopoulos, 2007).

The whole process of adaptation to aerobic load takes several years. The peak of the aerobic adaptation can be achieved after 15 weeks within the annual training cycle. Initial signs of adaptation begin to emerge after approx. 10 – 14 days. Periodisation of the endurance training will therefore depend on the individual – on their inborn predispositions, sports discipline they practise (sprinter, middle-distance runner, professional long-distance runner, team sports runner, etc.), their training period and their time available (Valiska, 2012).

Many authors (Weltman, 1995; Gladden, 2000; Bonetti, 2012; Dalleck & Kravitz, 2012) consider the  $VO_2$  max and particular thresholds determination to be the determining factors in endurance sports. Knowing the optimal training load allows us to develop the lactate threshold (Weltman, 1995).

The lactate threshold is an important determinant of the endurance activities. The physiological parameters of an individual are being developed by various endurance training programmes. Knowledge of the training load intensity and its correct designation are essential for the proper determination of the appropriate training programmes (Dalleck & Kravitz, 2012).

Assessment of the physical fitness level is based on the observation of the lactate concentration changes in blood in relation to the level of the load or in relation to the heart rate during the load testing. Basic parameter for assessment of the athlete physical fitness is the anaerobic threshold. It corresponds with the aero-anaerobic transition and stands at the beginning of a rapid increase in the concentration of lactate during the continuously growing load.

The level of lactate in relation to the heart rate is used to determine the training intensity zones and to assess the level of athlete's physical fitness. Among the athletes with higher level of physical fitness, the anaerobic threshold remains almost unchanged. However, the ability to increase their performance at the same heart rate level never ceases to grow. This parameter is used primarily for the aerobic zone management.

#### OBJECTIVES:

1. to determine the dynamics of the load training methods and the changes in the physiological parameters during the ATC.
2. to highlight the impact of the load training to the dynamics of the changes in physiological parameters during the ATC.

## METHODOLOGY

### Subject Characteristics

The subject represents Slovakia in cross and winter triathlon. He regularly takes part in the races of international importance (World and European Championship) as well as in the national races in sprint, Olympic and half-ironman types of tracks.

He began his career in sports as a swimmer in Zilina swimming club – Nereus Zilina. This club participated in the formation of the triathlon club under the same name. Their swimming coach was P.F. As a swimmer, he has excellent fundamentals for triathlon.

T.J., born in 1983, is 179 cm tall with an average weight of 74 kg. He has been a triathlete since he was 13 years old. Physiological parameters of this competitor are:  $VO_2$  max 78.8 ml/kg/min, HR max 184, HR AeT  $138 \pm 2$  and HR AT 171. As mentioned above, he represents swimming and triathlon club Nereus Zilina. He prepares his own training plan. He trains with his training group which is under his professional guidance. During winter training, he cooperates with M.S., an athletics coach and a national coach for winter triathlon and cross triathlon from Banska Bystrica.

T.J. won the Slovak Championship 2011 in winter triathlon. He came in second place at the Slovak Championship 2011 in cross triathlon. He is the Champion of Slovakia 2012 in winter as well as cross triathlon. In 2012, he came in third place at the Winter Triathlon European Cup in Switzerland and in fourth place in Estonia. He came in seventh place at the Winter Triathlon World Championship, but due to technical reasons he could not finish the race at the Winter Triathlon European Championship. He finished eighth at the Cross Triathlon European Championship (the Hague, the Netherlands).

### Characteristics of the Research

Our research had an intra-individual character and was carried out “ex post facto”. The subject was a cross triathlete.

The test period – the annual training cycle (ATC) 2011/2012 – comprised 13 four-week mesocycles and lasted from 12 September 2011 to 9 September 2012.

The training stimuli included general and specific training load indicators.

To evaluate the data, we used the method of training log assessment, more precisely, we assessed the triathlete's 2011/2012 training log. In order to collect information about the training load in particular bio-energetic H1 – H3 zones, the GARMIN system was employed. When specifying the training methods, we respected the basic condition of equidistant numerical data regarding the quantitative and qualitative aspects of the training load during

individual periods in relation to the conditions underlying the methods used for data processing and evaluation.

The annual results of the function and the lactate tests (4x2 km) represent the criterion of physiological performance (“Y” – dependant variables). Both tests were carried out on HP COSMOS PULSAR 4.0/QUASAR treadmill. The function tests were carried out in laboratory conditions in the Institute of Special Health Care and Training of the Ministry of Defence of the Slovak Republic in Lest. The lactate tests were also done in laboratory conditions at Matej Bel University in Banska Bystrica. We focused on values regarding the anaerobic (AT) and the aerobic threshold in relation to speed ( $v = m \cdot s^{-1}$ ), heart rate ( $HR = n \cdot \text{min}^{-1}$ ), lactate ( $\text{mmol.l}^{-1}$ ), workout load (W), oxygen uptake ( $\% \text{VO}_2 \text{max}$ ), energy delivery (%).

As soon as the testing is finished, we can observe a decrease in pulse rate and thus assess the regenerative abilities of the body (Casri, 2012).

Importance of the workout load and better sport performance increases with the collection and transfer of knowledge in other scientific fields as well as with the experiments concerning specific sport in specific conditions (Kellmann, 2002).

To obtain particular values of the training methods (“X” – independent variables), we chose general as well as specific training indicators used equidistantly in the training practice considering the age. The training and the racing loads were recorded during the individual training cycles. In our study, mesocycles consisting of four seven-day cycles were used. We obtained 21 training indicators relevant to the test period of 13 mesocycles – ATC.

Table 2 General and Specific Training Indicators in Off-road Triathlon

	<b>Training Indicators</b>
<b>General Training Indicators (GTI)</b>	Load Days [n]
	Load Time [h]
	Training Units [n]
	Number of Starts [n]
	Recovery [h]
<b>Specific Training Indicators (STI)</b>	Swimming [km]
	Swimming [h]
	Swimming H1 [h]
	Swimming H2 [h]
	Swimming H3 [h]
	Cycling [km]
	Cycling [h]
	Cycling H1 [h]
	Cycling H2 [h]
	Cycling H3 [h]
	Running [km]



	Running [h]
	Running H2 [h]
	Running H3 [h]
	Running H4 [h]
	Other [h]
	Fitness [h]

## RESULTS

Changes in the subject's AT that occurred during the ATC were the results of the observed training parameters impact (Table 2), especially volume parameters in the individual training zones.

During the season 2011/2012 the subject took part in Cross Triathlon European Championship and in Winter Triathlon World Championship. He also participated in various races of European Triathlon Cup. It follows that during 2011/2012 ATC the subject had planned a two-peak season with the first peak in March (the seventh mesocycle) and the second peak in July (the eleventh to the twelfth mesocycle).

In our research, we took the subject's anaerobic threshold for his current performance level. As seen in Figures 2 – 5, the curve has a sinusoidal character. It proves that the subject's form in the winter season was well timed (depending on the AT) since the curve tells the rise in the seventh mesocycle.

Even though the summer season was successful, based on our graphs and findings, we assume that it could have been more successful. The AT curve only begins to tell the rise while it should have already peaked for the second time. The comparison of volume parameters in all three disciplines and speed zones revealed smaller or bigger differences between the winter and the summer trainings.

Based on our findings, the winter training was managed significantly better in relation to the volume parameters (taking into consideration all three zones) and the subject's form was almost ideally timed.

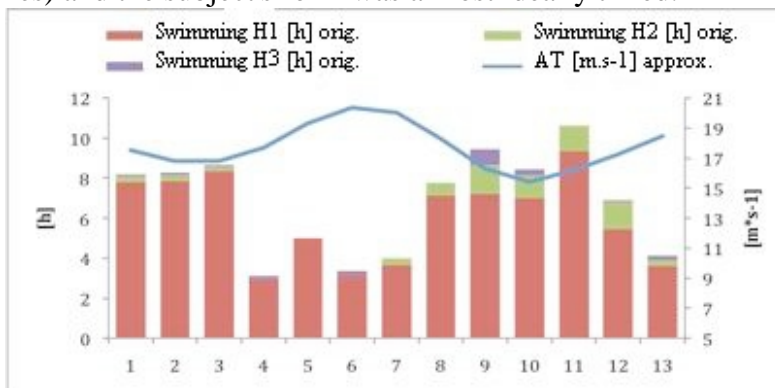


Figure 2 Dynamics of the Workout Load Volume of STI Regarding Swimming and the AT Curve during the ATC

Figure 2 shows the volume parameters in all three tested zones with the curve of the AT level during the whole ATC. We can see that in comparison to the summer training, building of the swimming base was different during the winter training. The workout load volume in the H1 zone does not increase as significantly during the summer training as it does during the winter training, which can be explained by the fact that in the course of the summer training, the subject regularly went swimming to recover from the races. As for the AT, it is a pity, since the big volume of exercise in the H1 zone caused that the AT curve could not rise sooner than it did. Subsequently, the workout load volume in this zone decreased and the AT curve began to rise.

The decrease in the H1 zone is more distinct in the winter training. It was also caused by the cross-country skiing training but nevertheless, the fact remains that swimming in the H1 zone had a positive influence on the AT curve.

The intensification phase during summer started too soon – in the eighth month – which should have been purely aerobic as far as the two-peak season is concerned. The values in the following months are also relatively high. During his training, the subject took part in the first triathlons; the swimming leg was done in the transition zone. To gradually increase the workout load volume would be better solution in this season as well.

The high level of the workout load volume in the H3 zone was observed in the ninth mesocycle, too. It does not correspond to the gradual preparation for the peak of the summer season, i.e. the end of the eleventh mesocycle.

During the winter training, the small workout load volumes appear in this zone each month. The subject was getting to the H3 zone for the short periods of time during the longer sessions in the course of training.

The optimal inclusion and effect of the training method at the time is also proved by the time series correlation, more precisely the time lag.

When applying the time series correlation to the data, we can observe a positive effect of the swimming aerobic base on the increase of AT, especially with a lag of two to five months ( $p < 0.01$ ). On the other hand, it was negatively influenced with a lag of one to six months ( $p < 0.10$ ).

The volume of the aero-anaerobic zone in swimming positively developed after the increase of AT with a lagged cumulative effect of the first ( $p < 0.05$ ) up to the seventh ( $p < 0.01$ ) mesocycle.

The swimming load volume in the transition zone (H2) negatively affected

the AT increase during the whole ATC ( $p < 0.10$ ) with a lag of two ( $p < 0.20$ ) to six ( $p < 0.20$ ) months (Table 3).

The swimming zone with the highest speed led to the positive AT increase with a lag of four mesocycles. During that month, the subject took part in aquathlon, which, four months later, led to AT increase.

The negative effect of the aerobic zone on the AT increase showed with a lag of five months.

The overall volume of swimming as well as the workout load volume in the H1 zone positively correlates with the AT in the fifth time lag. The maximum volume of the workout load in five months before the peak of the season corresponds to the accumulation phase so the positive effect is justified.

The aerobic base positively correlates with the AT – two months before the curve peaks. This is the intensification phase where training sessions are shorter and more intensive. The longer recovery training sessions can have a positive effect.

The positive correlation between the H1 zone and the AT can be noticed in all three disciplines. During 2011/2012 ATC, the subject integrated the low-intensity volume parameters into the training in the correct ratio two months before the AT curve peaked, at least before the peak of the winter season.

On the contrary, negative correlation can be observed a month before the AT reaches its maximum. During this period, the subject should only undergo the trainings at or under the AT level, i.e. the fast and intensive training sessions to increase his speed. The results from the H2 zone also prove the above-mentioned. Positive correlation can be observed in the first time lag and negative correlation in the second time lag. It follows that the zones H1 and H2 are interrelated.

The H3 zone positively correlates with the AT level four months before the increase of the AT. The most intensive training sessions, from our point of view in the ninth mesocycle, when the subject took part in duathlons, had a positive effect on the increase of the AT level four months later. One month earlier (in the fifth mesocycle), we do not recommend any training sessions in this zone.

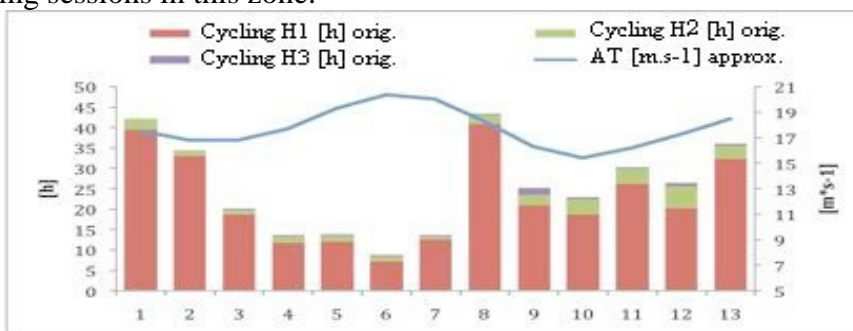


Figure 3 Dynamics of the Load Volume of STI Regarding Cycling and the AT Curve during ATC

As for cycling, the course of the training before the summer as well as the winter season was more balanced. It is quite self-explanatory that the building of an aerobic base during winter trainings takes longer since there is not enough time to build the base before the summer season. The higher volume parameters during the summer training were influenced by natural conditions, which allowed the subject to spend more time cycling. Even during the race, he was in the aerobic zone while cycling. As for cycling, triathletes usually ride the road bicycles. When they descend, they do not have to pedal and worry about dangerous potholes, branches etc. as it is in case of mountain biking. These factors cause an increase of volume parameters in the H1 zone in summer. In the thirteenth mesocycle, the aerobic volume parameter is unnecessarily high.

The values of aero-anaerobic zone are stable during the whole ATC, and change only because of the different character of the summer and winter trainings, which I have already mentioned. The length of tracks is also different in winter and cross triathlon. In winter, the tracks are shorter. In summer months, training in the H2 zone is the most frequently undergone. The subject stays in this zone the longest time even during the race. In the ninth mesocycle, he went to a training camp to increase his cycling speed. Thanks to early spring, he could build a cycling base in home conditions, where he could cycle more kilometres at higher speed and heart rate.

In this mesocycle, the subject also took part in the first duathlons of the season. Duathlon activities consist of running-cycling-running, so he ran the race at higher heart rate (above the AT level) even during the cycling leg.

For the next season we would recommend to completely eliminate training in the H2 zone in the eight mesocycle (after the peak of the winter season) so the AT would be represented by a curve with sinusoidal character. It would also enable the subject to take some rest from training in the H2 zone because the following month, he trained in it again.

The question is whether the training sessions should not be more intensive towards the peak of the season.

The anaerobic zone appears in the third mesocycle. It is quite soon considering that the first peak is planned in four months. In the winter training, the values in the anaerobic zone are approx. at the same level, as was the case in the H2 zone. We recommend intensifying the training. In the summer training, there is a considerable difference in the ninth mesocycle. The subject competed in several duathlons during which he was in this zone as well. The curve may have not risen because it was a while before the peak of the season.

The volume cycling base positively correlates with the increase of the AT level with a lag of two months. A month before the increase of the AT level, the H1 zone negatively correlates with the AT level. However, we can

see the positive relationship between the AT level and the H3 zone. In the cycling training, it is necessary to decrease the volume. On the other hand, a month before the best performance, the training sessions above the AT level are allowed.

The recommended period to intensify the training to the highest extent is four months prior to the performance.

Considering the mathematical and statistical methods, i.e. time series correlation, the cycling training and its volume also influenced the AT level during ATC.

The volume of cycling load positively influenced the increase of the AT level with the cumulative effect lagged by 2 months ( $p < 0.05$ ). On the other hand, the cycling volume in the H1 zone had a negative impact on the increase of the AT level with a lag of a month ( $p < 0.10$ ).

The AT level increased thanks to the number of kilometres ridden in the aero-anaerobic zone, which had a cumulative effect lagged by four months ( $p < 0.20$ ). A month later, the volume parameters in the transition zone negatively influenced the curve of the AT level ( $p < 0.20$ ).

The amount of kilometres ridden in the H3 zone had a positive impact on the increase of the AT level with a lag of two to seven mesocycles at the same level of significance ( $p < 0.20$ ) (Table 3).

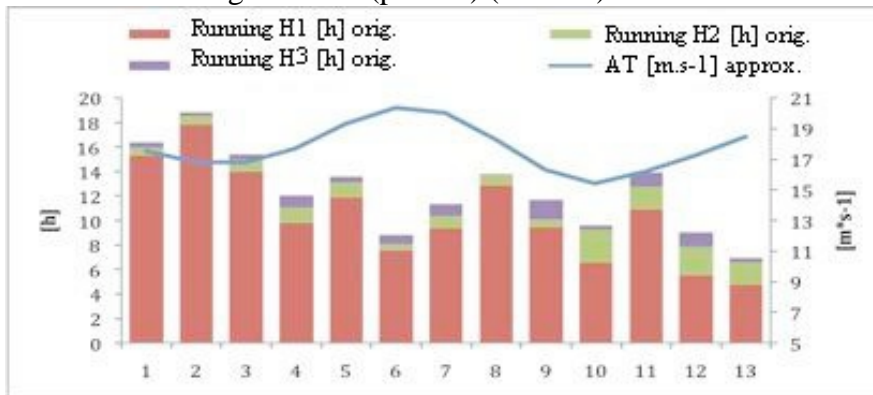


Figure 4 Dynamics of the Load Volume of STI Regarding Running and the AT Curve during the ATC

The aerobic base is being built similarly before the peak of each season. It is only four months during the summer season. Differences can be observed in the other two zones.

In the summer training, the subject adapted to the racing pace a month before the peak of the season – the highest volume parameters; in the following mesocycle, there was a decrease of the volume parameters. In the winter training, the curve had an inverse character and two to three months before the peak of the season, the subject's plan included more volume parameters in the aerobic zone.

As for the increase of the AT level, the winter training sessions and the winter training plan were more efficacious before the first peak of the season.

The anaerobic zone has a positive effect only in the seventh time lag. It negatively influences the curve of the AT level in the first and sixth time lags.

The differences between the winter and the summer trainings are the most evident in this running zone. In the winter training, there is a gradual increase from the fifth to the seventh mesocycle; in the winter training, the increase of the AT level is more chaotic. In our opinion, the great increase of volume parameters in the ninth mesocycle is counterproductive. This may be caused by the fact that the triathlon season and duathlons begin in this mesocycle.

The following increase is due to the subject's participation in half-ironman triathlon in which he mostly raced in the H2 zone and needed more time to recover, i.e. he could not train and race enough in this zone.

In the fifth month, we can observe a positive correlation between the H1 zone and the AT level before the peak of the curve – the accumulation phase, and in the second month, i.e. two months before the rise of the curve. Based on the diagrams, it is clear that less intensive training is better, i.e. to keep his heart rate at lower level two months before the planned peak.

More evident differences can be observed in the transition zone. In the winter training, a gradual increase can be observed from the fifth to the seventh mesocycles. Before the seventh mesocycle, the volume in the H2 zone decreased while in the summer season, it increased. In the summer training, the subject raced on the half-ironman tracks and that obviously did not help him to reach and increase the AT level at the right time. In our opinion, the great increase of the volume parameters in the ninth mesocycle is counterproductive. The reason could be the beginning of the triathlon season and duathlons in this mesocycle.

The following increase is due to the subject's participation in half-ironman triathlon where he mostly raced in the H2 zone and needed more time to recover, i.e. could not train/race enough in this training zone.

This correlation also reflects the negative influence of the transition zone before the rise of the AT curve. In the following season, the subject should reconsider the load in this training zone.

The relationship between the H3 zone and the curve of the AT level and their mutual influence is almost insignificant in 2011/2013 season. The running races and the first duathlons of the season, where the subject reached that level, began too soon before the planned peak of the season. Unfortunately, they did not have a significant effect on the increase of the AT level.

The volume of running load in the H1 zone proved positive with the cumulative effect lagged by two ( $p < 0.20$ ) and five mesocycles ( $p < 0.20$ ).

On the other hand, the cycling volume had negative impact on the increase of the AT level in the first time lag ( $p < 0.10$ ). The same negative impact can be observed in the transition zone ( $p < 0.05$ ) (Table 3).

Table 3 Pair Correlations of Special Training Indicators and Speed Changes in AT

		Time lag (1 lag = 4-week mesocycle)							
		0	1	2	3	4	5	6	7
Anaerobic threshold	Swimming [km]	*				**			
	Swimming H [h]	*				*	*		
	Swimming H1 [h]		****	**			*	**	
	Swimming H2 [h]	**	**	*				*	****
	Swimming H3 [h]					**	**		
	Cycling [km]		*	****	**				**
	Cycling H [h]			**					
	Cycling H1 [h]		*	**					
	Cycling H2 [h]					*	*		
	Cycling H3 [h]		*						*
	Running [km]	*	**				*		
	Running H [h]	*	**				*		
	Running H1 [h]	*	****	*			*		
	Running H2 [h]	****	**						
	Running H3 [h]	*						*	**

Key	$p < 0,20$	$p < 0,10$	$p < 0,05$	$p < 0,01$
Positive level of significance	*	**	***	****
Negative level of significance	*	**	***	****

### Conclusion

The peak of the winter season 2011/2012 came rather late (March = the seventh mesocycle). The European Championship took place at the beginning and the World Championship at the end of the same month. The short transition period came only after this racing phase. Due to the opening of the summer season in April, the subject did not have enough time for the several-months-lasting aerobic training like he did before the winter season. That is the reason why he had to draw largely from the training volumes he already had from the winter season. Before the summer season, he spent one month (the eighth mesocycle) completing the aerobic base, followed by an intensification phase, which lasted 2 – 2.5 months, i.e. 10 weeks.

During the training before the winter season, he devoted two mesocycles to accumulation and 3 mesocycles to the intensification with the gradual reduction of volume parameters and the intensity increase. The winter training culminated in the seventh mesocycle, i.e. during Winter Triathlon European and World Championships. The volume parameters increased during that period.

The subject cannot change the dates of the season’s top sports events he intends to participate in. However, we need to consider adjusting the summer part of the ATC so that the AT has enough time to rise.

The intensification performed too early and the transformation performed in the ninth mesocycle when the subject took part in many races

at and above his AT level may have prevented the situation. We recommend substituting at least two races in that period of time by the high quality training during which the subject can control his heart rate and keep to the precisely set limits. That approach could have helped the subject to improve his physical fitness towards the planned peak of the season.

In the first part of the ninth month, I would pay greater attention to the volume and started the intensification phase in the second half of the same month and continue until the mid-part of the eleventh month, i.e. during the subject's second peak of the season.

In this sense, the training cycle would be divided as follows: 6 weeks of accumulation + 8 weeks of intensification + 3–4 weeks of transformation.

Winter training: 10 weeks of accumulation + 12 weeks of intensification + 6 weeks of transformation.

The duathlon season in the ninth mesocycle ruined our AT increase and the peak achievement at the end of the eleventh and the beginning of the twelfth mesocycles.

This study is a part of the grant project VEGA 1/1158/12: Adaptation Effect of the Training Load in Individual Sports.

### References:

- BONACCI, J. – GREEN, D. et al. 2010). Changes in running kinematics after cycling are related to alterations in running economy in triathletes. In *Journal of Science and Medicine in Sport*, 13, 2010 pp. 460-464.
- BONETTI, D. 2010. *Periodisation for Endurance Sports*. [online]. 2010). [ibid. 2012.04.28] Available on the Internet: <[www.ausport.gov.au](http://www.ausport.gov.au)>
- CASRI. 2012. *Test pro zjistení laktátové křivky*. [online]. 2012. [ibid. 2012.05.01.] Available on the Internet: <<http://casri.cz/web/index.php/produkty/83-5-test-pro-zjitni-laktatove-kivky>>
- CILLIK, I. – TATARUCH, R. 2013. Effect on load in athletics training. Opole: University of Technology. 2013. 77 p. ISBN 978-83-928426-3-7
- DALLECK, L.C. - KRAVITZ, M.S. & L. 2012. *Optimize Endurance Training*. [online]. 2012. [ibid. 2012.05.01]. Available on the Internet: <<http://www.unm.edu/~lkravitz/Article%20folder/optimizeendurance.html>>
- FORMANEK, J. - HORCIC, J. et al. 2003. *Triatlon*. Prague: Olympia, 2003. 248 p. ISBN 80-7033-567-X.
- GLADDEN, L. B. 2000. Muscle as a consumer of lactate. In *Medicine and Science in Sport and Exercise* 32 (4), 2000. pp. 764-771.
- HAMAR, D. 1989. *Vsetko o behu*. Bratislava. Sport, 1989. ISBN 8070960108.
- HRUZOVA, A. 2006. *Analyza stvorrocneho treningoveho cyklu triatlonistky I. vykonnostnej triedy*. (Master's thesis). Banska Bystrica: Department of



physical education and sport, FHV, Matej Bel University in Banska Bystrica, 2006, 55 p.

KELLMANN, M. 2002. *Enhancing Recovery : Preventing Underperformance in Athletes*. Human Kinetics. 2002, 334 p. ISBN 0736034005.

LACZO, E. 2004. Vytrvalostne schopnosti a ich rozvoj. In: *Teoria a didaktika sportu*. Bratislava : FSPORT CU, 2004, 117 p.

MADER, A. 1994. Die Komponenten der Stoffwechsellistung in den leichtathletischen Ausdauerdisziplinen . Bedeutung für die Wettkampfleistung und Möglichkeiten zu ihrer Bestimmung. In *TCHIENE, P. (Hrsg.): Neue Tendenzen im Ausdauertraining. Informationen zum Leistungssport. Bd. 12. Frankfurt: Bundesausschuß Leistungssport*.

MANDZAKOVA, M. 2012. Analysis of selected training tools of an athlete in duathlon. In *Acta Universitatis Matthiae Belii = physical education and sport* . Banska Bystrica : Department of physical education and sport, FHV, Matej Bel University in Banska Bystrica, 4 (2), 2012, pp. 48-56, ISSN 1338-0974.

MISAROSOVA, M. - MANDZAK, P. 2003. Horsky duatlon ako vhodny doplnok pripravy mladych triatlonistov v pred a po sutaznom období.. In: *Turistika a sporty v prirode „ Sucasny stav a najnovsie trendy“*. Liptovsky Mikulas: Military Academy, 2003. 98 pp. ISBN 80-8040-221-3.

NEUMANN, G. - PFUNTZNER, A. - HOTTENROTT, K. 2005. *Trénink pod kontrolou*. Prague: Grada Publishing, 2005. 184 p. ISBN 80-247-0947-3.

PAPADIMITRIOU, I. – PAPADOPOULOS, CH. 2007. Are running and swimming two independently evolved behaviors? A study of world-class triathletes. In *New Studies in Athletics*, 22, no. 4, 2007, pp. 81-85.

REISSE, M. et al. 1994. *Untersuchungen zur wirksamen Gestaltung des kraftbetonten Grundlagenausdauertrainings*. Ergebnisbericht. Institut für Angewandte Trainingswissenschaft, Leipzig.

SURIANO, R. - BISHOP, D. 2007. Physiological attributes of triathletes. In *Journal of Science and Medicine in Sport* [online]. 2010, no.13., pp. 340 - 347. [ibid. 2012.04.24.] Available on the Internet: <www.sciencedirect.com>

VALISKA, G. 2012. *Adaptacny efekt na aerobne treningove zatazenie v jednorocnom treningovom cykle*. [online]. 2012. [ibid. 2012.04.12.] Available on the Internet: <<http://www.sportcenter.sk/stranka/adaptacny-efekt-na-aerobne-treningove-zatazenie-v-jednorocnom-treningovom-cykle>>

VERCHOJANSKY, J. 1992. *Ein neues Trainingssystem für zyklische Sportarten*. Köln : Trainerbibliothek des DSB Bd. 29. 1992.

WELTMAN, A. 1995. *The Blood Lactate Response to Exercise*. Champaign, IL: Human Kinetics, 1995.