HEART RATE AND ANAEROBIC THRESHOLD DETERMINED BY SPECIFIC FIELD TESTS AS INDICATORS OF INTENSITY RACE PACE IN DOUBLE OLYMPIC TRIATHLON AND IRONMAN.

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1. Introduction

Triathlon is an endurance sport that implies swim, ride and run consecutively .It began in 1.978 in Hawaïi, U.S.A., at the called Ironman distance, 3,8 Km swim, 180 Km ride and 42,2 Km run, a full marathon. Actually there are many shorter distances in competitive triathlon. One of this is the new Double Olympic which distances are 3-80-20 Km respectively.

In attend the total time spent in this kind of race, around 4 hours for the top athletes, this can be classed as Long Lenght Endurance III (LLE, Zintl, 1991, IV for Ironman course). Regardless, the change in discipline, with important differences in the medio, in respect to the athlete position and the muscles implied, and the different lenght (swim: LLE I, cycle: LLE III, run: LLE II) implies differents work intensities in each discipline.

Most of studies in triathlon has focused on short distance triathlon. So, González-Haro et al. (2005) found important differences in relative intensities in swim and cycle in regional triathletes in a 1.500 m swim trial followed by 1h cycle trial at race pace in cycloergometer. The speed swim was 1,29 m/s (1’17”5/100 m), 98% of Maximal Aerobic Speed (MAS), lactate of 6,8 mMol/L and heart rates of 162 bpm while power supply in cycle was of 266 W, 77% Maximal Aerobic Power (MAP), heart rates of 162 bpm, with losses of 2,8% of live weight and changes in power supply, speed and cadence in the late minutes of the 1h trial.

Peeling et al. (2005) found that in sprint triathlon, swim at best pace imply loses in cycle performance in reference a swim at a 80% and 90% best pace.

These results agree with those from Rubert-Alemán (2006) who observed that an explosive first 25 m in a 100 m test modify significantly the final performance, while Farber et al. (1991) found that lactatemie after swim was higuer than after cycle or run in a sprint triathlon.

Delextrat et al. (2003) observed that an intense 750 m swim increase energetic cost of a subsequent 15 min cycle test at a 105% VT2 intensity, mostly due to the thermoregulation adaptations and the amount of respiratory work that it means and not due to the leg work in the previous swim. Boussana et al. (2003) obtained similar results in olympic triathlon.

Regarding Long Distance, Laursen et al. (2005) showed that the heart rate in bike segment (148 ± 9 bpm) and run lap (143 ± 13 bpm) of an Ironman race in well trained triathletes were significantly lower than VT2 (160 ± 13 bpm and 165 ± 14 bpm respectively) and Conconi's Threshold too (170 ± 13 bpm y 179 ± 9 bpm respectively). However, the heart rates were correlated and not differents from VT1 (146 ± 12 bpm and 148 ± 15 bpm respectively).

In another study with pro triathletes (top 10% in bike segment) Abbis et al. (2006) showed a significant decrease in mean power (239 vs 203 W), cadence (89 vs 82 rpm) and speed (36,5 vs 33,1 km/h) between the first, the second and the third lap of a bike ironman race (3 laps of 60 Km). However, this parameters were not different with favourable or adverse wind conditions (17-30 Km/h).

Meyer et al. (2002) showed that 4 hours 70% IAT cycling performed with energy drink at differents carbohydrates concentrations (0%, 6% y 12%, 50 mL/Kg) resulted in significantly differences between 0 and the others doses in Respiratory Quote and in blood glucose while Free Fatty Acids and Glycerol in plasma were depending upon carbohydrates dose.

Whyte et al. (2000) showed correlations between final performance in ironman and half ironman and left ventricle's (LV) thickness and mass. Oxygen consumption at UAN, %VO2max at UAN and the maximal aerobic power per kg were positive correlated to bike performance in half ironman but not in full ironman race.

Hausswirth y Lehenaff (2001) showed that run economy falled in an ironman marathon, due to several physiological questions: increased body temperature and dehydratation mainly.

Finally, a Menéndez de Luarca (2003) study showed that, in half ironman race, the time spent over the aerobic treshold (UA, 2 mMol/L) and over anaerobic treshold (UAN, 4 mMol/L (UAN4) was 23% and 75% in swimming lap, 49% and 47% in cycling lap and 80% and 14% in running lap.

2. Objetives

The aim of this work was:

- To determinate the profil of regional mid and long distance triathletes by specific pruebas de campo with ATL, speed and heart rate.
- To determinate the influence of cycling on running performance on a specific mid-distance transition field test.
- To determinate the intensity profils developed during the 3 segments of the Double Olympic Elche Triathlon with heart rate and lactate monitoring.
- To study the correlations between the different parameters considered.
- To compare this results with those obtained in an Ironman distance triathlon.

3. Material and methods

3.1. Subjects

6 national triathletes racing the II Triatlón Doble Olímpico de Elche on 06/05/06 were studied. The triathletes characteristics are shown in table 1.

Table 1: Subjects characteristics.

	Mean	Standard Deviation
Age (years)	35,7	8,3
Weight (kg)	74,2	6,1
Height (cm)	179,5	3,6
BMI (kg/m2)	23,01	1,70

3.2. Field tests

We developed 4 field test for the determination of Anaerobic Treshold (AT, Davis et al., 1976), one test in swimming, one in cycling, one running and one in a bike-run transition. In the 4 tests the blood lactate was determined by Lactate Scout device (EKF-diagnostic GMBH, Germany, Biolaster, Spain, www.biolaster.com) previously validated (Trigo et al., 2000), and the heart rate was monitoring by Polar S810i device (Polar, Finland).

Swimming test was performed by several 300 m repetitions (between 4 and 6 depending upon triathlete), with an initial charge equivalent to a swim pace of 1'45"/100 m (0,95 m/s), increased by 4"/100 m and 2 minutes of recovery between reps. Tests were performed in a climated 25 m pool, with one triathlete by lane and with neoprene weitsuit.

Cycling test consisted in 2.500 m reps, with an initial charge of 25 km/h and increased by 1,5 km/h, and 2 minutes of recovery. The test was developed in a flat circuit (Padilla et al., 1996).

Running test consisted in 1.600 m reps, with an initial charge equivalent to 5'/Km run pace, increased by 12"/Km and 2 minutes of recovery. The test was developed in a track.

Transition bike-run test consisted in 50 km cycling at an individual race pace (heart rate between 85 and 90 % AT determined previously in cycling test), with 2 30" stops to monitoring blood lactate, followed by a transition of 3' and a running test like previous one.

For the determination of the intensity developed during the race, we used 5 levels based on heart rate at specific AT (ATHR, Torres, 2005):

- N0, HR < 0,85*ATHR,
- N1, 0,85*ATHR < HR < 0,90*ATHR,
- N2, 0,90*ATHR < HR < 0,95*ATHR,
- N3, 0,95*ATHR < HR < ATHR,
- N4, HR > ATHR.

3.3. The Race

The Double Olympic Elche Triathlon (DOET) was performed on the distances 2,9 Km swim, 84 Km cycle and 20 Km run.
Swimming was achieved onto 2 laps with mass start.
Cycling segment was 3 parts clearly diferents:

- 40 Km totally flat and with favorable wind conditions,
- 10,8 Km in Albaterolo climbing, with 470 m vertical gap, 4% mean drop and last 2,5 km at 10% mean drop and 14% maximal drop,
- finally, 33 km with favourable drop,

Run segment consist in 3 laps of 6,66 km.

To monitoring blood lactate, 6 samples of blood from ear lobe were performed:

- at the T1, just after the swimming segment,
- in the Albaterolo's pass,
- at T2, just after the cycling segment,
- 3 times in the running segment after each lap.

3.4. Quelle Challange Roth (QCR), case study.

2 triathletes raced at QCR 8 weeks after the DOET, a triathlon over Ironman distances, 3,8 Km swimming, 180 Km cycling and 42,2 Km running.

4. **Results and Discussion**

4.1. Specific Field Tests

Figures 1 to 4 show the individual results at the 4 specific field tests to determined the AT.

For the transition test, triathletes were commited to develope a 50 km cycling at individual race pace (90-95 % ATHR) before the run test.
Table 2 shows how this 50 Km cycling were really performed.

Table 2: 50 km cycling in the trasition test.

	Mean	SE
Speed (km/h)	32,91	0,6
HR (ppm)	146,0	2,2
La (Mmol/L)	4,6	0,3
%Sat	91,67%	1,54%
%ATHR	88,46%	1,33%

SE: standard error, HR: heart rate,

%Sat=100*S/Sat, %ATHR=100*HR/ATHR

Table 3 shows the individual AT obtained in the 4 tests performed.

Table 3: Anaerobic Treshold obtained in the field tests.

Segment	S (km/h)		Pace (Swim min/100, Run min/km)		HR (bpm)		La (mMol/L)	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Swim	4,17	0,11	01:26,7	00:02,2	159,8[abc]	5,8	6,0[ab]	0,9
Cycle	34,43	0,67			160,5[a]	3,2	6,8[a]	0,8
Run	14,86[a]	0,27	04:04,4	00:05,2	171,7[bc**]	2,8	4,7[b]	0,5
Transition run	13,58[b]	0,21	04:25,5	00:04,0	159,3[bc*]	3,9	5,1[ab]	0,4
Significance	0,004				*: 0,002 **: 0,04		0,02	

As we can see in the table 3, there were significant differences between ATHR in cycling and running (P=0,002) and transition running (P=0,04), while in blood lactate the differences only were significants between cycling and running (P=0,02). Aunque no significant differences were observed between running and transition running in ATHR nor blood lactate, the speed at AT was significant lower (P=0,004, 13,58 vs 14,86 km/h) in the transition running. This means a transition running speed at AT 91,6 % than running speed at AT without previous 50 Km cycling.

Figure 1: Swimming field test.

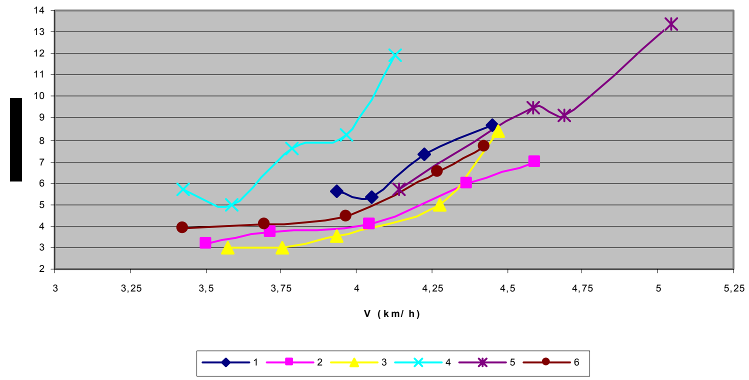


Figure 2: Cycling field test.

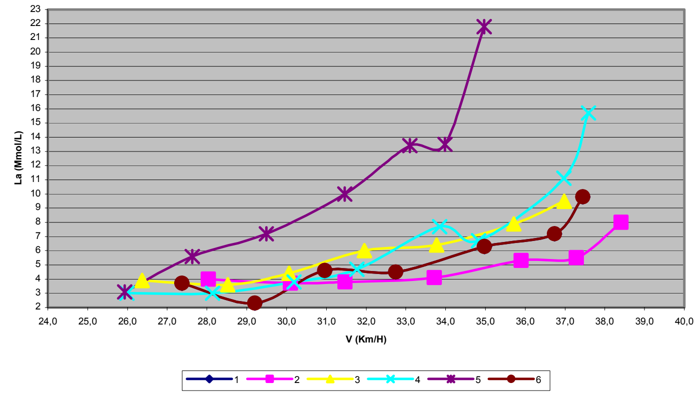


Figure 3: Running field test.

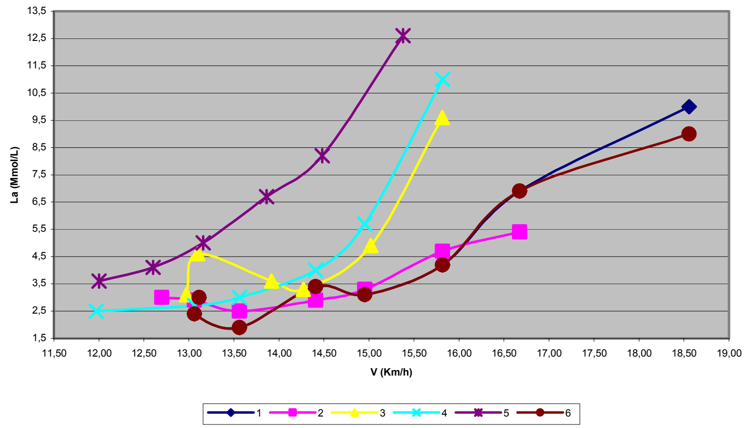
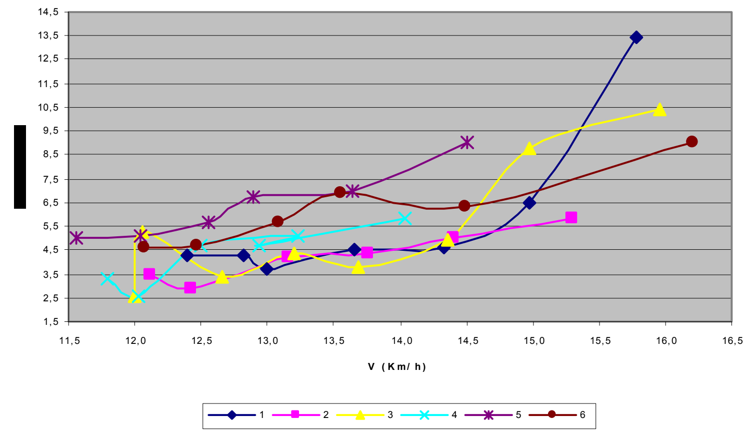


Figure 4: Transition running field test.



4.2. Double Olympic Elche Triathlon (DOET)

4.2.1. Race generalanalysis

Table 4 and figure 5 show the main characteristics of the DOET.

Table 4: General results of DOET.

CAT	RACERS		Finish time	Swimming time	Swimming pace (mm:ss/100 m)	Swimming speed (km/h)	Cycling time CIC	Cycling speed (km/h)	Time at T2	Running time	Running pace (mm:ss/km)	Running speed (km/h)
MEN	261 (27 DNF)	Mean	5:22:36	0:52:18	0:01:45	3,33	2:45:13	31,35	3:37:34	1:44:53	0:05:15	11,44
		1º	4:01:10	0:34:25	0:01:09	5,06	2:09:41	39,78	2:44:12	1:15:00	0:03:45	16,00
WOMEN	16 (3 DNF)	Mean	5:50:45	0:57:20	0:01:55	3,03	3:04:41	28,05	4:02:01	1:48:44	0:05:26	11,04
		1ª	5:06:04	0:48:05	0:01:36	3,62	2:37:11	32,69	3:27:32	1:35:58	0:04:48	12,50

Figure 5: Segment distribution in DOET.

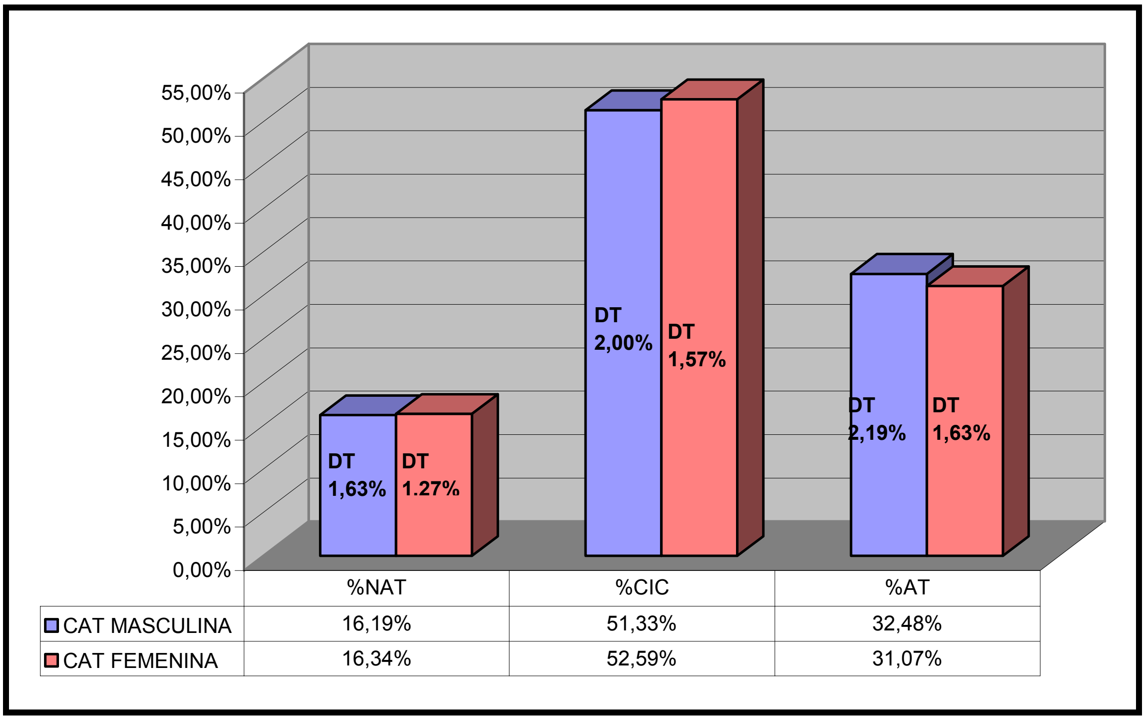


Table 5 shows correlational analysis results obtained from the different variables of the DOET general results list.

Table 5: Correlations between finish time and partials times.

		Swimming time	Cycling time	Running time	
Finish time	Men	0,775	0,969	0,818	Coef. Pearson
		1,86E-03	5,17E-08	6,41E-04	Signif.
	Women	0,762	0,924	0,883	Coef. Pearson
		1,61E-44	3,78E-96	2,26E-76	Signif.

4.2.2. <u>Triathletes studied</u>

Performance of studied triathletes is shown in tables 6 and 7, and figures 6 and 7.

Table 6: Performance of studied triathletes.

		Swimming	T1	Cycling	T2	Running	Time spent in Lactate stop
Time	Mean	0:44:37	0:02:10	2:39:52	0:01:07	1:40:26	0:02:27
	SE	0:01:36	0:00:12	0:03:20	0:00:14	0:03:12	0:00:13
%	Mean	14,50%	0,70%	51,89%	0,36%	32,57%	
	SE	0,54%	0,07%	0,84%	0,08%	0,68%	

Figure 6: Time performance in DOET.

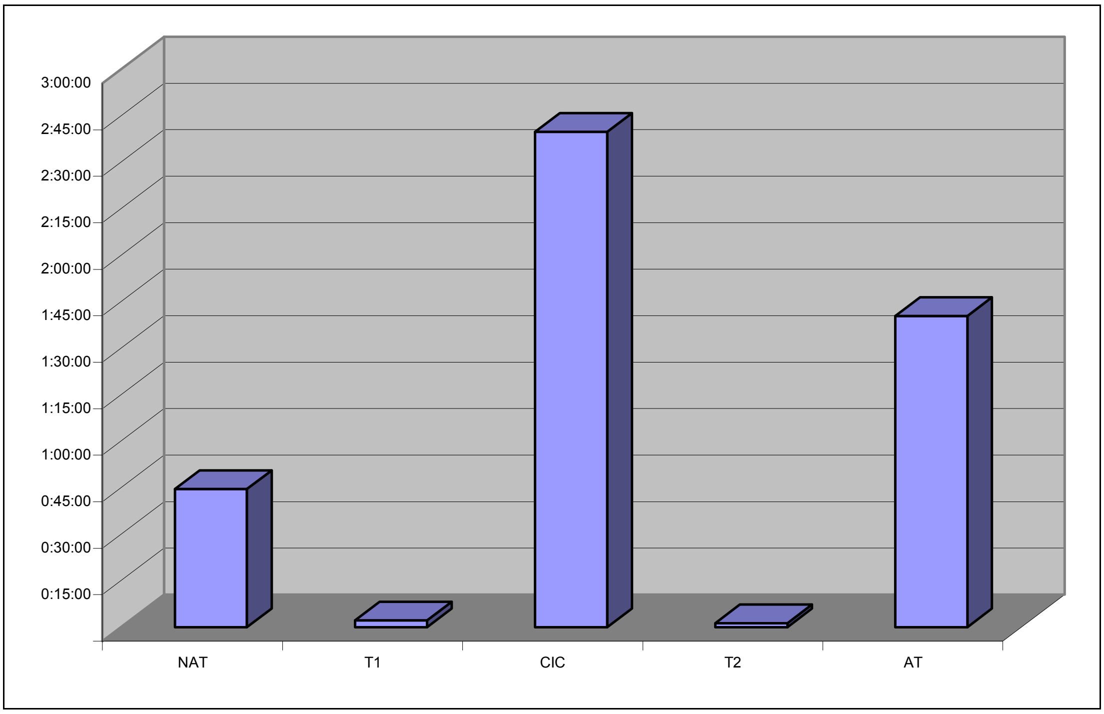


Figure 7: % Distribution in DOET.

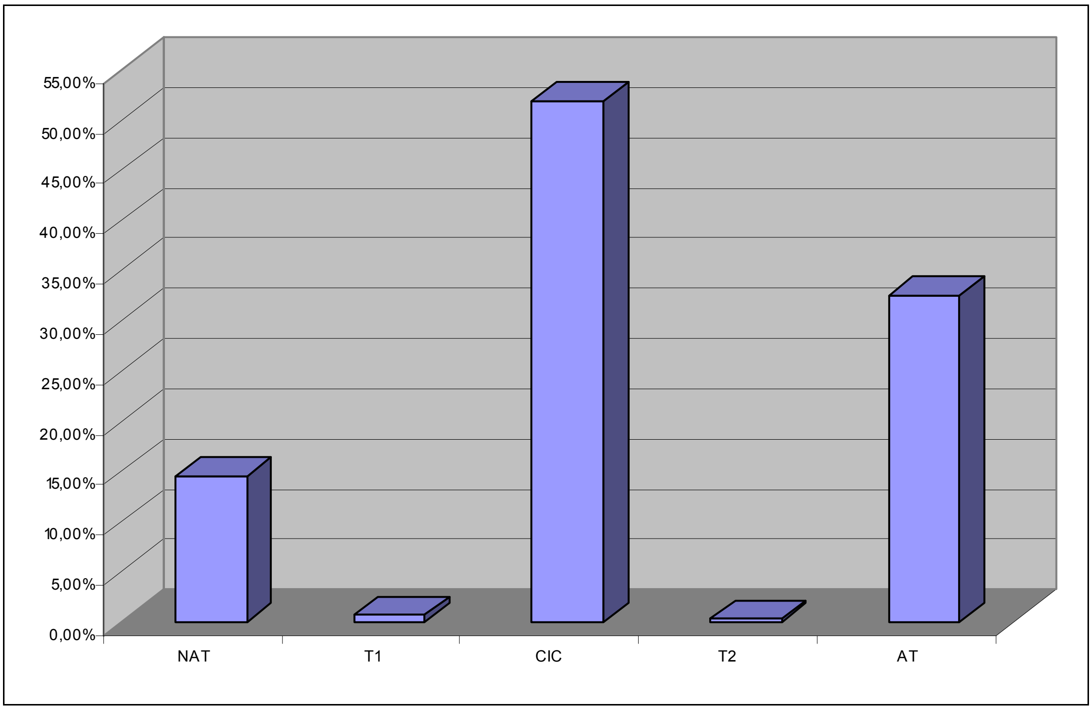


Table 7: Race results in DOET of studied triathletes.

	Swimming	Cycling	T2	Running	Finish
Mean	52,0	118,0	96,0	101,0	99,0
SE	16,7	17,1	12,7	17,6	13,9
Best result	7	72	57	40	52
Worst result	119	190	141	151	137
Mean Percentil	80%	55%	63%	61%	62%
Best Percentil	97%	72%	78%	85%	80%
Worst Percentil	54%	27%	46%	42%	48%

Table 8 shows ANOVA results between triathletes studied results and general results of DOET. In swimming, triathletes studied obtained better results than general results (Swimming time 44’37” ± 1’36” vs 52’18” ± 0’33”, Swimming speed 3,98 ± 0,16 km/h vs 3,40 ± 0,04 km/h, Swimming position 52,0 ± 16,7 vs 116,5 ± 4,4). In cycling and running we didn’t observe significant diferences.

In % distribution, we observed significant diferences in swimming and cycling (14,5 ± 0,6 % vs 16,2 ± 0,1 % in swimming and 53,0 ± 14,5 % vs 51,3 ± 16,2 % in cycling), but not significant in running (32,45 ± 0,5 % vs 32,48 ± 0,5 %).

Table 8: Significant Diferences in DOET results between studied triathletes and general results.

Variable	Swimming time	Swimming Speed	Swimming position	% Swimming	% Cycling
Significance	0,03	0,03	0,02	0,01	0,03

4.2.3. Swimming segment in DOET

4.2.3.1.Heart Rate

Figures 8 and 9 and table 9 show swimming heart rate performance.

Figure 8: Time spent in diferent intensity levels in swimming segment.

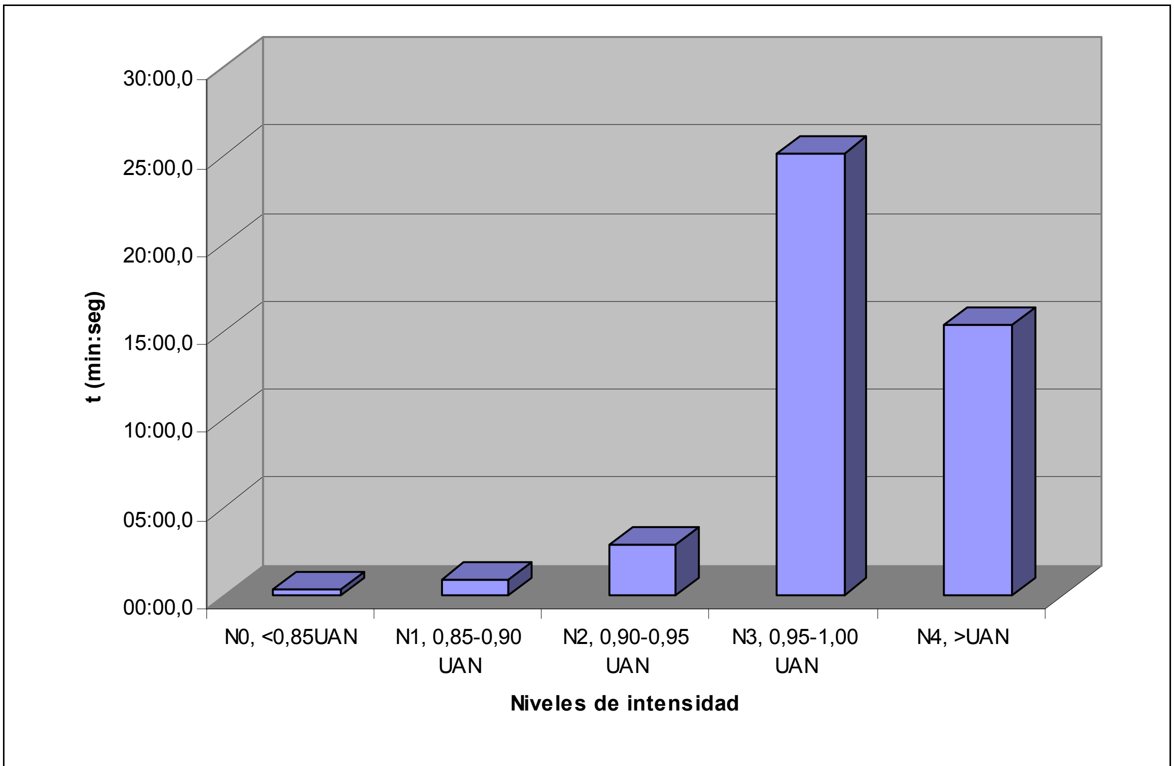


Figure 9: % of time spent in diferent intensity levels in swimming segment

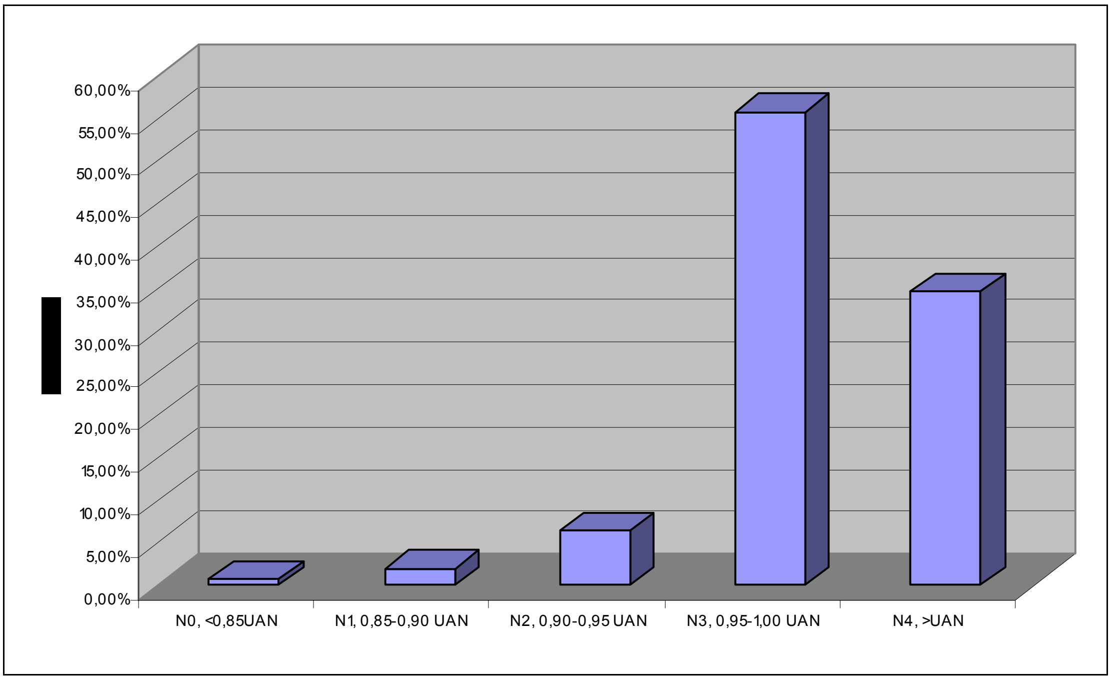


Table 9: Intensity level in swimming of DOET.

Intensity level	N0, <0,85AT	N1, 0,85-0,90 AT	N2, 0,90-0,95 AT	N3, 0,95-1,00 AT	N4, >AT	TOTAL
MEAN TIME	00:20,7	00:53,4	02:57,0	25:04,4	15:22,4	44:37,8
SE	00:03,5	00:31,2	00:48,7	03:52,1	03:37,9	01:36,1
% total swimming	0,77%[a]	2,04%[a]	6,54%[a]	55,91%[b]	34,74%[b]	100,00%
SE	0,12%	1,23%	1,72%	7,95%	7,97%	0,00%

a,b: significants diferences P<0,01, excepto N2 ≠ N4, P<0,05

Comparing phases I, II and III from Menéndez de Luarca work in El Chorro Half Ironman (ECHI 2003, HR<Aerobic treshold, between aerobic treshold and AT and >AT respectively) with N0, N1+N2+N3 and N4 respectively in our study, it became that swimming in ECHI was raced at a higher intensity level than DOET (63% vs 23% and 35% vs 75% in the 2 highest levels). This would have be due to shorter distance (1.900 m vs 2.900 m), quiest waters and mass start in ECHI vs DOET.

In addition, Menéndez de Luarca fixed AT at 4 mMol/L, while in our study we used individual AT criteria and the AT obtained were 6,0 ± 0,9 mMol/L, 6,8 ± 0,8 mMol/L, 4,7 ± 0,5 mMol/L and 5,1 ± 0,4 mMol/L in swimming, cycling, running and transition running respectively.

Finally, swimming was performed at 3,98 ± 0,42 km/h (1'32"± 8"/100 m), that means 96,19 ± 5,08 % AT speed, and we didn't found significant diference between these 2 speeds.

4.2.3.2.Blood Lactate

Blood lactate levels after swimming lap means 6,0 ± 1,6 mMol/L, 0,5 ± 0,3 mMol/L highers to ATL determined in field test.

These results show that swimming lap was performed at a high intensity level in view to the total distance, 2.900 m, with 93% of total swimming time near to AT intensities and 53% beyond this AT.

4.2.4. Cycling lap in DOET

We have considered 3 tramos in cycling lap (figure 10), FLAT (40 Km), CLIMBING (10.8 Km, 4,3% mean slope and the last 2,5 km at 10% mean slope and 14% maximal slope (figure 11) and DOWN (33 Km and 400 m down).

Figure 10: Cycling lap.

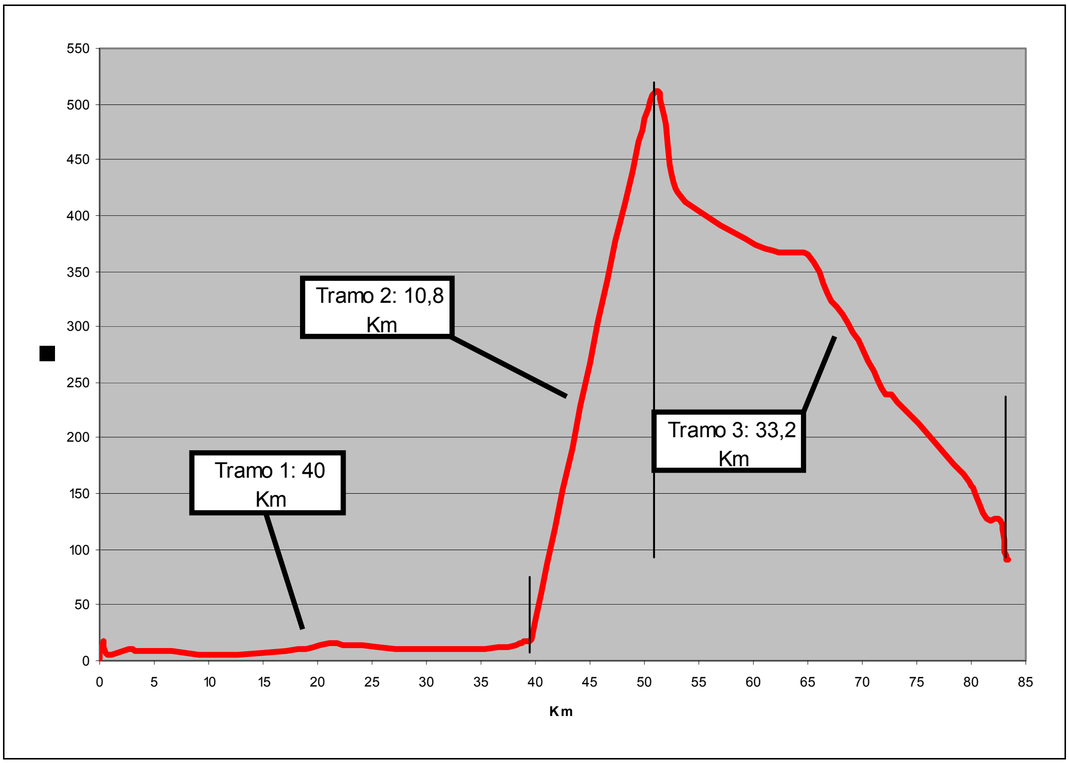
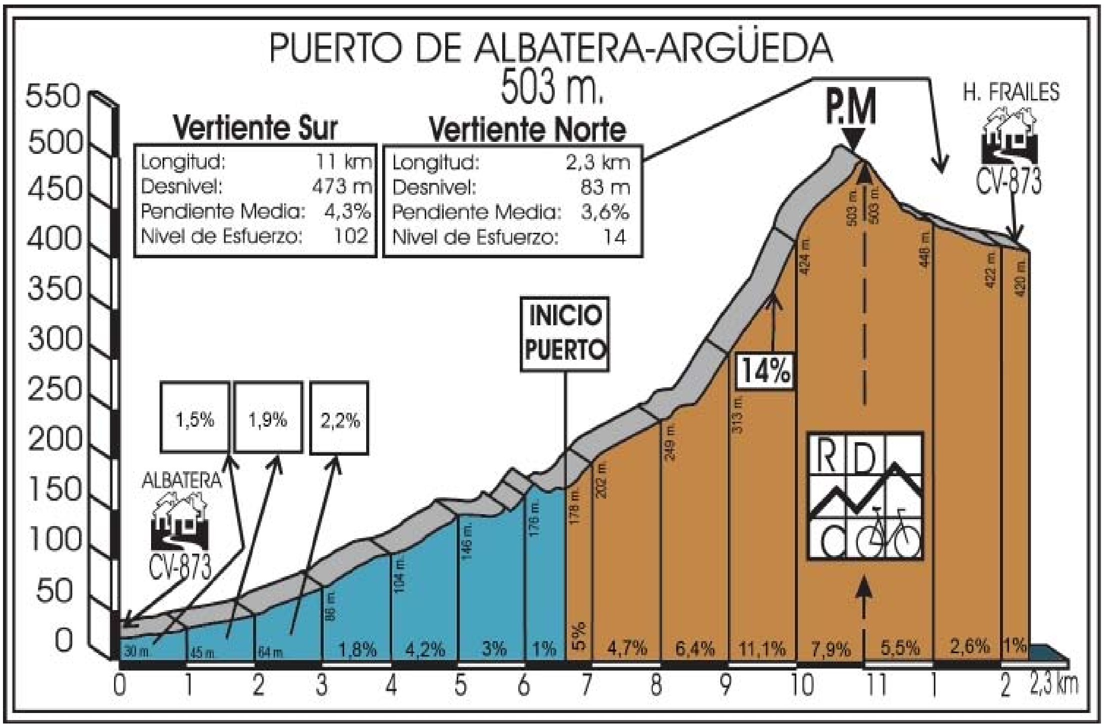


Figure 11: Albaterolo climbing.



4.2.4.1. Heart rate

Results are show in figures 12 and 13 and table 10.

Figure 12: Intensity levels in cycling lap.

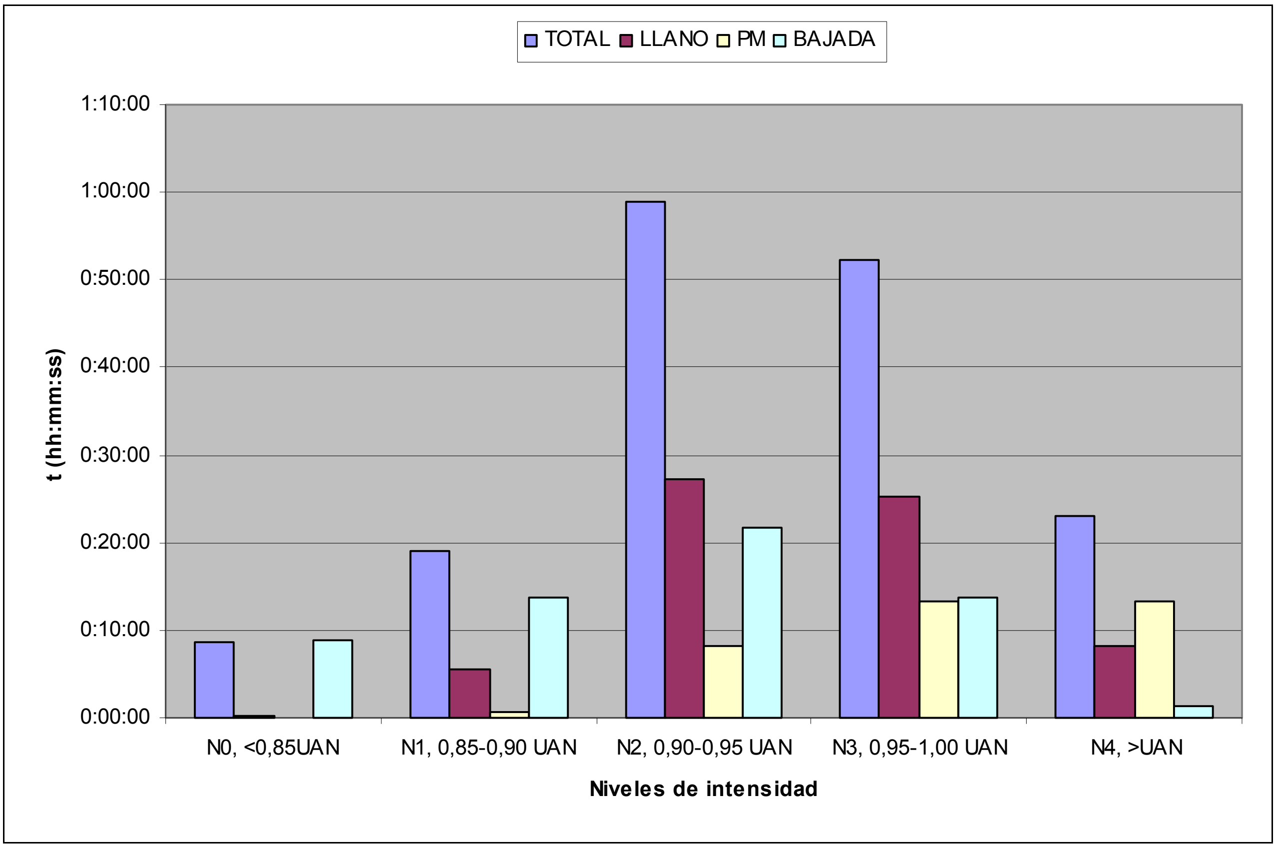


Figure 13: % distribution in intensity levels in cycling lap.

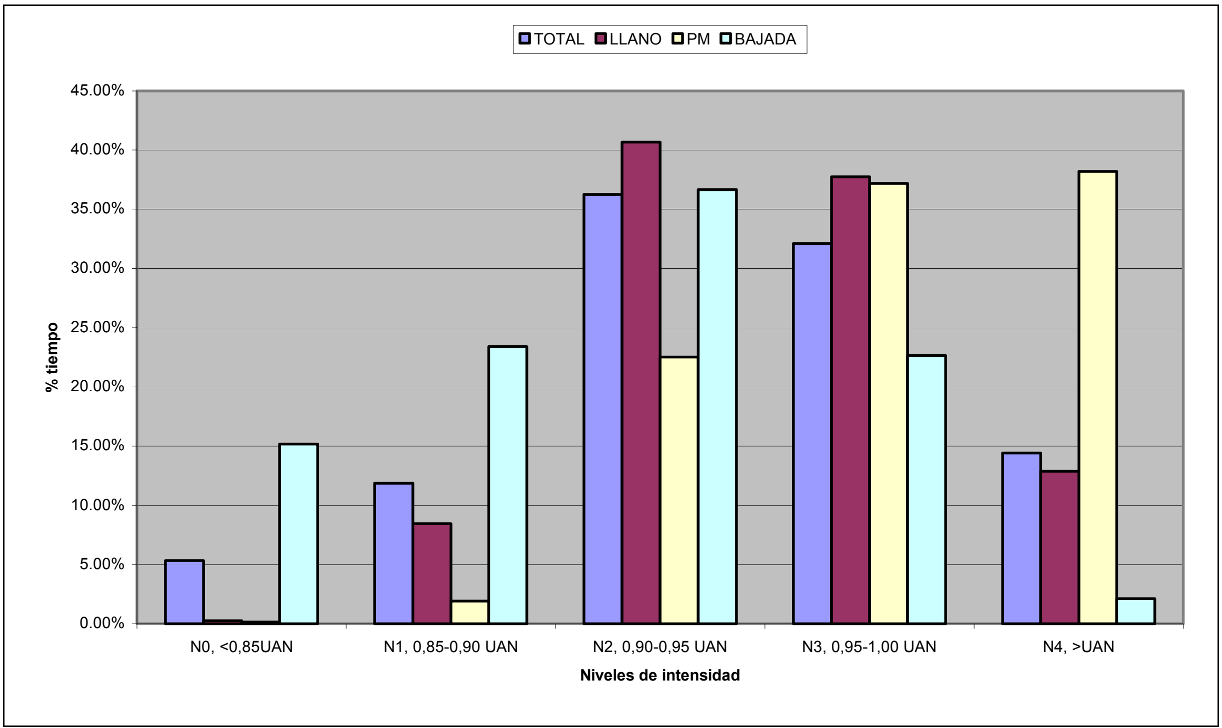


Tabla 10: Intensity levels in cycling lap.

	Nivel de intensidad	N0, <0,85UAN		N1, 0,85-0,90 UAN		N2, 0,90-0,95 UAN		N3, 0,95-1,00 UAN		N4, >UAN	
	SEGMENTO	MED	EE	MEDIA	EE	MEDIA	EE	MEDIA	EE	MEDIA	EE
T	TOTAL	0:08:33	0:03:18	0:19:02	0:07:10	0:58:51	0:07:08	0:52:19	0:10:25	0:23:02	0:07:11
	LLANO	0:00:10	0:00:06	0:05:30	0:02:27	0:27:17	0:05:37	0:25:15	0:05:23	0:08:14	0:03:12
	PUERTO DE MONTAÑA	0:00:03	0:00:03	0:00:41	0:00:27	0:08:08	0:03:12	0:13:20	0:01:38	0:13:17	0:04:01
	BAJADA	0:08:57	0:03:21	0:13:48	0:04:29	0:21:46	0:03:07	0:13:38	0:05:33	0:01:18	0:00:53
%	TOTAL	5,34%$^{a\beta}$	2,08%	11,87% ^{a}	4,41%	36,26% ^{b}	4,22%	32,12% ^{bc}	5,96%	14,42% ^{ac}	4,66%
	LLANO	0,25% $^{a\alpha}$	0,14%	8,46% ^{a}	3,69%	40,67% ^{b}	8,11%	37,74% ^{bc}	7,49%	12,88% ^{ac}	5,16%
	PUERTO DE MONTAÑA	0,15% $^{a\alpha}$	0,15%	1,92% ^{a}	1,27%	22,53% ^{ab}	8,82%	37,20% ^{b}	4,24%	38,19% ^{b}	12,10%
	BAJADA	15,18% $^{ab\beta}$	5,75%	23,39% ^{ab}	7,55%	36,68% ^{b}	5,27%	22,64% ^{ab}	9,01%	2,11% ^{a}	1,41%

a, b, c: in the same line, significance, $P<0,05$

α, β: in the same row, significance, $P<0,05$

As swimming lap, the cycling lap of ECHI was performed at higher intensity level than DOET (49% vs 80% and 47% vs 15%, Menéndez de Luarca, 2003). In this lap the differences may be due to togher profile in ECHI or methodes differences before described.

Whole cycling lap was performed at 31,52 ± 1,56 km/h, that means 91,61 ± 4,39 % of AT speed.

4.2.4.2.Blood lactate

Blood lactate in Albaterolo (10,8 km at 4%) was 5,4 ± 1,2 mMol/L, not different from lactate AT, while in T2 this value was 4,0 ± 1,4 mMol/L, significantly lower than lactate AT ($P<0,05$).

4.2.5. Running lap in DOET

4.2.5.1.Heart rate

Figures 14 and 15 show results in reference to AT obtained in running test field.

Figure 14: Running lap in DOET.

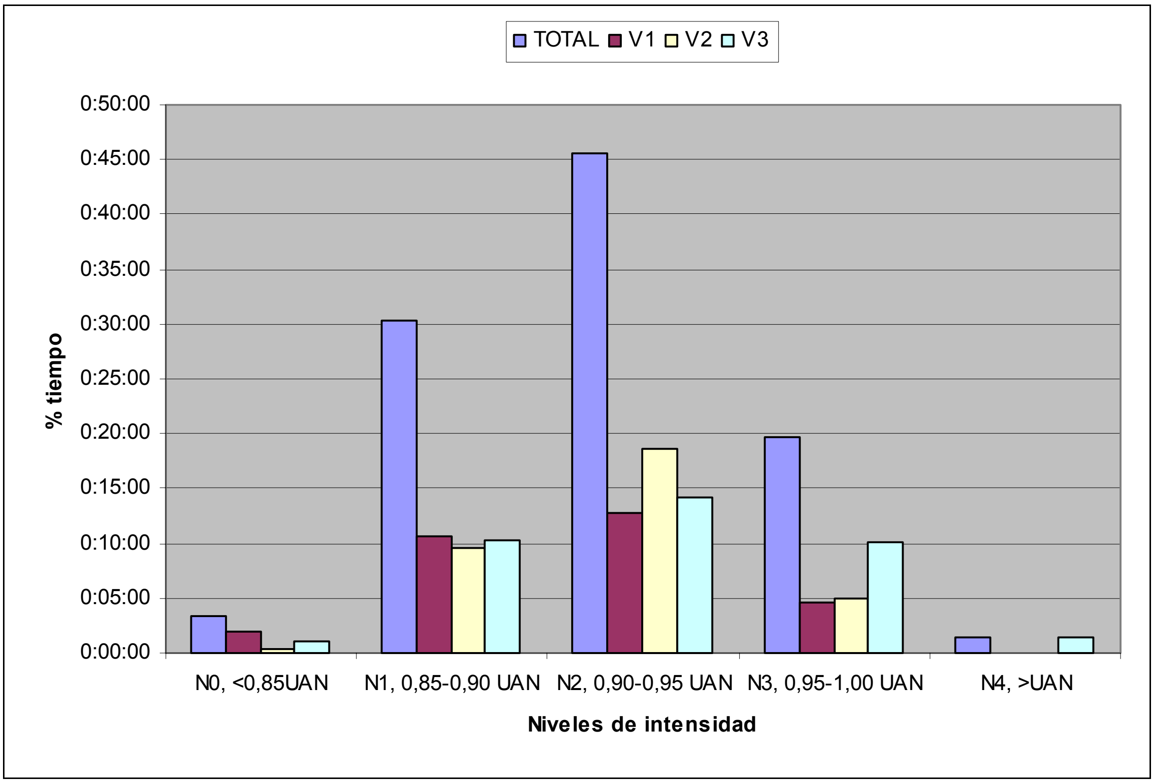


Figure 15: % results in running lap.

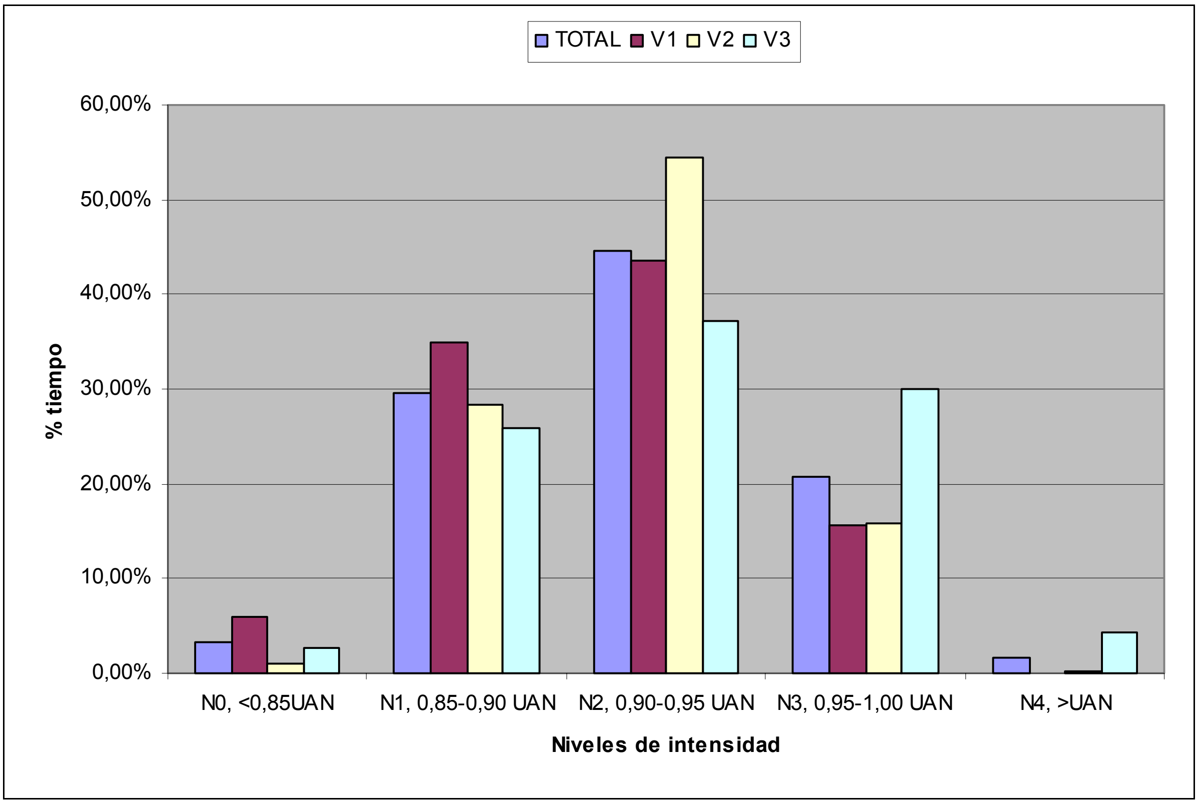


Figure 16 shows results in reference to AT obtained in transition field test.

Figure 16: % results in reference to AT obtained in transition field test.

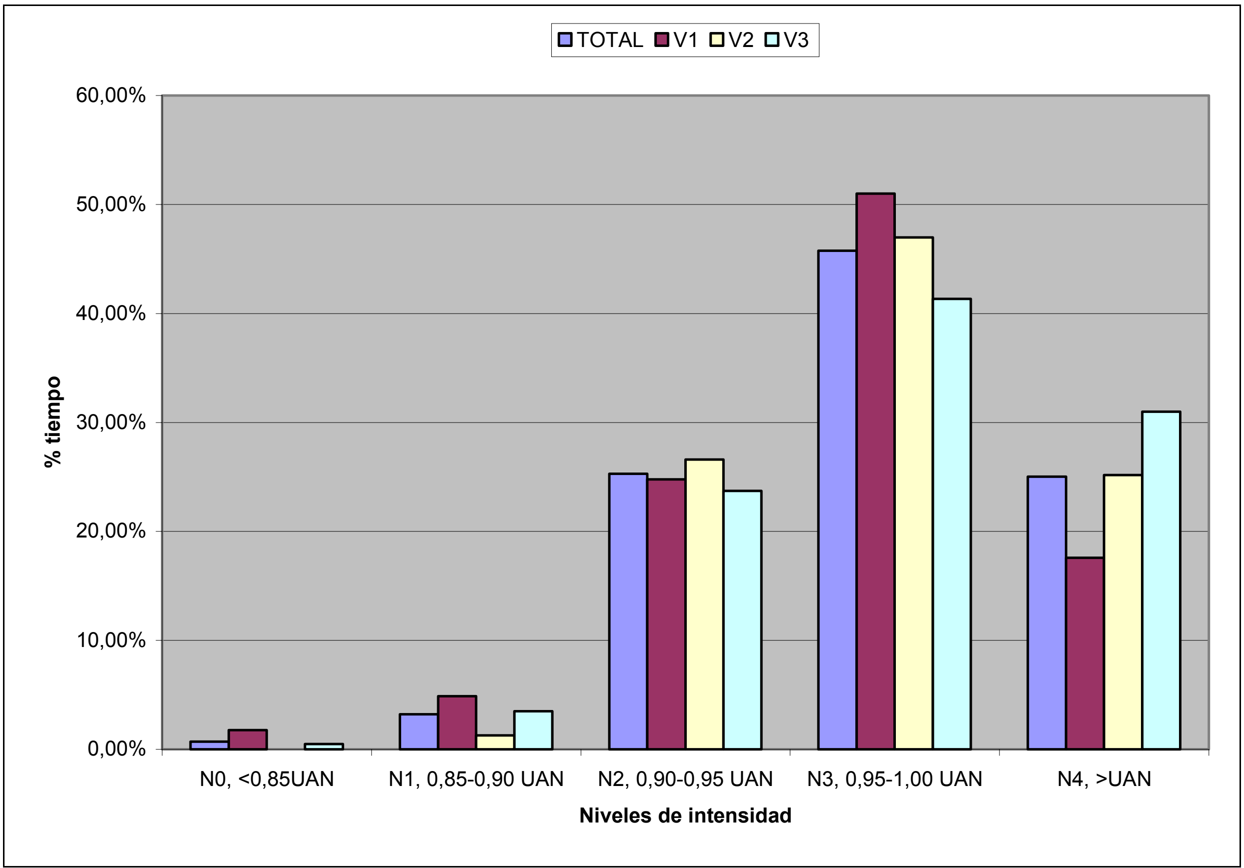


Table 11 shows numerical results.

Table 11: Intensity levels in running lap.

		N0, <0,85 UAN	N1, 0,85-0,90 UAN	N2, 0,90-0,95 UAN	N3, 0,95-1,00 UAN	N4, >UAN
Running AT	TOTAL	3,23%[a]	29,69%[ab]	44,63%[b]	20,82%[ab]	1,63%[a]
	V1	6,05%[ac]	34,85%[ab]	43,46%[b]	15,64%[ac]	0,00%[c]
	V2	1,10%[a]	28,46%[ab]	54,53%[b]	15,75%[ab]	0,16%[a]
	V3	2,95%[a]	27,13%[ab]	50,19%[b]	17,80%[ab]	1,93%[a]
Transition AT	TOTAL	1,79%[a]	34,15%[a]	30,10%[ab]	28,79%[b]	5,17%[ab]
	V1	0,80%[a]	5,08%[a]	21,03%[ab]	68,81%[b]	4,28%[ab]
	V2	8,20%[a]	50,04%[a]	41,76%[ab]	0,00%[b]	0,00%[ab]
	V3	0,00%	0,00%	0,00%	0,00%	0,00%

a, b, c: in the same file, significance, P<0,05

Results show that triathletes raced at N2 mainly if we consider running AT while if we consider transition AT, this level is N3 and this means that transition field test may be an useful key to adjust triathletes posibilities.

As in others laps, running in ECHI was performed at a higher intensities than DOET (80% "N2" ECHI vs 95% N1+N2+N3 in DOET running AT vs 93 % N1+N2+N3 in DOET transition AT and 14% "N4" ECHI vs 2% N1+N2+N3 in DOET running AT vs 5% N1+N2+N3 in DOET transition AT, Menéndez de Luarca, 2003).

Running lap was performed at 12,01 ± 0,98 km/h, that means 80,88 ± 6,10 % running AT speed and 88,37 ± 4,88 % transition AT speed.

4.2.5.2.Blood lactate

In each 6,66 Km running lap, blood lactate was 4,2 ± 1,2 mMol/L, 3,7 ± 0,8 mMol/L and 4,0 ± 1,3 mMol/L, lower than running AT values (0,5 ± 0,7 mMol/L, 0,9 ± 1,3 mMol/L and 0,6 ± 1,5 mMol/L lower respectively). If we consider transition AT, these values are 0,9 ± 1,0 mMol/L, 1,4 ± 1,3 mMol/L and 1,0 ± 1,6 mMol/L respectively (without significant differences in any case).

4.2.6. Heart Rate and Blood Lactate resume.

Figures 17 and 18 show in schema all values considered before.

Figure 17: Blood lactate in DOET and AT.

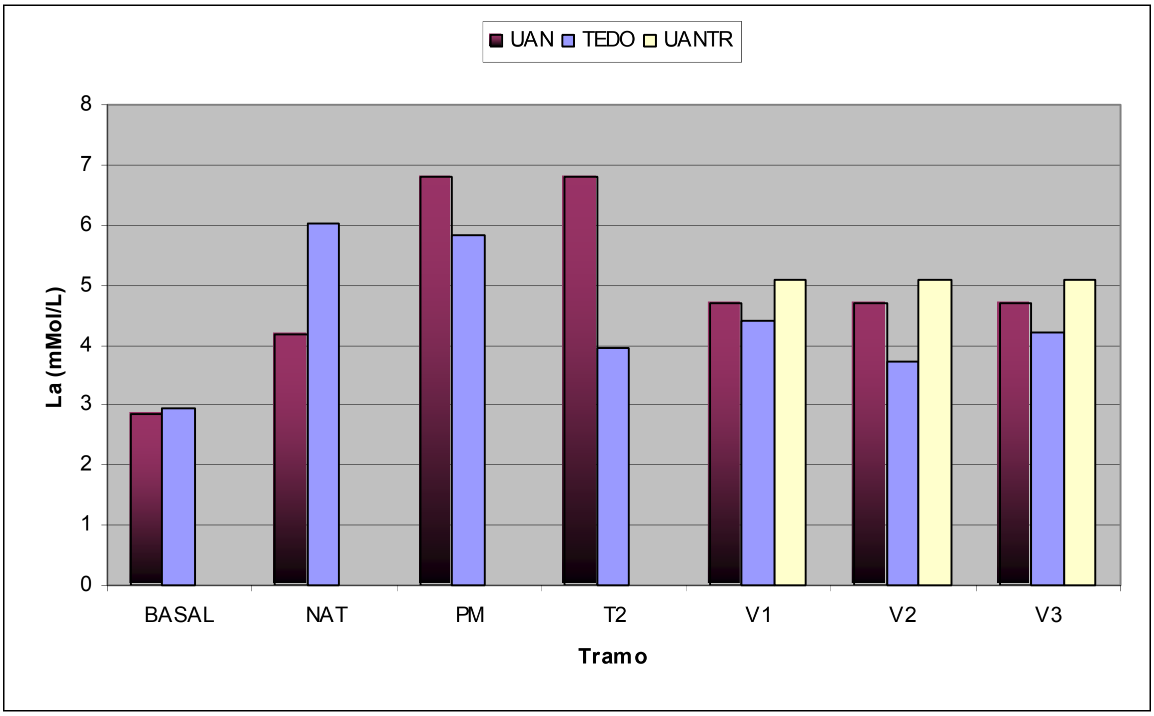
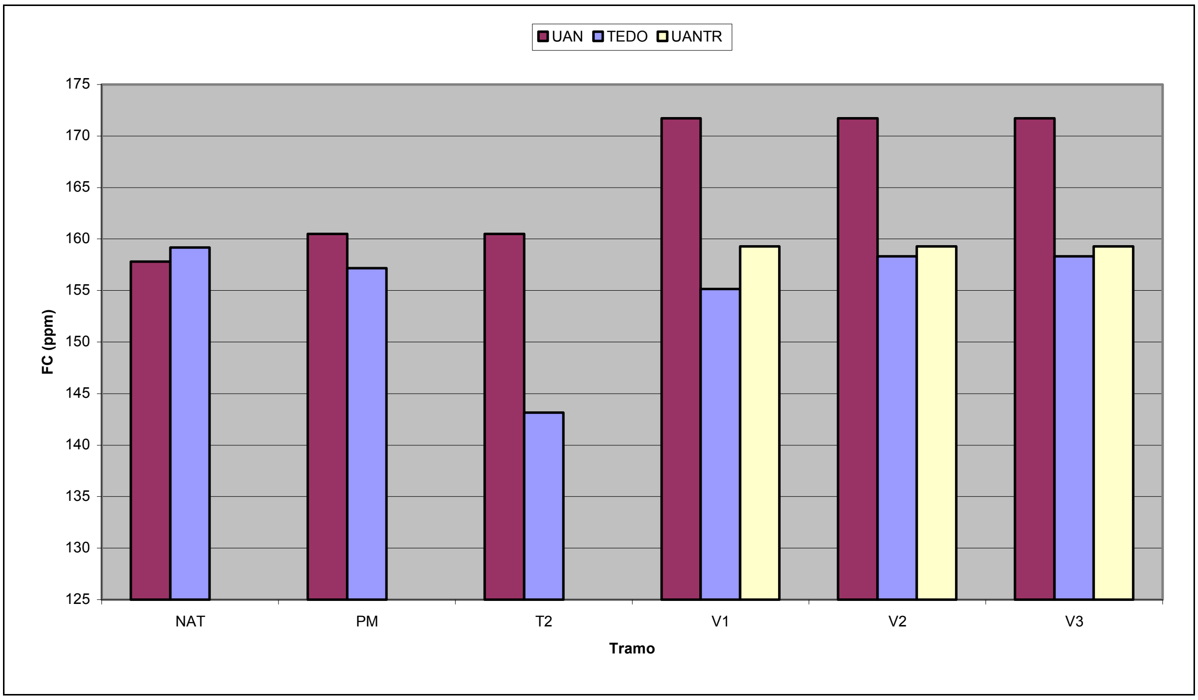


Figure 18: Heart rate in DOET and AT.



4.2.7. *Correlatioal analyse and regression ecuations.*

Table 12 shows mean results.

Swimming speed at AT, VUNAT, was correlated with swimming time, -0,92, and with swimming speed, 0,88. The equations obtained to predict swimming performance were:

$$Tswim = 1{,}537 - 0{,}192 * VUNAT, \quad P<0{,}01$$

$$Sswim = -0{,}814 + 1{,}160 * VUNAT, \quad P<0{,}05$$

Transition AT speed, STAT VUTR, was correlated with final position, -0,817. STAT was not significantly (P=0,07) correlated with final time (pearson coef. -0,77).

STAT was also correlated to running time (-0,82), running speed (0,82) and running position (-0,83).

Table 12: Correlational study.

	PMETA	TMETA	TNAT	VNAT	PNAT	TCIC	VCIC	PCIC	TT2	PT2	TAT	VAT	PAT	
VUNAT			-0,92	0,875										C. Pearson
			0,009	0,022										Signif.
VUTR	-0,817	-0,7679									-0,82	0,822	-0,83	C. Pearson
	0,0473	0,0746									0,044	0,045	0,042	Signif.
PMETA		0,9951							0,809	0,81	0,85	-0,85	0,837	C. Pearson
		4E-05							0,051	0,051	0,032	0,032	0,038	Signif.
TMETA									0,828	0,83	0,845	-0,85	0,823	C. Pearson
									0,042	0,041	0,034	0,034	0,044	Signif.
TNAT				-0,95	0,921									C. Pearson
				0,004	0,009									Signif.
VNAT					-0,9									C. Pearson
					0,013									Signif.
TCIC							-1	0,929	0,914	0,915				C. Pearson
							2E-05	0,007	0,011	0,011				Signif.
VCIC								-0,91	-0,9	-0,9				C. Pearson
								0,012	0,013	0,013				Signif.
PCIC									0,865	0,872				C. Pearson
									0,026	0,023				Signif.
TT2										1				C. Pearson
										6E-08				Signif.
TAT												-1	0,99	C. Pearson
												3E-06	1E-04	Signif.
VAT													-0,98	C. Pearson
													5E-04	Signif.

The regression equations were:

$$PMETA = 833{,}793 - 54{,}132*VUTR, P<0{,}05$$

$$TAT = 4{,}352 - 0{,}197*VUTR, P<0{,}05$$

$$VAT = -8{,}100 + 1{,}481*VUTR, P<0{,}05$$

$$PAT = 1030{,}812 - 68{,}505*VUTR, P<0{,}05$$

Finish time correlated with finish position (r^2=0,995):

$$. PMETA = -770{,}667 + 166{,}667*TMETA, P<0{,}001$$

4.3. Case study in Quelle Challenge Roth (QCR, full Ironman triathlon)

4.3.1. Case1

Subject 1, 31 years old, 70 Kg weight, 1,82 m height and 21,1 Kg/m^2 BMI. It was his third Ironman (IM) experience (Zurich 2004 and Nice 2005 were the previously IM).

Tables 13 and 14 show the comparative between DOET and QCR.

Table 13: Comparative between DOET and QCR.

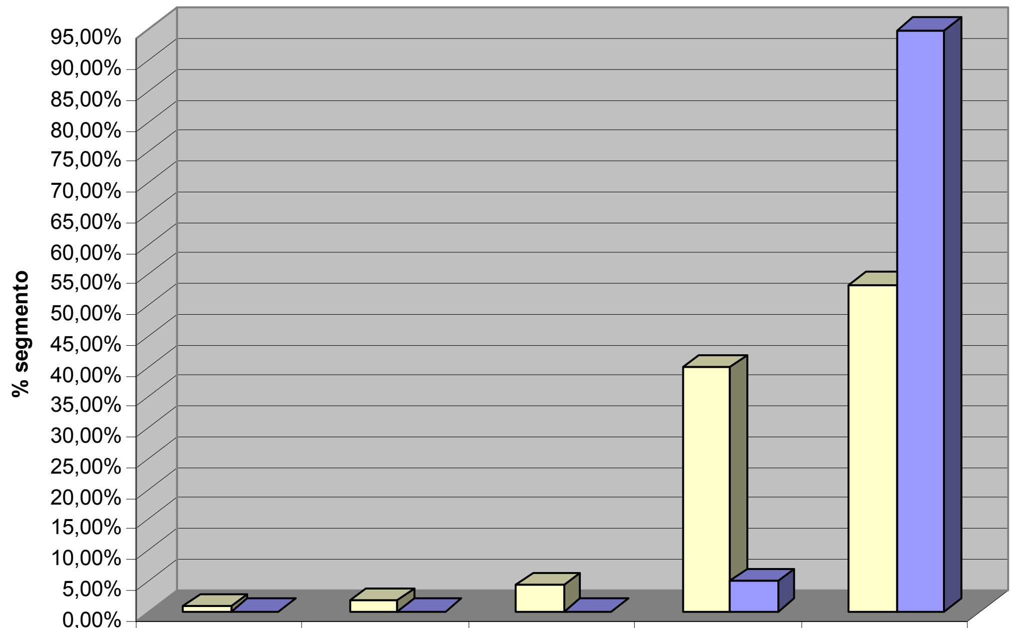
	DISTANCIAS (KM)			TIEMPO TOTAL			TIEMPO PARCIAL		
	IMR	TEDO	IMR/TEDO	IMR	TEDO	IMR/TEDO	IMR	TEDO	IMR/TEDO
NAT	3,8	2,9	131,03%	1:01:36	0:43:13	142,54%	1:01:36	0:43:13	142,54%
T1				1:05:08	0:45:31		0:03:33	0:02:18	
CIC	180	84	214,29%	7:08:15	3:21:35	212,45%	6:03:07	2:36:04	232,67%
T2				7:09:43	3:22:57		0:01:28	0:01:22	
AT	42,2	20	211,00%	11:12:50	4:51:32	230,80%	4:03:07	1:28:35	274,44%

Table 14: Comparative between DOET and QCR speed, % of AT speed and pace.

	V (Km/h)							RITMO (min/100 o min/Km)		
	IMR	%UAN		TEDO	%UAN		IMR/TEDO	IMR	TEDO	IMR/TEDO
NAT	3,70	91,40%		4,03	99,43%		91,93%	0:01:37	0:01:29	108,78%
T1										
CIC	29,74	82,84%		32,22	89,74%		92,31%			
T2		AT	TR		AT	TR				
AT	10,41	69,43%	72,83%	13,55	90,31%	94,73%	76,88%	0:05:46	0:04:26	130,07%

Figures 19 to 22 show heart rate intensity levels in the two races studied.

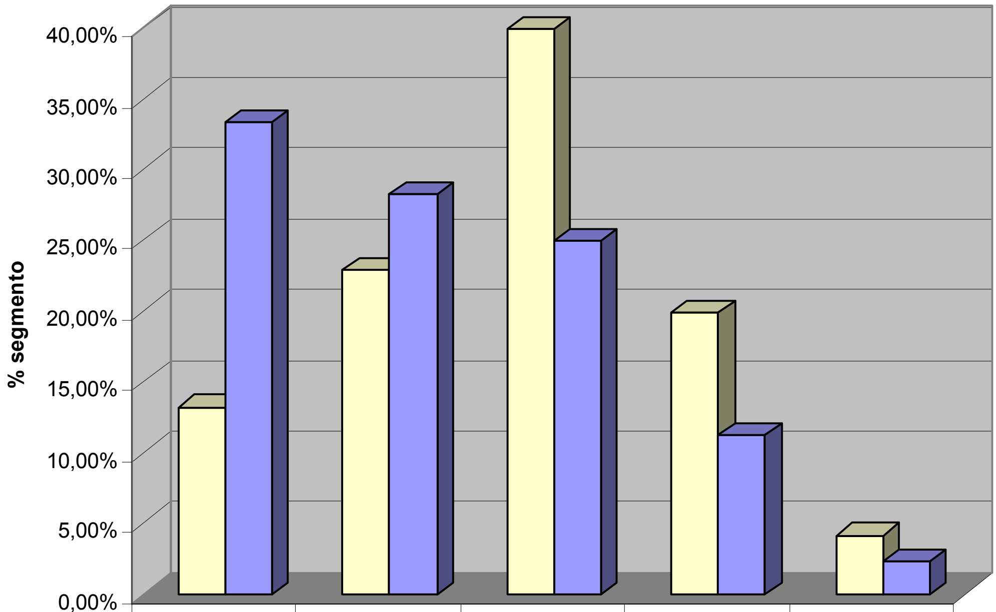
Figure 19: Intensity levels in swimming lap.



	N0, <0,85UAN	N1, 0,85-0,90 UAN	N2, 0,90-0,95 UAN	N3, 0,95-1,00 UAN	N4, >UAN
sujeto 1 TEDO	0,73%	1,75%	4,32%	39,80%	53,40%
sujeto 1 IMRoth	0,00%	0,00%	0,00%	5,05%	94,95%

In QCR, subject 1 swim at a higher intensity level than DOET but final swimming time was 8% slower. This result can be explained by the final trainning phase with an emphasis in cycling and running and a low train level in swimming.

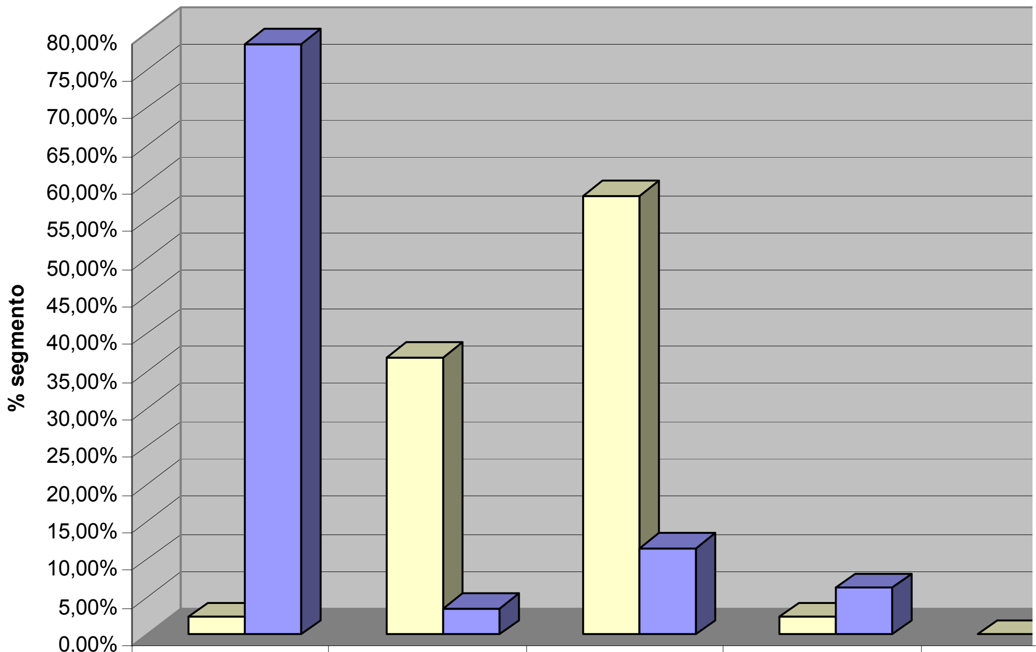
Figure 20: Intensity levels in cycling lap.



	N0, <0,85UAN	N1, 0,85-0,90 UAN	N2, 0,90-0,95 UAN	N3, 0,95-1,00 UAN	N4, >UAN
sujeto 1 TEDO	13,21%	22,84%	39,89%	19,89%	4,16%
sujeto 1 IMRoth	33,33%	28,25%	24,95%	11,18%	2,30%

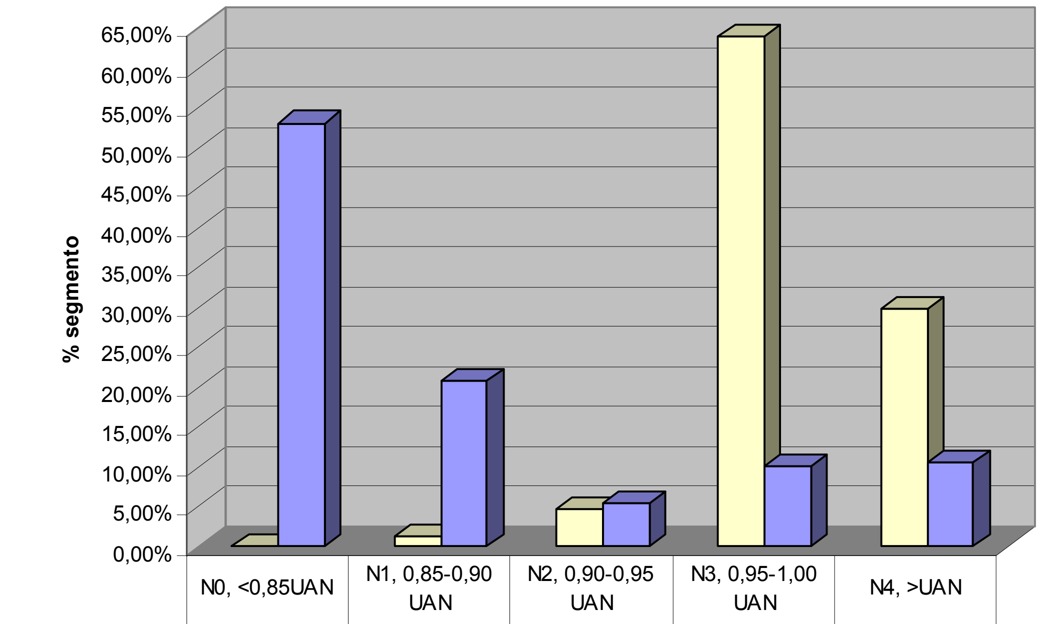
In bike lap, the triathlete rode at speed 83 % of the VUAN. In figure 19 we can observe that the most intensity level performed was N0 in front of N2 in DOET. This is a low level, even in a full ironman race. The triathlete relate muscular problems in his left calf from km 140.

Figure 21: Intensity levels in running lap regarding UANAT.



	N0, <0,85UAN	N1, 0,85-0,90 UAN	N2, 0,90-0,95 UAN	N3, 0,95-1,00 UAN	N4, >UAN
sujeto 1 TEDO	2,35%	36,88%	58,42%	2,35%	0,00%
sujeto 1 IMRoth	78,57%	3,57%	11,59%	6,27%	0,00%

Figure 22: Intensity levels in running lap regarding UANTR.



	N0, <0,85UAN	N1, 0,85-0,90 UAN	N2, 0,90-0,95 UAN	N3, 0,95-1,00 UAN	N4, >UAN
sujeto 1 TEDO	0,09%	1,32%	4,80%	63,97%	29,82%
sujeto 1 IMRoth	53,10%	20,84%	5,52%	10,01%	10,52%

In this lap, the muscular problems kept on and the triathlete alterned run and walk.

4.3.2. Case 2

The other racer in QCR was DOET subject 6, 27 years old, 78 Kg weight live, 1,85 m height and 22,8 Kg/m^2 BMI. He was a novel Ironman triathlete who QCR was his goal. He raced too Valencia marathon in 20 February.

The comparison tables 15 and 16 show the results in DOET and QCR:

Table 15: Comparison distance, total time and lap time between DOET and QCR

	DISTANCIE (KM)			TOTAL TIME			LAP TIME		
	QCR	DOET	QCR/DOET	QCR	DOET	QCR/DOET	QCR	DOET	QCR/DOET
SWIM	3,8	2,9	131,03%	1:05:52	0:48:49	134,94%	1:05:52	0:48:49	134,94%
T1				1:12:27	0:51:07		0:06:36	0:02:18	
BIKE	180	84	214,29%	7:15:32	3:32:37	204,85%	6:03:05	2:41:30	224,81%
T2				7:18:48	3:33:59		0:03:16	0:01:22	
RUN	42,2	20	211,00%	11:47:46	5:16:44	223,45%	4:28:57	1:42:45	261,74%

Table 16: Comparison speed, %VUAN and pace between DOET and QCR.

	V (Km/h)							RITMO (min/100 o min/Km)		
	QCR	%UAN		DOET	%UAN		QCR/DOET	QCR	DOET	QCR/DOET
SWIM	3,46	78,68%		3,56	81,02%		97,11%	0:01:44	0:01:41	102,98%
T1										
BIKE	29,74	84,99%		31,13	88,95%		95,55%			
T2		AT	TR		AT	TR				
RUN	9,41	59,51%	71,97%	11,68	73,82%	89,28%	80,61%	0:06:22	0:05:08	124,05%

Figures 23 to 26 show intensity race levels of heart rate regarding previous field tests results.

Figure 23: Swim intensity in DOET vs QCR.

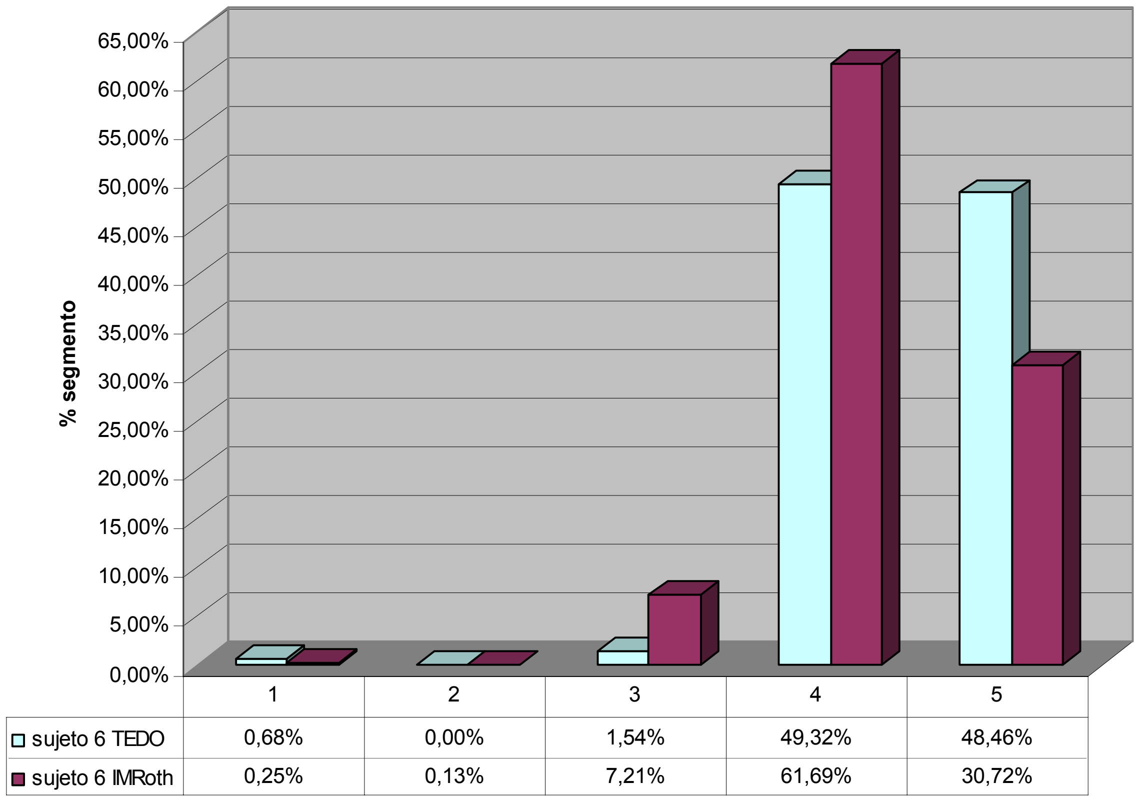
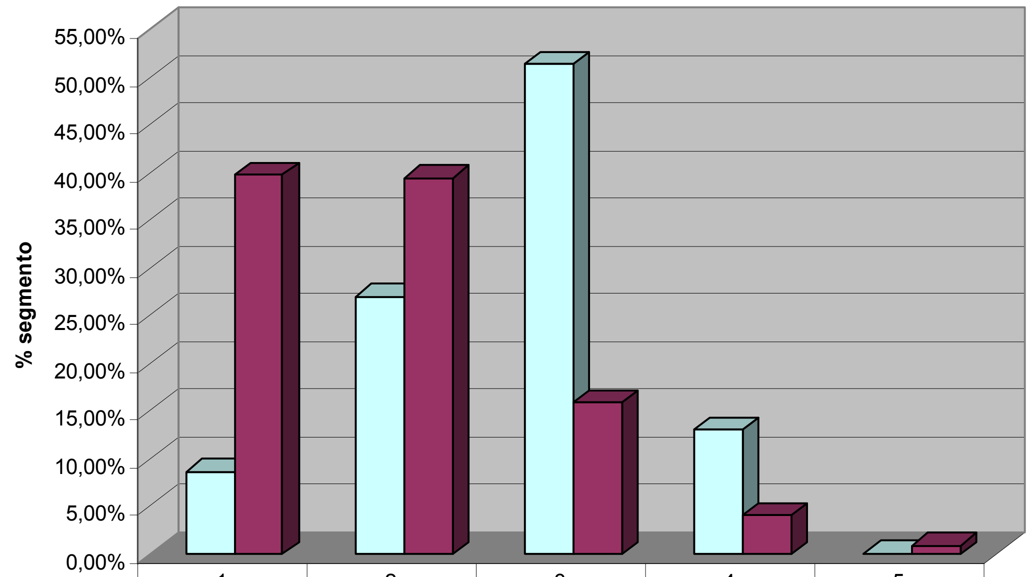
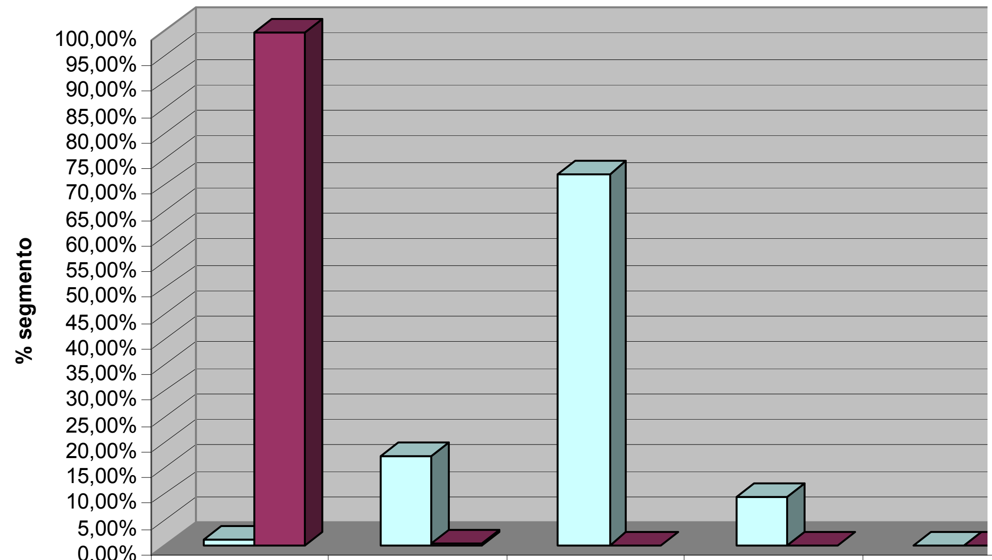


Figure 24: Bike intensity in DOET vs QCR.



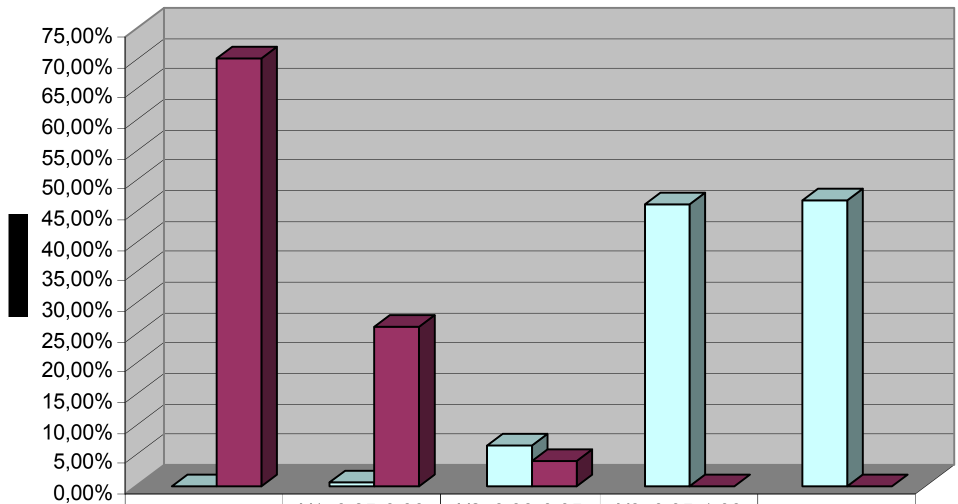
	1	2	3	4	5
sujeto 6 TEDO	8,65%	26,96%	51,29%	13,05%	0,05%
sujeto 6 IMRoth	39,75%	39,38%	15,88%	4,11%	0,87%

Figure 25: Run intensity in DOET vs QCR regarding UANAT.



	N0, <0,85UAN	N1, 0,85-0,90 UAN	N2, 0,90-0,95 UAN	N3, 0,95-1,00 UAN	N4, >UAN
□ sujeto 6 TEDO	1,22%	17,34%	72,04%	9,40%	0,00%
■ sujeto 6 IMRoth	99,57%	0,43%	0,00%	0,00%	0,00%

Figure 26: Run intensity in DOET vs QCR regarding UANTR.



	N0, <0,85UAN	N1, 0,85-0,90 UAN	N2, 0,90-0,95 UAN	N3, 0,95-1,00 UAN	N4, >UAN
□ sujeto 6 TEDO	0,00%	0,57%	6,56%	46,03%	46,84%
■ sujeto 6 IMRoth	70,07%	25,88%	4,06%	0,00%	0,00%

5. Conclusions

The field test for transition Bike – Run, specific for middle distancia triathlon, tested in this study has result a good tool to predict the performance in Double Olympic Triathlon.

Swim intensity in a Double Olympic Triathlon is very high regarding the distance and the two following segments, bike and run, with 35% of time spent over the anaerobic treshold with lactate values at the end of swimming over this treshold.

Bike lap is competed at a high intensity, mainly N2, 36%, opposite N3, 32%, and N4 (over AT), 14%. In the mountain pass, the lactate values were close to AT.

In the run lap, the intensity level decreased considerably, with 30% of run time spent in N1, N2 and N3 levels regarding anaerobic treshold obtained in specific transition field test, with lactate values at the end of triathlon close to this AT.

Final performance and run performance were correlated significantly with speed at anaerobic treshold obtained in specific transition field test while swim performance was correlated with speed at anaerobic swim treshold.

The case study developed with two people in QCR 8 weeks after DOET showed that swim lap was performed at similar or slightly higher intensity level in ironman than double olympic distance. Bike lap was performed at lower intensity level and, specially run lap was performed at very much lower intensity level in ironman distance with several muscular problems related by triathletes allmost all the marathon.

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References

Abbiss, C.R., Quod, M.J., Martin, D.T., Netto, K.J., Nosaka, K., Lee, H., Surriano, R., Bishop, D., Laursen, P.B., 2006. Dynamic pacing strategies during the cycle phase of an Ironman triathlon. Med Sci Sports Exerc, 38 (4): 726-734.

Bentley, D.J., McNaughton, L.R., Thompson, D., Vleck, V.E., Batterham, A.M., 2001. Med Sci Sports Exerc, 33 (12): 2077-2081.

Boussana, A., Galy, O., Matecki, S., Hue, O., Ramonatxo, M., Varray, A., Le Gallais, D., 2003. Influence of a short distance triathlon on respiratory muscle performance Sci Sports, 18, 34-36.

Costill, D.L., Maglischo, E.W., Richardson, A.B., 1992. Natación. Barcelona. Ed. Hispano Europea S.A.

Davis, J.A., Vodak, P., 1976. Anaerobic threshold and maximal aerobic power for three modes of exercise. J Appl Physiol, 41, 18-23.

Delextrat, A., Bernard, T., Vercruyssen, F., Hausswirth, C., Brisswalter, J., 2003. Influence of swimming characterisics on performance during a swim-to-cycle transition. Sci Sports, 18, 188-195.

Farber, H.W., Schaefer, E.J., Franey, R., Grimaldi, R., Hill, N.S., 1991. The endurance triathlon: metabolic changes after each event and during recovery. Med. Sci. Sports Exerc., 23, 959-963.

González Haro, C., González de Suso, J.M., Padulles, J.M., Drobnic, F., Fernando Escanero, J., 2005. Physiological adaptation during short distance triathlon swimming and cycling sectors simulation. Physiol and Behavior, 86 (4): 467-474.

Hausswirth, C., Lehenaff, D., 2001. Physiological demands on running during long distance runs and triathlons. Sports Med, 31 (9): 679-689.

Hausswirth, C., Vallier, J.M., Lehenaff, D., Brisswalter, J., Smith, D., Millet, G., Dreano, P., 2001. Effect of two drafting modalities in cycling on running performance. Med Sci Sports Exerc, 33 (3), 485-492.

Hue, O., 2003. Prediction of drafted-triathlon race time from submaximal laboratory testing in elite triathletes. Can J Appl Physiol, 28 (4): 547-560.

Laursen, P.B., Knez, W.L., Shing, C.M., Langill, R.H., Rhodes, E.C., Jenkins, D.G., 2005. Relationship beteween laboratory-mesured variables and heart rate during an ultra-endurance triathlon. J Sports Sci, 23 (10): 1111-1120.

Menéndez de Luarca, J., 2003. Frecuencia cardiaca en triatlón medio ironman. D.E.A., Universidad Europea de Madrid.

Meyer, T., Gabriel, H.H.W., Auracher, M., Scharhag, J., Kindermann, W., 2002. Metabolic profile of 4 h cycling in the field with varying amounts of carbohydrate supply. European J Appl Physiol, 106: 245-255.

Millet, G.P., Vleck, V.E., 2000. Physiological and biomechanical adaptations to the cycle to run transition in Olympic triathlon: review. Br J Sports Med, 34 (5): 384-390.

Navarro, F., 1998. La Resistencia. Madrid. Ed. Gymnos.

O'Toole, M.L., Douglas, P.S., 1995. Applied physiology of triathlon. Sports Med, 19 (4): 251-267.

Padilla S., Mujika I., Cuesta G., Polo J., Chatard J., 1996. Validity of a velodrome test for competitive road cyclists. Eur J Appl Physiol, 73, 446-451.

Peeling, P.D., Bishop, D.J., Landers, G.J., 2005. Effect of swimming intensity on subsequent cycling and overall triathlon performance. Br J Sports Med, 39 (12): 960-1004.

Rubert-Alemán, X., 2006. Relación entre velocidad de nado, longitud y frecuencia de brazada en triatletas de categoría regional en la prueba de 100 m crol. Resultados no publicados.

Torres, M., 2005. Curso de Entrenador de Base de Triatlón, Valencia, Federación de Triatlón de la Comunidad Valenciana.

Trigo P.I., Castejón-Montijano F., Baxter M., 2000. Precisión de las tiras reactivas Lactate Scout para la medida del ácido láctico en la sangre equina. Resultados preliminares. www.biolaster.com.

Whyte, G., Lumley, S., George, K., Gates, P., Sharma, S., Prasad, K., McKenna, W.J., 2000. Physiological profile and predictors of cycling performance in ultra-endurance triathletes. J Sports Med Phys Fitness, 40 (2): 103-109.