England Athletics Academic Research Series

Interval training for middle-distance performance

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Rationale

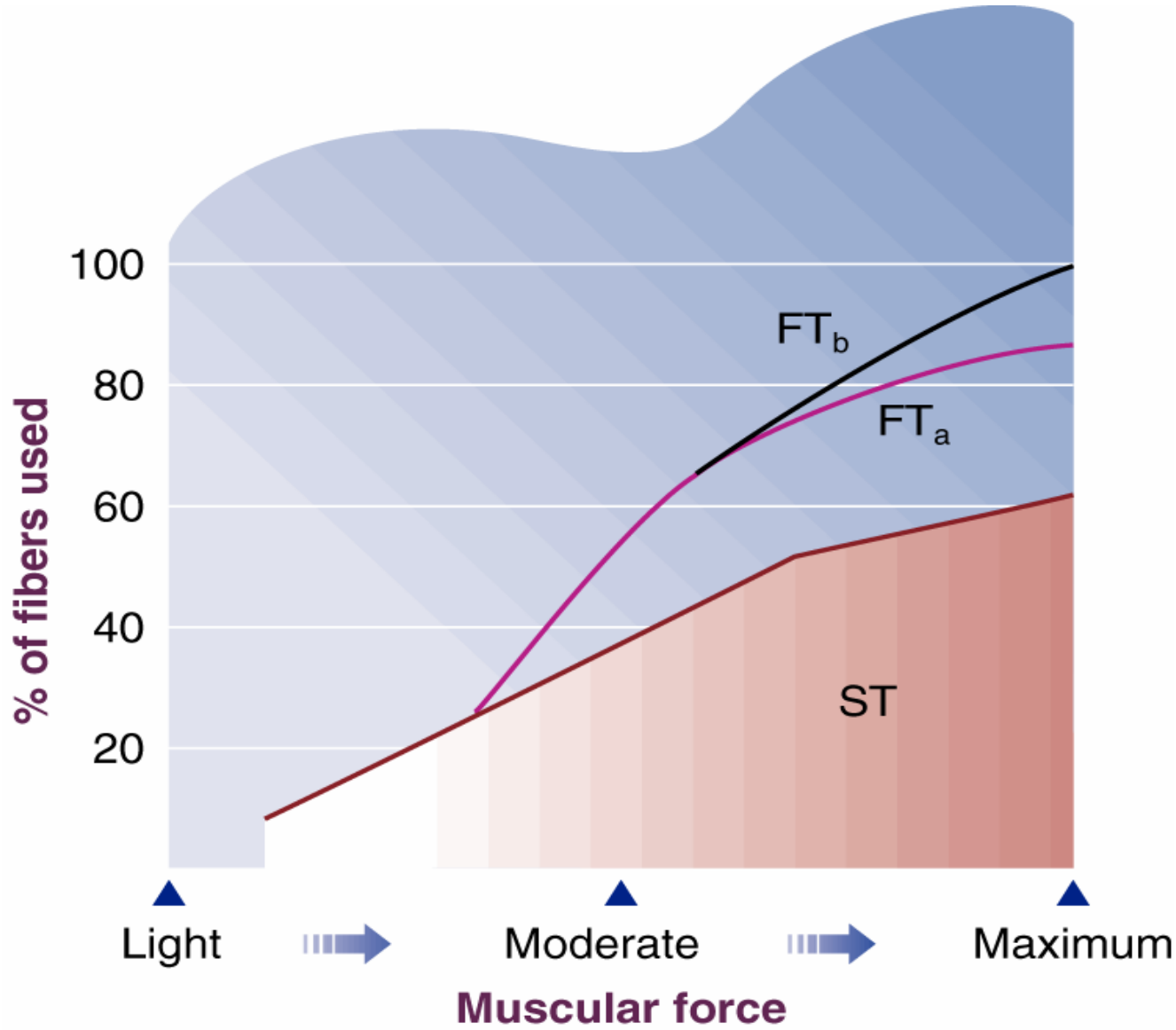
“In contrast to submaximal exercise training… HIT is normally achieved through the use of intervals.

HIT can be broadly defined as repeated bouts of short to moderate duration exercise (i.e. 10 seconds to 5 minutes) completed at an intensity that is greater than the anaerobic threshold.

Exercise bouts are separated by brief periods of low-intensity work or inactivity that allow a partial but often not a full recovery.

The purpose of HIT is to repeatedly stress the physiological systems that will be used during a specific endurance-type exercise to a greater extent than that which is actually required during the activity” (Laursen & Jenkins 2001).

Benefits of training partially depend on the distance covered at a high velocity which determines the muscular adaptation (Noakes 1991)


100
80
60
40
20
% of fibers used
FTb
FTa
ST
Light
Moderate
Maximum
Muscular force

What do you need to be able to do?

Race distance (m)[a]	*% $\dot{V}O_{2max}$*	*% Aerobic*	*% Anaerobic*
800	115–130	60–70	30–40
1500	105–115	80–85	15–20
3000	~100	85–90	10–15
5000	95–100	90–95	5–19
10000	90–95	97	3
Marathon	75–80	99.9	0.1

Hayes & Gordon 2021

Origins

The original ‘Flying Finn’, Hannes Kohlemainen questioned why he should train by running 10km continuously when he could instead run 1000 metres 10 times at higher speeds than were achievable in a steady run

Whilst there is some mystery over exactly how Zatopek trained, there seems to be some consensus that he did perform enormous volumes of intervals, in the region of 40-80 x 400m daily.

Van Aaken described this training as 400 runs at ‘jogging’ speed, separated by 200 recovery runs at ‘less than jogging’ speed, and gave the typical time of 96s for each of the 400’s.

Gerschler interval training

Winter conditioning work could be effectively organised around interval training using two distances – 100m and 200m, with jogged recoveries.

“A … capable of running 800m man under 1:53 and a 1,500m runner under 3:50 in 14-15 secs; The jogged interval 100m should take 30 secs if the athlete is highly trained, 45 secs if in the intermediate stage and 60 secs if he is a beginner.....

For training at 200 metres… 800 and 1,500m men in about 30 secs… The intervals between repetitions will, like those for the 100m training, depend on the athlete's ability: if in the intermediate stage, 60 secs; if a beginner, 75 secs.

After three or four months, 40 repetitions should be reached.”

Repetition training

400m (down to 50.0), rest 20 mins, repeat 4-8 times.

600m (down to 1:14), rest 20 mins, repeat 4-8 times.

800m (down to 1:50), rest 20 mins, repeat 4-8 times.

1,000m (down to 2:28), rest 20 mins, repeat 4-8 times

.

1,200m (down to 2:50), rest 20 mins, repeat 2-6 times

.

2,000m (down to 4:58), rest 20 mins, repeat 2-3 times.

Physiology of interval training

Astrand et al (1962)

On cycle ergometer – subject maintained 360W for 9 minutes.

Using shorter work periods allowed accumulation of longer periods at VO_2 max with lower blood lactate accumulation.

All combinations allowed maintenance of workload for 1 hour

30s – 1minute: Blood lactate 2mmol.l^{-1}

2-3 minutes: Blood lactate 16mmol.l^{-1}

Christiansen et al (1960). Subjects ran at 20kph on a treadmill. Either – continuous run, or 30 minutes of 5/5', 10/10', 15/15'.

No subject ran for more than 4 mins continuously.

Using short work bouts – [Bla] increased very little

Billat 2001

The three types of short interval-training exercise were:

a) An intermittent exercise of 15 s runs alternating between 90% and 80% vVO2 max.

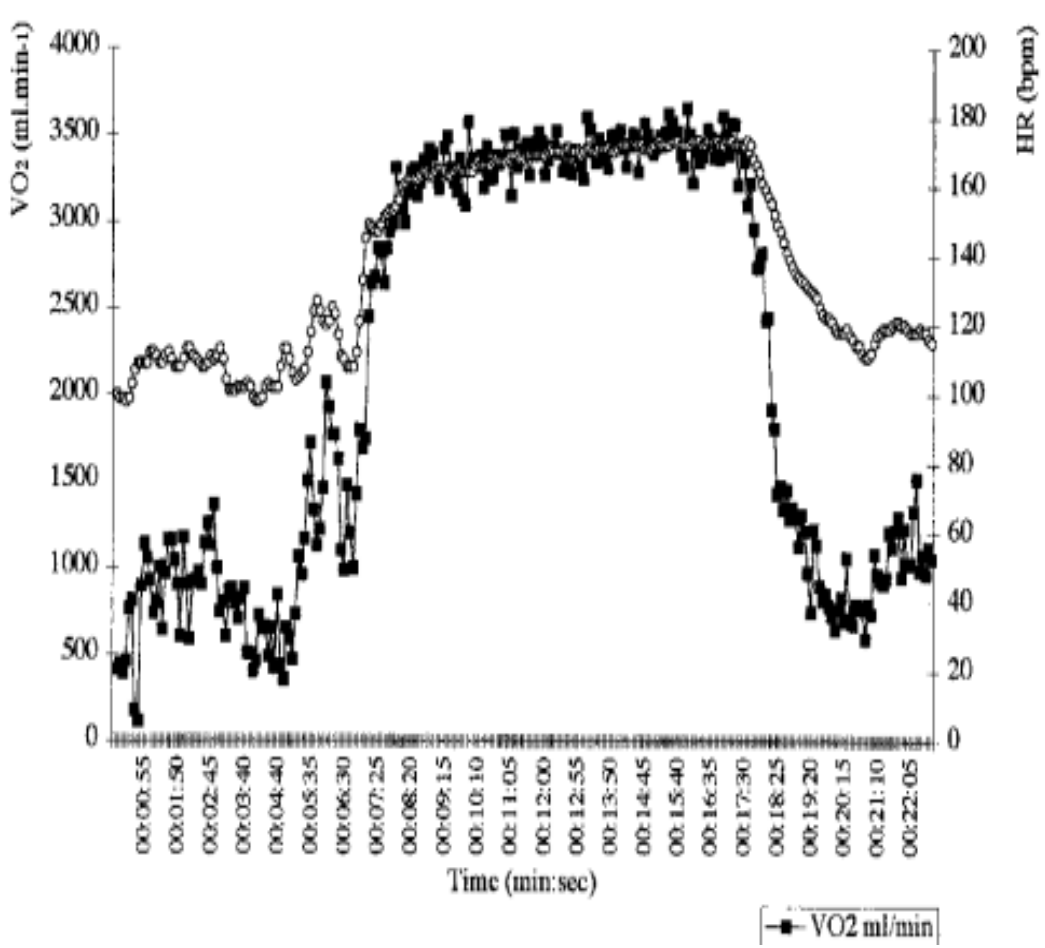
b) An intermittent exercise of 15 s runs alternating between 100% and 70% vVO2 max.

c) An intermittent exercise of 15 s runs alternating between 110% and 60% v vVO2 max.

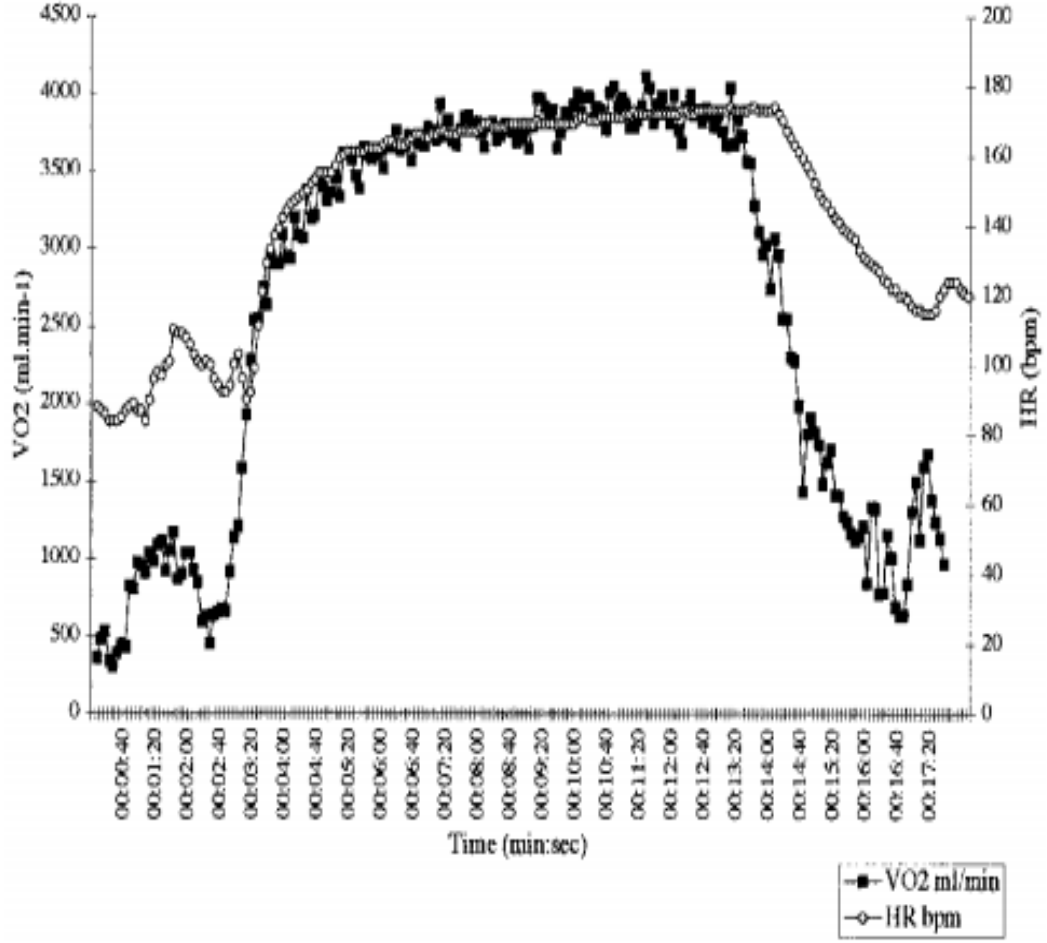
Findings

Protocol	90/80	100/70	110/60
TTE	14:21 ± 0:21 mins	14:31 ± 5:30 mins	7:24±2:00 mins
[Bla]	9.2 ± 1.3 mmol.l	9.8 ± 1.4 mmol.l	11.3 ± 1.3 mmol.l
Number hard intervals	42 ± 12	36 ± 10	18 ± 6
Total distance run	4780 ± 1630 m	3960 ± 1222 m	2096 ± 730 m

90-80


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

100-70


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

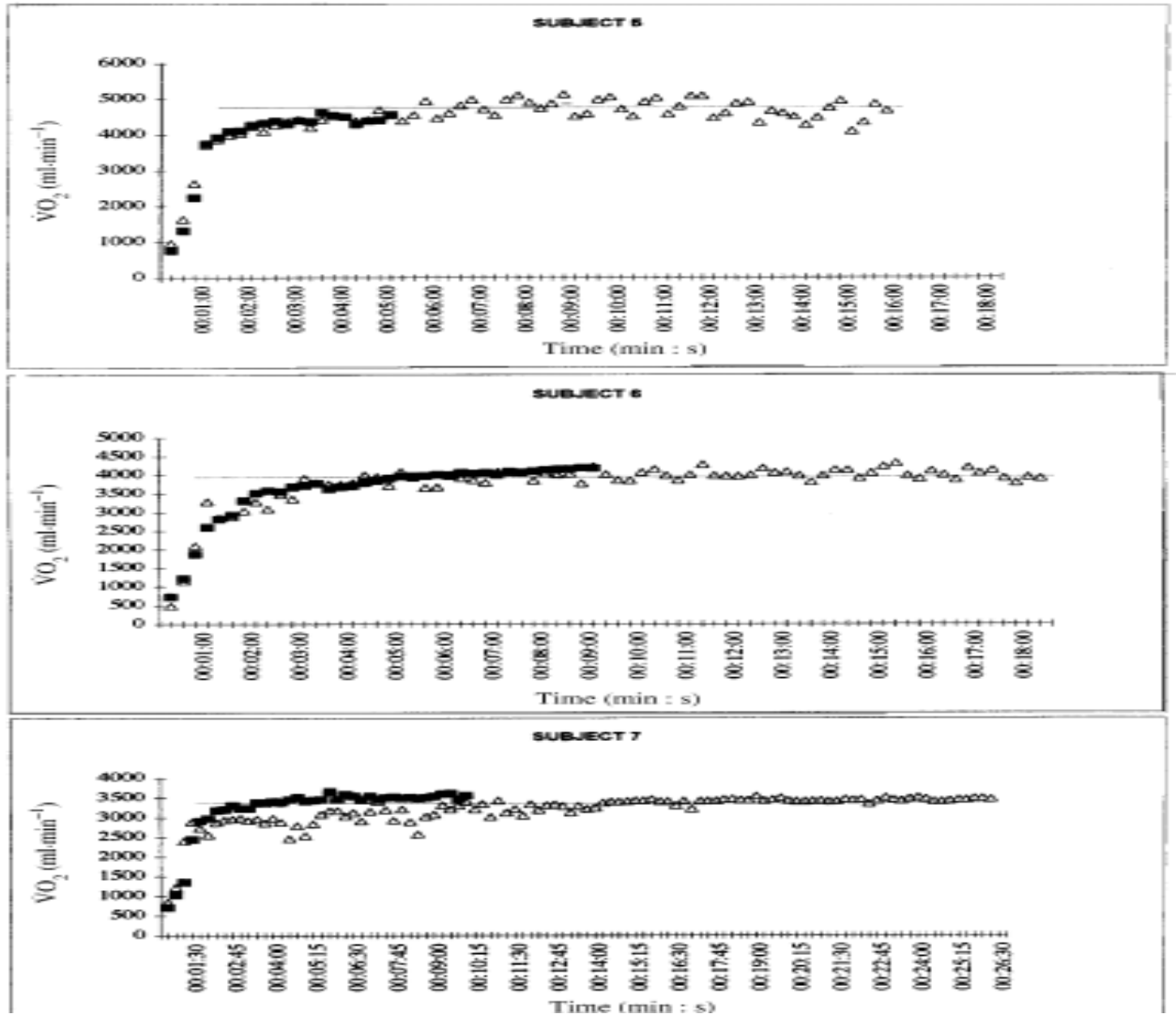
Billat et al 1999

Purpose of this study was to compare the times spent at VO_2 max during an interval training programme and during continuous strenuous runs.

Interval training protocol consisting of alternately running at 100% and at 50% of vVO2 max (30 s each)

Continuous high intensity run was performed at vLT + 50% of the difference between vLT and vVO2 max

Findings



“Therefore, from the cardiovascular and muscle adaptation point of view, intermittent exercise at vVO2 max would be likely to produce an increase in performance at middle-distances”

What about longer intervals?

- 30s appears to be longest interval duration allowing work at pVO_2 max to elicit VO_2 max even in the recovery period.

- Longer runs at pVO_2 max result in high [Bla] due to depletion of CP. Takes longer to recover, and also experience drop in VO_2 during longer recovery.

- Long interval training is difficult to perform if you aim to avoid acidosis and maximise time ~VO_2 max

Superior performance improvements following short-interval vs effort-matched long-interval training (Ronnestad et al 2019)

3 weeks with three weekly sessions (ie, nine sessions in total) of short intervals (SI; n = 9; 3 series with 13 × 30-second work intervals interspersed with 15-second recovery and 3-minutes recovery between series)

OR…

effort-matched (rate of perceived effort based) long intervals (LI; n = 9; 4 series of 5-minute work intervals with 2.5-minutes recovery between series)

	SI	LI
	Mean ± SD	Mean ± SD
Number of HIT sessions	8.8 ± 0.4	8.9 ± 0.3
Mean power in HIT work intervals (W)	441 ± 31*	368 ± 35
% of W_{max} (%)	94 ± 3*	79 ± 7
Mean RPE after HIT series (6-20)	17.8 ± 0.6	17.6 ± 0.6

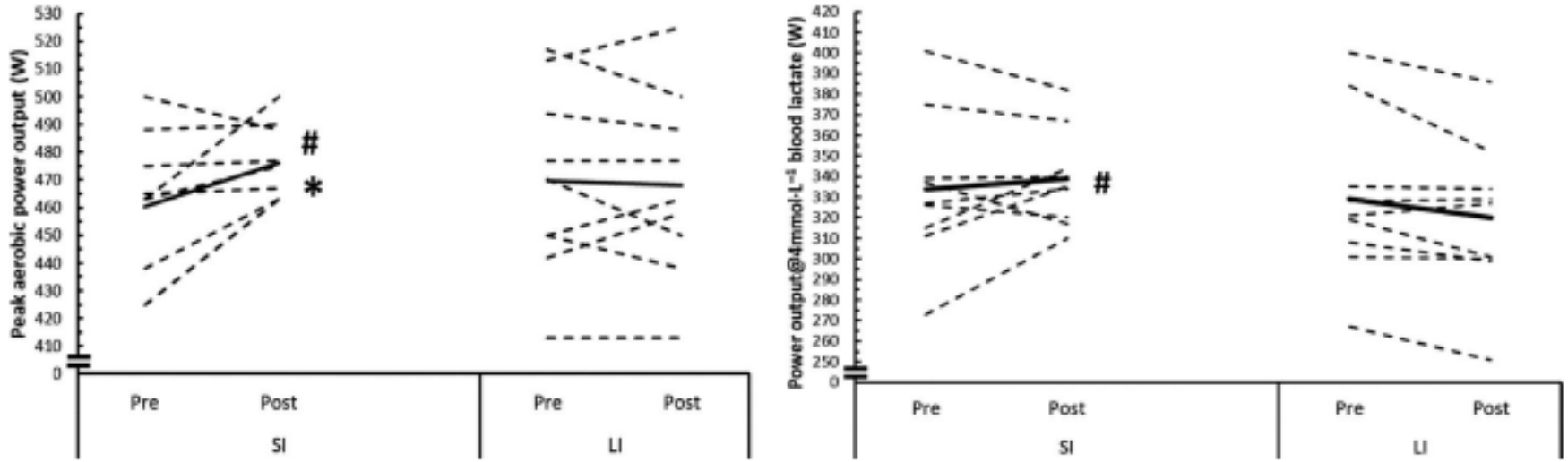
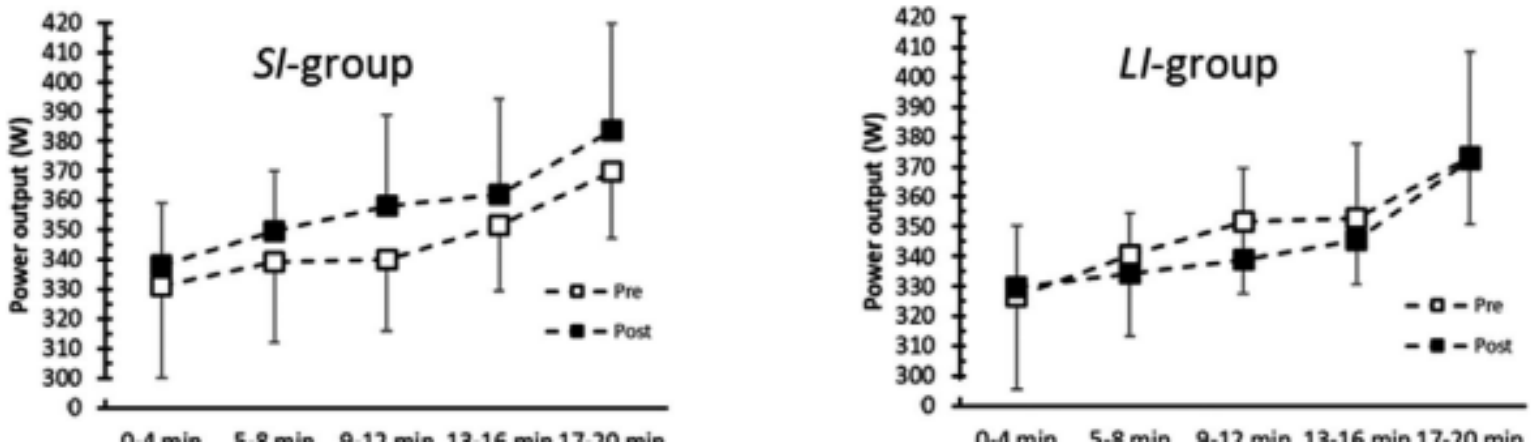
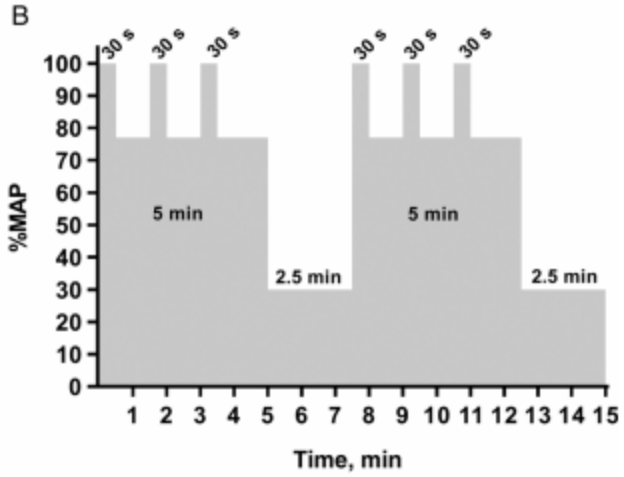
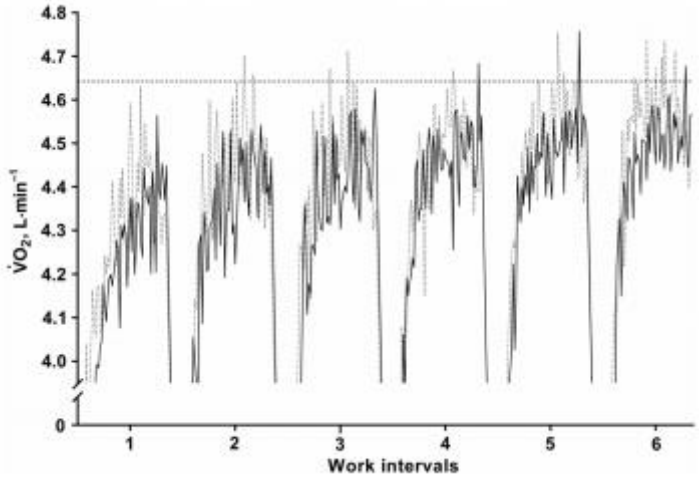


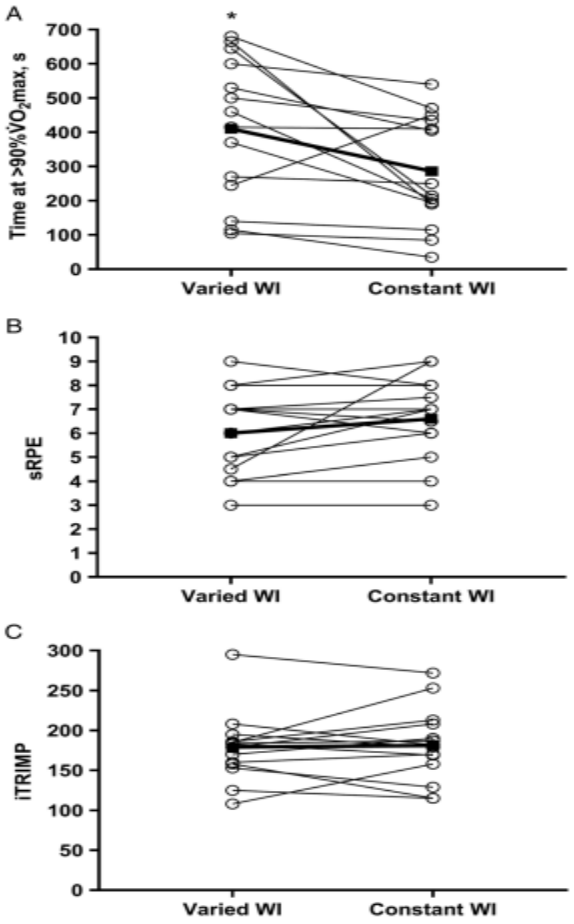
FIGURE 1 Individual data points and mean values (solid line) for peak aerobic power output (left panel) and power output at 4 mmol L^{-1} blood lactate concentration (right panel) before (pre) and after the intervention period (post) for the short-interval group (SI) and the long-interval group (LI). *Larger than at pre ($P < .05$), #the relative change from pre is larger than in LI ($P < .05$)



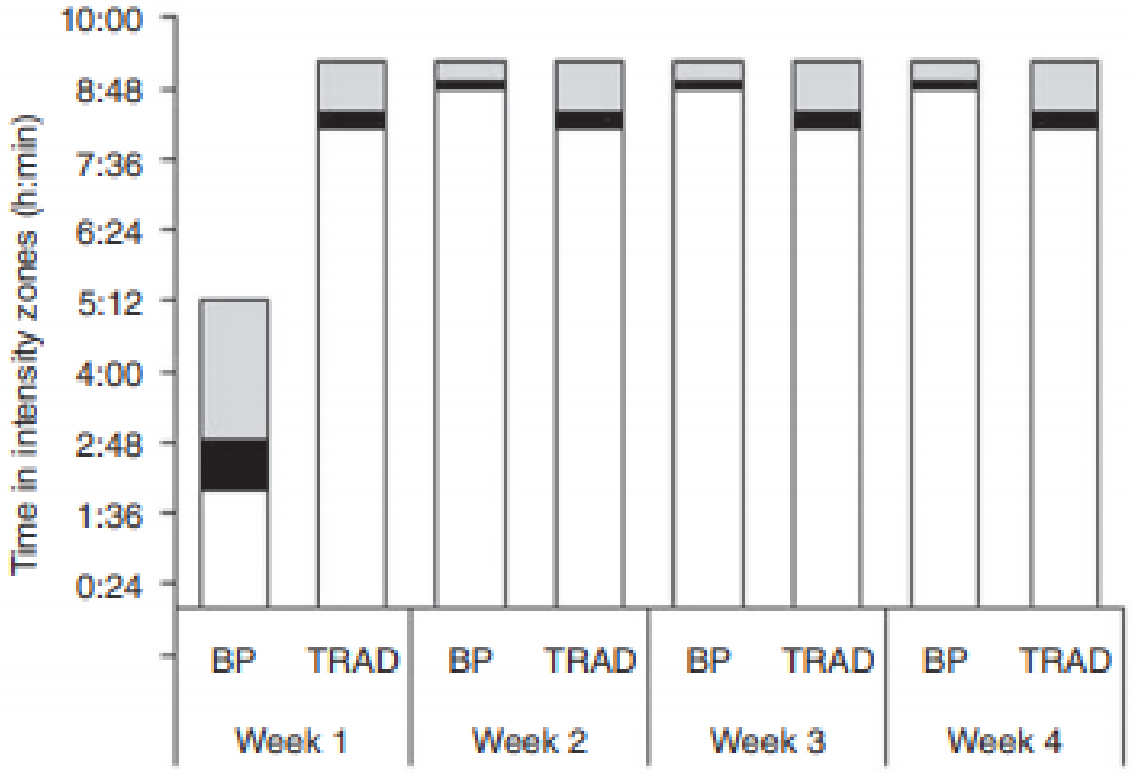
Optimizing Interval Training Through Power-Output Variation Within the Work Intervals (Bossi et al 2020)

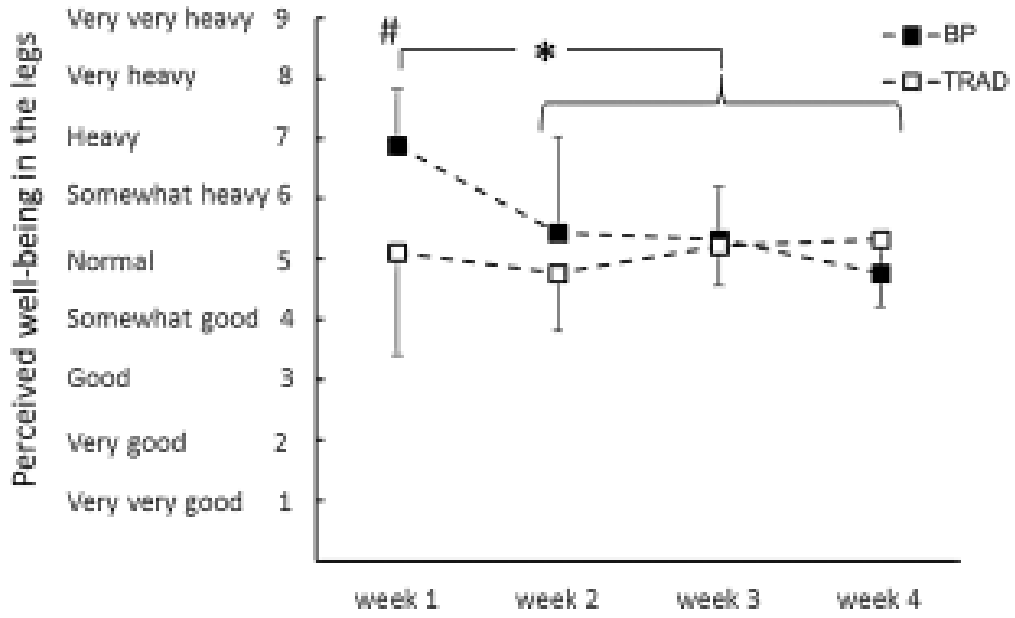


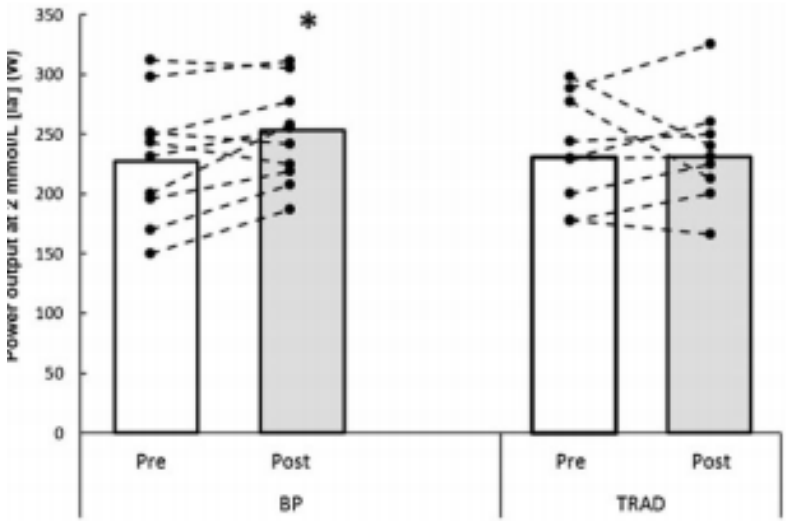


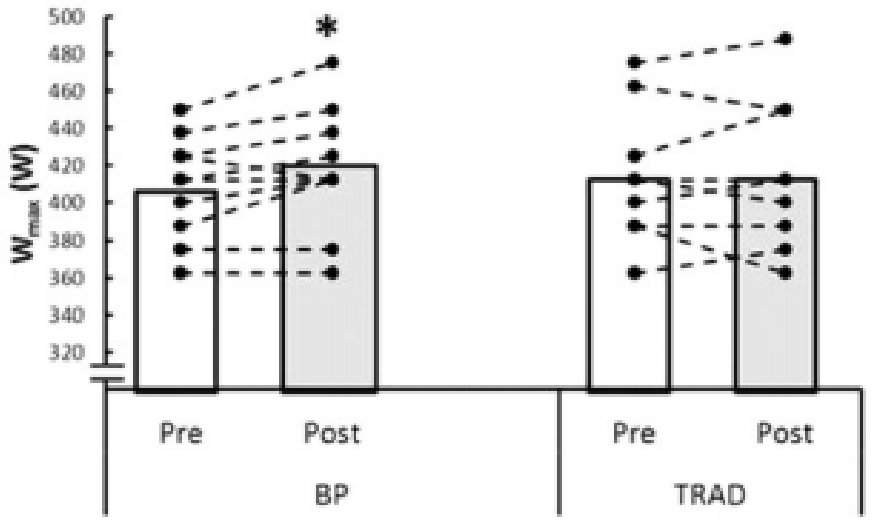


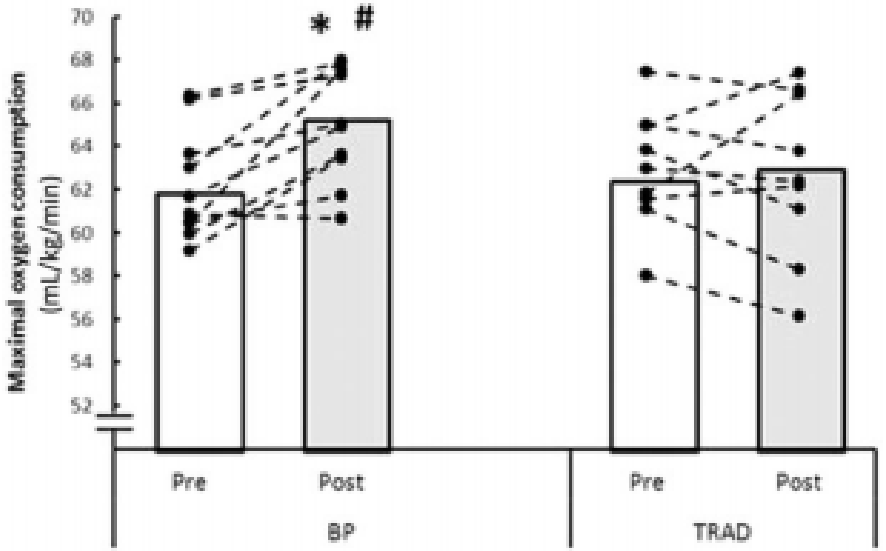
Block periodization of high-intensity aerobic intervals provides superior training effects Ronnestad et al. (2012)



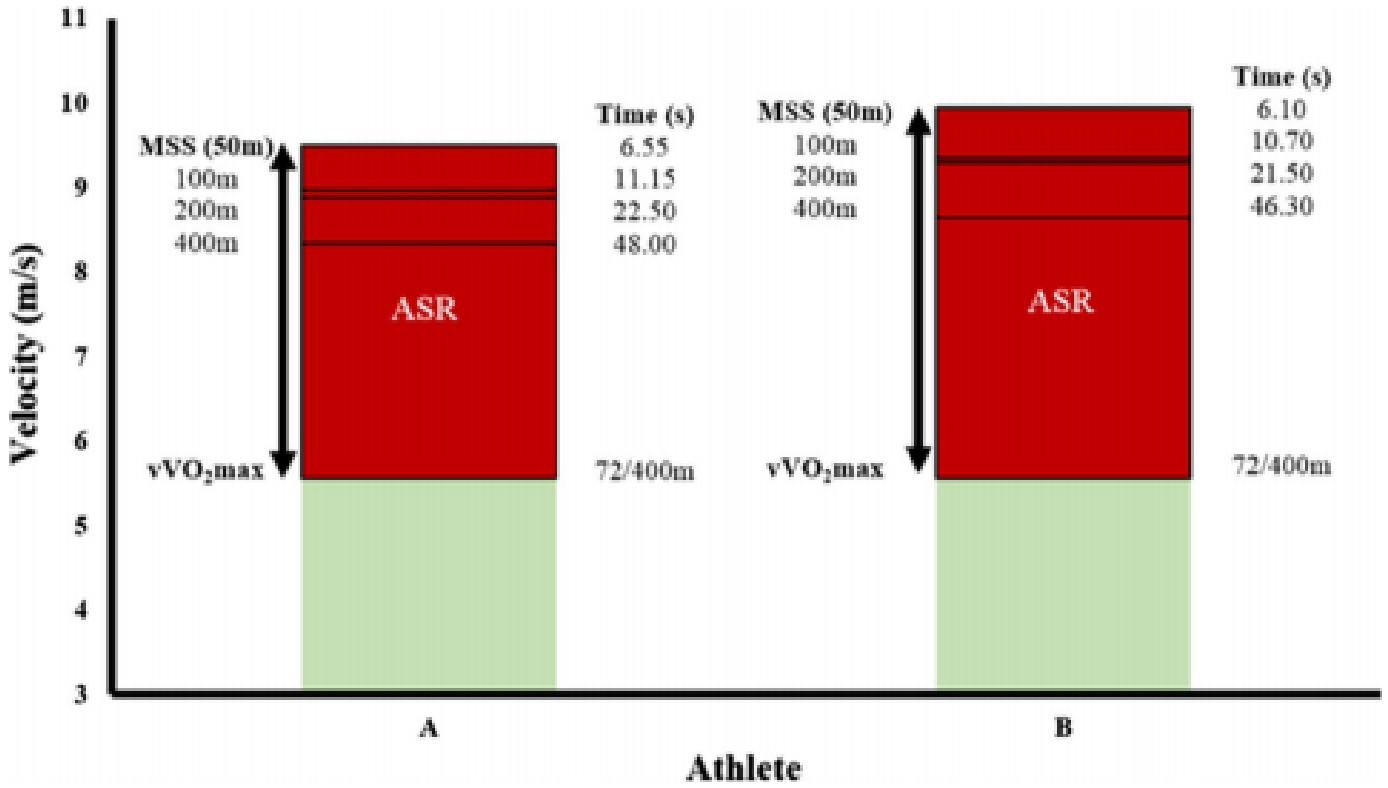



Power output at 2 mmol/L [La] (W)
350
300
250
200
150
100
50
0
*
Pre
Post
BP
Pre
Post
TRAD


W_{max} (W)
500
480
460
440
420
400
380
360
340
320
*
Pre
Post
BP
Pre
Post
TRAD

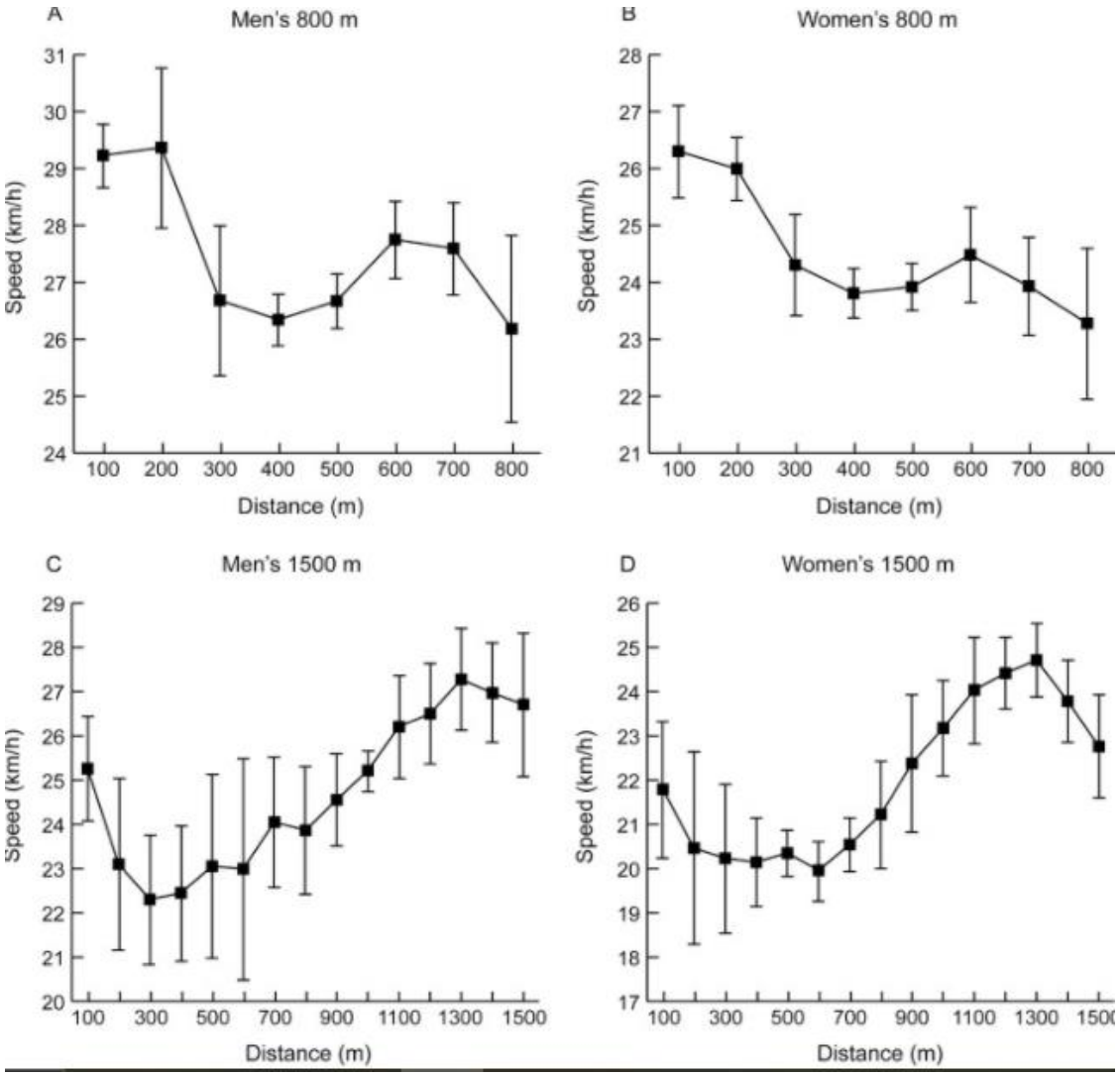

Maximal oxygen consumption (mL/kg/min)
70
68
66
64
62
60
58
56
54
52
*
#
Pre
Post
BP
Pre
Post
TRAD

What about anaerobic power and capacity?



Sandford et al 2018

MD 2008, 2013, 2017



Casado *et al* 2020

Glycolytic interval training

"interval training using short all-out bouts of exercise elicits the glycolytic pathway and can be used to prepare long sprint (200 to 400m) and middle distance (800 to 1500m) runners whose anaerobic metabolism is a determinant for performance" (Billat 2001b)

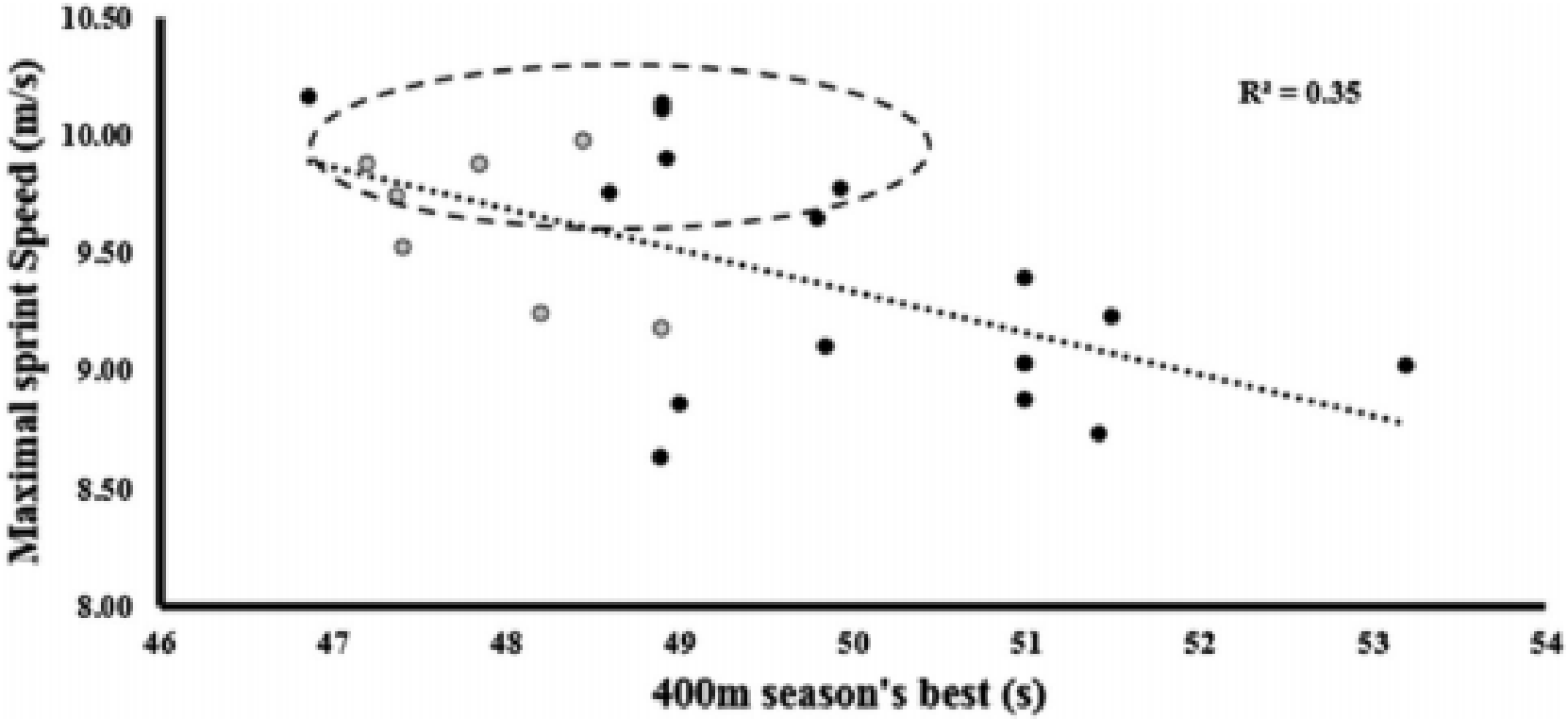
e.g. Roberts et al. (1982):

Sessions of 2x4x200M (2&10min) @ 90% max speed – improved TTE at 16kph on 15% gradient.

[Bla] of 14.5 mmol.l and 17.6 mmol.l after each set

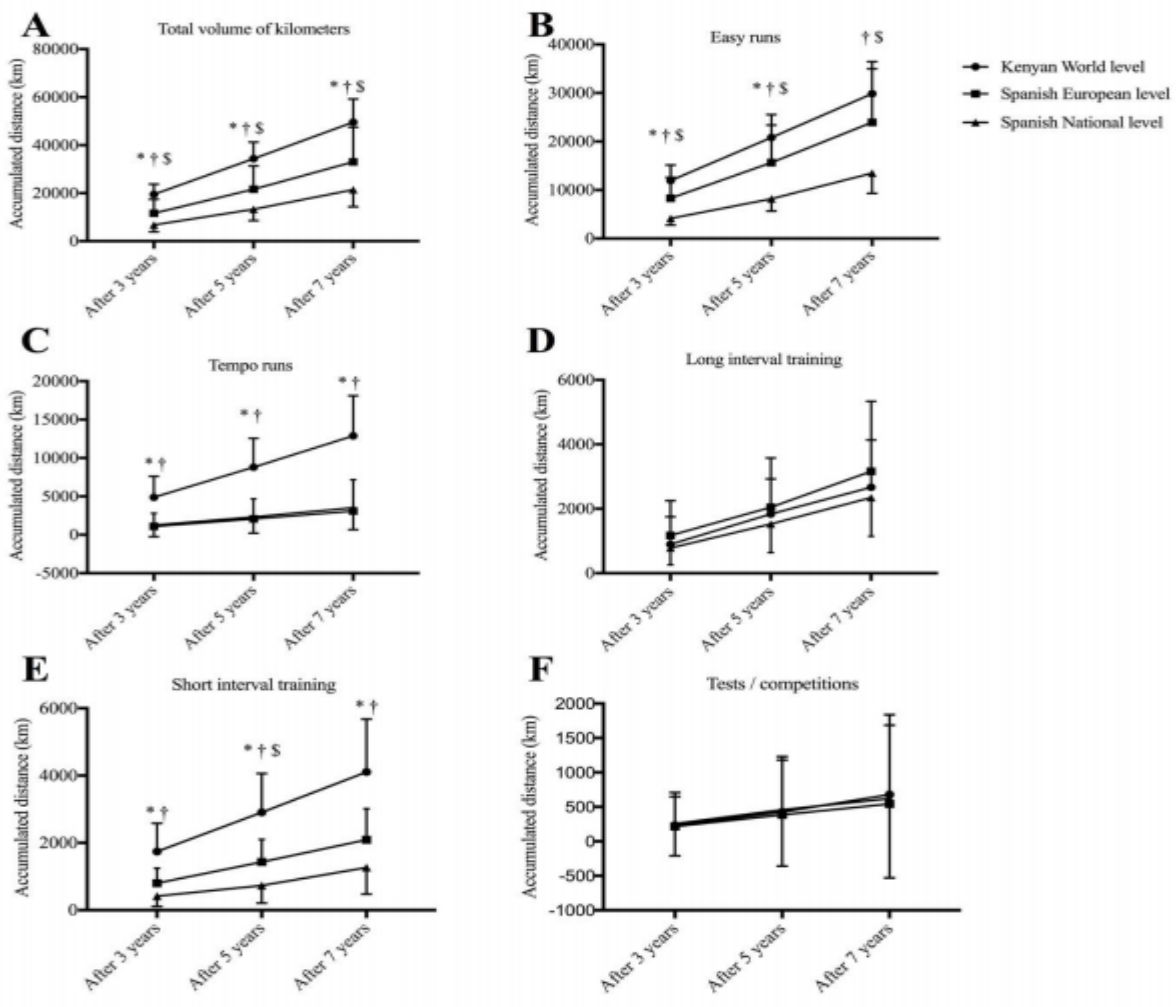
1:4 work/rest ratio increased activity of key glycolytic enzymes and performance.

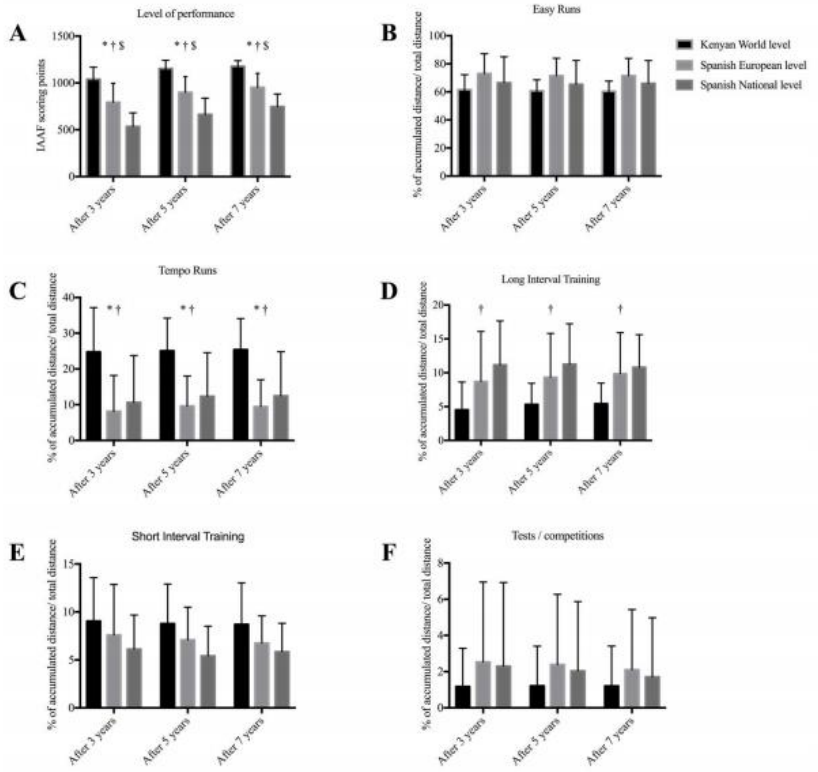
Key factors:
i) Intensity >VO_2 max (~3k pace) ii) runs should be long enough to deplete intramuscular CP and / or recovery sufficiently short to prevent reconstitution of CP reserve.



Sandford et al 2018

How much?





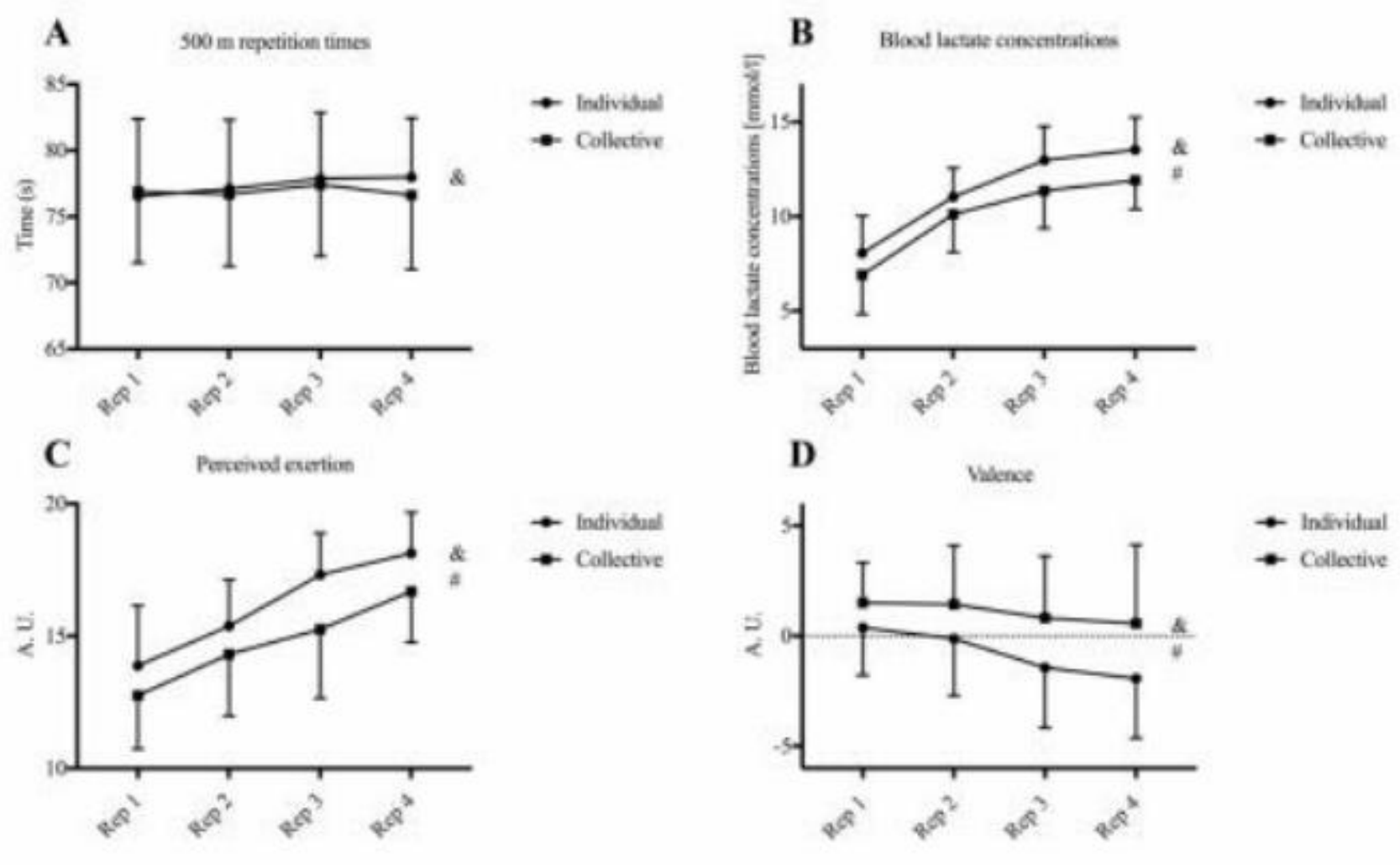
Casado et al 2020

Table 2. Pearson's correlation values between running performance (measured as IAAF score) and training starting age, total volume of training, easy runs, tempo runs, long interval training and short interval training volumes (km) after 3, 5 and 7 years of systematic training.

	After 3 years N = 85 *r*	After 5 years N = 77 *r*	After 7 years N = 65 *r*
Total volume	0.76§	0.77§	0.75§
Easy runs	0.72§	0.71§	0.68§
Tempo runs	0.50§	0.54§	0.58§
Long interval training	0.27*	0.31†	0.22
Short interval training	0.55§	0.53§	0.56§
Competitions and time trials	–0.06	–0.07	0.03
Starting age	0.29†	0.45§	0.52§

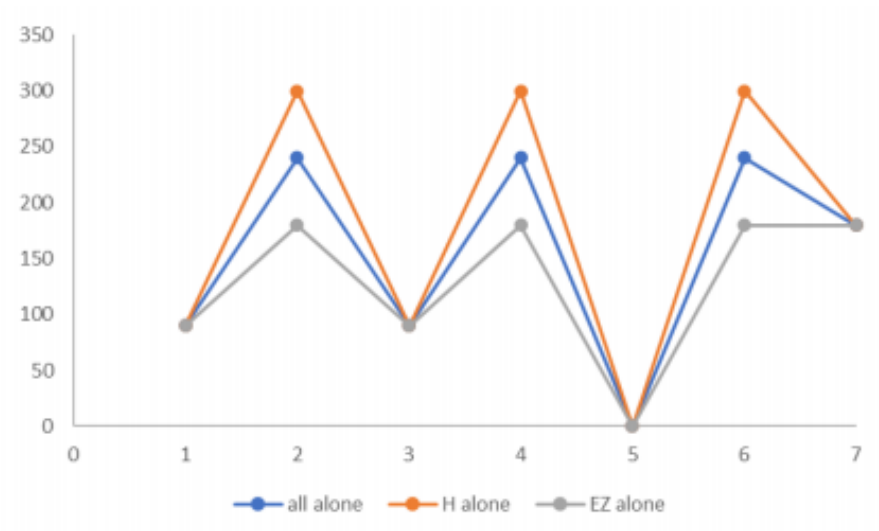
Casado et al 2019

How?



Casado & Renfree 2019

	RPE				LOAD		
	Duration (	all alone	H alone	EZ alone	all alone	H alone	EZ alone
Mon	30	3	3	3	90	90	90
Tue	30	8	10	6	240	300	180
Wed	30	3	3	3	90	90	90
Thu	30	8	10	6	240	300	180
Fri					0	0	0
Sat	30	8	10	6	240	300	180
Sun	60	3	3	3	180	180	180
			Daily mean load		154.2857	180	128.5714
			SD of daily load		95.54356	123.6932	70.81162
			Monotony (mean/SD		1.614821	1.455214	1.815683
			Weekly load		1080	1260	900
			Strain (load*monotc		1744.006	1833.569	1634.114



Summary

- MD performance requires high VO2 max, anaerobic power / capacity, and speed abilities.
- Interval training allows accumulation of greater volumes of high intensity running with less fatigue.
- Shorter (<30s) facilitate greater volumes with less physiological / perceptual fatigue than longer reps.
- Specific anaerobic adaptations are relatively ‘easy’ to achieve.
- ‘How’ sessions are performed likely effects adaptations.

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