Science behind high-intensity interval training (HIT) in endurance sports

Bent Rønnestad
bent.ronnestad@inn.no

Inland Norway University of Applied Sciences

1

Intro | Short vs. long intervals: – acute responses | Programming long intervals | Short vs. long intervals: -training adaptations | Training structure

Science behind high-intensity interval training (HIT) in endurance sports

Bent Rønnestad

2

Intro | Short vs. long intervals: – acute responses | Programming long intervals | Short vs. long intervals: -training adaptations | Training structure

Science behind high-intensity interval training (HIT) in endurance sports

Bent Rønnestad

3

Intro | Short vs. long intervals: – acute responses | Programming long intervals | Short vs. long intervals: -training adaptations | Training structure

Science behind high-intensity interval training (HIT) in endurance sports

Bent Rønnestad

4

Intro | Short vs. long intervals: – acute responses | Programming long intervals | Short vs. long intervals: -training adaptations | Training structure

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}

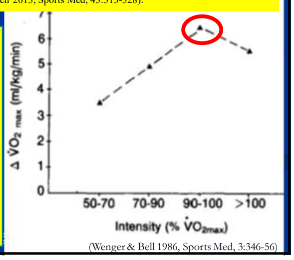
(Wenger & Bell 1986)

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)

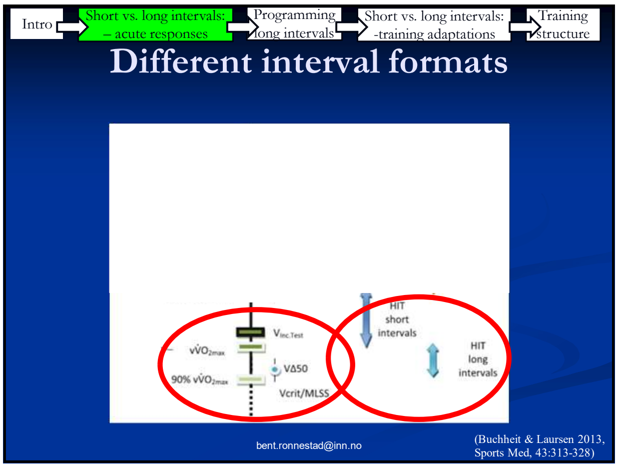
5

Intro | Short vs. long intervals: – acute responses | Programming long intervals | Short vs. long intervals: -training adaptations | Training structure

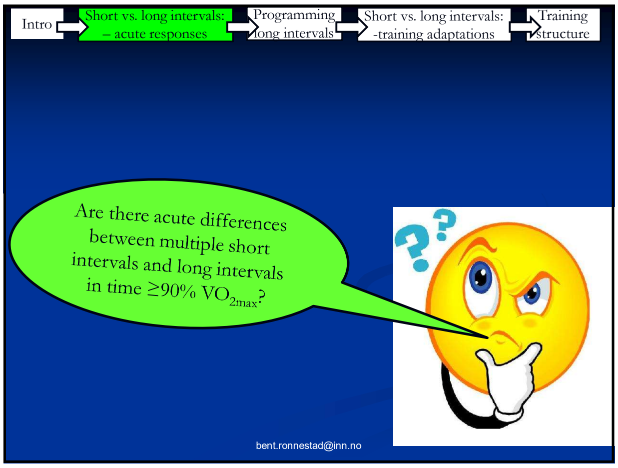
Training time ≥ 90% VO_{2max} can be a good criteria to judge the effectiveness of the training program to improve aerobic fitness

bent.ronnestad@inn.no

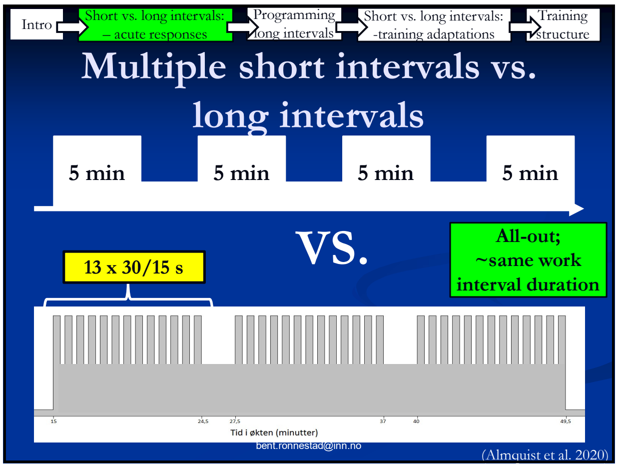
6


Intro
Short vs. long intervals: – acute responses
Programming long intervals
Short vs. long intervals: -training adaptations
Training structure
Different interval formats
vVO2max
90% vVO2max
VInc.Test
VΔ50
Vcrit/MLSS
HIT short intervals
HIT long intervals
bent.ronnestad@inn.no
(Buchheit & Laursen 2013, Sports Med, 43:313-328)

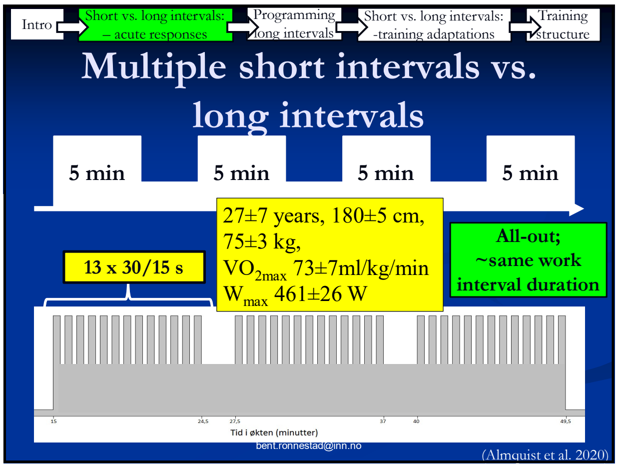
7


Intro
Short vs. long intervals: – acute responses
Programming long intervals
Short vs. long intervals: -training adaptations
Training structure
Are there acute differences between multiple short intervals and long intervals in time ≥90% VO2max?
bent.ronnestad@inn.no

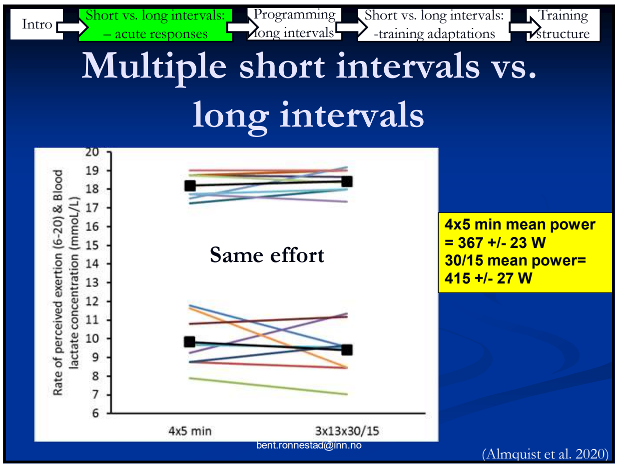
8


Intro
Short vs. long intervals: – acute responses
Programming long intervals
Short vs. long intervals: -training adaptations
Training structure
Multiple short intervals vs. long intervals
5 min
5 min
5 min
5 min
VS.
13 x 30/15 s
All-out; ~same work interval duration
Tid i økten (minutter)
bent.ronnestad@inn.no
(Almquist et al. 2020)

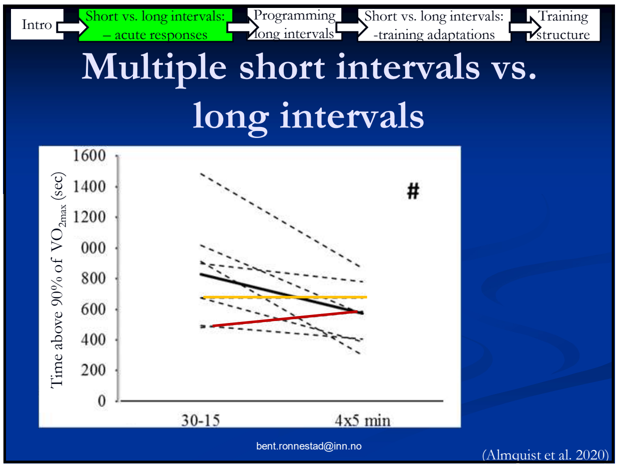
9


Intro
Short vs. long intervals: – acute responses
Programming long intervals
Short vs. long intervals: -training adaptations
Training structure
Multiple short intervals vs. long intervals
5 min
5 min
5 min
5 min
13 x 30/15 s
27±7 years, 180±5 cm, 75±3 kg, VO2max 73±7ml/kg/min Wmax 461±26 W
All-out; ~same work interval duration
Tid i økten (minutter)
bent.ronnestad@inn.no
(Almquist et al. 2020)

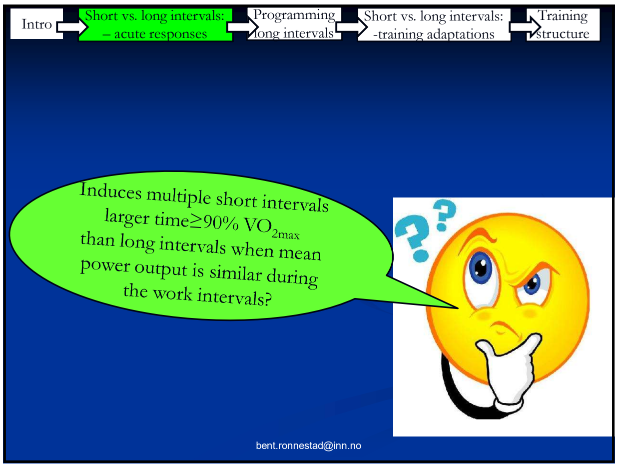
10


Intro
Short vs. long intervals: – acute responses
Programming long intervals
Short vs. long intervals: -training adaptations
Training structure
Multiple short intervals vs. long intervals
Rate of perceived exertion (6-20) & Blood lactate concentration (mmol/L)
Same effort
4x5 min
3x13x30/15
4x5 min mean power = 367 +/- 23 W 30/15 mean power= 415 +/- 27 W
bent.ronnestad@inn.no
(Almquist et al. 2020)

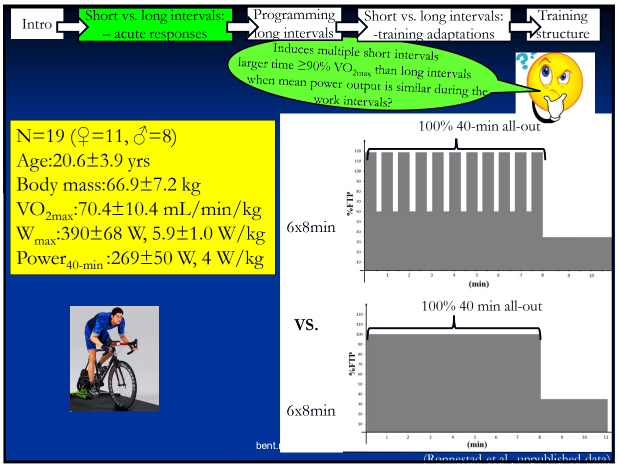
11


Intro
Short vs. long intervals: – acute responses
Programming long intervals
Short vs. long intervals: -training adaptations
Training structure
Multiple short intervals vs. long intervals
Time above 90% of VO2max (sec)
#
30-15
4x5 min
bent.ronnestad@inn.no
(Almquist et al. 2020)

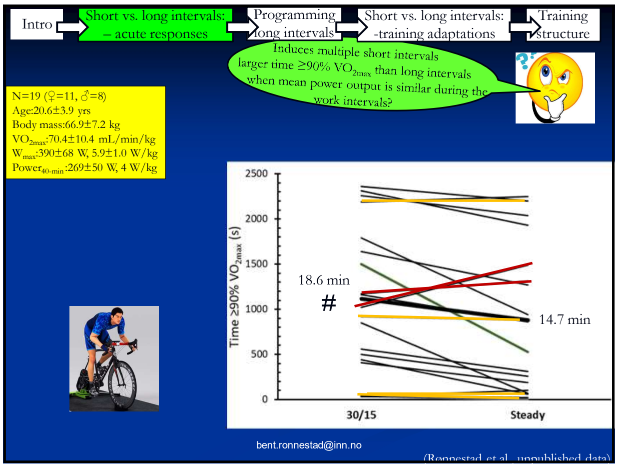
12



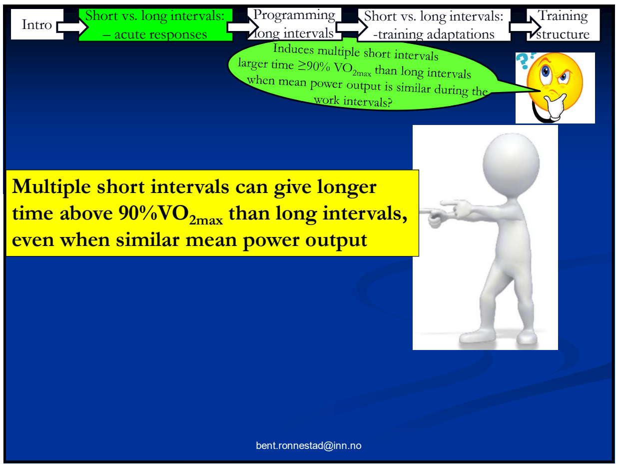
13



14

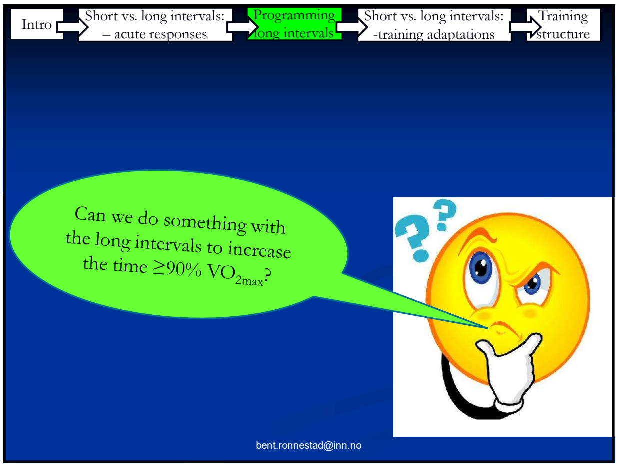


15

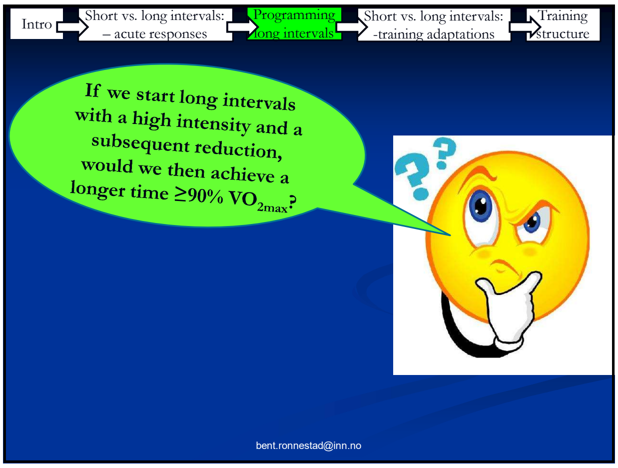


16

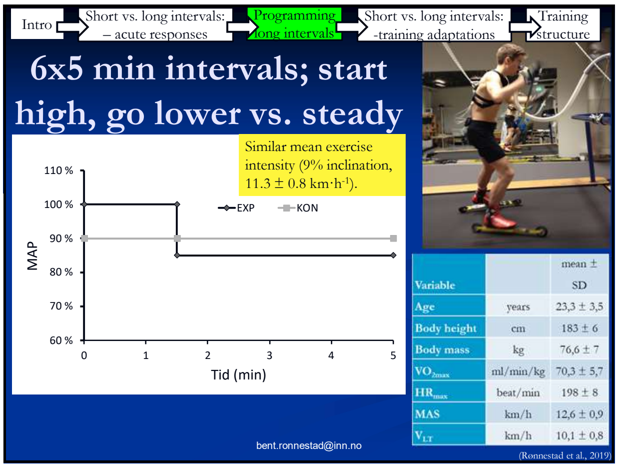
17



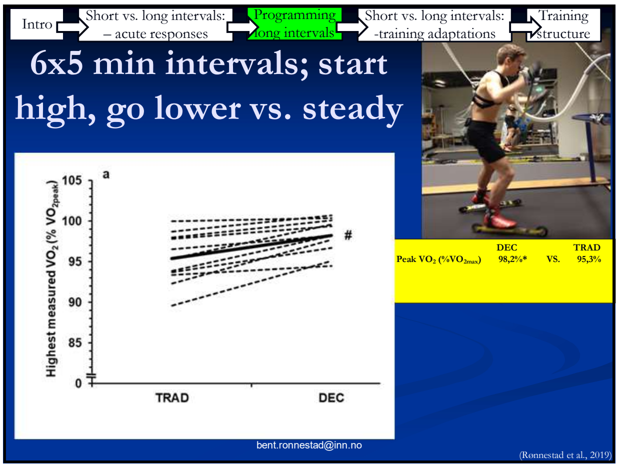
18



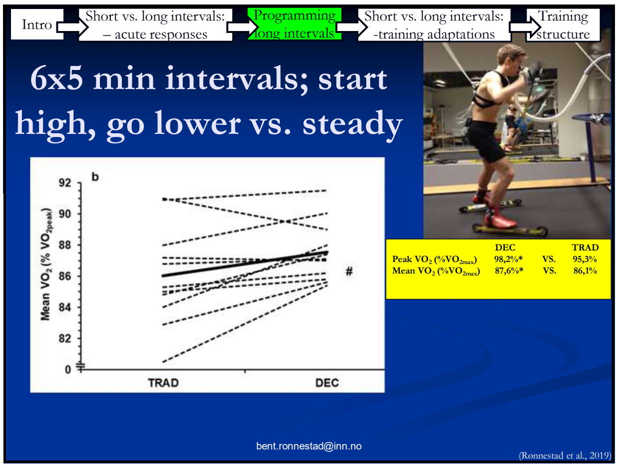
19



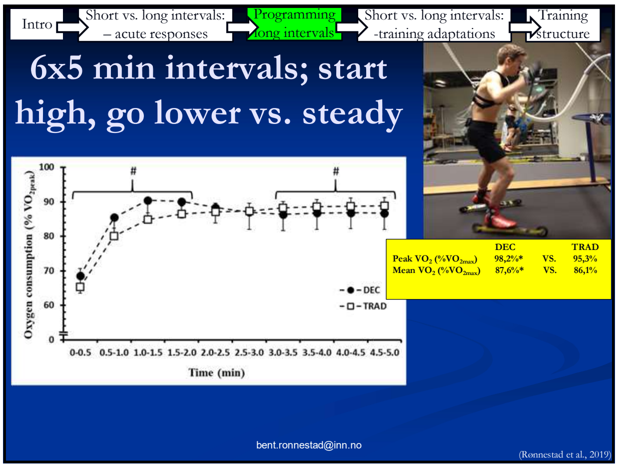
20



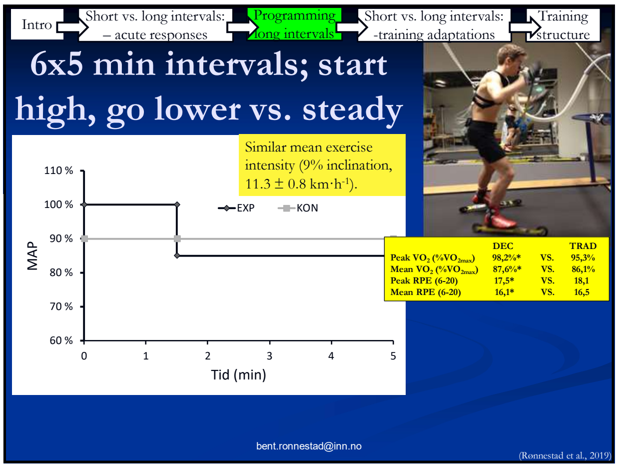
21



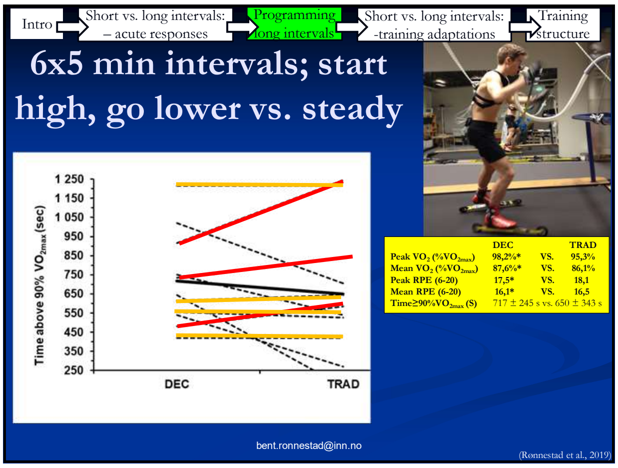
22



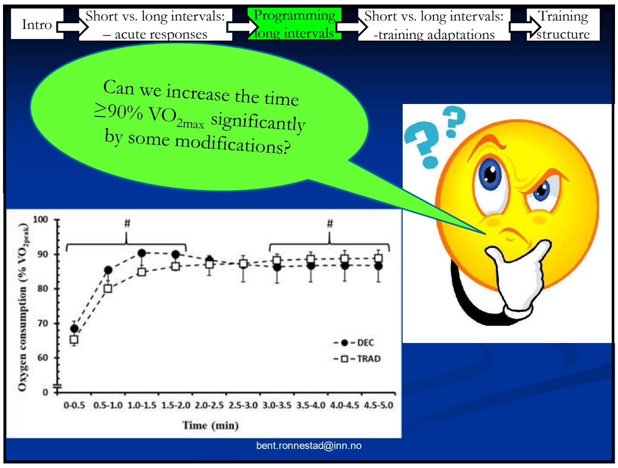
23



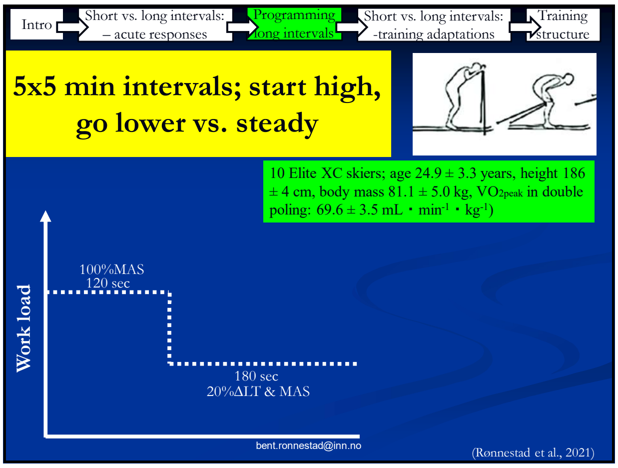
24



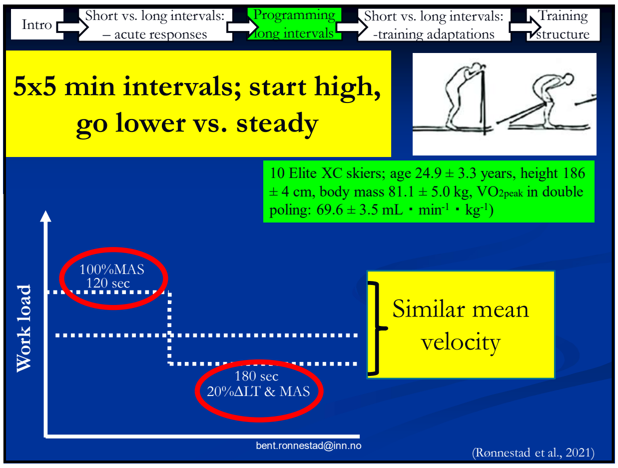
25



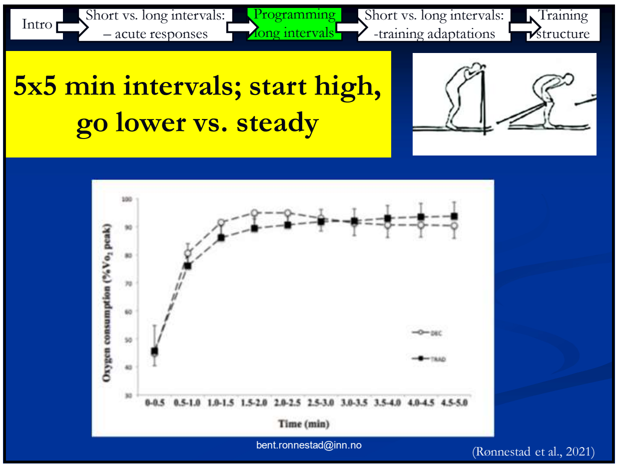
26



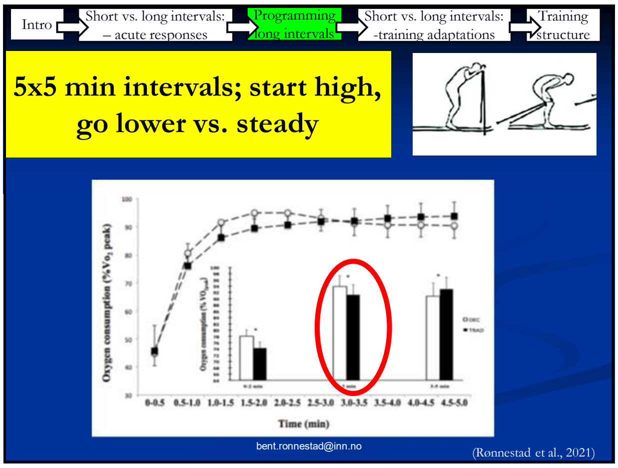
27



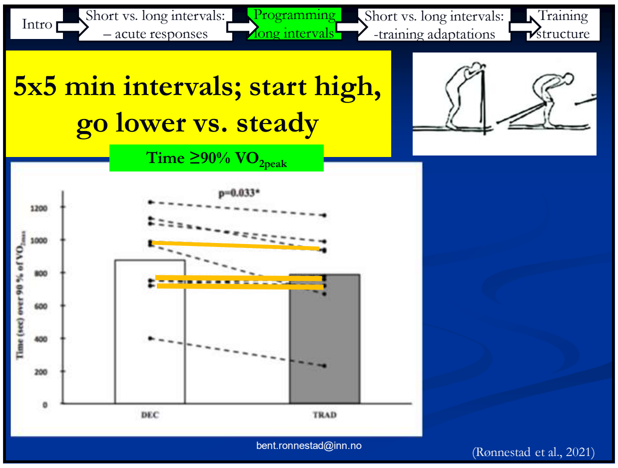
28



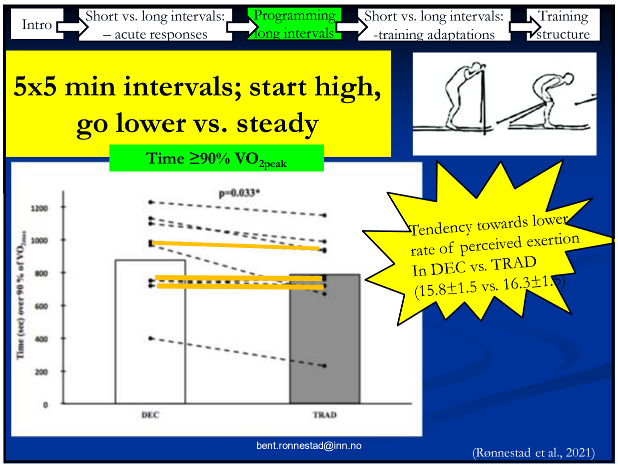
29



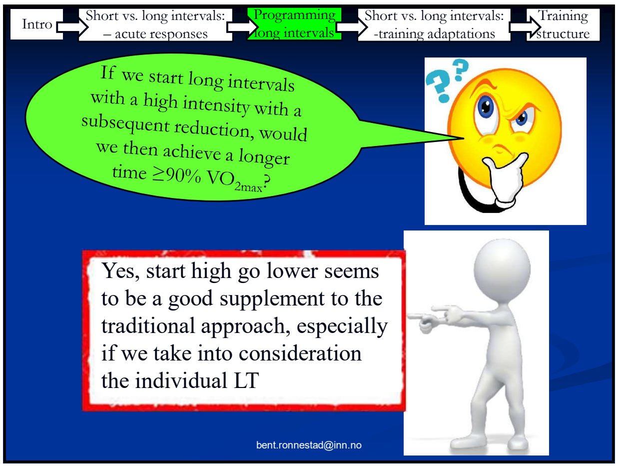
30



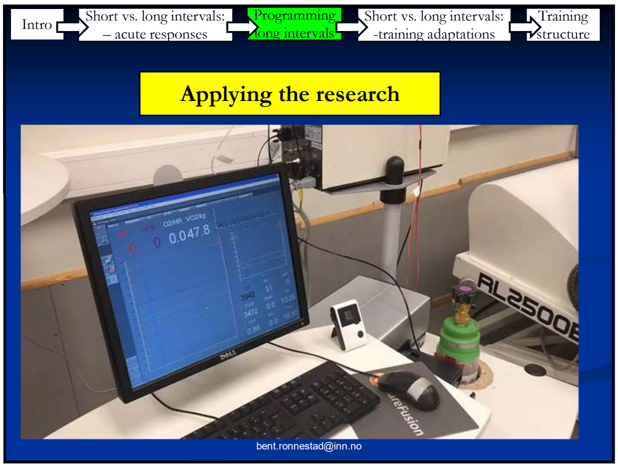
31



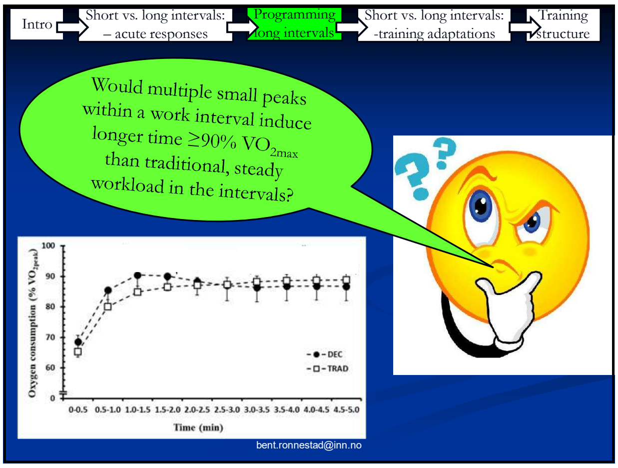
32



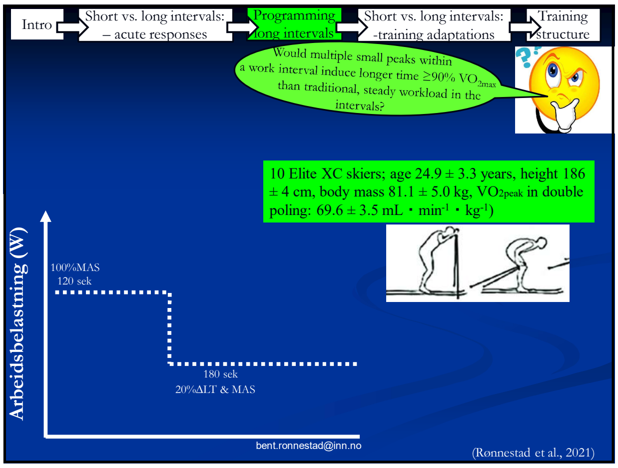
33



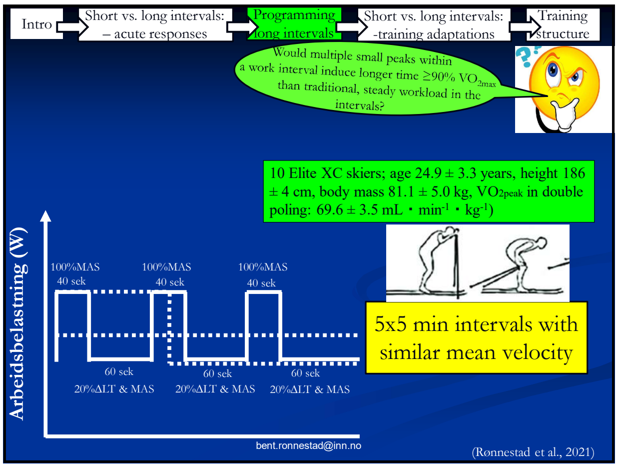
34



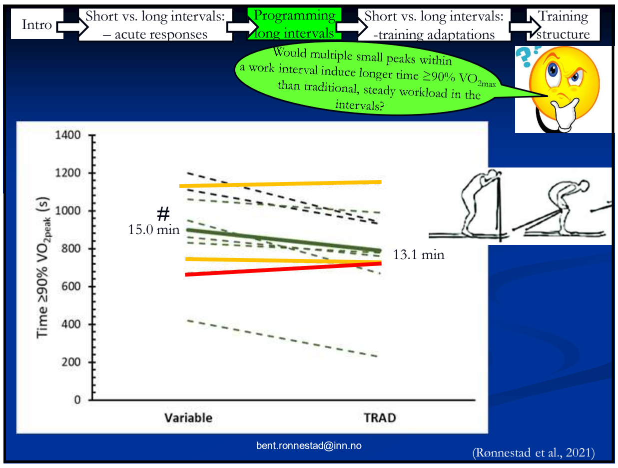
35



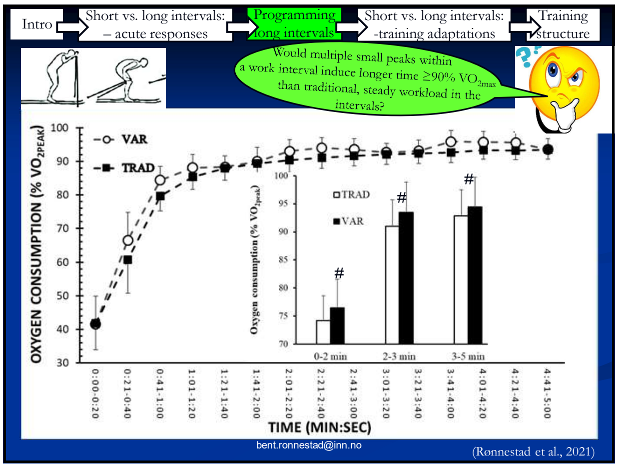
36



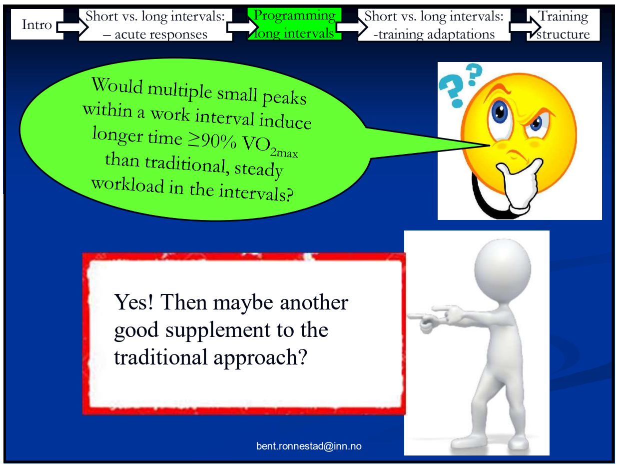
37



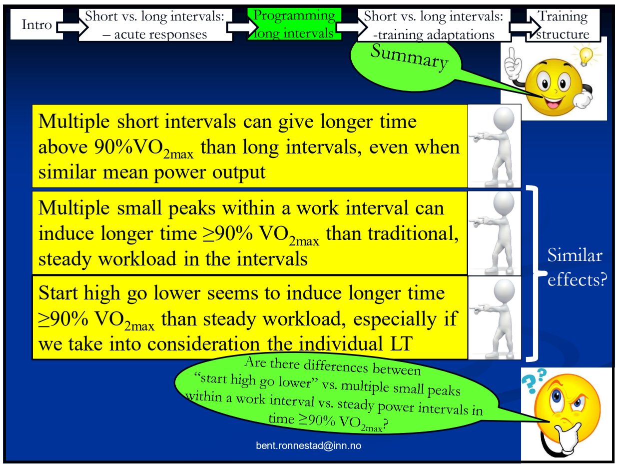
38



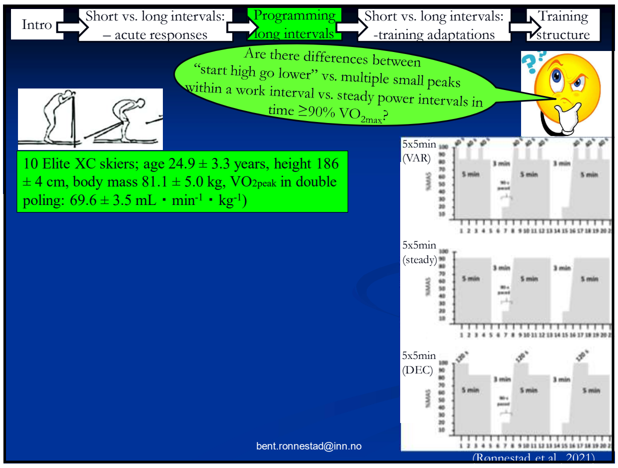
39



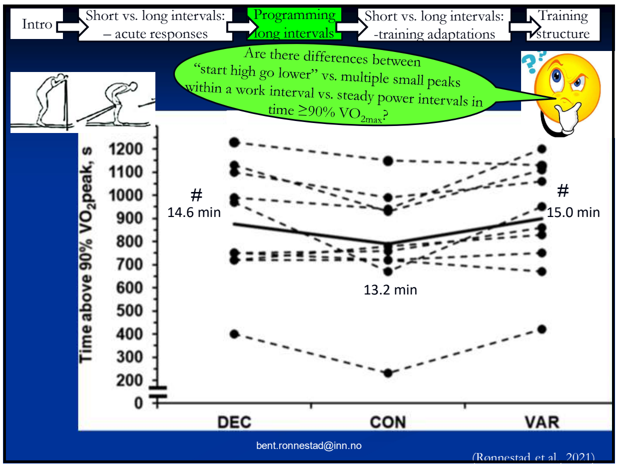
40



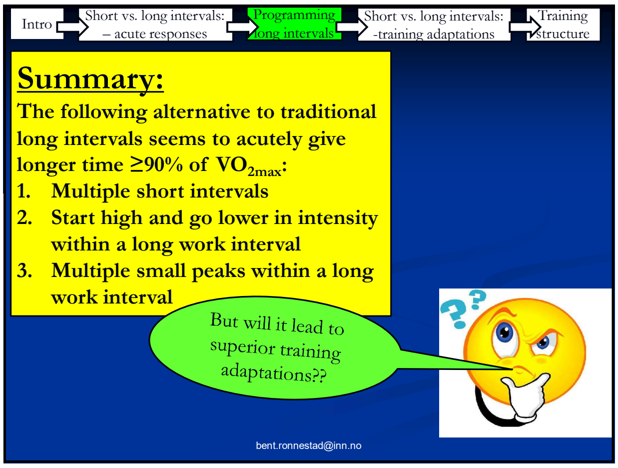
41



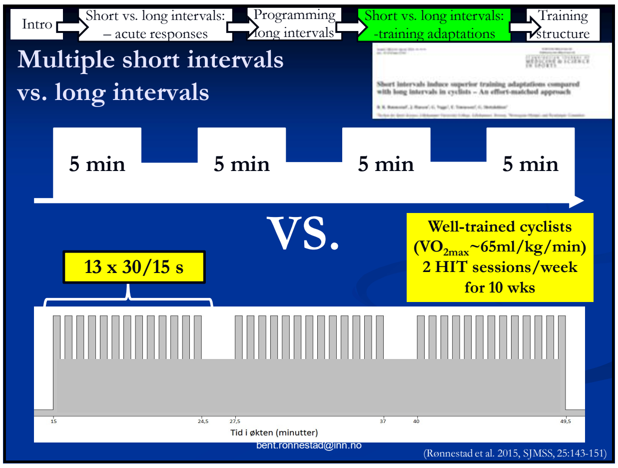
42



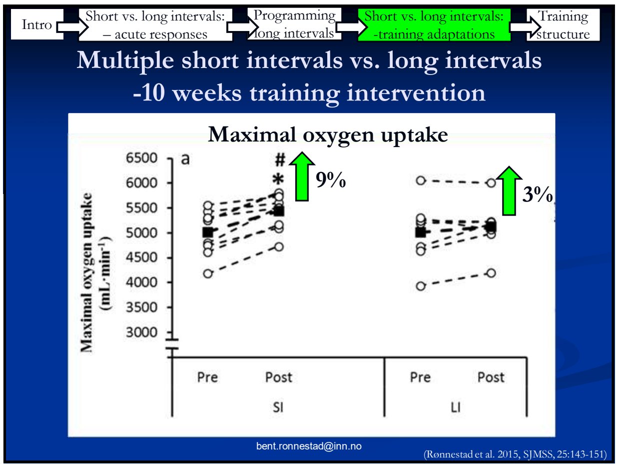
43



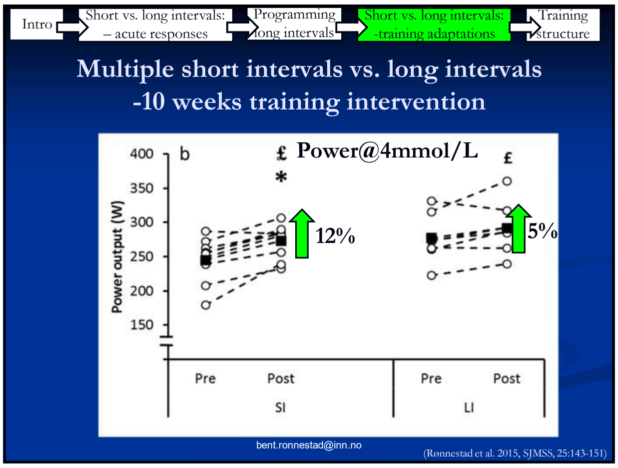
44



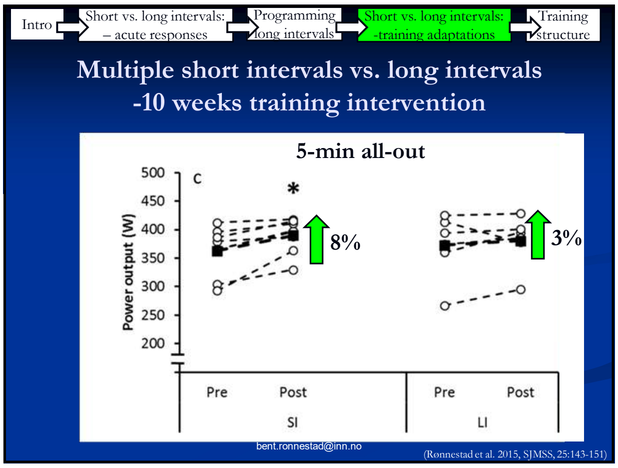
45



46

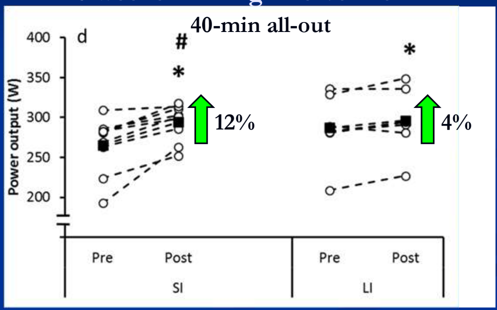


47



48

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



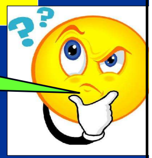
bent.ronnestad@inn.no

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

49

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

But will it lead to superior training adaptations??



Yes!

But is this true for even better athletes?

bent.ronnestad@inn.no

50

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

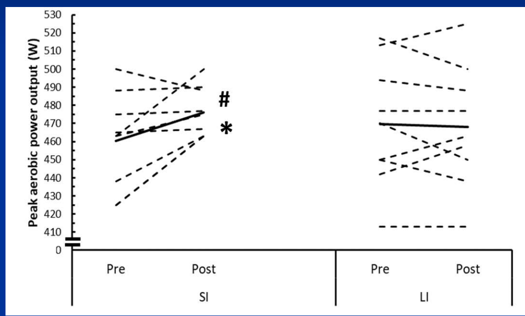
	30/15	4 x 5 min
Age (years)	24±4	25±5
Height (cm)	184±3	182±4
Body mass (kg)	75.2±3.6	74.5±5.1
VO_{2max} (mL·kg^{-1}·min^{-1})	73±3	74±4
W_{max} (W)	460±26	468±39
20 min all-out power (W)	343±31	348±32

bent.ronnestad@inn.no

(Rønnestad et al., 2020)

51

Peak aerobic power output

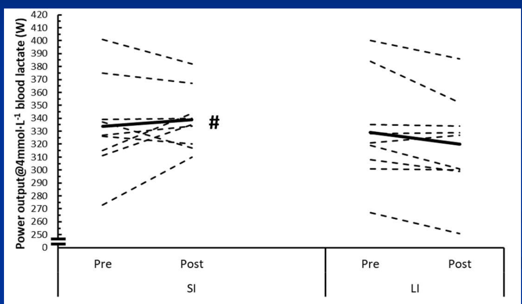


bent.ronnestad@inn.no

(Rønnestad et al., 2020)

52

Power@4mmol/L blood lactate

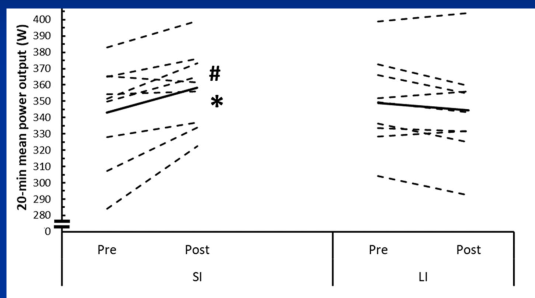


bent.ronnestad@inn.no

(Rønnestad et al., 2020)

53

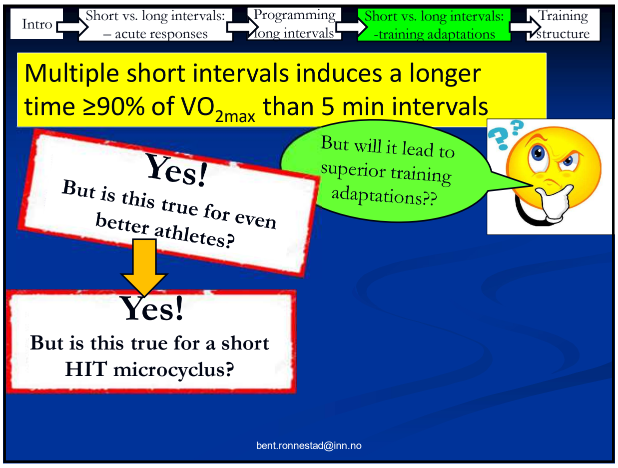
20 min all-out



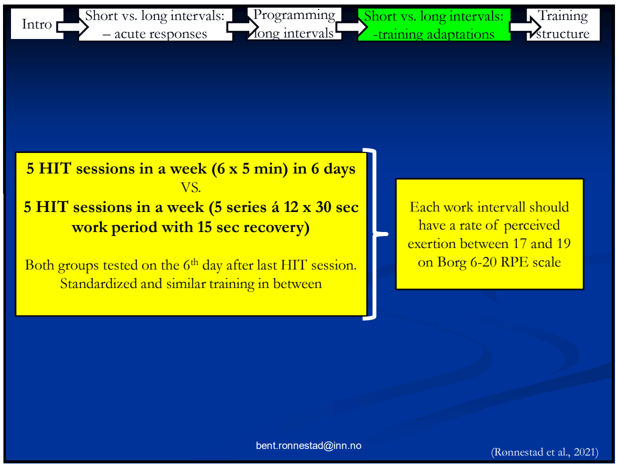
bent.ronnestad@inn.no

(Rønnestad et al., 2020)

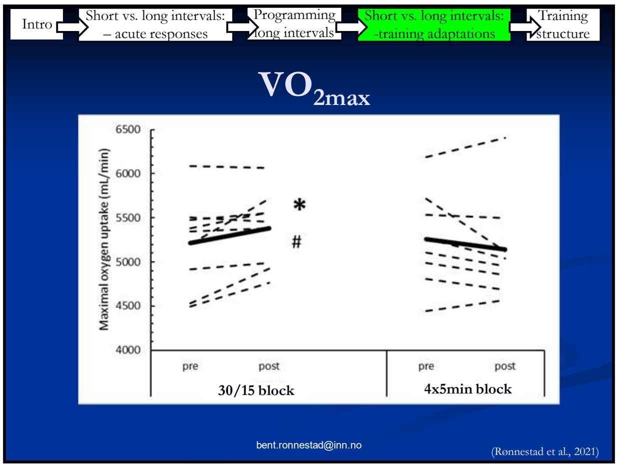
54



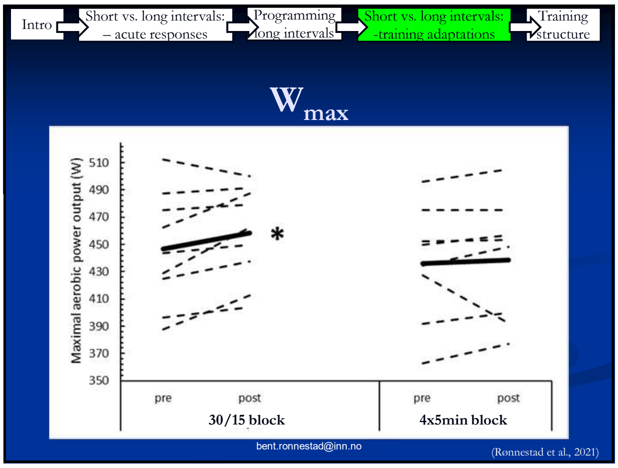
55



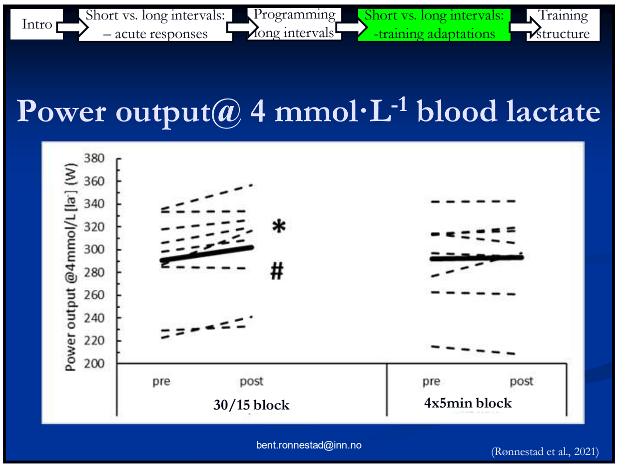
56



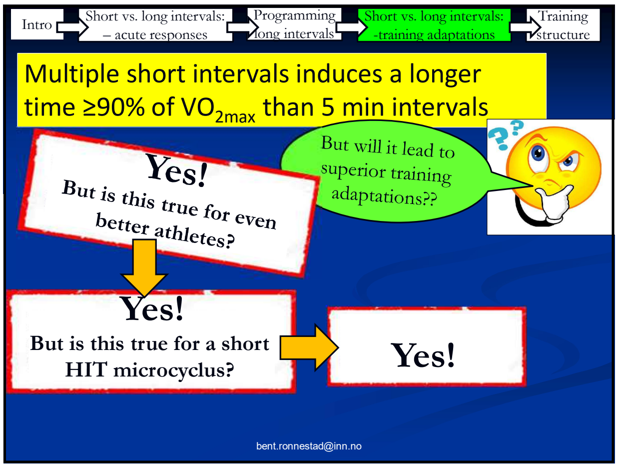
57



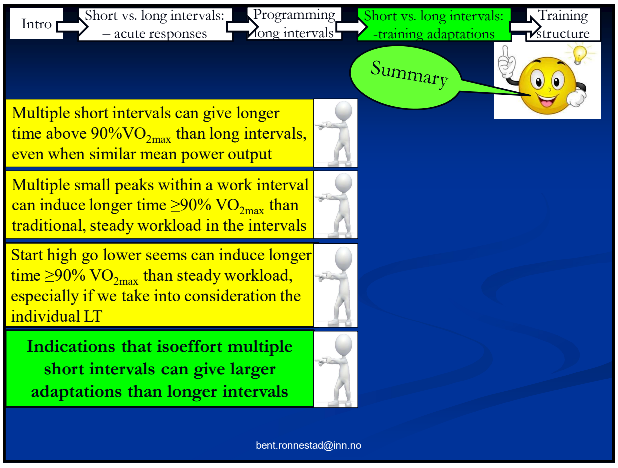
58



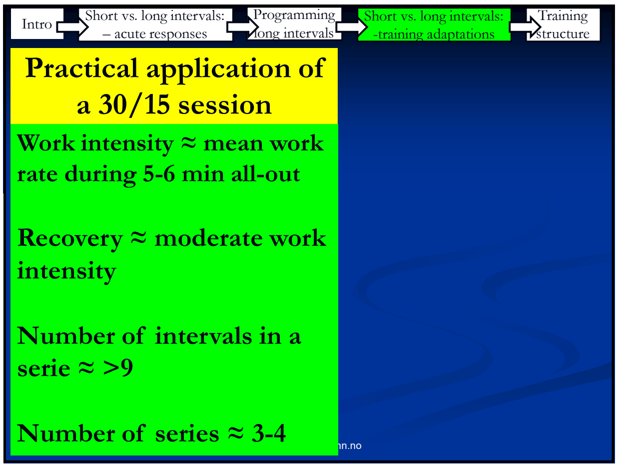
59



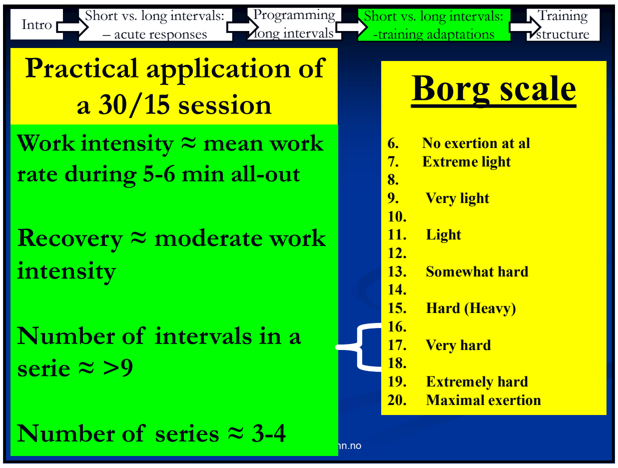
60



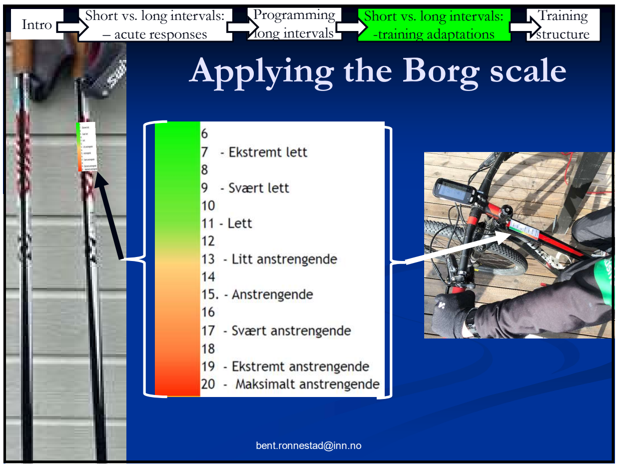
61



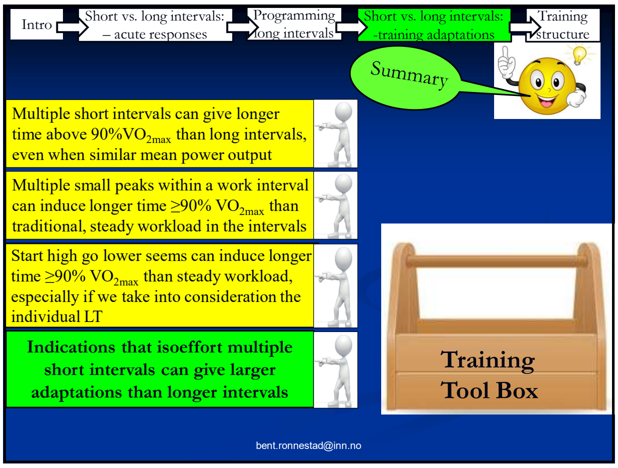
62



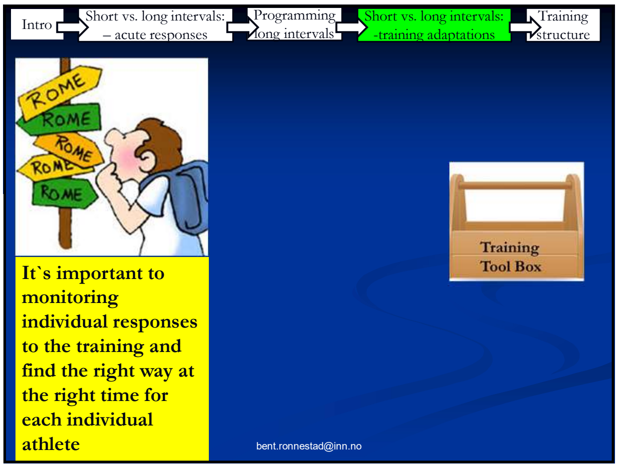
63



64



65



66

bent.ronnestad@inn.no

67

Weekly organization of HIT sessions

In general, it can be argued that the traditional way of implementing HIT is to regularly perform ≈2 HIT sessions per week interspersed with low and moderate intensity endurance training

(e.g. Sandbakk et al. 2016, MSSE, 48, 1091-100; Sandbakk & Holmberg 2017, IJSPP, doi: 10.1123/ijspp.2016-0749; Seiler 2010, IJSPP, 5,276–291; Tønnessen et al. 2014, PLoS ONE 9: e101796)

bent.ronnestad@inn.no

68

Weekly organization of HIT sessions

In general, it can be argued that the traditional way of implementing HIT is to regularly perform ≈2 HIT sessions per week interspersed with low and moderate intensity endurance training

(e.g. Sandbakk et al. 2016, MSSE, 48, 1091-100; Sandbakk & Holmberg 2017, IJSPP, doi: 10.1123/ijspp.2016-0749; Seiler 2010, IJSPP, 5,276–291; Tønnessen et al. 2014, PLoS ONE 9: e101796)

An alternative is a high concentration of specialized workloads during a short period

(Issurin 2016, Sports Med, 46:329-38)

bent.ronnestad@inn.no

69

A HIT microcyclus of 7-17 days increases performance related variables in semi-professional soccer players, male cyclists, professional tennis players, junior triathletes, elite junior alpine skiers

Breil et al. 2010, EJAP, 109:1077-1086; Clark et al. 2014, PLoS ONE 9(12): e115308; Fernandez-Fernandez et al. 2015, JSSM, 14:783-91; Rønnestad et al. 2017, JSS, 35, 1392-1395; Støren et al. 2012, 26, 2705–2711; Wahl et al. 2014, JSSM, 13:259-65; Wahl et al. 2013, JSCR, 27:1384-93.

bent.ronnestad@inn.no

70

A HIT microcyclus of 7-17 days increases performance related variables in semi-professional soccer players, male cyclists, professional tennis

How is the adaptations if total HIT stimulus is similar and only the organization of HIT sessions into microcycluses is the difference?

Interesting and useful knowledge

….Likely due to a larger HIT dose than the control group or difficult to interpret due to lack of a control group?

bent.ronnestad@inn.no

71

HIT micocycluses with mantaining focus

Scand J Med Sci Sports 2012: ••: ••–••
doi: 10.1111/sms.12016
© 2012 John Wiley & Sons A/S.
Published by Blackwell Publishing Ltd
SCANDINAVIAN JOURNAL OF MEDICINE & SCIENCE IN SPORTS

Effects of 12 weeks of block periodization on performance and performance indices in well-trained cyclists

B. R. Rønnestad[1], S. Ellefsen[1], H. Nygaard[1], E. E. Zacharoff[1], O. Vikmoen[1], J. Hansen[1], J. Hallén[2]

[1]Section for Sport Science, Lillehammer University College, Lillehammer, Norway, [2]Department of Physical Performance, Norwegian School of Sport Sciences, Oslo, Norway
Corresponding author: Bent R. Rønnestad, Section for Sport Science, Lillehammer University College, PB. 952, 2604 Lillehammer, Norway. Tel: 004761288193, Fax: +47 61288200, E-mail: bent.ronnestad@hil.no

72

Week	Blocking	Traditional
1	5	2
2	1	2
3	1	2
4	1	2
5	5	2
6	1	2
7	1	2
8	1	2
9	5	2
10	1	2
11	1	2
12	1	2
Total	24	24

HIT sessions:
6x5 min all-out
or
5x6 min all-out

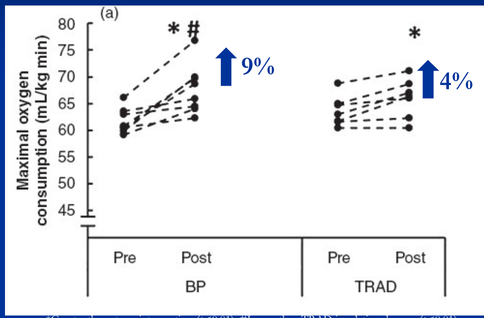
(Rønnestad et al. 2012)

bent.ronnestad@inn.no

73

Intro | Short vs. long intervals: – acute responses | Programming long intervals | Short vs. long intervals: -training adaptations | Training structure

Maximal oxygen uptake



*Greater than at pre-intervention ($p<0.01$). #Larger than TRAD in relative changes ($p<0.01$).

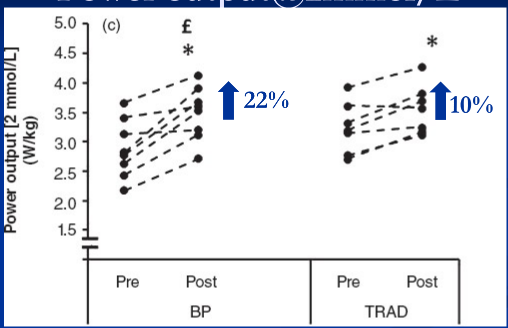
(Rønnestad et al. 2012)

bent.ronnestad@inn.no

74

Intro | Short vs. long intervals: – acute responses | Programming long intervals | Short vs. long intervals: -training adaptations | Training structure

Power output@2mmol/L



*Greater than at pre-intervention ($p<0.01$). £Tendency towards larger improvement than TRAD ($p=0.07$).

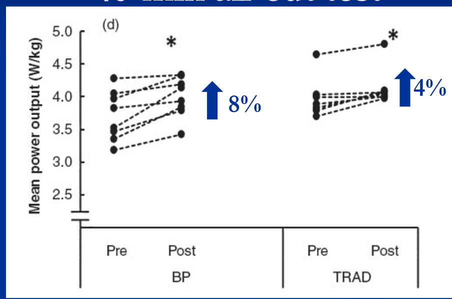
bent.ronnestad@inn.no

(Rønnestad et al. 2012)

75

Intro | Short vs. long intervals: – acute responses | Programming long intervals | Short vs. long intervals: -training adaptations | Training structure

Mean power output during 40-min all-out test



*Greater than at pre-intervention ($p<0.05$).

bent.ronnestad@inn.no

(Rønnestad et al. 2012)

76

Intro | Short vs. long intervals: – acute responses | Programming long intervals | Short vs. long intervals: -training adaptations | Training structure

Scand J Med Sci Sports 2015: ●●: ●●–●●
doi: 10.1111/sms.12418

SCANDINAVIAN JOURNAL OF MEDICINE & SCIENCE IN SPORTS

5-week block periodization increases aerobic power in elite cross-country skiers

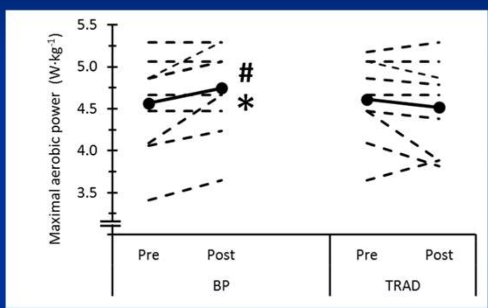
B. R. Rønnestad[1], J. Hansen[1], V. Thyli[1], T. A. Bakken[1], O. Sandbakk[2]

[1]Section for Sport Science, Lillehammer University College, Lillehammer, Norway, [2]Center for Elite Sports Research, Department of Neuroscience, Norwegian University of Science and Technology, Trondheim, Norway
Corresponding author: Bent R. Rønnestad, PhD, Lillehammer University College, PB. 952, 2604 Lillehammer, Norway.
Tel: +47 61288193, Fax: +47 61288200, E-mail: bent.ronnestad@hil.no

77

Intro | Short vs. long intervals: – acute responses | Programming long intervals | Short vs. long intervals: -training adaptations | Training structure

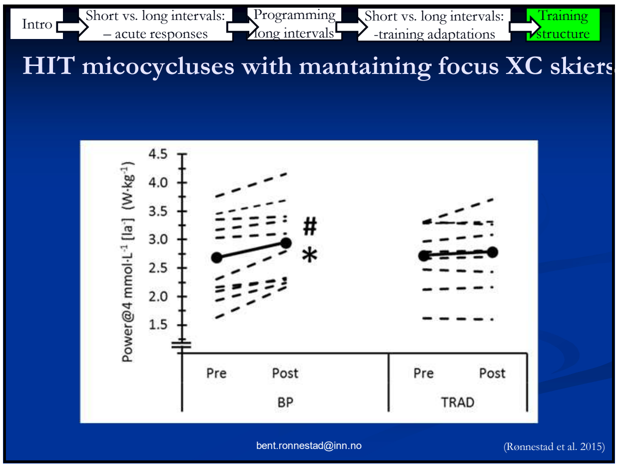
HIT micocycluses with mantaining focus XC skiers



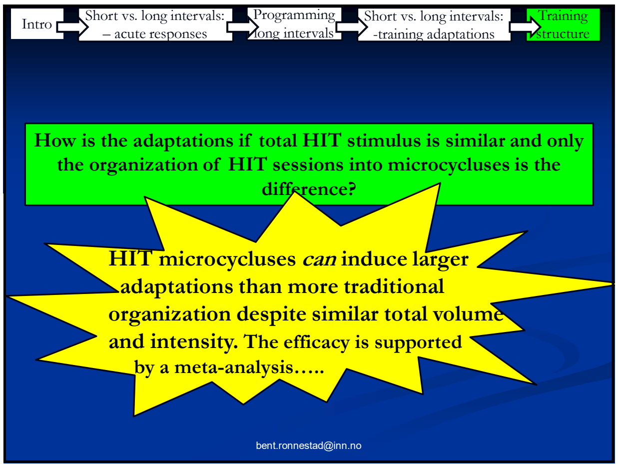
bent.ronnestad@inn.no

(Rønnestad et al. 2015)

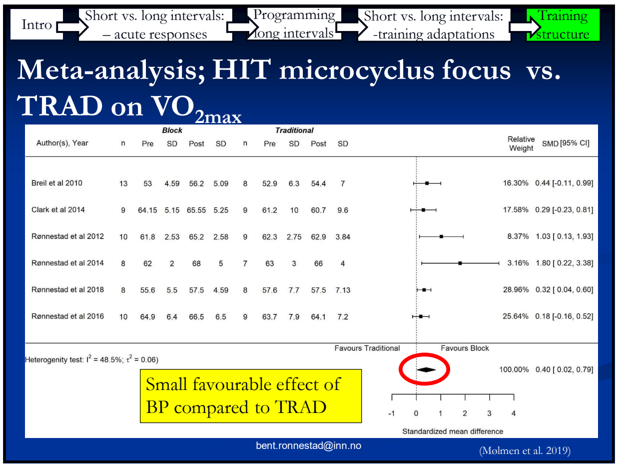
78



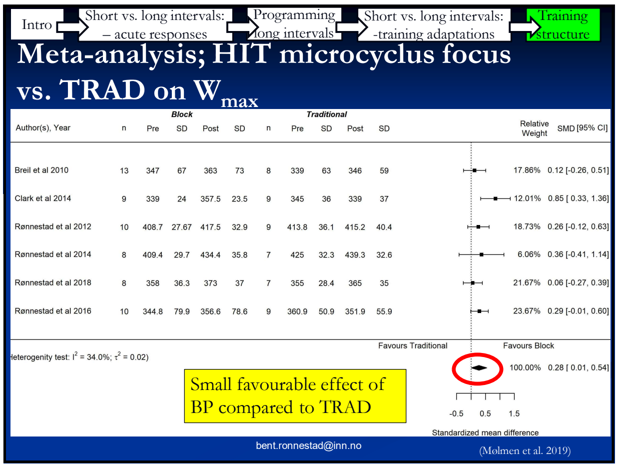
79



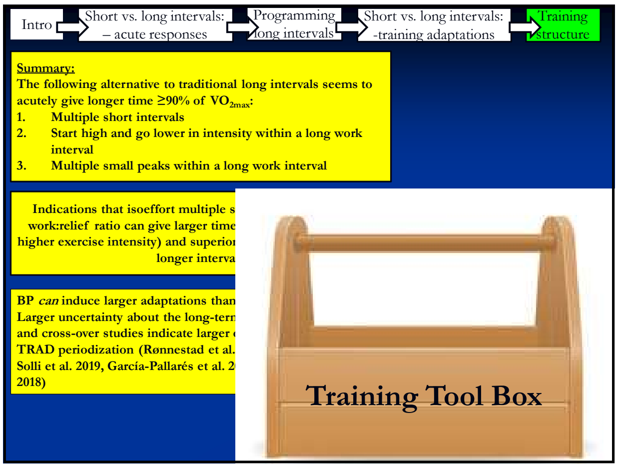
80



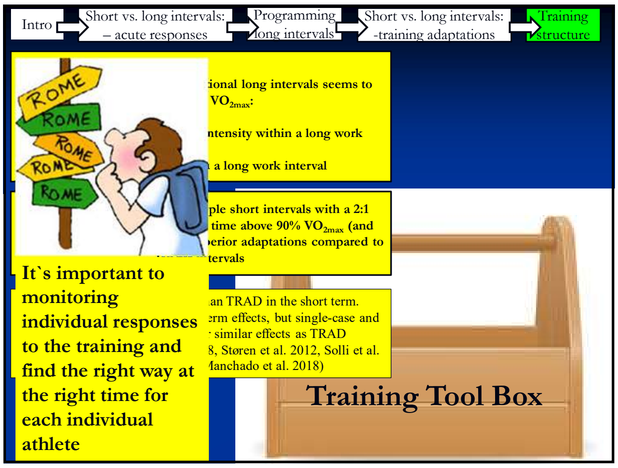
81



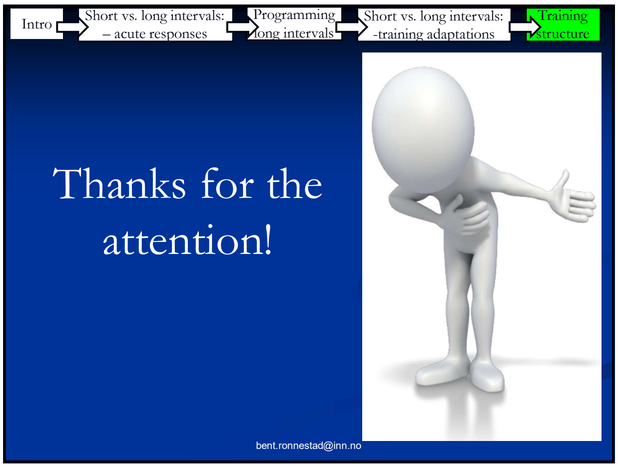
82



83



84


Intro
Short vs. long intervals:
– acute responses
Programming
long intervals
Short vs. long intervals:
-training adaptations
Training
structure
Thanks for the attention!
bent.ronnestad@inn.no

85