Optimizing high-intensity aerobic training sessions

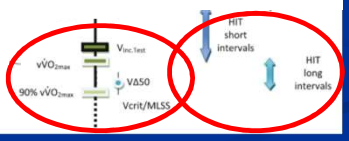
(based on our own data…..)

Bent Rønnestad
Innland Norway University, Lillehammer, Norway

Different HIT formats

Multiple short intervals vs. «long» intervals:

- Differences in acute responses?
- Optimization of «long» intervals?
- Differences in adaptations?



bent.ronnestad@inn.no

(Buchheit & Laursen 2013, Sports Med, 43:313-328)

Both multiple short intervals and longer continous intervals gives a good physiological stimulus

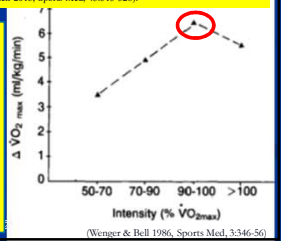
bent.ronnestad@inn.no

A review of 59 training studies concluded that the increase in VO_{2max} was positively related to training intensity in the range of 50–100% VO_{2max} (Wenger & Bell 1986)

Training time ≥ 90% VO_{2max} can be a good criteria to judge the effectiveness of the training program to improve aerobic fitness (Thevenet et al. 2007, EJAP, 99:133–142; Midgley et al. 2006, Sports Med, 36: 117–132; Turnes et al. 2016, EJAP, 116:161-9; Buchheit & Laursen 2013, Sports Med, 43:313-328).

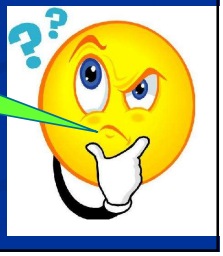
Several reviews have suported the superior efficacy of training at or near VO_{2max}

(Bacon et al. 2013, PLoS One, 8: e73182, MacInnis & Gibala 2017, J Physiol, 595:2915-2930; Milanovic et al. Sports Med. 2015,45:1469-81; Laursen & Jenkins 2002, Sports Med, 32:53-73; Midgley & Mc Naughton 2006, JSMPF, 46:1-14; Midgley et al. 2006, Sports Med, 36:117-132; Turnes et al. 2016, EJAP, 116:161-9; Buchheit & Laursen 2013; Billat 2001, Sports Med;31:13-31;



(Wenger & Bell 1986, Sports Med, 3:346-56)

Are there acute differences between effort matched multiple short intervals and long intervals in time ≥90% VO_{2max}?



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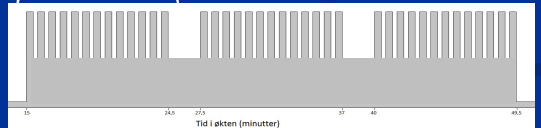
Multiple short intervals vs. long intervals

5 min | 5 min | 5 min | 5 min

VS.

13 x 30/15 s

All-out; ~similar work interval duration



bent.ronnestad@inn.no

(Almquist et al. 2020)

Short vs. long intervals: – acute responses → Optimizing long intervals → Short vs. long intervals: -training adaptations

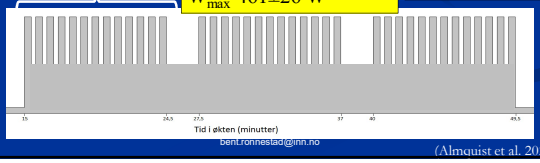
Multiple short intervals vs. long intervals

5 min | 5 min | 5 min | 5 min

27±7 years, 180±5 cm, 75±3 kg, VO_{2max} 73±7ml/kg/min W_{max} 461±26 W

13 x 30/15 s

All-out; ~similar work interval duration



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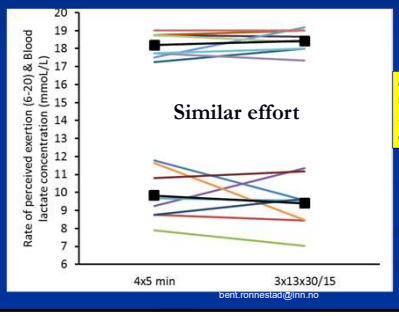

4x5 min mean power = 367 +/- 23 W
30/15 mean power= 415 +/- 27 W

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(Almquist et al. 2020)

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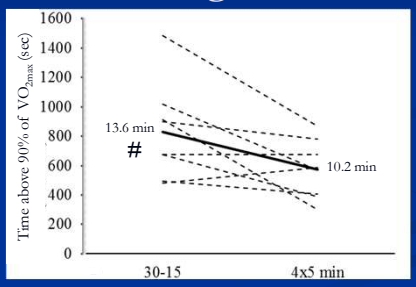


bent.ronnestad@inn.no

(Almquist et al. 2020)

Short vs. long intervals: – acute responses → Optimizing long intervals → Short vs. long intervals: -training adaptations

Induces multiple short intervals larger time ≥90% VO_{2max} than long intervals when mean power output is similar during the work intervals?

Multiple short intervals can give longer time above 90%VO_{2max} than long intervals, even when similar mean power output

bent.ronnestad@inn.no

Short vs. long intervals: – acute responses → Optimizing long intervals → Short vs. long intervals: -training adaptations

Induces multiple short intervals larger time ≥90% VO_{2max} than long intervals when mean power output is similar during the work intervals

Multiple short intervals can give longer time above 90%VO_{2max} than long intervals, even when similar mean power output

Can we do something with the long intervals to increase the time ≥90% VO_{2max}?

bent.ronnestad@inn.no

Short vs. long intervals: – acute responses → Optimizing long intervals → Short vs. long intervals: -training adaptations

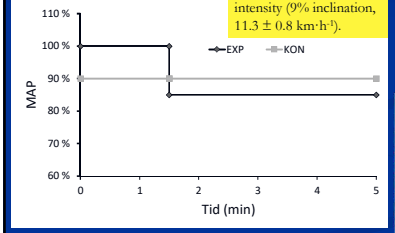
If we start long intervals with a high intensity and a subsequent reduction, would we then achieve a longer time ≥90% VO_{2max}?

bent.ronnestad@inn.no

Short vs. long intervals: – acute responses → Optimizing long intervals → Short vs. long intervals: -training adaptations

6x5 min intervals; start high, go lower vs. steady

Similar mean exercise intensity (9% inclination, 11.3 ± 0.8 km·h⁻¹).



Variable		mean ± SD
Age	years	23,3 ± 3,5
Body height	cm	183 ± 6
Body mass	kg	76,6 ± 7
VO_{2max}	ml/min/kg	70,3 ± 5,7
HR_{max}	beat/min	198 ± 8
MAS	km/h	12,6 ± 0,9
V_{LT}	km/h	10,1 ± 0,8

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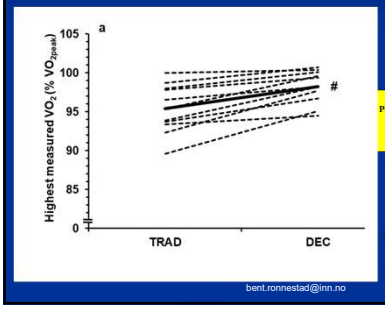

	DEC		TRAD
Peak VO_2 (%VO_{2max})	98,2%*	VS.	95,3%

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(Ronnestad et al., 2019)

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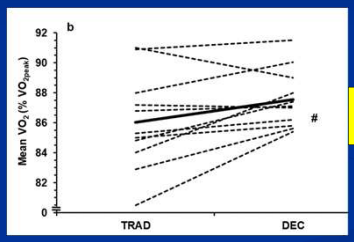

	DEC		TRAD
Peak VO_2 (%VO_{2max})	98,2%*	VS.	95,3%
Mean VO_2 (%VO_{2max})	87,6%*	VS.	86,1%

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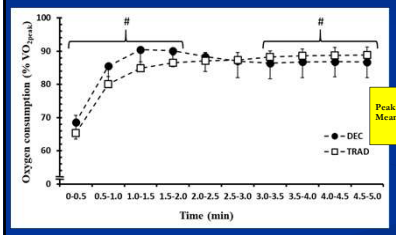

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Peak VO_2 (%VO_{2max})	98,2%*	VS.	95,3%
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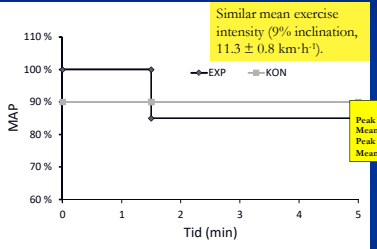
Similar mean exercise intensity (9% inclination, 11.3 ± 0.8 km·h⁻¹).



	DEC		TRAD
Peak VO_2 (%VO_{2max})	98,2%*	VS.	95,3%
Mean VO_2 (%VO_{2max})	87,6%*	VS.	86,1%
Peak RPE (6-20)	17,5*	VS.	18,1
Mean RPE (6-20)	16,1*	VS.	16,5

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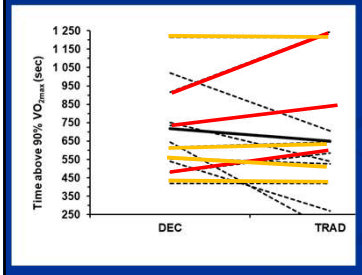

	DEC		TRAD
Peak VO_2 (%VO_{2max})	98,2%*	VS.	95,3%
Mean VO_2 (%VO_{2max})	87,6%*	VS.	86,1%
Peak RPE (6-20)	17,5*	VS.	18,1
Mean RPE (6-20)	16,1*	VS.	16,5
Time≥90%VO_{2max} (S)	717 ± 245 s	vs.	650 ± 343 s

bent.ronnestad@inn.no

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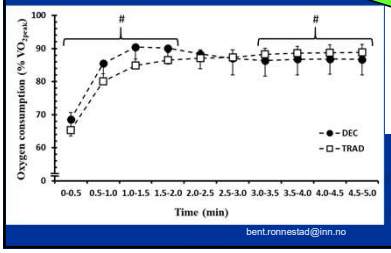
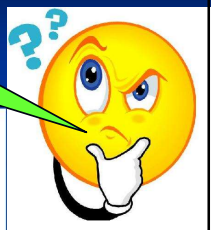
Short vs. long intervals: – acute responses → Optimizing long intervals → Short vs. long intervals: -training adaptations

Can we increase the time ≥90% VO_{2max} significantly by some modifications?





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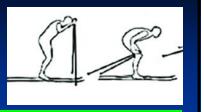
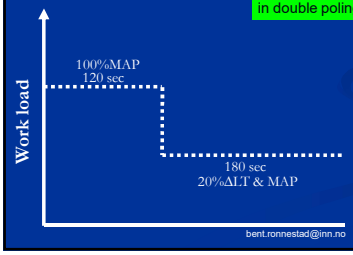
Short vs. long intervals: – acute responses → Optimizing long intervals → Short vs. long intervals: -training adaptations

5x5 min intervals; start high, go lower vs. steady



10 Elite XC skiers; age 24.9 ± 3.3 years, height 186 ± 4 cm, body mass 81.1 ± 5.0 kg, VO_{2peak} in double poling: 69.6 ± 3.5 mL · min^{-1} · kg^{-1})



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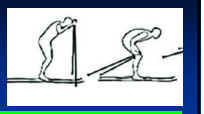

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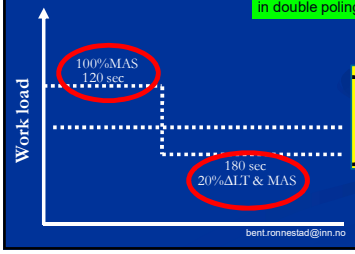

Similar mean velocity

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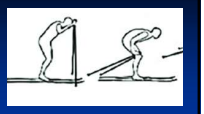

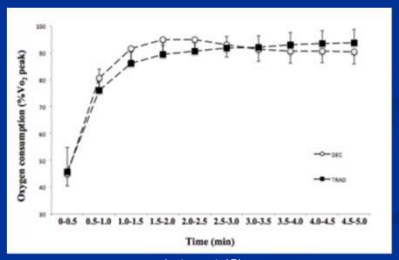

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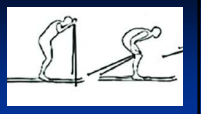

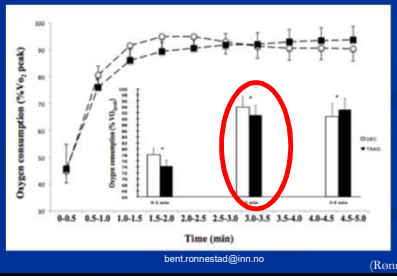

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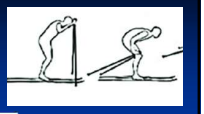
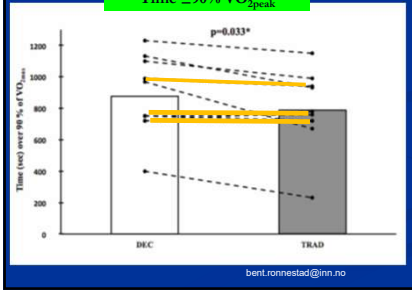


Time ≥90% VO_{2peak}



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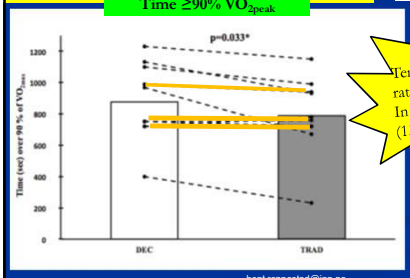
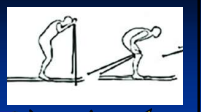


Tendency towards lower rate of perceived exertion In DEC vs. TRAD (15.8±1.5 vs. 16.3±1.1)



bent.ronnestad@inn.no

(Rønnestad et al., in press)

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If we start long intervals with a high intensity with a subsequent reduction, would we then achieve a longer time ≥90% VO_{2max}?

Yes, start high go lower seems to be a good supplement to the traditional approach, especially if we take into consideration the individual LT

bent.ronnestad@inn.no

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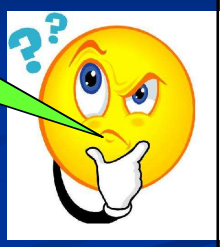
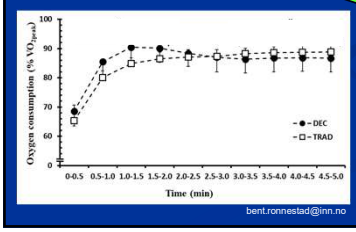
Would multiple small peaks within a work interval induce longer time ≥90% VO_{2max} than traditional, steady workload in the intervals?





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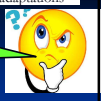

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Arbeidsbelastning (W)

100%MAS 120 sek

180 sek 20%ΔLT & MAS

bent.ronnestad@inn.no

(Rønnestad et al., in press)

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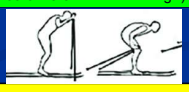

Arbeidsbelastning (W)

100%MAS 40 sek — 60 sek 20%ΔLT & MAS

100%MAS 40 sek — 60 sek 20%ΔLT & MAS

100%MAS 40 sek — 60 sek 20%ΔLT & MAS

5x5 min intervals with similar mean velocity

bent.ronnestad@inn.no

(Rønnestad et al., in press)

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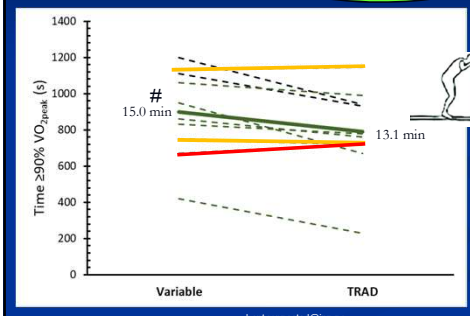

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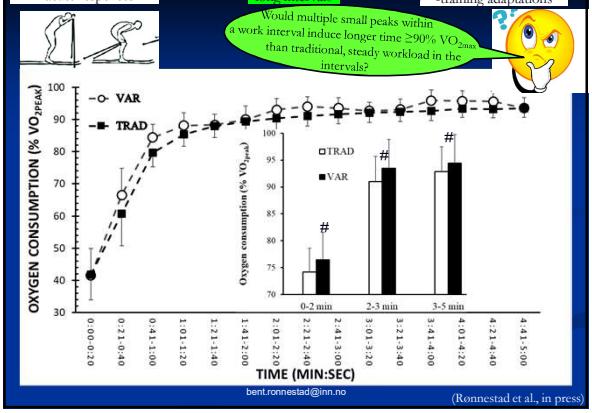

bent.ronnestad@inn.no (Rønnestad et al., in press)

Short vs. long intervals: – acute responses → Optimizing long intervals → Short vs. long intervals: -training adaptations

Would multiple small peaks within a work interval induce longer time ≥90% VO_{2max} than traditional, steady workload in the intervals?

Yes, during double poling in cross-country skiers, but how is it with cyclists?

bent.ronnestad@inn.no

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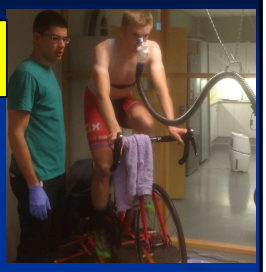
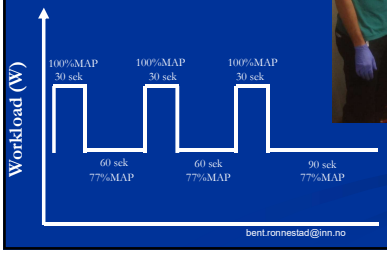
Varied vs. steady power (6 x 5 min, similar mean power)

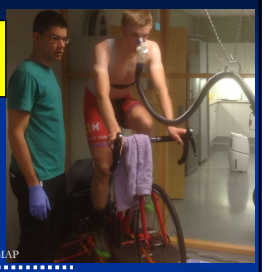


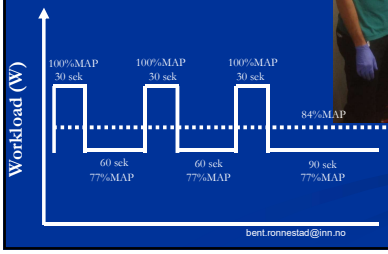


bent.ronnestad@inn.no (Bossi et al. 2020)

Short vs. long intervals: – acute responses → Optimizing long intervals → Short vs. long intervals: -training adaptations

Varied vs. steady power (6 x 5 min, similar mean power)



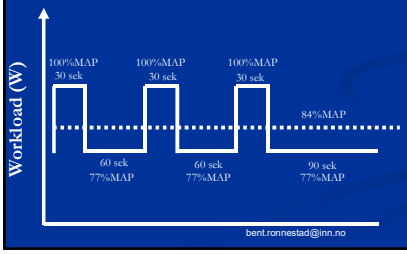


bent.ronnestad@inn.no (Bossi et al. 2020)

Short vs. long intervals: – acute responses → Optimizing long intervals → Short vs. long intervals: -training adaptations

Varied vs. steady power (6 x 5 min, similar mean power)

14 cyclists (24±6 year)
VO_{2max}: 69±6 ml·min^{-1}·kg^{-1}
W_{max}: 430 ± 35 W
MAP: 387 ± 33 W



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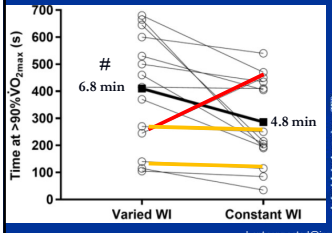
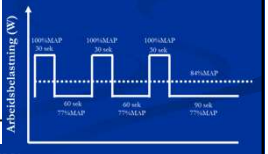




bent.ronnestad@inn.no (Bossi et al. 2020)

Short vs. long intervals: – acute responses → Optimizing long intervals → Short vs. long intervals: -training adaptations

Would multiple small peaks within a work interval induce longer time ≥90% VO_{2max} than traditional, steady workload in the intervals?

Yes! Then maybe another good supplement to the traditional approach?

bent.ronnestad@inn.no

Short vs. long intervals: – acute responses → Optimizing long intervals → Short vs. long intervals: -training adaptations

Summary

Multiple short intervals can give longer time above 90%VO_{2max} than long intervals, even when similar mean power output

Multiple small peaks within a work interval can induce longer time ≥90% VO_{2max} than traditional, steady workload in the intervals

Start high go lower seems to induce longer time ≥90% VO_{2max} than steady workload, especially if we take into consideration the individual LT

Similar effects?

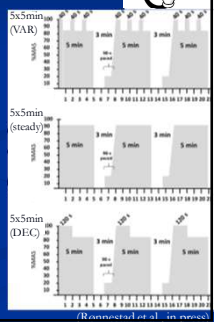
Are there differences between "start high go lower" vs. multiple small peaks within a work interval vs. steady power intervals in time ≥90% VO_{2max}?

bent.ronnestad@inn.no

Short vs. long intervals: – acute responses → Optimizing long intervals → Short vs. long intervals: -training adaptations

Are there differences between "start high go lower" vs. multiple small peaks within a work interval vs. steady power intervals in time ≥90% VO_{2max}?

10 Elite XC skiers; age 24.9 ± 3.3 years, height 186 ± 4 cm, body mass 81.1 ± 5.0 kg, VO_{2peak} in double poling: 69.6 ± 3.5 mL · min⁻¹ · kg⁻¹)



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(Rønnestad et al., in press)

Short vs. long intervals: – acute responses → Optimizing long intervals → Short vs. long intervals: -training adaptations

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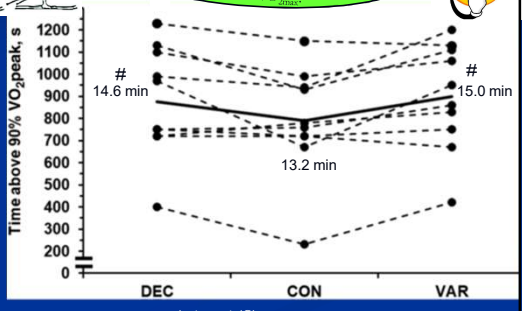

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Short vs. long intervals: – acute responses → Optimizing long intervals → Short vs. long intervals: -training adaptations

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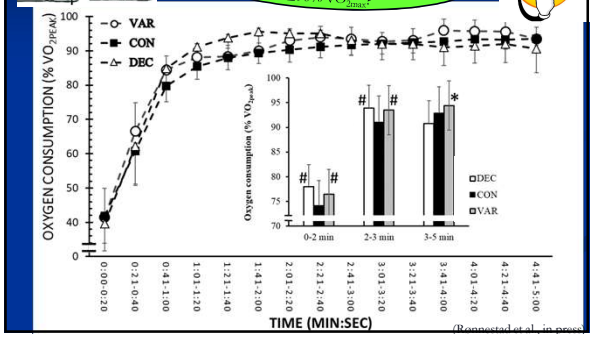

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Short vs. long intervals: – acute responses → Optimizing long intervals → Short vs. long intervals: -training adaptations

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Multiple small peaks within a work interval can induce longer time ≥90% VO_{2max} than traditional, steady workload in the intervals

Start high go lower seems can induce longer time ≥90% VO_{2max} than steady workload, especially if we take into consideration the individual LT

Similar effects?

YES

Are there differences between multiple short intervals vs. multiple small peaks within a work interval in time ≥90% VO_{2max}?

bent.ronnestad@inn.no

Short vs. long intervals: – acute responses → Optimizing long intervals → Short vs. long intervals: -training adaptations

Are there differences between multiple short intervals vs. multiple small peaks within a work interval vs. steady power intervals in time ≥90% VO_{2max}?

Multiple short intervals can give longer time above 90%VO_{2max} than long intervals, even when similar mean power output

Multiple small peaks within a work interval can induce longer time ≥90% VO_{2max} than traditional, steady workload in the intervals

Similar effects?

No, multiple short intervals seems to induce longer time ≥90% VO_{2max}

bent.ronnestad@inn.no

Short vs. long intervals: – acute responses → Optimizing long intervals → Short vs. long intervals: -training adaptations

Summary:

The following alternative to traditional long intervals seems to acutely give longer time ≥90% of VO_{2max}:

1. **Multiple short intervals**
2. **Start high and go lower in intensity within a long work interval**
3. **Multiple small peaks within a long work interval**

But will it lead to superior training adaptations??

bent.ronnestad@inn.no

Short vs. long intervals: – acute responses → Optimizing long intervals → Short vs. long intervals: -training adaptations

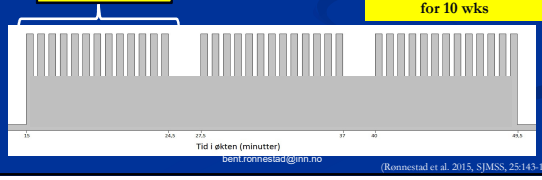
Multiple short intervals vs. long intervals

5 min | 5 min | 5 min | 5 min

VS.

13 x 30/15 s

Well-trained cyclists (VO_{2max}~65ml/kg/min) 2 HIT sessions/week for 10 wks



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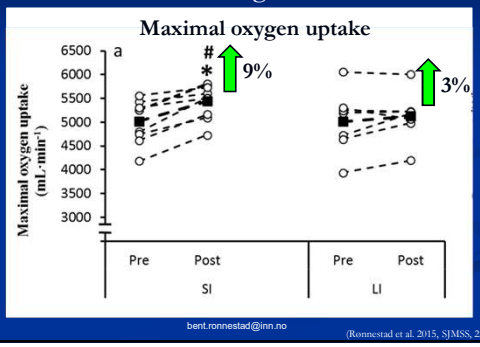
(Rønnestad et al. 2015, SJMSS, 25:143-151)

Short vs. long intervals: – acute responses → Optimizing long intervals → Short vs. long intervals: -training adaptations

Multiple short intervals vs. long intervals -10 weeks training intervention



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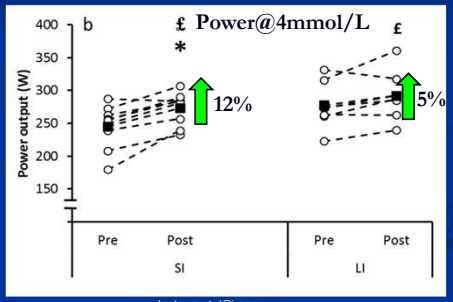

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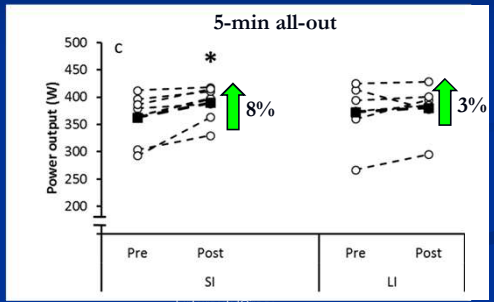

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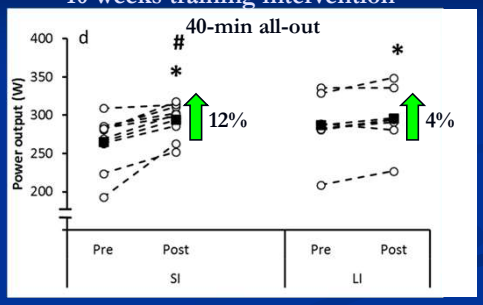


bent.ronnestad@inn.no

(Rønnestad et al. 2015, SJMSS, 25:143-151)

Multiple short intervals induces a longer time ≥90% of VO_{2max} than 5 min intervals

bent.ronnestad@inn.no

Multiple short intervals vs. long intervals -even better cyclists

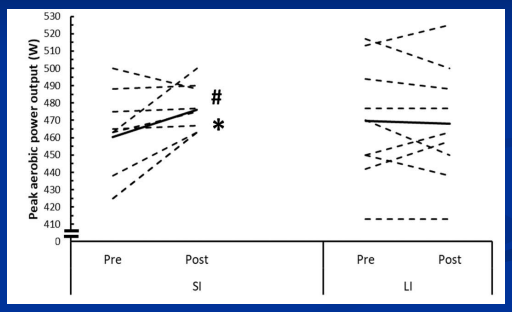
3 HIT sessions per week for 3 weeks with 5 days after last HIT before post-test

	30/15	4 x 5 min
Age (years)	24±4	25±5
Height (cm)	184±3	182±4
Body mass (kg)	75.2±3.6	74.5±5.1
VO_{2max} ($mL \cdot kg^{-1} \cdot min^{-1}$)	73±3	74±4
W_{max} (W)	460±26	468±39
20 min all-out power (W)	343±31	348±32

bent.ronnestad@inn.no

(Rønnestad et al., 2020)

Peak aerobic power output



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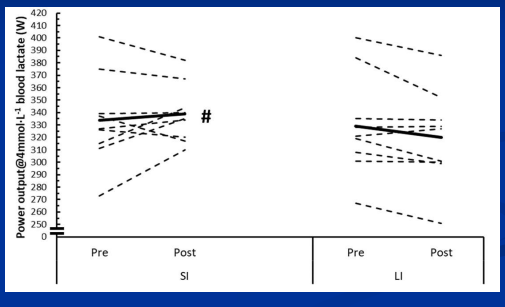
(Rønnestad et al., 2020)

Power@4mmol/L blood lactate



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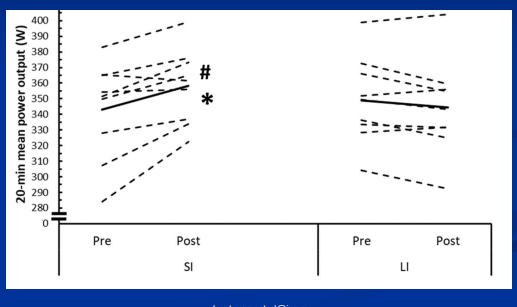
20 min all-out



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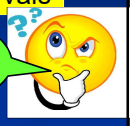
(Rønnestad et al., 2020)

Short vs. long intervals: – acute responses → Optimizing long intervals → Short vs. long intervals: -training adaptations

Multiple short intervals induces a longer time ≥90% of VO_{2max} than 5 min intervals

Yes!
But is this true for even better athletes?

But will it lead to superior training adaptations??



Yes!
But is this true for a short HIT block?

bent.ronnestad@inn.no

Short vs. long intervals: – acute responses → Optimizing long intervals → Short vs. long intervals: -training adaptations

5 HIT sessions in a week (6 x 5 min) in 6 days
VS.
5 HIT sessions in a week (5 series á 12 x 30 sec work period with 15 sec recovery)

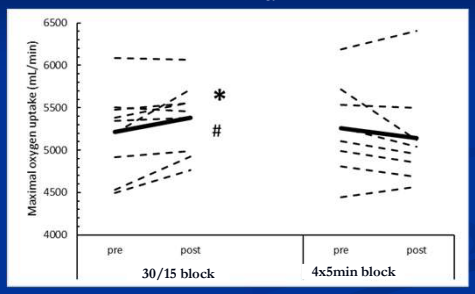
Both groups tested on the 6th day after last HIT session. Standardized and similar training in between

Each work intervall should have a rate of perceived exertion between 17 and 19 on Borg 6-20 RPE scale

bent.ronnestad@inn.no (Rønnestad et al., 2021)

Short vs. long intervals: – acute responses → Optimizing long intervals → Short vs. long intervals: -training adaptations

VO_{2max}



Bent Rønnestad 2021 (Rønnestad et al., 2021)

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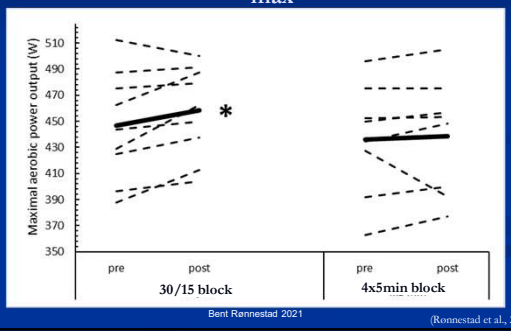
W_{max}



Bent Rønnestad 2021 (Rønnestad et al., 2021)

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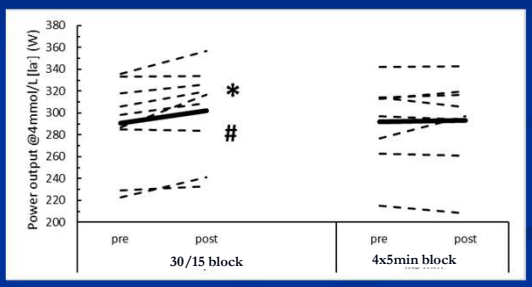
Power output@ 4 mmol·L^{-1} blood lactate



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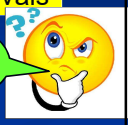

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But is this true for a short HIT block?

Yes!

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Short vs. long intervals: – acute responses → Optimizing long intervals → Short vs. long intervals: -training adaptations

Summary

- Multiple short intervals can give longer time above 90%VO_{2max} than long intervals, even when similar mean power output
- Multiple small peaks within a work interval can induce longer time ≥90% VO_{2max} than traditional, steady workload in the intervals
- Start high go lower seems can induce longer time ≥90% VO_{2max} than steady workload, especially if we take into consideration the individual LT
- **Indications that isoeffort multiple short intervals can give larger adaptations than to longer intervals**

bent.ronnestad@inn.no

Practical application of a 30/15 session

Work intensity ≈ mean work rate during 5-6 min all-out

Recovery ≈ moderate work intensity

Number of intervals in a serie ≈ >9

Number of series ≈ 3-4

Borg scale

6. No exertion at al
7. Extreme light
8.
9. Very light
10.
11. Light
12.
13. Somewhat hard
14.
15. Hard (Heavy)
16.
17. Very hard
18.
19. Extremely hard
20. Maximal exertion

bent.ronnestad@inn.no

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Short vs. long intervals: – acute responses → Optimizing long intervals → Short vs. long intervals: -training adaptations

It`s important to monitoring individual responses to the training and find the right way at the right time for each individual athlete

bent.ronnestad@inn.no

Short vs. long intervals: – acute responses → Optimizing long intervals → Short vs. long intervals: -training adaptations

Thanks for the attention!

bent.ronnestad@inn.no