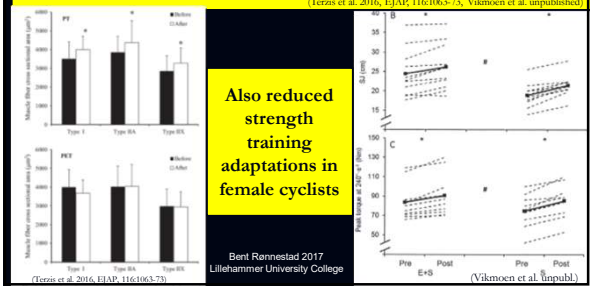
The role of strength training on cycling performance for male and female cyclists

Bent R. Rønnestad
Lillehammer University College

Effects of combining strength and endurance training on endurance performance - females

Concurrent strength and 1.5 - 5 hrs endurance training gives similar increase in maximal leg strength and similar or no muscle hypertrophy as strength training alone, and reduced adaptations in ability to rapidly exert force

(Terzis et al. 2016, EJAP, 116:1063-73, Vikmoen et al. unpublished)



Also reduced strength training adaptations in female cyclists

Bent Rønnestad 2017
Lillehammer University College

(Terzis et al. 2016, EJAP, 116:1063-73)

(Vikmoen et al. unpubl.)

The role of strength training on cycling performance for male and female cyclists

1. Effects of combining strength and endurance training on strength training adaptations
2. Effects of combining strength and endurance training on cycling performance
3. Potential mechanisms
4. Maintenance of developed strength throughout the competition season
5. Practical applications

Bent Rønnestad 2017
Lillehammer University College

The role of strength training on cycling performance for male and female cyclists

1. Effects of combining strength and endurance training on strength training adaptations
2. Effects of combining strength and endurance training on cycling performance

Bent Rønnestad 2017
Lillehammer University College

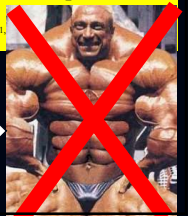
Effects of concurrent strength and endurance training on strength training adaptations

A relative large volume of endurance training seems to reduce strength training adaptations:

- Reduced increase in maximal strength
- Reduced muscle hypertrophy
- Reduced increase in rate of force development

(e.g. Hickson 1980, Dudley & Djamil 1985, Hunter et al. 1987, Hennessy & Watson 1994, Kraemer et al. 1995, Hakkinen et al. 2003, Putman et al. 2004, Izquierdo et al. 2005, Aagaard et al. 2011, Rønnestad et al. 2011, Wilson et al. 2011, Jones et al. 2013)

What`s the responds of female athletes?



Bent Rønnestad 2017
Lillehammer University College

Important determinants of endurance performance

Performance power output

Maximal oxygen consumption

Lactate threshold power output

Gross mechanical efficiency & cycling economy

Effects of concurrent strength and endurance training?

Bent Rønnestad 2017
Lillehammer University College

(Modified and inspired from Pate & Kriska 1984, Hawley & Noakes 1992, Coyle 1995; 1999, Paavolainen et al. 1999, Joyner & Coyle 2008, Midgley et al. 2007, Tanaka & Seals 2008, Aagaard & Andersen 2010)

Concurrent training and maximal oxygen consumption

There seems to be neither a positive nor negative effect of concurrent strength and endurance training compared to endurance training alone regarding VO_{2max} adaptations in endurance trained athletes

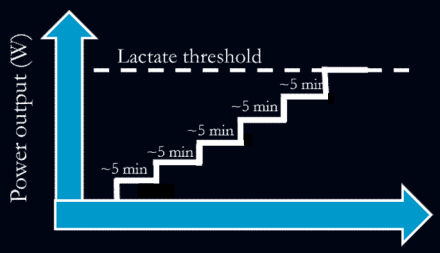
(e.g. Hickson et al., 1988; Bishop et al., 1999; Bastiaans et al., 2001; Levin et al., 2009; Rønnestad et al., 2010a, b; Sunde et al., 2010; Aagaard et al., 2011; Rønnestad et al. 2015, Rønnestad et al. 2001, Vikmoen et al. 2016), long-distance runners (Johnston et al., 1997; Paavolainen et al., 1999; Spurrs et al., 2003; Turner et al., 2003; Saunders et al., 2006; Mikkola et al., 2007a, 2011; Storen et al., 2008; Taipale et al., 2010), cross-country skiers (Hoff et al., 1999, 2002; Osteras et al., 2002; Mikkola et al., 2007b; Losnegard et al., 2011; Rønnestad et al., 2012), or triathletes Millet et al., 2002)

Effect of strength training on cycling economy$_2$

Seems like no clear effect during traditional 3-5 min submaximal workloads. Different findings during prolonged submaximal exercise?

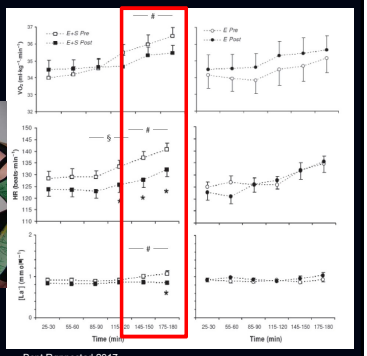
Cycling is, amongst others, characterized by several hours submaximal cycling

Effect of strength training on cycling economy



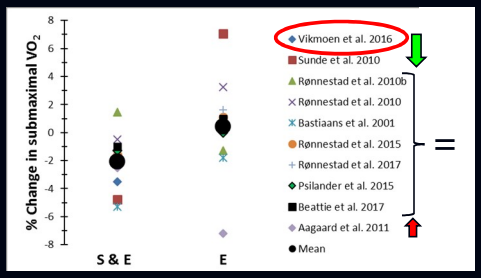
Effect of strength training on cycling economy$_3$

Prolonged submaximal cycling



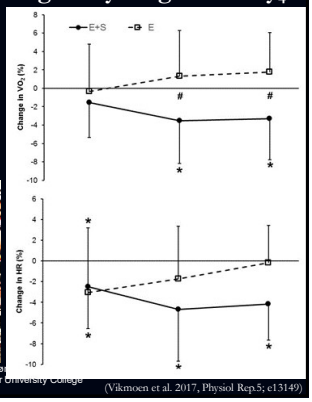
(Rønnestad et al. 2011)

Effect of strength training on cycling economy$_1$



Effect of strength training on cycling economy$_4$

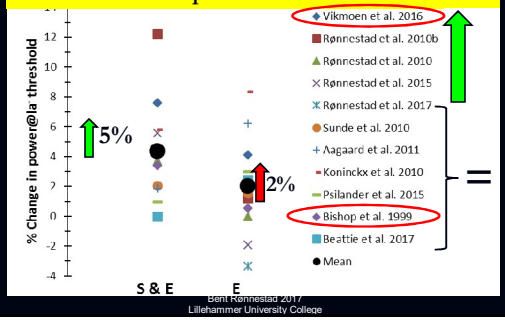
Prolonged submaximal cycling, female cyclists



(Vikmoen et al. 2017, Physiol Rep.5; e13149)

Effects of strength training on power output@lactate threshold in cyclists

Either positive or no effect



Alternative approach to measure cycling performance

Important determinants of endurance performance

Performance power output ??

Lactate threshold power output

Gross mechanical efficiency & cycling economy

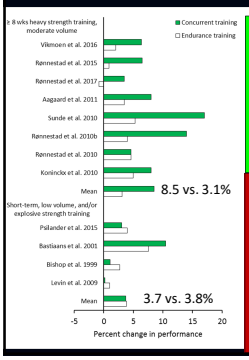
Maximal oxygen consumption

(Modified and inspired from Pate & Kriska [illegible], Coyle 1995; 1999, Paavolainen et al. 1999, Joyner & Coyle 2008, Midgley et al. 2007, Tanaka & Seals 2008, Aagaard & Andersen 2010)

In the Grand Tours, around 70% of the race duration is spent at exercise intensities characterized as "light intensity"

(Lucia et al. 1999; 2003)

Effect of concurrent training on cycling performance



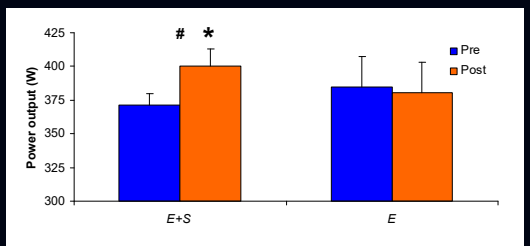
Characteristics of successful strength training:

Heavy loaded strength training with multiple leg exercises during a period of minimum 8 weeks

Characteristics of strength training with no additional effect:

Short-term strength training period, low volume of strength training or explosive strength training is performed

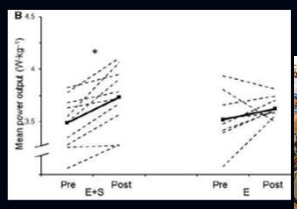
Mean power output during the 5-min all-out trial performed following 185 min of cycling -males



*Different from Pre ($P<0.01$). #Difference between groups in relative change from pre-test to post-test ($P < 0.01$).

(Rønnestad et al. 2011)

Mean power output during the 5-min all-out trial performed following 180 min of cycling -females



Bent Rønnestad 2017
Lillehammer University College

(Vikmoen et al. 2017, Physiol Rep.5; e13149)

Important determinants of endurance performance

Performance power output

Lactate threshold power output

Gross mechanical efficiency & cycling economy

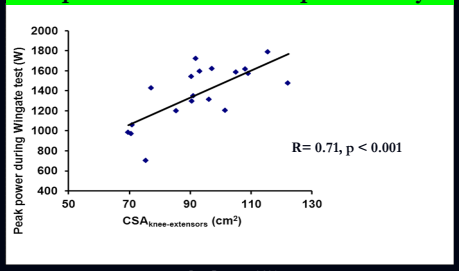
Maximal oxygen consumption

Bent Rønnestad 2017
Lillehammer University College

Sprint performance

- Sprint abilities – male cyclists

Importance of CSA for sprint ability



Bent Rønnestad 2017
Lillehammer University College

(Unpublished data, Rønnestad et al.)

Effect of strength training on cycling performance

Heavy strength training seems to positively affect cycling performance

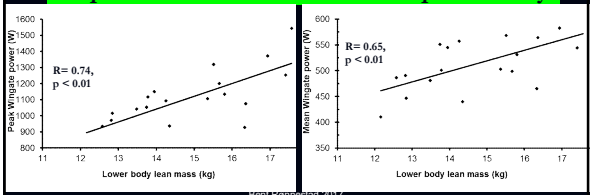
Supported by many reviews: Aagaard P, Andersen 2010, SJMSS, 20, 39-47; Beattie et al. 2014, Sports Med, 44:845-65; Mujika et al. 2016, IJSPP, 11:283-9; Rønnestad & Mujika 2014, SJMSS, 24:603-12; Yamamoto et al. 2010, JSCR, 24:560-6.

Bent Rønnestad 2017
Lillehammer University College

Sprint performance

- Sprint abilities- female cyclists

Importance of muscle mass for sprint ability



Bent Rønnestad 2017
Lillehammer University College

(Data from Vikmoen et al. 2016)

Important determinants of endurance performance

Performance power output

Why?

Lactate threshold power output

Gross mechanical efficiency & cycling economy

Maximal oxygen consumption

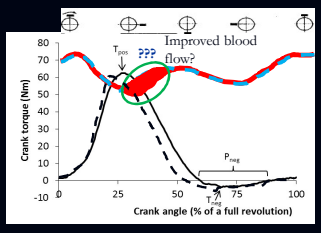
(Studies: Hickson et al. 1988, Sunde et al. 2010, Aagaard et al. 2011, Rønnestad et al. 2010a; 2010b; 2011)

Bent Rønnestad 2017
Lillehammer University College

The role of strength training on cycling performance for male and female cyclists

1. Effects of combining strength and endurance training on strength training adaptations
2. Effects of combining strength and endurance training on cycling performance
3. Potential mechanisms

Torque during the pedal stroke



Crank torque curve with selected characteristics. This data example from one of the cyclists represents a single random crank arm (right) revolution during one of the 5-min all-out trials. The following selected characteristics are indicated on the curve: T_{pos}, peak positive crank torque; T_{neg}, peak negative crank torque; P_{neg}, phase with negative crank torque.

Potential mechanisms behind improved performance

- Reduced blood flow during the power phase in the pedal stroke (i.e. downstroke) (Takaishi et al. 2002)

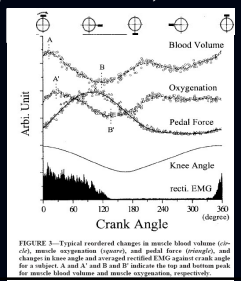
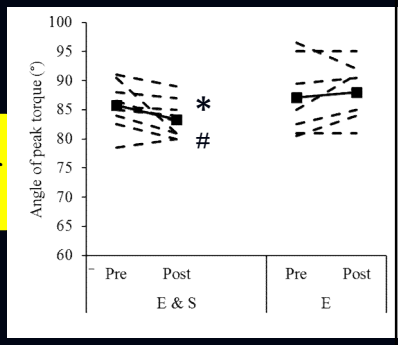


FIGURE 3.—Typical reordered changes in muscle blood volume (*circle*), muscle oxygenation (*square*), and pedal force (*triangle*), and changes in knee angle and averaged rectified EMG against crank angle for a subject. A and A' and B and B' indicate the top and bottom peak for muscle blood volume and muscle oxygenation, respectively.

(Takaishi et al. 2002)

Potential mechanisms behind improved performance

HSTR *can* change angle of peak torque

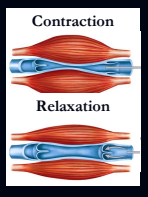


(Rønnestad et al. 2015)

Potential mechanisms behind improved performance

↑ RFD ➡ earlier peak torque in the pedal stroke?

↑ relaxation ➡ ↑ blood flow? ➡ ↑ performance?



Potential mechanisms behind improved performance

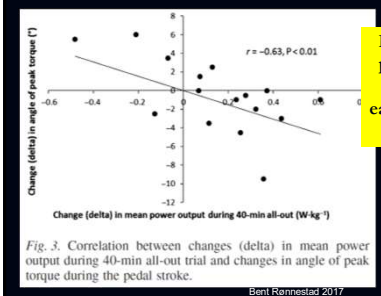


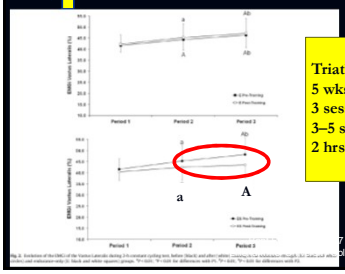
Fig. 3. Correlation between changes (delta) in mean power output during 40-min all-out trial and changes in angle of peak torque during the pedal stroke.

Improvement in 40-min power correlates largely with changes towards earlier peak torque during the pedal stroke

(Rønnestad et al. 2015)

Potential mechanisms to improved performance

- The more economical type I fibres becomes stronger ↑ contribution to power output ➡ ↑ long-term performance?



Triathletes, VO_{2max} ~68 ml/kg/min
5 wks strength training
3 sessions/wk
3–5 sets and 3–5 RM
2 hrs submaximal cycling

(Hausswirth et al. 2010)

The role of strength training on cycling performance for male and female cyclists

1. Effects of combining strength and endurance training on strength training adaptations
2. Effects of combining strength and endurance training on cycling performance
3. Potential mechanisms
4. Maintenance of developed strength throughout the competition season

Potential mechanisms to improved performance

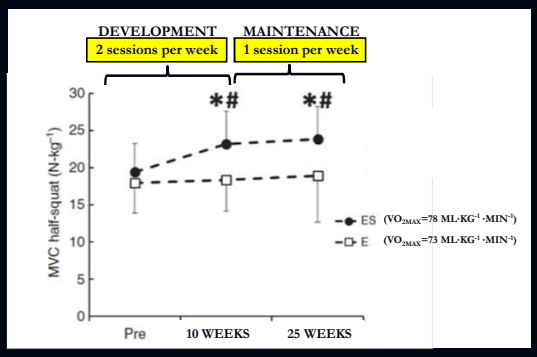
- Changed fibertype composition? IIx ➡ IIa

12 wks heavy strength training in female duathletes

- **Hybrid fibers (IIAX MyHC) was reduced from 9 ± 7% to 0%**
- **Increase in fibers positive for type 2A only (from 39 ± 13% to 51 ± 10%)**
- **Mean power during 40-min all-out trial increased by 6.4 ± 7.9%**

(Vikmoen et al. Unpublished results)

Maintenance of strength

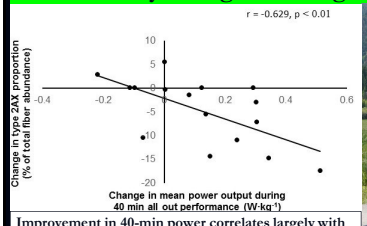


(Rønnestad et al. 2015)

Potential mechanisms to improved performance

- Changed fibertype composition? IIx ➡ IIa

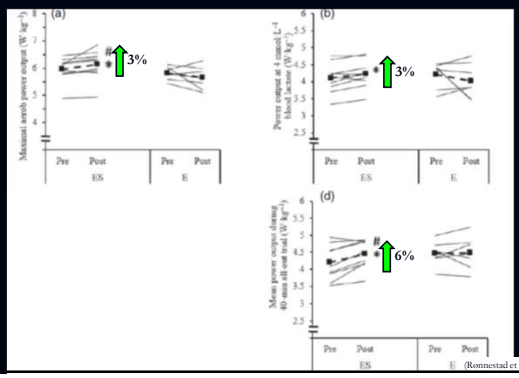
12 wks heavy strength training in female duathletes



Improvement in 40-min power correlates largely with reduction in type IIAX fibres

(Vikmoen et al. Unpublished results)

Maintenance of strength – training effects?

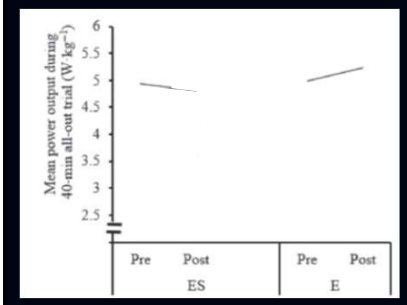


(Rønnestad et al. 2015)

Stop!!!!!

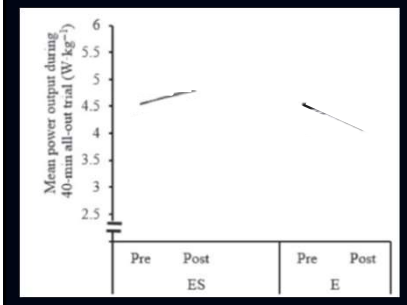
You don`t have to perform heavy strength training to be a world champion!!

Remember the individual response

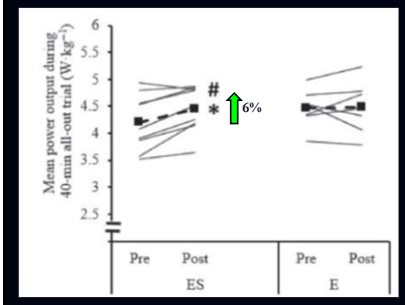


You have to find the right way for each individual cyclist

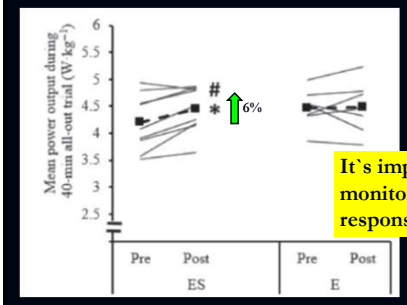
Remember the individual response



Remember the individual response



Remember the individual response



It`s important to monitoring individual responses to the training

Maintenance of strength

Cyclists have a relatively tight race schedule, making it challenging to prioritize strength training during the competition season.

Physical characteristics of the cyclists

Variables	EXP (n=7)	CON(n=7)
Age (years)	19±1	20±1
Body mass (kg)	67.8±7.8	74.3±7.5
Body height (cm)	179±8	183±9
VO_{2max}(ml·kg^{-1}·min^{-1})	77±6	73±5
Maximal aerobic power (W·kg^{-1})	5.9±0.5	5.8±0.2
Maximal isometric half-squat (N)	1400±378	1340±364
Squat jump (cm)	27±5	30±5
30-sec Wingate sprint (W·kg^{-1})	10.7±0.9	10.7±0.7
Power@4mmol (W·kg^{-1})	4.1±0.5	4.2±0.4

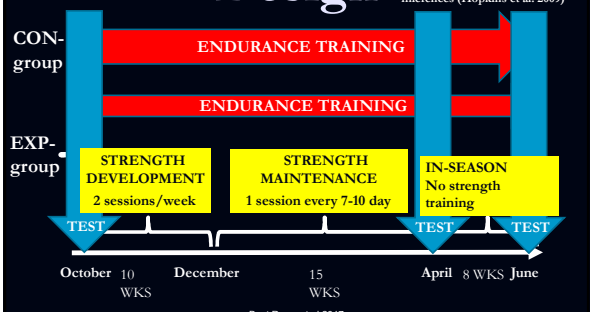
Values are mean ± SD

Maintenance of strength

Many cyclists who perform strength training during the preparatory period stops the strength training during the competition season.

Design

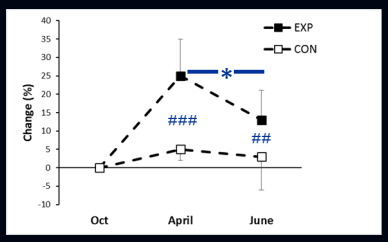
Data were assessed for practical significance using magnitude-based inferences (Hopkins et al. 2009)



Purpose

- To investigate the effects of 8 weeks strength training cessation after 25 weeks of strength training on indices of
  - Strength training adaptations
    - Maximal isometric half squat force
    - Lean lower body mass
    - Squat jump
  - Sprint performance
    - Power during 30-sec Wingate sprint
  - Endurance performance
    - Maximal oxygen uptake (VO_{2max})
    - Maximal aerobic power (W_{max})
    - Power output at 4 [mmol·L^{-1}]

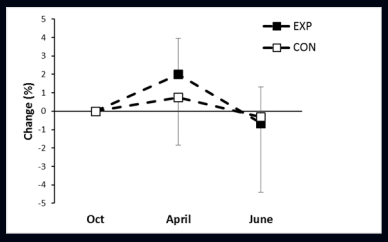
Maximal isometric half squat strength



##Very likely between-group differences from pre
###Most likely between-group differences from pre
*Likely between-group differences from pre

(Rønnestad et al. 2016)

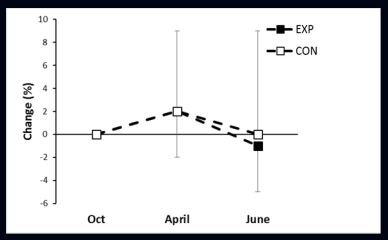
Lean lower body mass



Bent Rønnestad 2017
Lillehammer University College

(Rønnestad et al. 2016)

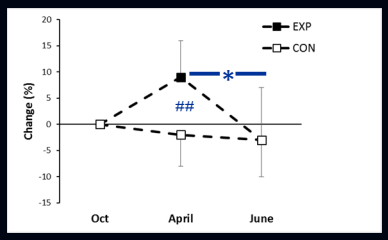
Maximal oxygen uptake



Bent Rønnestad 2017
Lillehammer University College

(Rønnestad et al. 2016)

Squat jump

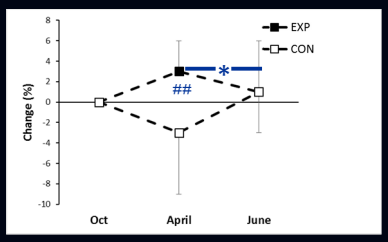


##Very likely between-group differences from pre
*Likely between-group differences from pre

Bent Rønnestad 2017
Lillehammer University College

(Rønnestad et al. 2016)

Maximal aerobic power output

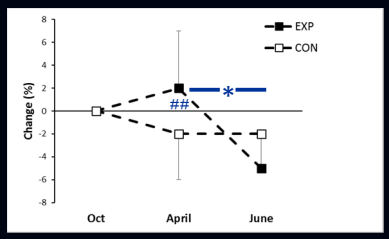


##Very likely between-group differences from pre
*Likely between-group differences from 25 weeks

Bent Rønnestad 2017
Lillehammer University College

(Rønnestad et al. 2016)

30-s Wingate Sprint

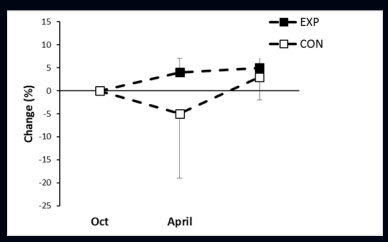


##Very likely between-group differences from pre
*Likely between-group differences from 25 weeks

Bent Rønnestad 2017
Lillehammer University College

(Rønnestad et al. 2016)

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



Bent Rønnestad 2017
Lillehammer University College

(Rønnestad et al. 2016)

Summary: Effects of EXP vs. CON

	October→April	April→June	October→June
Lean lower-body mass	🙂	😐	😐
MVC	🙂	☹	🙂
SJ	🙂	☹	😐
30-sec Wingate	🙂	☹	😐
W_{max}	🙂	☹	😐
Power@4mmol/L	🙂	😐	😐
VO_{2max}	😐	😐	😐

Bent Rønnestad 2017
Lillehammer University College

(Rønnestad et al. 2016)

Practical strength training

- Specificity
  - Movement and muscle groups
  - Contraction
- Maximal mobilization during the concentric phase
- Heavy loading (4-12RM)
- Multiple exercises for the target muscle groups
- 2 (to 3) strength training sessions per week to increase strength
- 1 strength training session per 7-10th day to maintain strength
- If long competition season, perform some weeks with 2 strength training sessions per week
- Remember the total training stress
- Some special differences between male and female cyclists?

Bent Rønnestad 2017
Lillehammer University College

Maintenance of strength

Strength maintenance training seems to be very important in a long-term strength training perspective

Bent Rønnestad 2017
Lillehammer University College

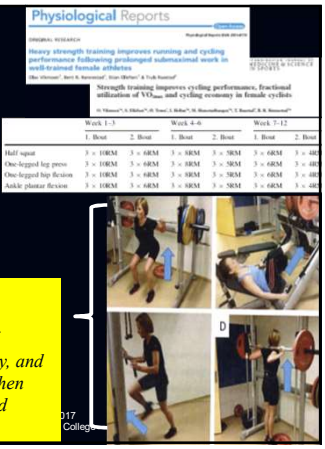
The effects of strength training on endurance performance and muscle characteristics.
BISHOP, DAVID; JENKINS, DAVID; MACKINNON, LAUREL; McENIERY, MICHAEL; CAREY, MICHAEL

Medicine & Science in Sports & Exercise. 31(6):886-891, June 1999.

	Week					
SQUAT	1–2	3–4	5–6	7–8	9–10	11–12
Sets	5	4	3	5	4	3
Repetitions	6–8 RM	4–6 RM	2–4 RM	6–8 RM	4–6 RM	2–4 RM

"The present data suggest that increased leg strength does not improve cycle endurance performance in endurance-trained, female cyclists"

"Adding heavy strength training improved cycling performance, increased fractional utilization of VO_{2max}, improved cycling economy, and improved cycling performance when tested immediately after prolonged submaximal work"



The role of strength training on cycling performance for male and female cyclists

1. Effects of combining strength and endurance training on strength training adaptations
2. Effects of combining strength and endurance training on cycling performance
3. Potential mechanisms
4. Maintenance of developed strength throughout the competition season
5. Practical applications

Bent Rønnestad 2017
Lillehammer University College

Conclusion

Heavy strength training *can* improve female & male`s cycling performance

- Performance power output
- Lactate threshold power output
- Gross mechanical efficiency & cycling economy
- Maximal oxygen consumption

Remember the total training stress – do as little strength training as necessary

Strength training adaptations needs to be maintained

Don`t forget monitoring individual responses to the training and talk *with* your rider…..It doesn't matter if a cyclist can squat 250 kg, but is overtrained.

Bent Rønnestad 2017
Lillehammer University College

Thank you!

Acknowledgement:

Truls Raastad
Ernst Albin Hansen
Joar Hansen
Geir Vegge
Stian Ellefsen
Håvard Nygaard
Eirik Grindaker
Olav Vikmoen
Daniel Hammarstrøm
Marit Roland Udnæss
++