Area:
Documentazione,
Informazione e Ricerca

L'Allenamento Aerobico nello Sport

Relatore: **Carlo Castagna**

Corso di Laurea in Scienze Motorie
Facoltà Medicina e Chirurgia,
Roma Tor Vergata

4 Luglio 2007, Sala CONI Regionale, Ancona

Introduzione

Allenare:

- **Cosa?**
- **Come?**
- **Quanto?**

Introduzione

Allenare

Cosa?

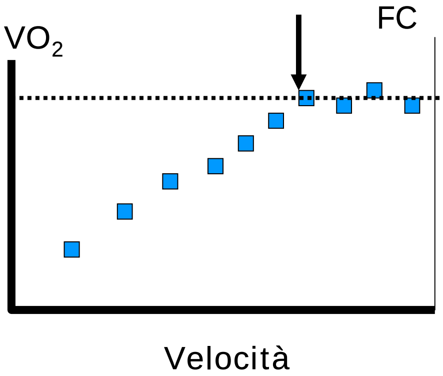
VO_2max

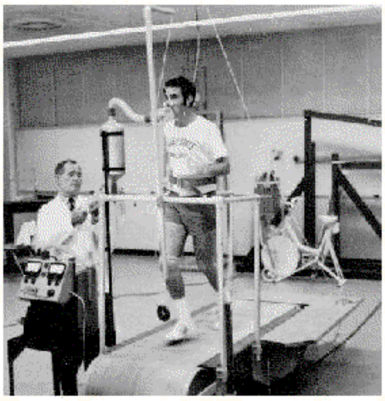
$\%VO_2max$

Allenare

Allenare

VO_2max

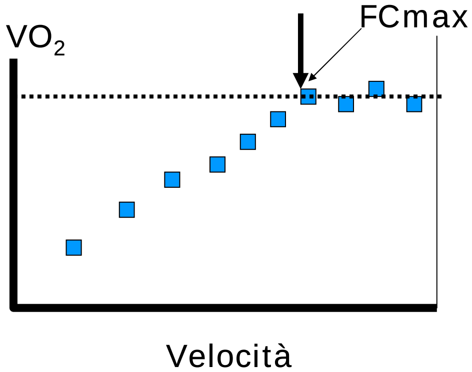


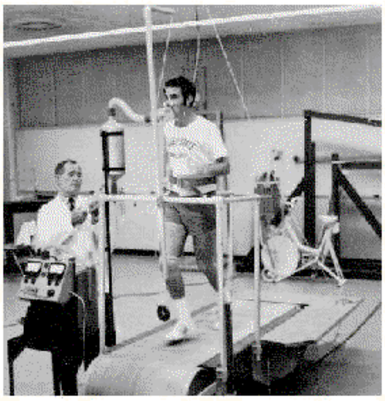


Allenare

Allenare

VO_2max





Allenare

Allenare

VO_2max

- FC
- Velocità
- RPE

Rate of Perceived Exertion

Allenare

Borg CR10-Scale

Foster et al (1995) E J Appl Physiol

Rating	Descriptor
0	Rest
1	Very, very Easy
2	Easy
3	Moderate
4	Somewhat Hard
5	Hard
6	
7	Very Hard
8	
9	
10	Maximal

Allenare: VO_2max

Frequenza Cardiaca

- FC: 90-95%
- FCmax
- Metodo?

Helgerud et al. 2001; Impellizzeri et al. 2006

Allenare: VO_2max

Allenare: VO_2max

VO_2

- $VO_2 > 80\text{-}85\%$
- ↑VO_2max
- Metodo?

Helgerud et al. 2001; Impellizzeri et al. 2006

Allenare: VO_2max

Allenare: VO_2max

Velocità

- MVA
- **M**assima
- **V**elocità
- **A**erobica

Billat et al. 1996

Allenare: VO_2max

Allenare: VO_2max

MVA

- Minima
- Velocità
- Al VO_2max

APPLIED SCIENCES
Biodynamics

Training and Bioenergetic Characteristics in Elite Male and Female Kenyan Runners

VERONIQUE BILLAT[1,3], PIERRE-MARIE LEPRETRE[3], ANNE-MARIE HEUGAS[2], MILLE-HAMARD LAURENCE[1], DRAI SALIM[3], and JEAN PIERRE KORALSZTEIN[3]

[1]Faculty of Sport Science, University of Evry-Val d'Essonne, FRANCE; [2]Faculty of Sport Science, University of Paris 11, FRANCE; and [3]Sports Medicine Center CCAS, Paris, FRANCE

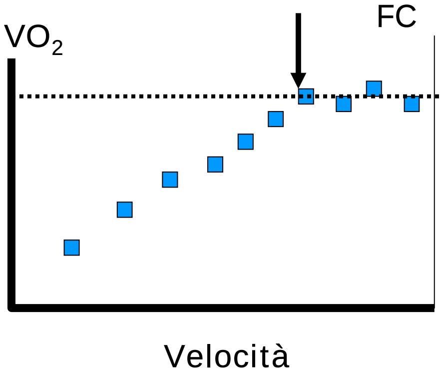
ABSTRACT

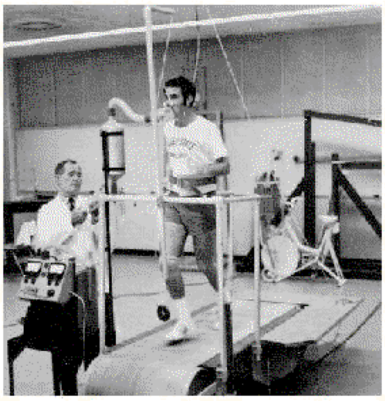
BILLAT, V., P.-M. LEPRETRE, A.-M. HEUGAS, M.-H. LAURENCE, D. SALIM, and J. P. KORALSZTEIN. Training and Bioenergetic Characteristics in Elite Male and Female Kenyan Runners. *Med. Sci. Sports Exerc.*, Vol. 35, No. 2, pp. 297–304, 2003. **Purpose:** This study compares the training characteristics and the physical profiles of top-class male and female Kenyan long-distance runners. **Method:** The subjects were 20 elite Kenyan runners: 13 men (10-km performance time: 10-km performance time of 28 min, 36 s ± 18 s) and 7 women (32 min, 32 s ± 65 s). The male runners were separated into high-speed training runners (HST: $N = 6$) and low-speed training runners (LST: $N = 7$) depending on whether they train at speeds equal or higher than those associated with the maximal oxygen uptake ($v\dot{V}O_{2max}$). All but one woman were high-speed training runners (female HST: $N = 6$). Subjects performed an incremental test on a 400-m track to determine $\dot{V}O_{2max}$, $v\dot{V}O_{2max}$, and the velocity at the lactate threshold (vLT). **Results:** Within each gender among the HST group, 10-km performance time was inversely correlated with $v\dot{V}O_{2max}$ (rho = −0.86, $P = 0.05$, and rho = −0.95, $P = 0.03$, for men and women, respectively). HST male runners had a higher $\dot{V}O_{2max}$, a lower (but not significantly) fraction of $v\dot{V}O_{2max}$ ($F\dot{V}O_{2max}$) at the lactate threshold, and a higher energy cost of running (ECR). Among men, the weekly training distance at $v\dot{V}O_{2max}$ explained 59% of the variance of $v\dot{V}O_{2max}$, and $v\dot{V}O_{2max}$ explained 52% of the variance of 10-km performance time. Kenyan women had a high $\dot{V}O_{2max}$ and $F\dot{V}O_{2max}$ at vLT that was lower than their male HST counterparts. ECR was not significantly different between genders. **Conclusion:** The velocity at the $\dot{V}O_{2max}$ is the main factor predicting the variance of the 10-km performance both in men and women, and high-intensity training contributes to this higher $\dot{V}O_{2max}$ among men. **Key Words:** AFRICA, $\dot{V}O_{2max}$, OXYGEN UPTAKE, RUNNING, PERFORMANCE

Allenare: VO_2max

Allenare

VO_2max

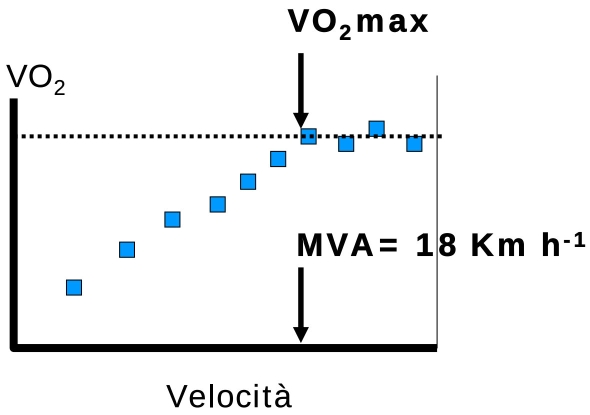




Allenare

Allenare

VO_2max

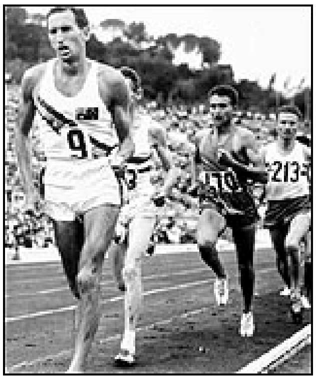


Allenare

Allenare: VO_2max

MVA

- **Quanto Tempo?**
- **5-6 min?**
- **Tlim (tempo limite)**



Allenare: VO_2max

Allenare: VO_2max

Tlim-*v*VO_2max

- N=14
- Male Sub-elite

MVA	21.5±1 kmh^{-1}
VO_2max	68.9±4.6 $mlkg^{-1}min^{-1}$
Tlim	269±77s
CV Tlim	29%

Renoux al. 2000

Allenare: VO_2max

Allenare: VO_2max

Tlim-*v*VO_2max

- N=14
- Male Sub-elite

MVA *vs* VO_2max	r=0.66 $p<0.05$
MVA *vs* TlimMVA	r=-0.50 $p<0.05$
MVA *vs* Tlim120%MVA	r=0.52 $p<0.05$
MVA *vs* pH120%MVA	r=-0.68 $p<0.05$
Tlim 100% *vs* 120%MVA	r=0.52 $p<0.05$

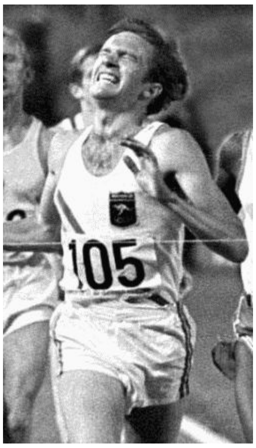
Renoux al. 2000

Allenare: VO_2max

Allenare: VO_2max

Tlim $v$$VO_2$max?

- **Stabilire**
- **Carichi**
- **Allenamento**



Allenare: VO_2max

Tlim $v$$VO_2$max?

$v$$VO_2$max	
90%	731s
100%	333s
120%	123s
140%	73s

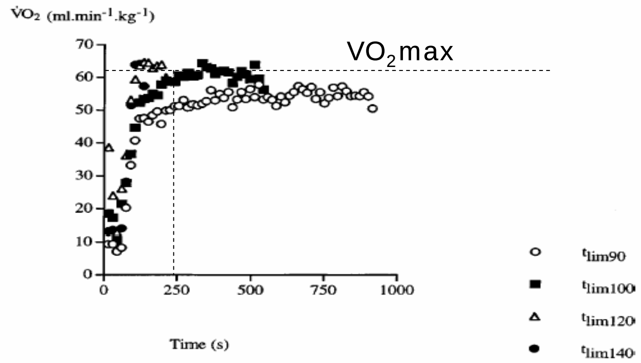


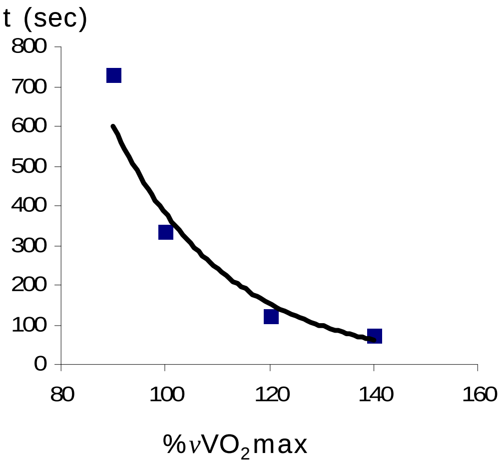
Fig. 1 A typical example of the time courses of oxygen uptake ($\dot{V}O_2$) during runs to exhaustion at 90%, 100%, 120% and 140% of the velocity at which maximal oxygen uptake was achieved in the incremental test ($t_{lim,90,100,120,140}$). Data from subject 6

Billat et al. 1999

Allenare: VO_2max

Tlim vVO_2max?

		VO_2max
90%	731s	88%
100%	333s	100%
120%	123s	100%
140%	73s	94%

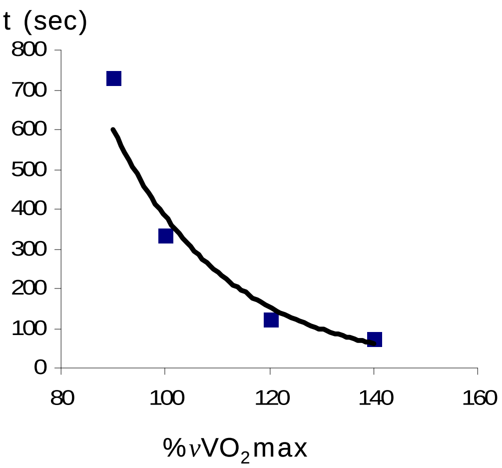


Billat et al. 1999

Allenare: VO_2max

Dlim vVO_2max?

	Tlim	Distanza
90%	731s	3087m
100%	333s	1580m
120%	123s	696m
140%	73s	481m



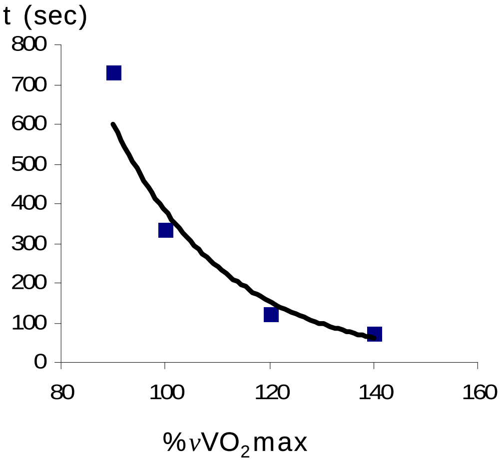
Billat et al. 1999

Allenare: VO_2max

Dlim?

Dlim vVO_2max

	VO_2max	Distanza
90%	70m	3087m
100%	907m	1580m
120%	425m	696m
140%	113m	481m



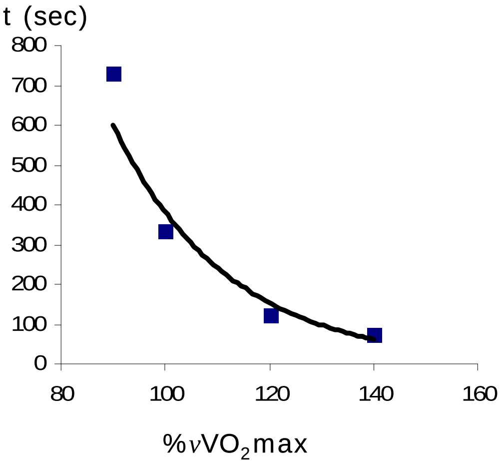
Billat et al. 1999

Allenare: VO_2max

Dlim?

Dlim vVO_2max

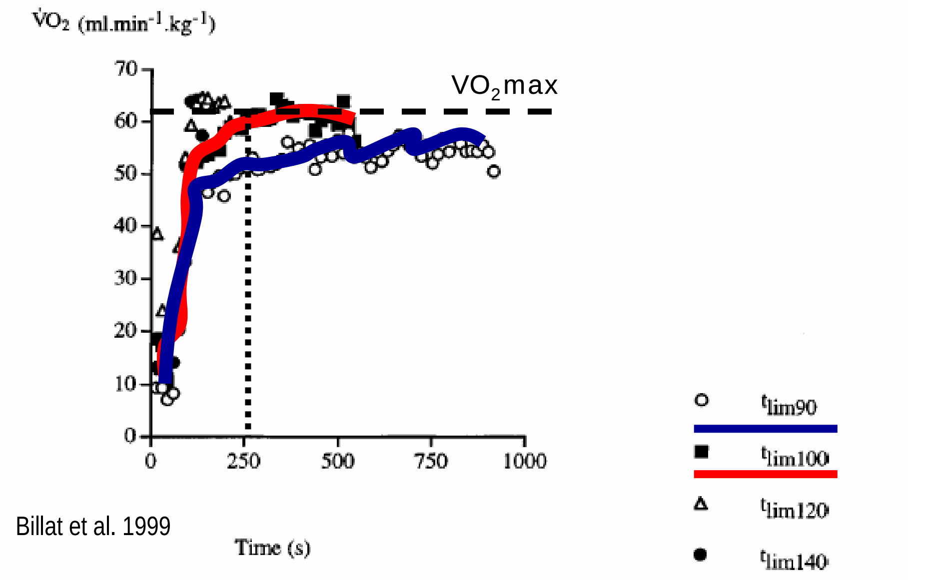
	VO_2max	Distanza
90%	16s	3087m
100%	190s	1580m
120%	73s	696m
140%	18s	481m



Billat et al. 1999

Allenare: VO_2max

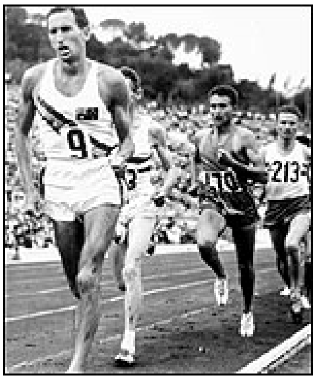
Tlim *v*VO_2max



Allenare: VO_2max

Carichi

- Tlim ?
- Continuo
- Intermittente



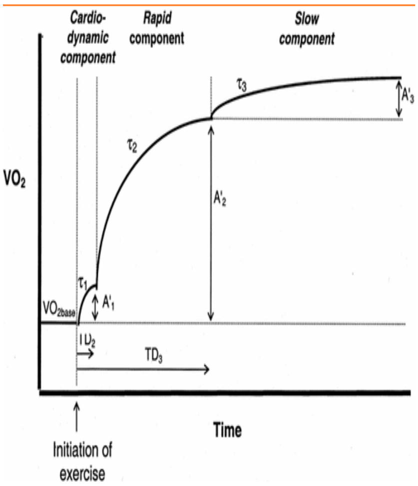
Allenare: VO_2max

Allenare: VO_2max

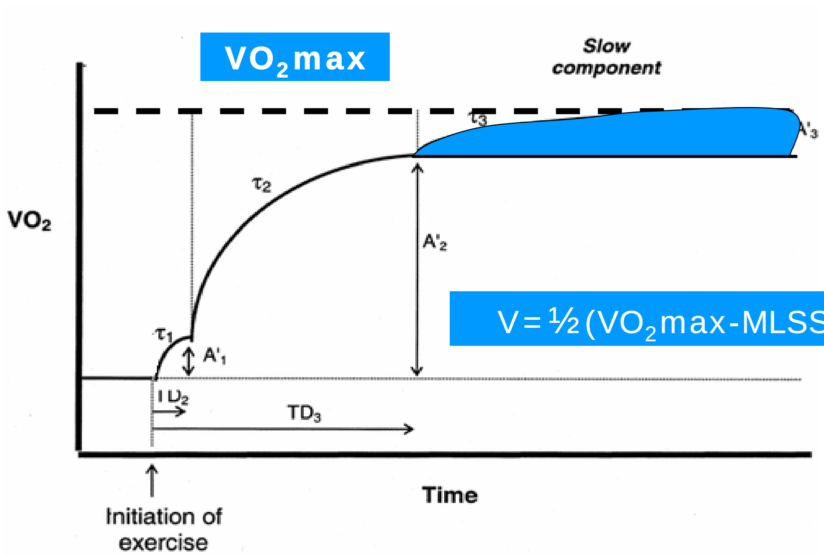
Continuo

- 100% MVA
- <100% MVA

Componente Lenta VO_2



Componente Lenta



$V = ½(VO_2max-MLSS)$

Allenare: VO_2max

Continuo

- N=8
- Male Sub-elite

MVA	20.5±0.8 kmh^{-1}
VO_2max	71.2±5 $mlkg^{-1}min^{-1}$
Tlim	301.3±54s
DTlim	2052±332m

Billat al. 1999

Allenare: VO_2max

Allenare: VO_2max

Billat e coll. 1999

Training Set-Up:

Allenare: VO_2max

Allenare: VO_2max

Continuo

- 5x ½ Tlim vVO_2max — 1 volta settimana
- 2x 20’ OBLA — 1 volta settimana

↑ vVO_2max

---- VO_2max

---- OBLA

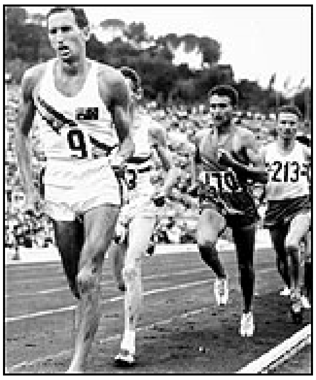
Billat al. 1999

Allenare: VO_2max

Allenare: VO_2max

Intermittente

- Lavoro
- Pause
- Sequenze

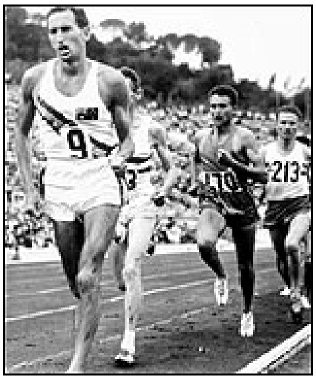


Allenare: VO_2max

Allenare: VO_2max

Intermittente

- 30-30s
- 15-15s
- $v VO_2max$

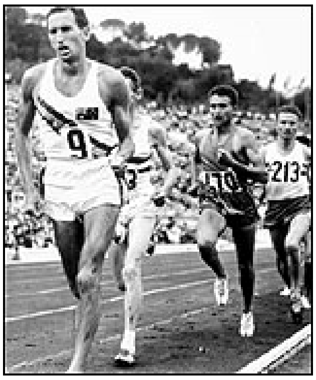


Allenare: VO_2max

Allenare: VO_2max

Intermittente

- 30-30s
- 30s $v VO_2max$
- 30s ½ $v VO_2max$



Billat al. 2000

Allenare: VO_2max

30-30s

Eur J Appl Physiol (2000) 81: 188–196

ORIGINAL ARTICLE

Véronique L. Billat · Jean Slawinski · Valery Bocquet
Alexandre Demarle · Laurent Lafitte
Patrick Chassaing · Jean-Pierre Koralsztein

Intermittent runs at the velocity associated with maximal oxygen uptake enables subjects to remain at maximal oxygen uptake for a longer time than intense but submaximal runs

Accepted: 27 July 1999

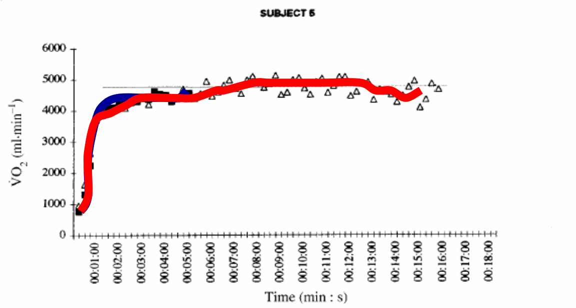
Abstract Interval training consisting of brief high intensity repetitive runs (30 s) alternating with periods of complete rest (30 s) has been reported to be efficient in improving maximal oxygen uptake ($\dot{V}O_{2max}$) and to be tolerated well even by untrained persons. However, these studies have not investigated the effects of the time spent at $\dot{V}O_{2max}$ which could be an indicator of the benefit of training. It has been reported that periods of continuous running at a velocity intermediate between that of the lactate threshold (v_{LT}) and that associated with $\dot{V}O_{2max}$ ($v_{\dot{V}O_{2max}}$) can allow subjects to reach $\dot{V}O_{2max}$ due to an additional slow component of oxygen uptake. Therefore, the purpose of this study was to compare the times spent at $\dot{V}O_{2max}$ during an interval training programme and during continuous strenuous runs. Eight long-distance runners took part in three maximal tests on a synthetic track (400 m) whilst

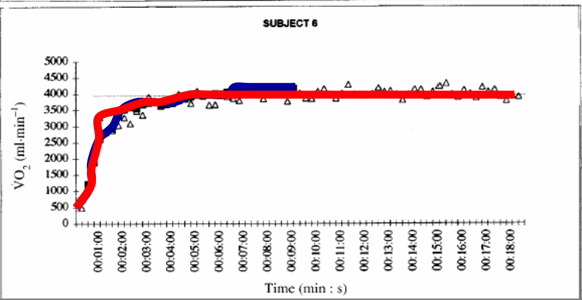
reach $\dot{V}O_{2max}$, but the time spent specifically at $\dot{V}O_{2max}$ was much less than that during the alternating low/high intensity exercise protocol [2 min 42 s (SD 3 min 09 s) for $v_{\Delta 50}$ run vs 7 min 51 s (SD 6 min 38 s) in 19 (SD 5) interval runs]. The blood lactate responses were less pronounced in the interval runs than for the $v_{\Delta 50}$ runs, but not significantly so [6.8 (SD 2.2) mmol · l^{-1} vs 7.5 (SD 2.1) mmol · l^{-1}]. These results do not allow us to speculate as to the chronic effects of these two types of training at $\dot{V}O_{2max}$.

Key words Intermittent exercise · Running · Training · Oxygen consumption

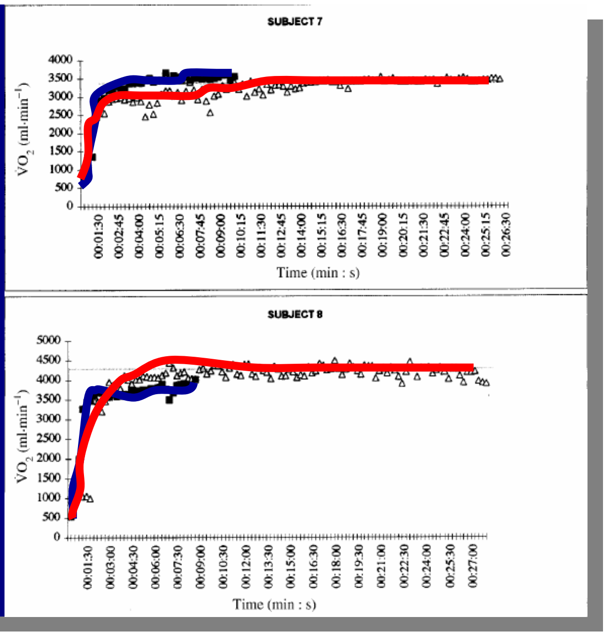
Introduction

30-30s *vs* Slow-Comp





30-30s *vs* Slow-Comp



Eur J Appl Physiol (2000) 81: 188–196

ORIGINAL ARTICLE

Véronique L. Billat · Jean Slawinski · Valery Bocquet
Alexandre Demarle · Laurent Lafitte
Patrick Chassaing · Jean-Pierre Koralsztein

Intermittent runs at the velocity associated with maximal oxygen uptake enables subjects to remain at maximal oxygen uptake for a longer time than intense but submaximal runs

Accepted: 27 July 1999

Abstract Interval training consisting of brief high intensity repetitive runs (30 s) alternating with periods of complete rest (30 s) has been reported to be efficient in improving maximal oxygen uptake ($\dot{V}O_{2max}$) and to be tolerated well even by untrained persons. However, these studies have not investigated the effects of the time spent at $\dot{V}O_{2max}$ which could be an indicator of the benefit of training. It has been reported that periods of continuous running at a velocity intermediate between that of the lactate threshold (v_{LT}) and that associated with $\dot{V}O_{2max}$ ($v_{\dot{V}O_{2max}}$) can allow subjects to reach $\dot{V}O_{2max}$ due to an additional slow component of oxygen uptake. Therefore, the purpose of this study was to compare the times spent at $\dot{V}O_{2max}$ during an interval training programme and during continuous strenuous runs. Eight long-distance runners took part in three maximal tests on a synthetic track (400 m) whilst … reach $\dot{V}O_{2max}$, but the time spent specifically at $\dot{V}O_{2max}$ was much less than that during the alternating low/high intensity exercise protocol [2 min 42 s (SD 3 min 09 s) for $v_{\Delta50}$ run vs 7 min 51 s (SD 6 min 38 s) in 19 (SD 5) interval runs]. The blood lactate responses were less pronounced in the interval runs than for the $v_{\Delta50}$ runs, but not significantly so [6.8 (SD 2.2) mmol · l^{-1} vs 7.5 (SD 2.1) mmol · l^{-1}]. These results do not allow us to speculate as to the chronic effects of these two types of training at $\dot{V}O_{2max}$.

Key words Intermittent exercise · Running · Training · Oxygen consumption

Introduction

	30-30s	Δ50
tVO_2max	7’51”	2’42”
$[La]_b$	6.8	7.5
tlim	~20’	8’20”

15-15s

Very Short (15 s – 15 s) Interval-Training Around the Critical Velocity Allows Middle-Aged Runners to Maintain $\dot{V}O_2$ max for 14 minutes

V. L. Billat[1], J. Slawinksi[1], V. Bocquet[2], P. Chassaing[1], A. Demarle[1], J. P. Koralsztein[2]

[1] Laboratoire d'étude de la motricité humaine, Université de Lille II, Faculté des Sciences du Sport, Ronchin, France
[2] Centre de Médecine du Sport C.C.A.S., Paris, France

Billat VL, Slawinksi J, Bocquet V, Chassaing P, Demarle A, Koralsztein JP. Very Short (15 s – 15 s) Interval-Training Around the Critical Velocity Allows Middle-Aged Runners to Maintain $\dot{V}O_2$ max for 14 minutes. Int J Sports Med 2001; 22: 201 – 208

Accepted after revision: August 15, 2000

The purpose of this study was to compare the effectiveness of three very short interval training sessions (15 – 15 s of hard and easier runs) run at an average velocity equal to the critical velocity to elicit $\dot{V}O_2$ max for more than 10 minutes. We hypothesized that the interval with the smallest amplitude (defined as the ratio between the difference in velocity between the hard and the easy run divided by the average velocity and multiplied by 100) would be the most efficient to elicit $\dot{V}O_2$ max for the longer time. The subjects were middle-aged runners (52 ± 5 yr, $\dot{V}O_2$ max of 52.1 ± 6 mL × min^{-1} × kg^{-1}, v$\dot{V}O_2$ max of 15.9 ± 1.8 km × h^{-1}, critical velocity of 85.6 ± 1.2 % v$\dot{V}O_2$ max) who were used to long slow distance-training rather than interval training. They performed three interval-training (IT) sessions on a synthetic track (400 m) whilst breathing through the COSMED K4b^2 portable metabolic analyser. These three IT ses-

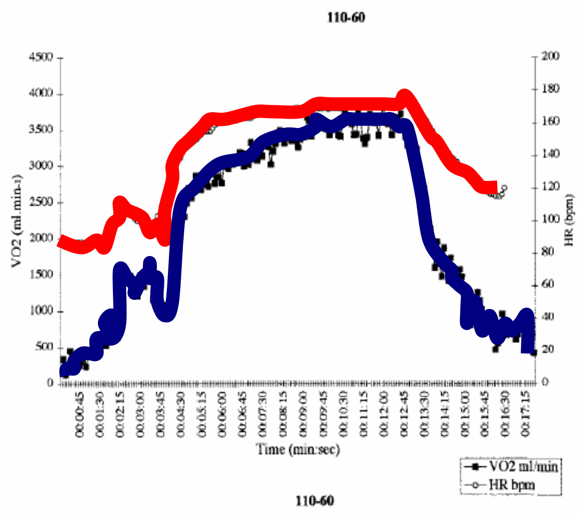
Introduction

Nowadays many runners are middle-aged (40 – 60 yr) and participate in amateur events run over 5 to 100 km. After several years of long slow distance training their performance no longer improves. Moreover, following this type of training, these long distance runners have a high endurance index defined as the ability to use a high fraction of maximal oxygen consumption $\dot{V}O_2$ max for a given running duration [24]. Therefore, in order to improve their performances, they need to increase $\dot{V}O_2$ max and the velocity associated with $\dot{V}O_2$ max (v$\dot{V}O_2$ max) [5,11,20].

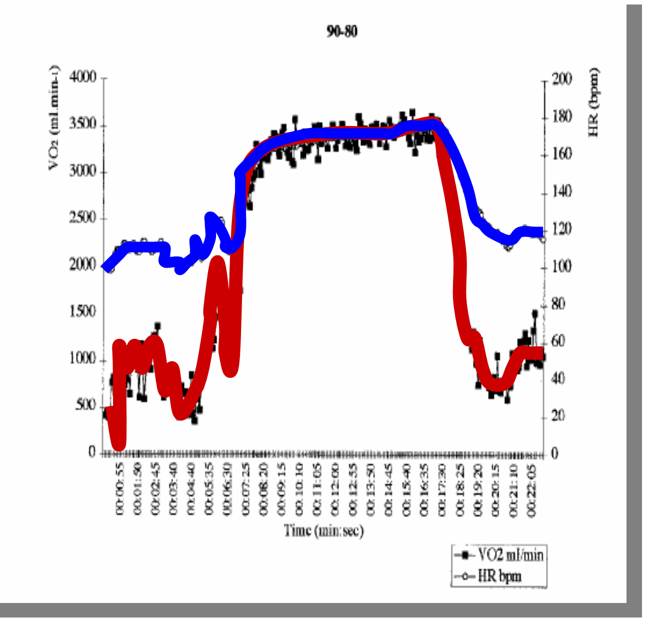
To achieve this improvement of v$\dot{V}O_2$ max, interval training (IT) involving repeated bouts of work, each lasting from 30 sec at v$\dot{V}O_2$ max to 5 min at 95% of v$\dot{V}O_2$ max was introduced [11]. Gorostiaga et al. [15] showed that interval training with 30 s work at 100% v$\dot{V}O_2$ max, separated by 30 s of rest, produced a greater increase in $\dot{V}O_2$ max than continuous training at 50% v$\dot{V}O_2$ max.

However, as underlined by Astrand and Rodahl [2] "it is an important but unsolved question which type of training is most effective: to maintain a level representing 90% of the maximal

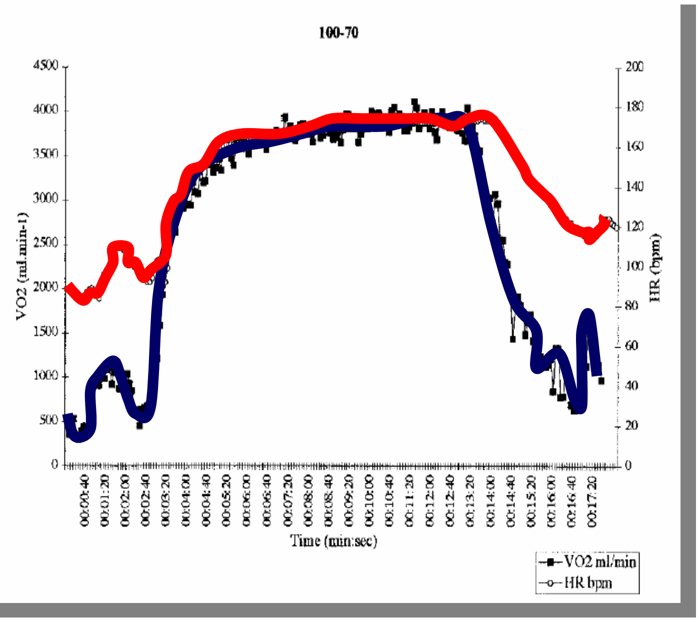
15-15s



15-15s


90-80
VO2 (ml.min-1)
HR (bpm)
Time (min:sec)
VO2 ml/min
HR bpm

15-15s


100-70
VO2 (ml.min-1)
HR (bpm)
Time (min:sec)
VO2 ml/min
HR bpm

15-15s

Table 2 Individual data in the three intermittent runs until exhaustion. See legend in text

Subjects	max $\dot{V}O_2$ ($ml \times min^{-1} \times kg^{-1}$)	tlim at $\dot{V}O_2$ max min:sec	Max blood lactate (mM)	Number of hard intervals (n)	*Total distance run at high velocity	§Total distance run at lower velocity	Total distance run Hard + recovery run
1A	54.0	15:00	6.4	50	2900	2580	5580
B	57.0	19:54	8.4	42	2714	1898	4612
C	51.0	7:06	9.4	18	1278	698	1976
2A	55.0	9:06	10.4	38	2280	2026	4306
B	59.0	15:42	10.0	34	2264	1588	3852
C	60.0	6:20	12.1	16	1172	640	1812
3A	47.5	9:00	9.7	22	1276	1136	2412
B	53.0	8:10	10.1	22	1422	994	2416
C	48.0	5:55	11.0	18	1278	698	1976
4A	64.0	17:45	9.6	42	2680	2382	5062
B	66.0	7:45	10.8	32	2266	1588	3854
C	66.0	4:45	10.6	10	780	426	1206
5A	44.0	14:40	10.0	36	1688	1502	3190
B	43.0	11:30	11.9	30	1560	1080	2640
C	44.0	9:15	11.7	22	1254	682	1936
6A	55.5	15:40	9.3	60	3828	3402	7230
B	58.0	21:36	7.7	50	3540	2480	6020
C	54.0	10:25	13.4	30	2338	1260	3598
7A	51.5	19:20	8.9	48	3062	2720	5782
B	54.0	17:00	10.0	36	2548	1786	4334
C	53.0	8:20	11.2	18	1148	1020	2168
Mean ± SD							
A	53.1 ± 6.0	14:21 ± 4:00	9.2 ± 1.3	42 ± 12	2530 ± 862	2250 ± 768	4780 ± 1630
B	55.7 ± 7.0	14:31 ± 5:30	9.8 ± 1.4	36 ± 10	2330 ± 716	1630 ± 504a	3960 ± 1222
C	54.1 ± 7.3	7:24 ± 2:00ab	11.3 ± 1.3ab	18 ± 6ab	1320 ± 480ab	774 ± 276ab	2096 ± 730ab
	NS						

A)15 seconds at 90% $v\dot{V}O_2$ max alternated with 15 seconds at 80% of $v\dot{V}O_2$ max
B)15 seconds at 100% $v\dot{V}O_2$ max alternated with 15 seconds at 70% of $v\dot{V}O_2$ max
C)15 seconds at 110% $v\dot{V}O_2$ max alternated with 15 seconds at 60% of $v\dot{V}O_2$ max
* The high velocity is the highest velocity run in the interval training:
A) 90% of $v\dot{V}O_2$ max, B) 100% of $v\dot{V}O_2$ max and C) 110% of $v\dot{V}O_2$ max
§ The lower velocity is the lowest velocity run in the interval training:
A) 80% of $v\dot{V}O_2$ max, B) 70% of $v\dot{V}O_2$ max, and C) 60% of $v\dot{V}O_2$ max
a and b significantly different from A and B, respectively

15-15s

Table 2 Individual data in the three intermittent runs until exhaustion. See legend in text

Subjects	max $\dot{V}O_2$ ($ml \times min^{-1} \times kg^{-1}$)	tlim at $\dot{V}O_2$ max min:sec	Max blood lactate (mM)	Number of hard intervals (n)	*Total distance run at high velocity	§Total distance run at lower velocity	Total distance run Hard + recovery run
Mean ± SD							
A	53.1 ± 6.0	14:21 ± 4:00	9.2 ± 1.3	42 ± 12	2530 ± 862	2250 ± 768	4780 ± 1630
B	55.7 ± 7.0	14:31 ± 5:30	9.8 ± 1.4	36 ± 10	2330 ± 716	1630 ± 504a	3960 ± 1222
C	54.1 ± 7.3	7:24 ± 2:00ab	11.3 ± 1.3ab	18 ± 6ab	1320 ± 480ab	774 ± 276ab	2096 ± 730ab
	NS						

A)15 seconds at 90% $v\dot{V}O_2$ max alternated with 15 seconds at 80% of $v\dot{V}O_2$ max
B)15 seconds at 100% $v\dot{V}O_2$ max alternated with 15 seconds at 70% of $v\dot{V}O_2$ max
C)15 seconds at 110% $v\dot{V}O_2$ max alternated with 15 seconds at 60% of $v\dot{V}O_2$ max
* The high velocity is the highest velocity run in the interval training:
A) 90% of $v\dot{V}O_2$ max, B) 100% of $v\dot{V}O_2$ max and C) 110% of $v\dot{V}O_2$ max
§ The lower velocity is the lowest velocity run in the interval training:
A) 80% of $v\dot{V}O_2$ max, B) 70% of $v\dot{V}O_2$ max, and C) 60% of $v\dot{V}O_2$ max
a and b significantly different from A and B, respectively

Training and Testing

Very Short (15 s – 15 s) Interval-Training Around the Critical Velocity Allows Middle-Aged Runners to Maintain $\dot{V}O_2$ max for 14 minutes

V. L. Billat[1], J. Slawinksi[1], V. Bocquet[2], P. Chassaing[1], A. Demarle[1], J. P. Koralsztein[2]

[1] Laboratoire d'étude de la motricité humaine, Université de Lille II, Faculté des Sciences du Sport, Ronchin, France
[2] Centre de Médecine du Sport C.C.A.S., Paris, France

Billat VL, Slawinksi J, Bocquet V, Chassaing P, Demarle A, Koralsztein JP. Very Short (15 s – 15 s) Interval-Training Around the Critical Velocity Allows Middle-Aged Runners to Maintain $\dot{V}O_2$ max for 14 minutes. Int J Sports Med 2001; 22: 201 – 208

Accepted after revision: August 15, 2000

The purpose of this study was to compare the effectiveness of three very short interval training sessions (15 – 15 s of hard and easier runs) run at an average velocity equal to the critical velocity to elicit $\dot{V}O_2$ max for more than 10 minutes. We hypothesized that the interval with the smallest amplitude (defined as the ratio between the difference in velocity between the hard and the easy run divided by the average velocity and multiplied by 100) would be the most efficient to elicit $\dot{V}O_2$ max for the longer time. The subjects were middle-aged runners (52 ± 5 yr, $\dot{V}O_2$ max of 52.1 ± 6 mL × min^{-1} × kg^{-1}, $v\dot{V}O_2$ max of 15.9 ± 1.8 km × h^{-1}, critical velocity of 85.6 ± 1.2 % $v\dot{V}O_2$ max) who were used to long slow distance-training rather than interval training. They performed three interval-training (IT) sessions on a synthetic track (400 m) whilst breathing through the COSMED K4b[2] portable metabolic analyser. These three IT ses-

Introduction

Nowadays many runners are middle-aged (40 – 60 yr) and participate in amateur events run over 5 to 100 km. After several years of long slow distance training their performance no longer improves. Moreover, following this type of training, these long distance runners have a high endurance index defined as the ability to use a high fraction of maximal oxygen consumption $\dot{V}O_2$ max for a given running duration [24]. Therefore, in order to improve their performances, they need to increase $\dot{V}O_2$ max and the velocity associated with $\dot{V}O_2$ max ($v\dot{V}O_2$ max) [5,11,20].

To achieve this improvement of $v\dot{V}O_2$ max, interval training (IT) involving repeated bouts of work, each lasting from 30 sec at $v\dot{V}O_2$ max to 5 min at 95% of $v\dot{V}O_2$ max was introduced [11]. Gorostiaga et al. [15] showed that interval training with 30 s work at 100% $v\dot{V}O_2$ max, separated by 30 s of rest, produced a greater increase in $\dot{V}O_2$ max than continuous training at 50% $v\dot{V}O_2$ max.

However, as underlined by Astrand and Rodahl [2] "it is an important but unsolved question which type of training is most effective: to maintain a level representing 90% of the maximal

"…intermittent-exercise alternating runs at vVO_2 max and 70% vVO2 $_{max}$ not only allowed a longer stimulation of cardiovascular function at its maximum (at $VO_{2\ max}$) but were run at a higher velocity (+ 1.6 km h^{-1}) than during the 90- 80% of $vVO_{2\ max}$ and with the same blood lactate accumulation (around 9 mM)."

Sprint Training

Eur J Appl Physiol (1998) 78: 163–169

ORIGINAL ARTICLE

Brian Dawson · Martin Fitzsimons · Simon Green
Carmel Goodman · Michael Carey · Keith Cole

Changes in performance, muscle metabolites, enzymes and fibre types after short sprint training

Accepted: 5 January 1998

Abstract In contrast to endurance training, little research has been carried out to investigate the effects of short (< 10 s) sprint training on performance, muscle metabolism and fibre types. Nine fit male subjects performed a mean of 16 outdoor sprint running training sessions over 6 weeks. Distances sprinted were 30–80 m at 90–100% maximum speed and between 20 and 40 sprints were performed in each session. Endurance (maximal oxygen consumption; $\dot{V}O_{2max}$), sprint (10 m and 40 m times), sustained sprint (supramaximal treadmill run) and repeated sprint (6 × 40 m sprints, 24 s recovery between each) performance tests were performed before and after training. Muscle biopsy samples (vastus lateralis) were also taken to examine changes in metabolites, enzyme activities and fibre types. After training, significant improvements were seen in 40 m time ($P < 0.01$), supramaximal treadmill run time ($P < 0.05$), repeated sprint performance ($P < 0.05$) ... thase activity decreased ($P < 0.01$), but no significant changes were recorded in myokinase and phosphofructokinase activities. The proportion of type II muscle fibres increased significantly ($P < 0.05$). These results demonstrate that 6 weeks of short sprint training can improve endurance, sprint and repeated sprint ability in fit subjects. Increases in the proportion of type II muscle fibres are also possible with this type of training.

Key words Maximal intensity · Phosphagens · Type I and II muscle fibres · Maximal oxygen consumption · Enzyme activities

Introduction

Short sprint training is utilised in the physical preparation of athletes for many sports, yet the physiological

Sprint Training

Protocol

Dawson e coll. EJAP 1998

N=9

20-40 rep./session

Sprint <10s

90-100% max

30-80 m

Sprint Training

Protocol

Dawson e coll. EJAP 1998

N=9

20-40 rep./session

Sprint <10s

90-100% max

30-80 m

Sprint Training

Protocol

Dawson e coll. EJAP 1998

N=9

20-40 rep./session

Sprint <10s

90-100% max

30-80 m

16 sessions

6 weeks ~3d/w

Sprint Training

Protocol

Dawson e coll. EJAP 1998

N=9

20-40 rep./session

Sprint <10s

90-100% max

30-80 m

Results

Test	Increments
10m	3.2%
40m	2.4% +++
RSA 6x40m/24s	2.2% +++
VO_{2max}	6.1% +++
Max Run	11.2% +++

16 sessions

6 weeks ~3d/w

Sprint Training

Dawson e coll. EJAP 1998

Table 2 Performance test scores [mean (SE)] measured before and after training ($n = 9$ except for repeated sprint test where $n = 6$). (*RST* repeated sprint test, $\dot{V}O_{2max}$ maximal oxygen consumption)

	Pre-training	Post-training
10 m Time (s)	1.87 (0.02)	1.81 (0.03)
40 m Time (s)	5.50 (0.05)	5.37 (0.08)***
Supramaximal run (s)	49.9 (3.5)	55.5 (4.0)*
RST total time (s)	35.66 (0.65)	34.88 (0.49)*
RST % decrement	7.1 (2.6)	5.9 (1.2)
$\dot{V}O_{2max}$ ($l \cdot min^{-1}$)	4.40 (0.18)	4.67 (0.16)***
$\dot{V}O_{2max}$ ($ml \cdot kg^{-1} \cdot min^{-1}$)	57.0 (2.4)	60.5 (1.9)***

*$P < 0.05$
***$P < 0.01$, significantly different from pre-training scores

Sprint Training

Protocol

Dawson e coll. EJAP 1998

N=9

20-40 rep./session

Sprint <10s

90-100% max

30-80 m

Results

Fiber II %&Area

+10%+++

16 sessions

6 weeks ~3d/w

Sprint Training

Protocol

Dawson e coll. EJAP 1998

Week	Session							% Maximum effort	W:R	Number of reps.
1	1	6 × 80	6 × 60	6 × 40	4 × 40			90	1:6	22
	2	6 × 80	6 × 60	6 × 40	4 × 40			90	1:6	22
	3	6 × 80	6 × 60	6 × 40	6 × 40			90	1:6	24
2	4	6 × 80	6 × 60	6 × 40	8 × 30			90	1:5	26
	5	6 × 80	6 × 60	6 × 40	8 × 30			90	1:5–6	26
	6	4 × 80	6 × 50	8 × 40	6 × 40	6 × 30		90/100	1:5–6	30
3	7	4 × 80	6 × 50	8 × 40	6 × 40	6 × 30		90/100	1:6	30
	8	8 × 30	6 × 50	8 × 30	6 × 40	6 × 30		90/100	1:5–6	34
	9	8 × 30	6 × 50	8 × 30	6 × 40	6 × 30		90/100	1:5–6	34
4	10	6 × 60	8 × 50	6 × 40	8 × 50	6 × 60		90/100	1:5	34
	11	6 × 60	8 × 50	6 × 40	8 × 50	6 × 60		90/100	1:6	34
	12[a]	6 × 60	8 × 50	6 × 40	6 × 40			90/100	1:5	24
5	13	8 × 50	8 × 40	8 × 40	8 × 40	8 × 50		90/100	1:5–6	40
	14	8 × 50	8 × 40	8 × 30	8 × 40	8 × 50		90/100	1:5–6	40
	15	8 × 50	8 × 40	8 × 30	8 × 40	8 × 50		90/100	1:4–6	40
6	16	8 × 50	8 × 40	8 × 30	6 × 50	6 × 40	6 × 30	90/100	1:4–6	42
	17	8 × 30	8 × 40	8 × 50	6 × 50	6 × 40	6 × 30	90/100	1:4–6	42
	18	8 × 30	8 × 40	6 × 50	6 × 50	6 × 40	6 × 30	90/100	1:4–6	40

Ferrari Bravo e coll. 2006

Aims:

Effects of RS Training on Physical Fitness in Football

Ferrari Bravo e coll. 2006

Design:

- Fully Experimental
- Longitudinal Pre-Post
- Randomized
- Parallel

Ferrari Bravo e coll. 2006

Subjects:

- N=26
- Age 21±5.1 years
- Height 178.6±5.0 cm
- Body Mass 73.2±7.8 kg
- VO_{2max} 54.3±2.7 ml $Kg^{-1}min^{-1}$

Ferrari Bravo e coll. 2006

Training Set-Up:

In Season September-December 2005

Testing | Training | Testing

2 weeks | 7 weeks | 2 weeks

Ferrari Bravo e coll. 2006

Grouping:

- Repeated Sprinting [RSG]
- Interval Running [IRG]
- N=13 Each Group

Ferrari Bravo e coll. 2006

Training Protocols:

- Repeated Sprinting [RSG]
- Interval Running [IRG]

Ferrari Bravo e coll. 2006

RSG Training Protocol:

- 2 RS Sessions a week

  + Usual Soccer Training

Ferrari Bravo e coll. 2006

RSG Training :

- 2-3 Series of 240-300m
- Shuttle Runnig Drills
- Drills Work/Rest; 1:3
- Recovery
  - *20” between Reps*
  - *3-5’ between Series*

Ferrari Bravo e coll. 2006

IRG Training Protocol:

- 2 IR Sessions a week at 90-95% HR_{max}

  + Usual Soccer Training

Ferrari Bravo e coll. 2006

IR Training:

- 3-4x4min at 90-95% HR_{max} with 3min Active Recovery

Helgerud et al. 2001; Impellizzeri et al 2006

Ferrari Bravo e coll. 2006

Results:

No significant differences in Pre-Post

- CMJ & SJ performances
- 10m Sprint Time

Ferrari Bravo e coll. 2006

Conclusions

Similar Aerobic Fitness Improvements with

- RS & IR Training

Ferrari Bravo e coll. 2006

Conclusions

RS Training ⇑ Specific Fitness

- ⇑ Yo-yo IRT Performance
- ⇑ RS Performance

Allenare: % VO_2max

Pflugers Arch - Eur J Physiol (2004) 447: 875–883
DOI 10.1007/s00424-003-1215-8

EXERCISE, TEMPERATURE REGULATION

Veronique Billat · Pascal Sirvent ·
Pierre-Marie Lepretre · Jean Pierre Koralsztein

Training effect on performance, substrate balance and blood lactate concentration at maximal lactate steady state in master endurance-runners

Received: 8 June 2003 / Revised: 1 August 2003 / Accepted: 10 November 2003 / Published online: 23 January 2004

Abstract Training effects on time-to-exhaustion, substrate and blood lactate balances at the maximal lactate steady state velocity (MLSSv) were examined. Eleven male, veteran, long-distance runners performed three tests before and after 6 weeks of training at MLSSv: an incremental test to determine maximum O_2 uptake ($\dot{V}O_{2,max}$) and the velocity at the lactate threshold (vLT), a sub-maximal test of two stages of 20 min at 95 and 105% of vLT separated by 40 min rest to determine the MLSSv and the corresponding lactate concentration (MLSSc) and a time-to-exhaustion run at MLSSv for which the substrate balance was calculated. Duration and distance run at MLSSv increased dramatically respectively the proportion of carbohydrate oxidized, which is the major substrate used during an exhaustive run at MLSS lasting 1 h.

Keywords Blood lactate · Running · Training · Carbohydrates · Exercise · Cross-over point

Introduction

The "maximal lactate steady state" is defined as the highest blood lactate concentration (MLSSc) and work load (MLSSw) or velocity (MLSSv) that can be

Allenare: % VO_2max

Allenare: % VO_2max

Billat e coll. 2004

Training Set-Up:

Allenare: % VO_2max

Allenare: %VO_2max

Billat e coll. 2004 **Protocollo Allenamento:**

Table 1 Training log at the velocity at maximal lactate steady state (*MLSSv*). For this subject, MLSSv was 4.3 m s^{-1}. An example (*in bold*) is shown for the 1st week, during which the subject underwent two training sessions at MLSSv: the first comprising three sets of 10-min runs at MLSSv, giving a distance of 2,532 m. Recovery comprised a 5-min run at 70% MLSSv. The second weekly session involved two repetitions of 15 min at MLSSv (for a total 3798 m). The total duration of the run at MLSSv was the 30 min/session in the 1st week. In subsequent weeks, the total time run at MLSSv was increased by 6 min/week

Week	First training session of the week	Distance per session (m)	Second training session of the week	Distance per session (m)	Total time run at MLSSv per session
1	**3×10 min**	**2532**	**2×15 min**	**3798**	**30 min**
2	3×12 min	3038	2×18 min	4558	36 min
3	3×14 min	3545	2×21 min	5317	42 min
4	3×16 min	4051	2×24 min	6077	48 min
5	3×18 min	4558	2×27 min	6836	54 min
6	3×20 min	5064	2×30 min	7596	60 min

Allenare: %VO_2max

Allenare: %VO_2max

Billat e coll. 2004 **Risultati:**

Variables	Pre-training	Post-training	Change (% of the pre-training value)	P^b
Weight (kg)	69.3±5.7	68.6±5.6	−1.1±1.4	0.04
$\dot{V}O_{2,max}$ (ml kg^{-1} min^{-1})	55.1±4.2	57.6±3.9	+3.6±4.3	<0.01
Fat mass (% body mass)	17.2±2.6	16.2±2.6	−6.7%±9.5	0.06
$\dot{V}O_{2,max}$ (ml kg^{-1} min^{-1})^a	66.6±5.7	68.8±4.9	+3.5±3.7	0.02
$\dot{V}O_{2,max}$ (ml min^{-1})	3824±504	3959±506	+4.4±3.6	0.03
v$\dot{V}O_{2,max}$ (km h^{-1})	16.8±1.3	17.5±1.1	+3.8±3.6	0.03
vLT (km h^{-1})	14.5±1.6	15.0±1.5	+3.3±3.8	0.03
MLSSv (km h^{-1})	13.8±1.5	15.2±1.6	+4.2±3.9	<0.01
MLSSv (%v$\dot{V}O_{2,max}$)	85.2±4.5	85.3±5.2	-	0.93
MLSSc (mM)	3.7±0.8	4.3±1.4		0.90
Peak $[la^-]_b$ at v$\dot{V}O_{2,max}$ (mM)	12.3±2.3	11.9±1.5	-	0.33
RER_{max} at v$\dot{V}O_{2,max}$	1.12±0.03	1.12±0.04	-	0.73
Peak HR at v$\dot{V}O_{2,max}$ (bpm)	181±9	181±10	-	0.5
Cross-over point velocity (km h^{-1})	8.9±1.4	9.9±1.8	-	0.1
Cross-over point velocity (%v$\dot{V}O_{2,max}$)	53.2±6.1	56.6±10.1	+6.8±17.9	0.29
Crossover point velocity (%MLSSv)	62.4±6.4	66.3±11.5	+6.8±20.7	0.36

Allenare: %VO_2max

Allenare: % VO_2max

Billat e coll. 2004

Risultati:

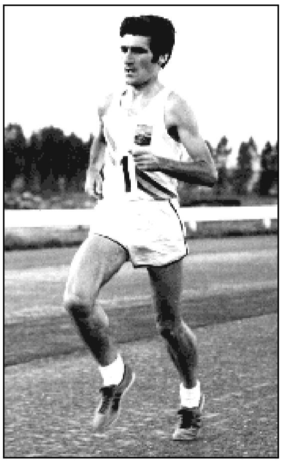
Variables	Pre-training	Post-training	Change (% of the pre-training value)	P^b
Weight (kg)	69.3±5.7	68.6±5.6	−1.1±1.4	0.04
$\dot{V}O_{2,max}$ (ml kg^{-1} min^{-1})	55.1±4.2	57.6±3.9	+3.6±4.3	<0.01
Fat mass (% body mass)	17.2±2.6	16.2±2.6	−6.7%±9.5	0.06
$\dot{V}O_{2,max}$ (ml kg^{-1} min^{-1})[a]	66.6±5.7	68.8±4.9	+3.5±3.7	0.02
$\dot{V}O_{2,max}$ (ml min^{-1})	3824±504	3959±506	+4.4±3.6	0.03
v$\dot{V}O_{2,max}$ (km h^{-1})	16.8±1.3	17.5±1.1	+3.8±3.6	0.03
vLT (km h^{-1})	14.5±1.6	15.0±1.5	+3.3±3.8	0.03
MLSSv (km h^{-1})	13.8±1.5	15.2±1.6	+4.2±3.9	<0.01
MLSSv (%v$\dot{V}O_{2,max}$)	85.2±4.5	85.3±5.2	-	0.93
MLSSc (mM)	3.7±0.8	4.3±1.4		0.90
Peak [la$^-$]$_b$ at v$\dot{V}O_{2,max}$ (mM)	12.3±2.3	11.9±1.5	-	0.33
RER$_{max}$ at v$\dot{V}O_{2,max}$	1.12±0.03	1.12±0.04	-	0.73
Peak HR at v$\dot{V}O_{2,max}$ (bpm)	181±9	181±10	-	0.5

Allenare: % VO_2max

Allenare: % VO_2max

Billat e coll. 2004

Risultati:



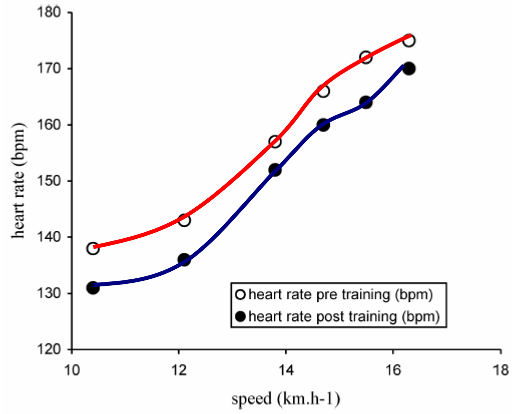


Fig. 3 Relationship between heart rate and the running speed during the incremental test to determine $\dot{V}O_{2,max}$ before and after 6 weeks training at MLSSv

Allenare: % VO_2max

Sprint Training

Protocollo

N=16

Burgomaster e coll. JAP 2005

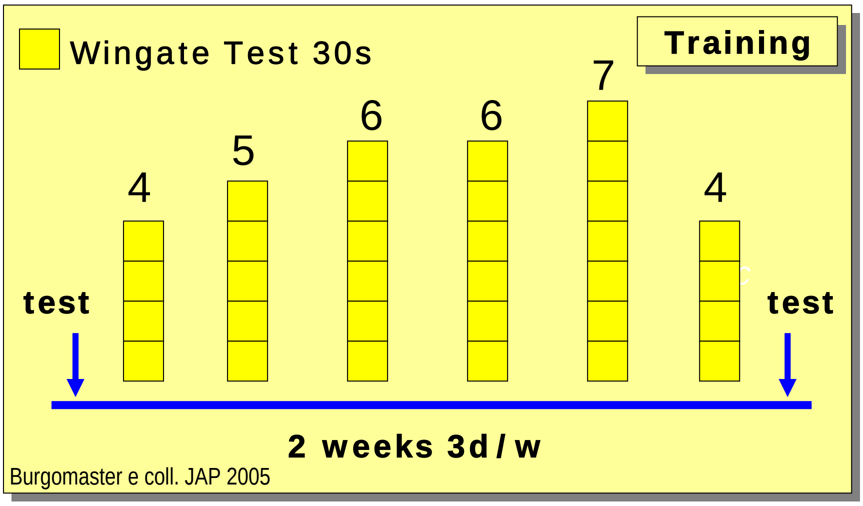
Sprint 30s Max

Wingate Test

4 min Recupero

Sprint Training

Sprint Training



Sprint Training

Sprint Training II

Risultati

Variabili	Post-Training
Citrato Sintasi	+38%
VO_{2max}	------
Glicogeno Muscolare	+26%
Prova 80% VO_{2max}	+100% [26→51min.]
Wingate Test 30s	↑ Picco Potenza

Burgomaster e coll. JAP 2005 N=16

Sprint Training II

Conclusioni

15 min Lavoro in 14 giorni

+ Endurance = 6-7 all. 2h
65% VO_{2max}

Burgomaster e coll. JAP 2005