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Smart training equals performance

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Abstract

Introduction: Training individualization is a key element for optimal sports performance and protection of the athlete's health. The training program should be adjusted according to each athlete's characteristics and should be based on data obtained using proper evaluation. Cardiopulmonary exercise testing (CPET) is considered the gold standard for aerobic exercise capacity assessment and provides an increased quantity of information in regard to body reaction to effort, offering a complete perspective over the O_2 transportation system and its utilization in metabolic processes.

The aim of this study was to highlight the importance of a scientific approach regarding the physical training, starting from junior level.

Methods: For a 3 years period (2013 - 2016) we followed the evolution of a professional cyclist (14 years old at baseline), in terms of cardiopulmonary parameters. During this period, he was tested 5 times and he followed a special training program adapted according the tests results. The CPET was performed in the laboratory using a stationary electronically braked cycle ergometer (Lode Corival, Netherland) and a breath by breath gas analyzer device (Cortex Metalyzer 3B, Germany).

Results: We observed an improvement trend in almost all parameters investigated during the 3 years evaluation period. Comparing post-season records from 2013 and 2016, we noticed an increase of 54% in maximal aerobic power and 50% in peak oxygen uptake at anaerobic threshold and an even greater increase (59%) of these parameters at maximal effort achieved during CPET. After these 3 years of training we observed a significant improvement of ventilatory efficiency and cardiac performance during exercise.

Conclusions: The study indicate that proper training adaptation according to data obtained using CPET, can bring an important progress in terms of performance.

***Key words**:* performance, cycling, individualized training, cardiopulmonary exercise testing

Rezumat

Introducere: Individualizarea antrenamentului sportiv este un element cheie pentru performanţa sportivă şi promovarea sănătăţii atletului. Programul de antrenament trebuie ajustat în funcţie de caracteristicile fiecărui sportiv şi trebuie să se bazeze pe date obţinute printr-o evaluare adecvată.Testarea cardio-pulmonară la efort (CPET) este considerată standardul de aur pentru evaluarea capacităţii aerobice şi oferă o cantitate sporită de informaţii privind reacţia organismului la efort, oferind o perspectivă completă asupra sistemului de transport a O_2 şi utilizarea acestuia în procesele metabolice.

Scopul acestui studiu a fost de a sublinia importanţa unei abordări ştiinţifice în ceea ce priveşte pregătirea fizică, pornind de la nivelul de juniori.

*Metode:*Pentru o perioadă de 3 ani (2013-2016) am urmărit evoluția unui ciclist profesionist (cu vârsta de 14 ani la momentul inițial), în ceea ce privește parametrii cardiopulmonari. În această perioadă a fost testat de 5 ori şi a urmat un program special de pregătire adaptat în funcţie de rezultatele testelor aplicate. CPET a fost efectuat în laborator folosind cicloergometrul staţionar (Lode Corival, Olanda) şi un dispozitiv de analiză a gazelor respiratorii (Cortex Metalyzer 3B, Germania).

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Rezultate: Am observat o tendinţă de îmbunătăţire în cazul majorităţii parametrilor investigaţi în perioada de studiu. Comparând înregistrările post-sezon din 2013 și 2016, observăm o creştere a puterii aerobe maxime de 54% și o absorbţie maximă a oxigenului de 50% la pragul anaerob și o creștere și mai mare (59%) a acestor parametri la efortul maxim obținut în timpul CPET. După acești 3 ani de antrenament, am observat o îmbunătățire semnificativă a eficienţei ventilatorii şi a performanţei cardiace în timpul exercițiilor fizice.
Concluzii: Studiul indică faptul că o adaptare adecvată a antrenamentului în funcţie de datele obținute prin utilizarea CPET poate aduce o îmbunătăţire semnificativă a performanţei.

***Cuvinte cheie**: performanţă, ciclism, antrenament individualizat, testare cardio-pulmonară*

Introduction

Lately, a large number of sports specialists show a special interest in the scientific approach of athletes' training, focusing on monitoring and individualization according to the individual particularities but also the characteristics and the specific objectives of the practiced sport.

Scientific evidence shows that training individualization is a key element for optimal sport performance and athletes' health protection [1]. The training program should be adjusted according to each athlete's characteristics and needs and should be based on data obtained using specific tests.

A proper individualization of the training, based on specific and eloquent tests, can boost training efficiency and at the same time prevent overloading and injuries [2].

The monitoring and individualization of the training is related to the intensity, duration and volume, but also to the psychological aspects and the training period.

Regarding training intensity, cardiopulmonary exercise testing (CPET) is considered the gold standard for aerobic exercise capacity assessment [3]. CPET provides a comprehensive assessment of the exercise response, and reflects the interactions and limitations of the cardiac, respiratory, musculoskeletal and haematological systems. CPET allows a complex evaluation of effort capacity through the direct measurement of gas exchanges and pulmonary ventilation, electrocardiography, blood pressure and heart rate measurement. This method provides an increased amount of information in regard to body response to effort and offers a complete perspective over the O_2 transportation system and its utilisation in metabolic processes.

The aim of this study was to highlight the importance of a scientific approach regarding the physical preparation starting from junior level.

Methods

For a 3 years period (2013 - 2016) we followed the evolution of a professional cyclist (14 years old at baseline), in terms of cardiopulmonary parameters. During this period he was tested 5 times and he followed a special training program adapted according the tests results.

Laboratory testings

The CPET was performed in the laboratory using a stationary electronically braked cycle ergometer (Lode Corival, Netherland) and a breath by breath gas analyzer device (Cortex Metalyzer 3B, Germany). The electrocardiogram was continuously recorded throughout and 5 minutes after the test, using a 12 lead stress electrocardiographic device (GE Medical System, Germany).

The cyclist performed an incremental exercise testing, which involves gradually increasing work rate up to exhaustion, in order to determine: peak work rate (WR) and heart rate (HR) response to exercise, and more complex parameters such as the peak oxygen uptake (VO2peak), anaerobic threshold (AT), respiratory compensation point (RCP). Cardiac performance, expressed by the oxygen pulse (VO2/HR) and indices of ventilatory efficiency, expressed by the lowest ventilatory equivalent ratio for oxygen and carbon dioxide (VE/VO2 and VE/VCO2) are also functional parameters that can emphasize cardiac or pulmonary limitation during exercise.

Criteria for achieving a maximal effort test were a plateau in VO2 and/or plateau in ventilation together with a subjective judgment that the subject could not continue even after verbal encouragement. The CPET results were used for setting the proper effort intensity of the exercise program in order to increase the VO_2peak and endurance of the sportsmen. For this, we divided the effort intensity according to VO_2 at AT and RCP, into 5 training zones: 1. Compensation Zone (for warm-up and cool down); 2. Extensive Endurance (low intensity to start the development of basic endurance); 3. Intensive Endurance (right after the AT); 4. Development Zone (aerobic-anaerobic transition - between AT and RCP); 5. Top Zone (over RCP).

The body composition assessment performed with the InBody 720 Body Composition Analyzer served to track the athlete in terms of anthropometric parameters evolution, nutritional status and muscle balance. We followed the evolution of muscle mass and its distribution, the evolution of fat mass, intra- and extracellular water, and bone minerals. In addition to laboratory tests, specific tests such as One Repetition Maximum (1Rmax) Bench Press Test and One

Repetition Maximum Squat Test have been used to determine the training parameters.

The training protocol was divided into the following specific phases:

1. **The Anatomical Adaptation phase** (mostly high-intensity interval training (HIIT)
2. **The Hypertrophy phase** (series of 10 repetitions with 70% 1Rmax)
3. **Maximum Strength phase** (MxS)
4. **Conversion to Power/Power Endurance (ConvP/PE) or Muscular Endurance (ME) phases of training** (included Pliometrics training).

In the pre-season period the training program had a 5 times per week frequency and consisted in circuit training in the gym, specific training and home training.

For the specific training the athlete used a Cervélo S3 with Sram Red etap bicycle (7 kg) and for home training an adapted version of his one bike was used. The intensity of effort in terms of heart rate was established according to the heart rate zones determined by the CPET. Usually the training was conducted in the extensive endurance area.

In post-season period the athlete trained the same as in pre-season but using 50-70% 1Rmax. Workout monitoring was done using a pulse meter Garmin Forerunner® 935.

Results

We observed an improvement trend in almost all parameters investigated during the 3 years evaluation period.

Comparing post-season records from 2013 and 2016, we noticed an increase of 54% in work rate (WR) and 50% in peak oxygen uptake at anaerobic threshold and an even greater increase (59%) of these parameters at maximal effort achieved during CPET (Table II and IV; Figure 1 and 3).

After these 3 years of training we also observed a significant improvement of ventilatory efficiency, expressed by the lowest ventilatory equivalent ratio for oxygen and carbon dioxide (VE/VO2 and VE/VCO2) and also an increased with 46% of the maximal cardiac performance during exercise (VO2/HR) (Figure 1).

We have to take into account the fact that our subject is a junior cyclist at the age of 14 by the time we started the monitoring and professional training sessions. The anthropometric parameters were modified according to his physical development and ageing (Table I).

Table I. Trend of anthropometric parameters

	Sept. 2013	Febr. 2014	Febr. 2015	Sept. 2015	Sept. 2016
Weight (Kg)	64	67.1	63.3	62.3	60.9
Height (cm)	171	171	173	173	175
BMI (Kg/m2)	21.9	22.9	21.2	20.8	19.9

BMI: body mass index

Some data that we present in the next tables are at the beginning of the training period (pre-season) which starts in February and the others are in the post-season (September). Despite this limitation of the data presented we may observe an improvement trend in almost all parameters investigated during the 3 years evaluation period (At anaerobic threshold and also at respiratory compensation point) (Table II, III; Figure 1,2).

Table II. The 3 year trend of CPET parameters, measured at anaerobic threshold (AT)

Parameter	AT_1	AT_2	AT_3	AT_4	AT_5
HR (b/min)	162	166	171	174	167
WR (Watt)	162	177	186	231	251
WR/kg (Watt/Kg)	3	3	3	4	4.1
METS	10.4	9.7	10.7	13.6	15.4
V'O2 (L/min)	2.32	2.28	2.37	2.95	3.28
V'O2/kg (ml/min/kg)	36	34	37	47	54
RER	0.96	1.2	1.01	0.99	0.9
V'O2/HR (ml)	14.3	13.7	13.9	17	20
V'E/V'O2	21.5	24.8	25.5	25	22.7
V'E/V'CO2	22.4	20.6	25.3	25.4	25.1

AT: anaerobic threshold (AT_1: AT record from September 2013; AT_2: AT record from February 2014; AT_3: AT record from February 2015; AT_4: AT record from September 2015; AT_5: AT record from September 2016); HR: heart rate; WR: work rate; METS: metabolic equivalents; V'O2: oxygen uptake; RER: rate expiratory ratio; V'O2/HR: oxygen pulse; V'E/V'O2: ventilator equivalent ratio for oxygen; V'E/V'CO2: ventilatory equivalent ratio for carbon dioxide;

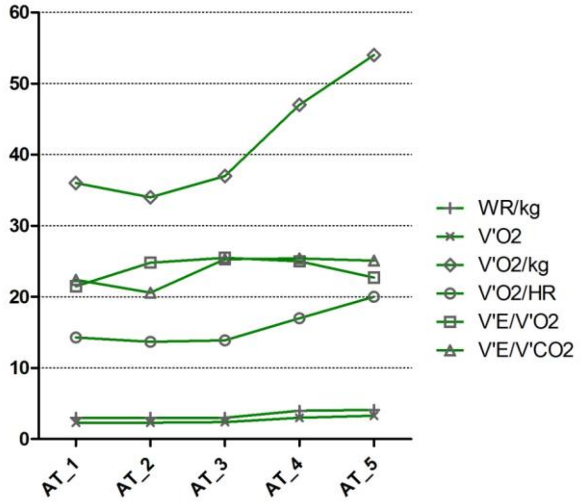

Figure 1. Trend of CPET parameters measured at anaerobic threshold (AT)

Table III. The 3 year trend of CPET parameters, measured at respiratory compensation point (RCP)

	RCP_1	RCP_2	RCP_3	RCP_4	RCP_5
HR (b/min)	188	200	193	186	177
WR (Watt)	246	267	276	285	284
WR/kg (Watt/Kg)	4	4	4	5	4.7
METS	13.2	11.5	14.9	15.9	17.4
V'O2 (L/min)	2.95	2.69	3.29	3.46	3.71
V'O2/kg (ml/min/kg)	46	40	52	55	61
RER	1.24	1.45	1.28	1.1	0.96
V'O2/HR (ml)	15.7	13.5	17.1	18.6	21
V'E/V'O2	29	37.3	29.9	28.9	25
V'E/V'CO2	23.3	25.7	23.4	26.2	26

RCP: respiratory compensation point;; VO2peak: peak oxygen uptake; HR: heart rate; WR: work rate; METS: metabolic equivalents; V'O2: oxygen uptake; RER: rate expiratory ratio; V'O2/HR: oxygen pulse; V'E/V'O2: ventilatory equivalent ratio for oxygen; V'E/V'CO2: ventilatory equivalent ratio for carbon dioxide;

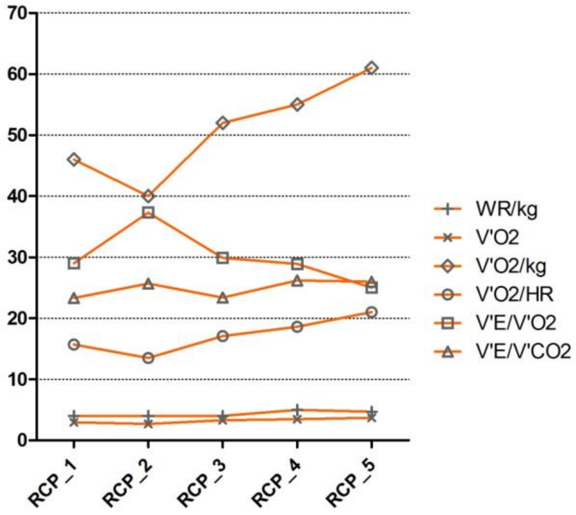

Figure 2. Trend of CPET parameters measured at respiratory compensation point (RCP)

Maximal cardiac performance during exercise, expressed by VO2/HR also increased with 46% in a 3 year period of exercise training. Consecutive to this, the heart systolic flows into the circulation and to the active muscles an amount of 20 ml of oxygen at the end of evaluation period (Table IV, Figure 3).

Table IV. The 3 year trend of CPET parameters, measured at maximal effort (peak oxygen uptake)

	VO_2 _1	VO_2_2	VO_2 _3	$V'O_2$ _4	$V'O_2$ _5
HR (b/min)	190	204	198	199	198
WR (Watt)	252	300	297	342	382
WR/kg (Watt/Kg)	4	4	5	6	6.3
METS	13.3	11.8	15.6	17.1	21.4
V'O2 (L/min)	2.99	2.78	3.5	3.74	4.59
V'O2/kg (ml/min/kg)	47	41	54	60	75
RER	1.2	1.49	1.43	1.32	1.11
V'O2/HR (ml)	15.7	13.6	17.4	18.7	23
V'E/V'O2	30	43.2	34.2	37.8	33.3
V'E/V'CO2	23.3	29	24	28.6	30.1

VO2: peak oxygen uptake; HR: heart rate; WR: work rate; METS: metabolic equivalents; V'O2: oxygen uptake; RER: rate expiratory ratio; V'O2/HR: oxygen pulse; V'E/V'O2: ventilatory equivalent ratio for oxygen; V'E/V'CO2: ventilatory equivalent ratio for carbon dioxide;

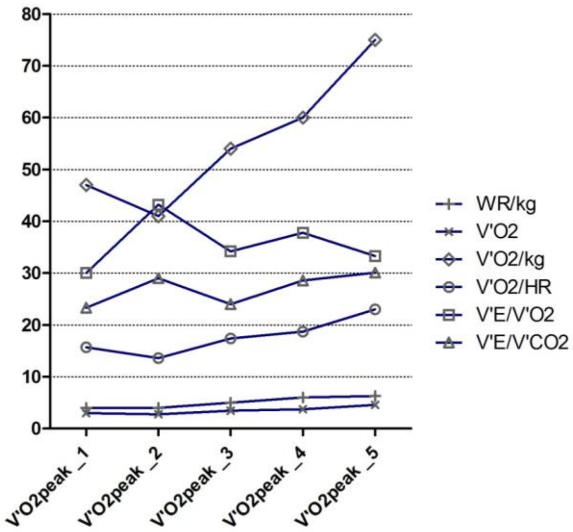

Figure 3. Trend of CPET parameters measured at maximal effort (VO2peak)

Discussions and Conclusions

Even at junior level, in elite sports, competition requires training regimens that could be considered extreme even for adults. The pressure for performance and results leads to continuously-increasing requirements. For this, the athletes have to train more intelligently and from a younger age.

The cruel nature of competitive sports can threaten the safety and health of athletes in the long run [4].

Only careful monitoring and work in a multidisciplinary team of specialists can bring a good evolution of the athlete without threatening his health. Nutrition, physical and mental training, careful medical monitoring are essential elements [5].

The literature is very poor in data on the evolution of exercise capacity and performance in young athletes but based on the remarkable evolution of the pursued sportsman and by comparing him with his colleagues we can state that the strategy of testing, adapting and monitoring the training was not just right, but very good.

Similar to the results of other studies, the present study shows that endurance training causes significant increases in effort capacity and can cause an upward trend of the athlete's performance [6].

The different types of training used helped the athlete to perform at high levels of physical stress.

Also the low rate of injuries, the positive evolution of the body composition, somatometric indices and the general health of the athlete, come to reinforce the above conclusions. Success and safety conditions can be reached only with a *smart training.*

References

1. Di Fiori J.P., Benjamin H.J., Brenner J.S., et al. (2014). *Overuse injuries and burnout in youth sports: a position statement from the American Medical Society for Sports Medicine*, Br. J. Sports. Med., 48,287-288.
2. Shona L. Halson. (2014). *Monitoring Training Load to Understand Fatigue in Athletes,* Sports. Med. 44 (Suppl 2), S139–S147.
3. Dafoe W. (2007). *Principles of Exercise Testing and Interpretation,* The Canadian Journal of Cardiology, 23(4), 274.
4. Anderson S.J., et. al. (2000). *Intensive Training and Sports Specialization in Young Athletes,* Pediatrics, Volume106 / ISSUE 1, 154.
5. Purcell L. K., & Canadian Paediatric Society, Paediatric Sports and Exercise Medicine Section. (2013). *Sport nutrition for young athletes,* Paediatrics & Child Health, 18(4), 200–202.
6. Holm P., Sattler A., Fregosi R. F. (2004). *Endurance training of respiratory muscles improves cycling performance in fit young cyclists*, BMC Physiology, 4-9.