FEDERAZIONE ITALIANA DI ATLETICA LEGGERA | atletica italiana

FIDAL CENTRO STUDI & RICERCHE

Strength training for endurance athletes: scientific principles and practical applications

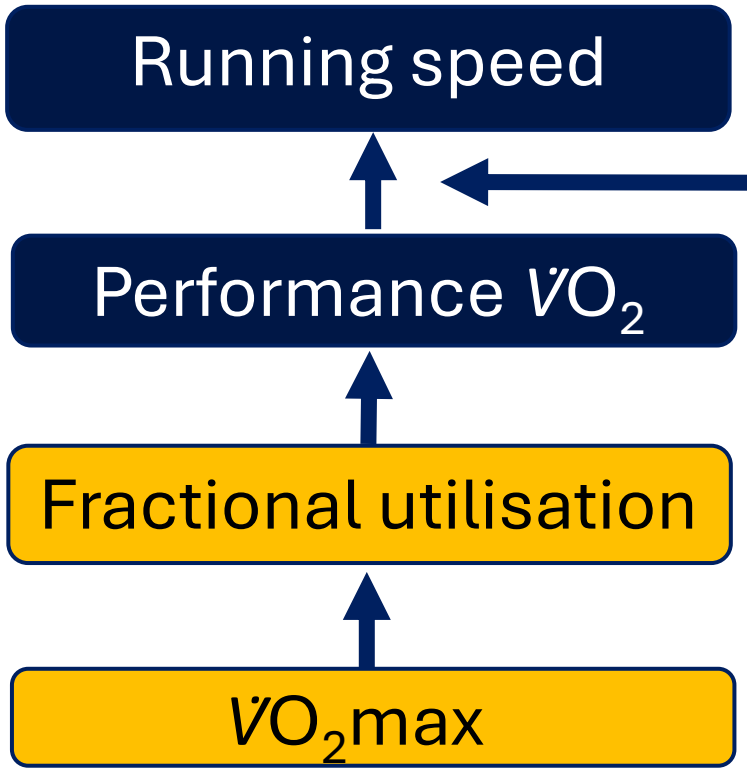
Allenamento della forza per atleti di resistenza: principi scientifici e applicazioni pratiche

Richard Blagrove PhD, ASCC, CSCS, PSCC

Session aims:

- Explain the physiological basis for strength training in endurance runners.
- Summarise the evidence that supplementary strength training may improve performance and reduce the risk of injury in endurance runners.
- Provide evidence-based recommendations for how strength training should be implemented with endurance runners.

(Joyner, 1991, *J Appl Physiol*, 70:683-7)



Test of the Classic Model for Predicting Endurance Running Performance

JAMES E. MCLAUGHLIN[1], EDWARD T. HOWLEY[2], DAVID R. BASSETT JR.[2], DIXIE L. THOMPSON[2], and EUGENE C. FITZHUGH[2]

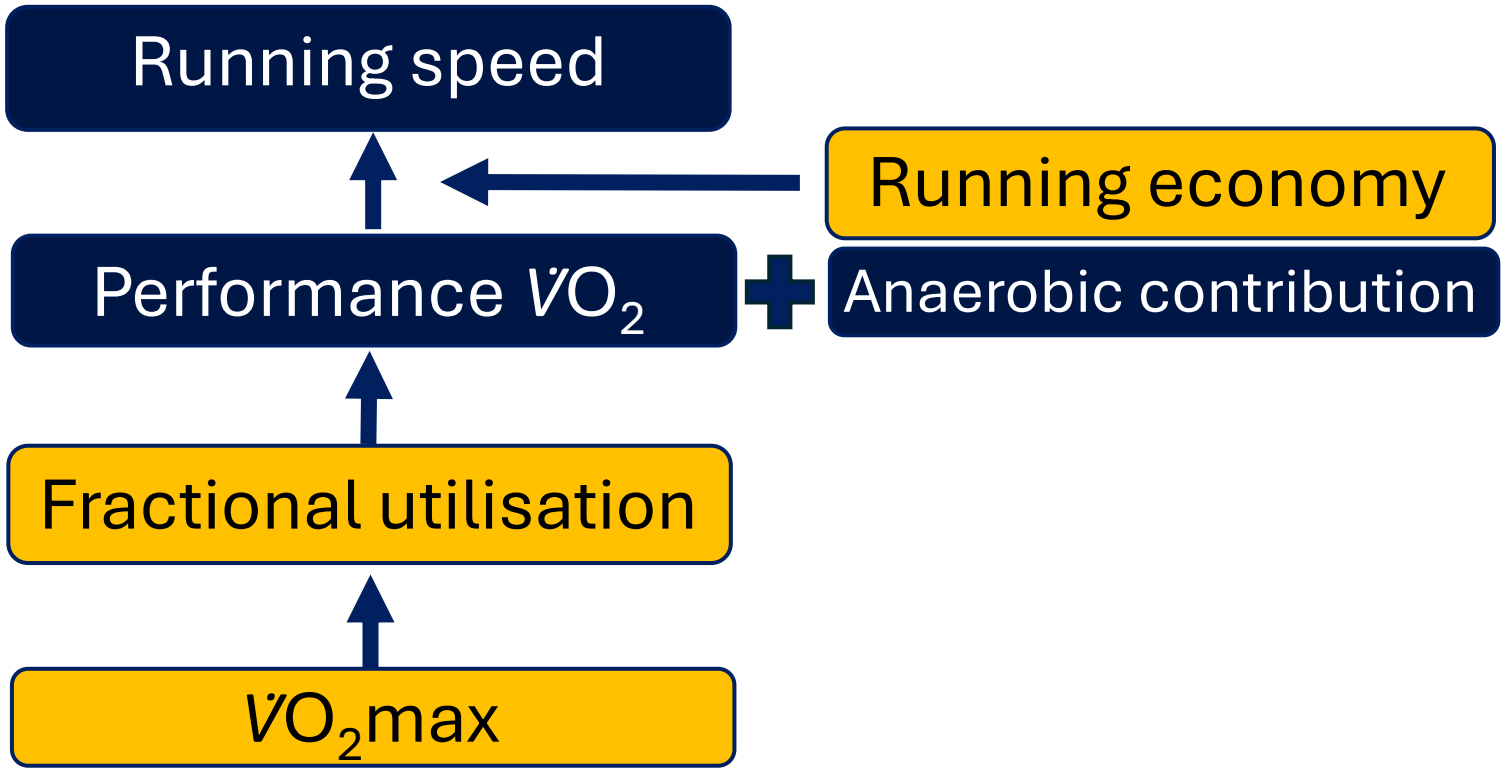
European Journal of Applied Physiology
https://doi.org/10.1007/s00421-019-04175-w

ORIGINAL ARTICLE

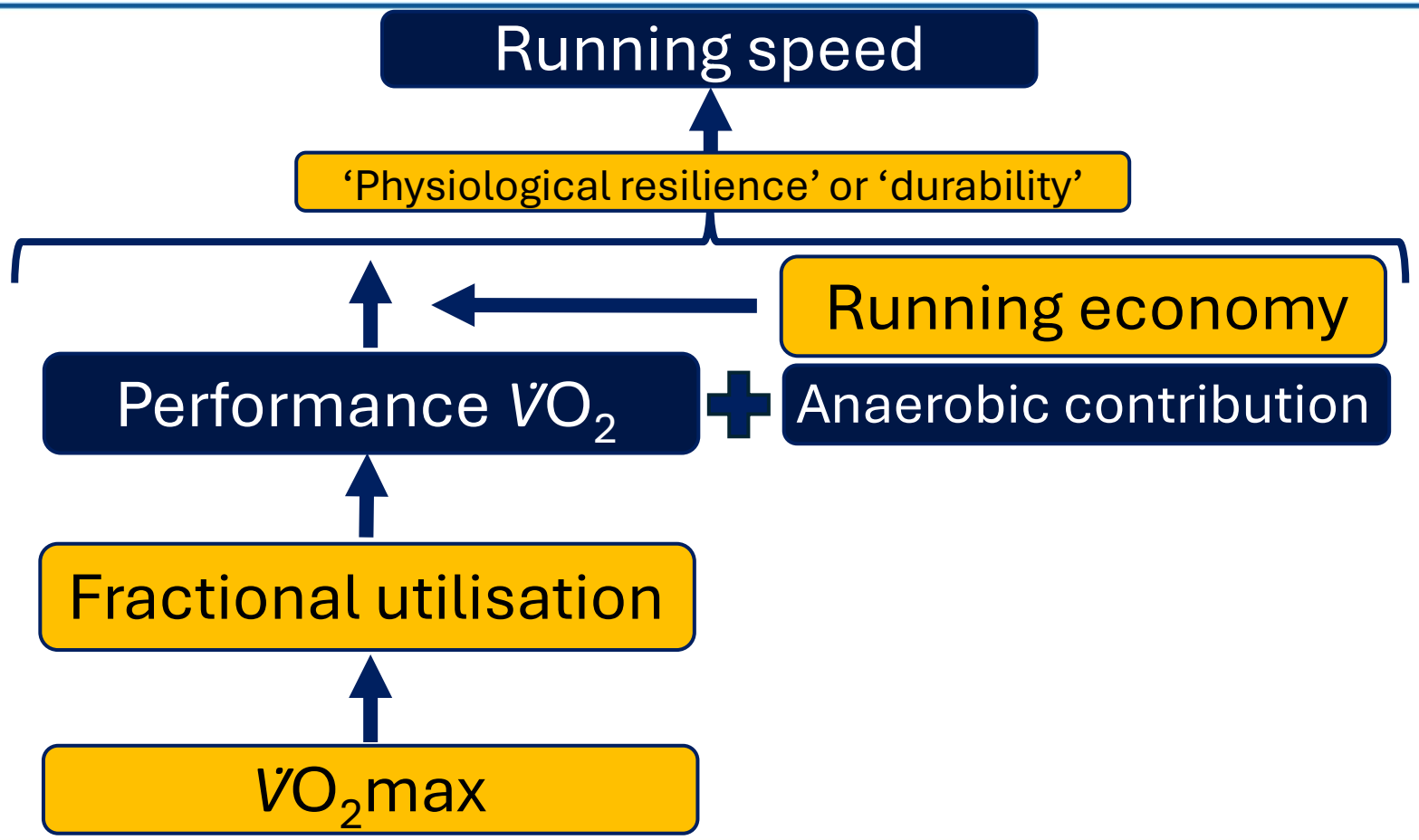
Quantification of aerobic determinants of performance in post-pubertal adolescent middle-distance runners

Richard C. Blagrove[1] · Glyn Howatson[2,3] · Charles R. Pedlar[4,5,6] · Philip R. Hayes[2]

(Adapted from: Joyner & Coyle, 2008, *J Physiol*, 586:35-44)



(Adapted from: Jones, 2024, *J Physiol*, 602:4113-28)



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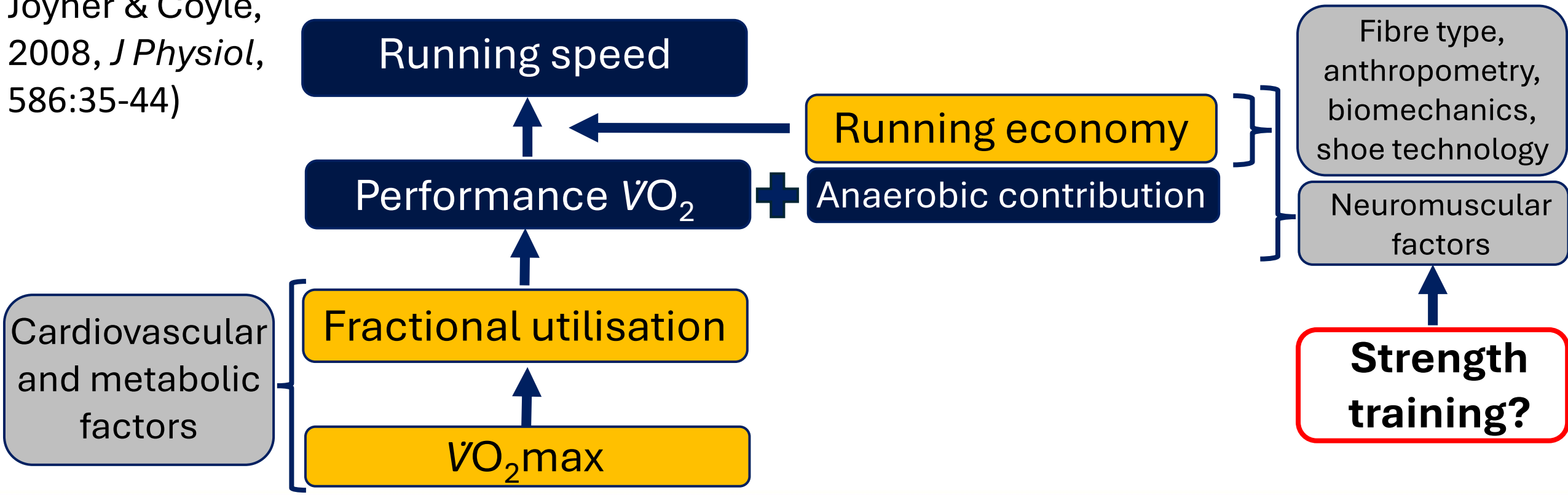
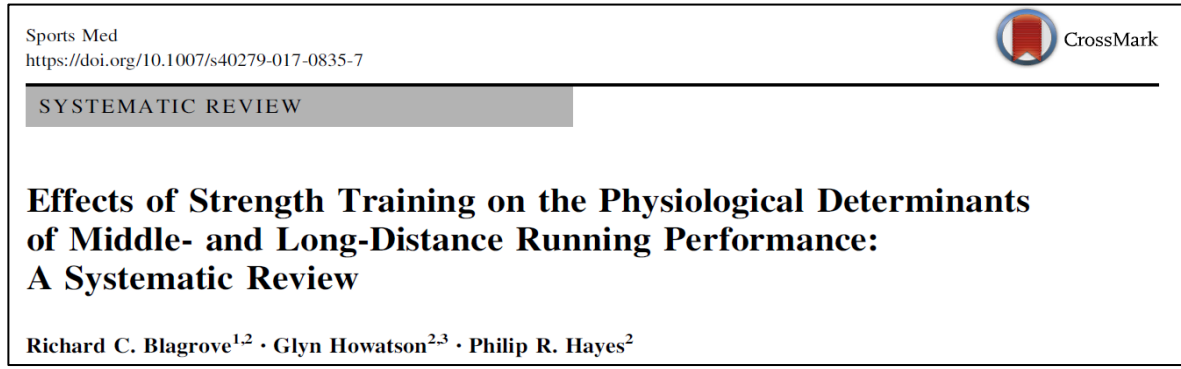


Eligibility criteria:

- Trained distance runners (≥ 6 months)
- Randomised control trials
- ≥ 4 weeks strength training intervention
  - ➢ Heavy resistance training (≤ 8 reps per set, ≥ 80% 1RM), explosive/ballistic strength training (30-79% 1RM), and plyometric training (jumps, skips, hops, bounds etc)
- At least one physiological or performance measure


Sports Med
https://doi.org/10.1007/s40279-017-0835-7

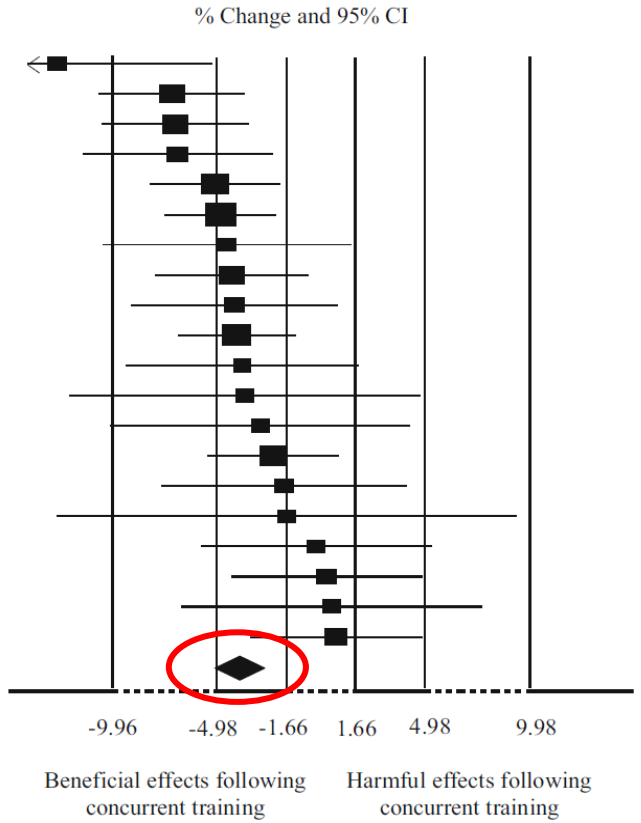
SYSTEMATIC REVIEW

Effects of Strength Training on the Physiological Determinants of Middle- and Long-Distance Running Performance: A Systematic Review

Richard C. Blagrove[1,2] · Glyn Howatson[2,3] · Philip R. Hayes[2]

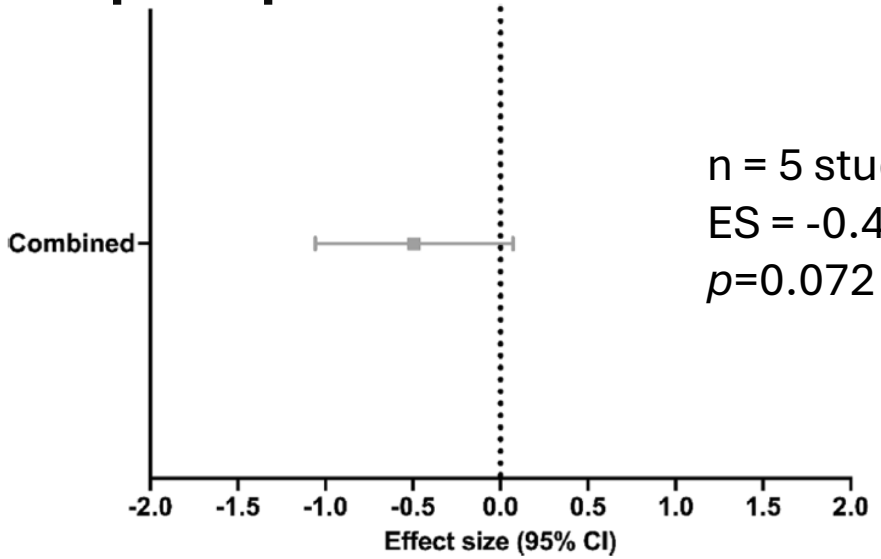
26 studies, *n*=469 runners

Variable	Change following strength-training (6-14 wk) intervention
Performance (1.5 km – 10 km)	12 studies ↑
Running economy	21 studies ↓
VO_{2max}	17 studies ↔
Speed at VO_{2max}	9 studies ↔
Speed at metabolic thresholds	11 studies ↔
Anaerobic qualities (maximum speed, anaerobic capacity)	5 studies ↑



(Denadai et al., 2017, *Sports Med*, 47:545-54)

Effect of combined heavy resistance, explosive/ballistic and plyometric training on **sprint performance**

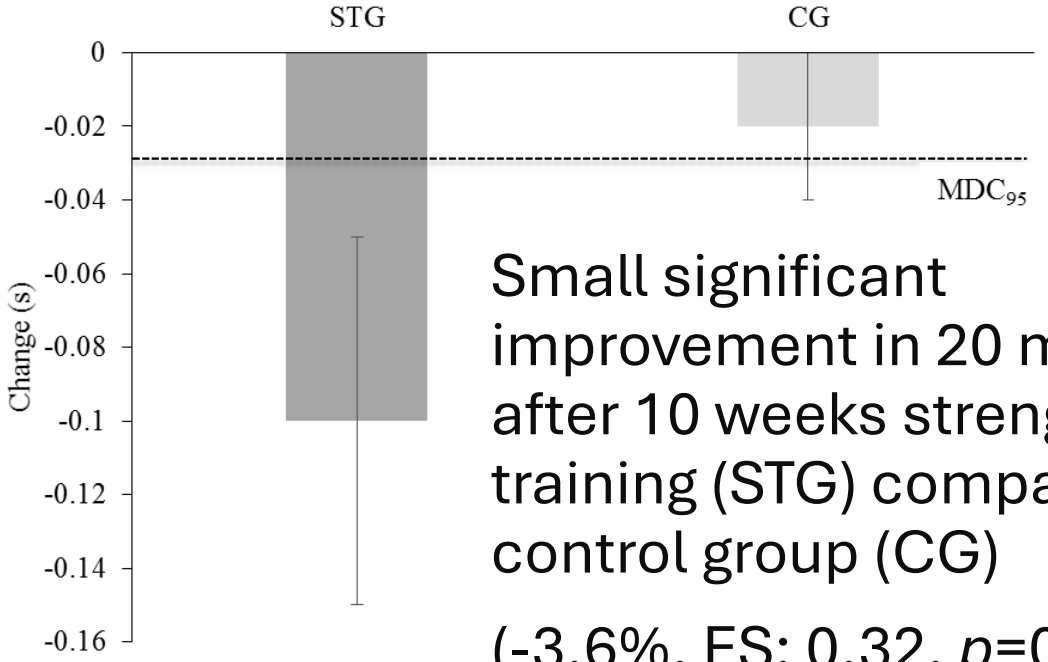


n = 5 studies,
ES = -0.49 (small),
p=0.072

(Llanos-Lagos et al, 2024a, *Sports Med*, 54:1801-33)

Effects of Strength Training on Postpubertal Adolescent Distance Runners

RICHARD C. BLAGROVE[1,2], LOUIS P. HOWE[3], EMILY J. CUSHION[4], ADAM SPENCE[4], GLYN HOWATSON[2,5], CHARLES R. PEDLAR[4,6], and PHILIP R. HAYES[2]



Small significant improvement in 20 m sprint after 10 weeks strength training (STG) compared to control group (CG)

(-3.6%, ES: 0.32, *p*=0.013)

Fear of gaining lean body mass?

- 22 of 24 studies showed no change in body composition values compared to a control group (Blagrove et al, 2018, *Sports Med*, 48:1117-49)

  ➢ Volumes of resistance training too low to generate hypertrophy?

  ➢ Training to non-repetition failure?

  ➢ Interference effect likely with high volumes of running training?

    - Endurance runners often in an energy deficit

Programmes of concurrent strength and endurance training: how to minimise the interference effect. Part 1: Evidence and mechanisms of interference

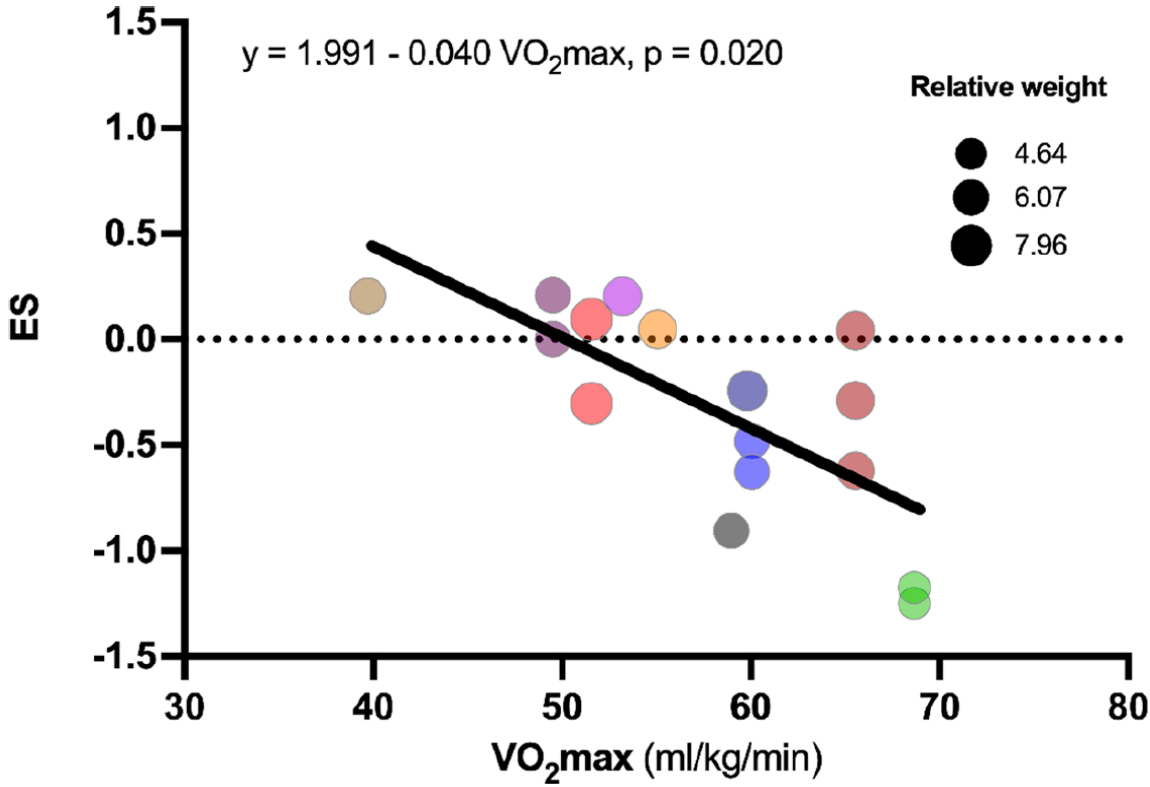
Richard Blagrove, BSc, MSc, PGCE, ASCC, CSCS / *St Mary's University College, Twickenham*

- Effects across sub-populations:
  - ➢ Well-trained runners benefit more

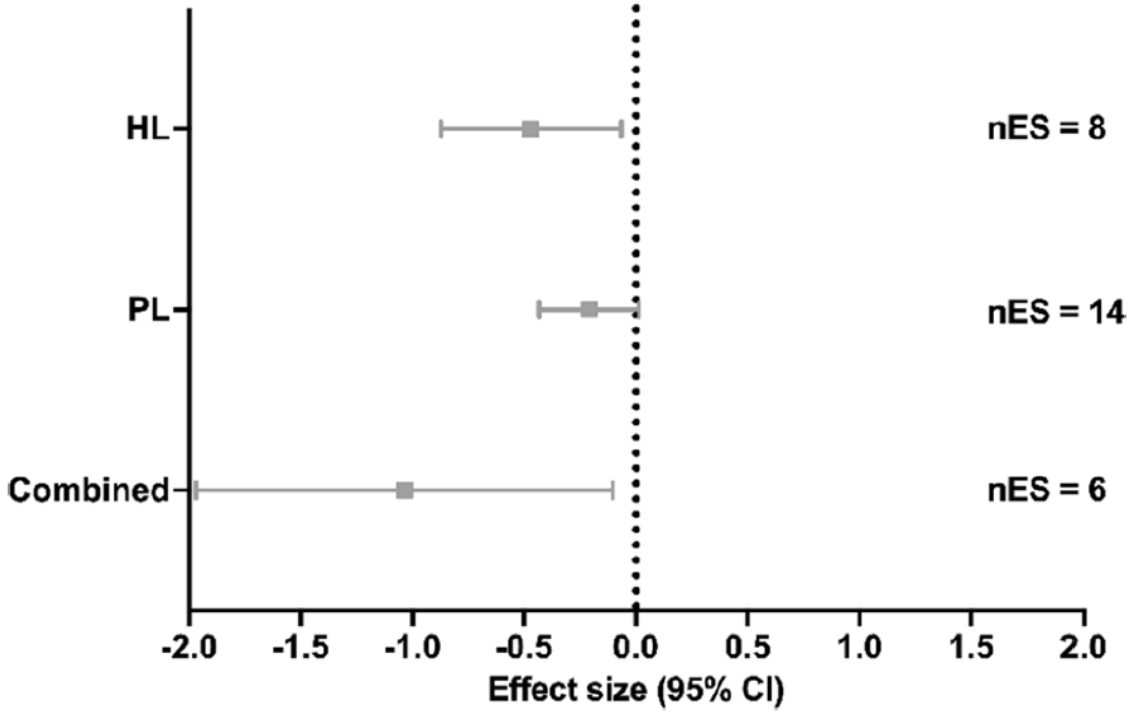
Performance level	Effect size for resistance training on running economy
Recreational	-0.27 (small)
Moderate	-0.18 (trivial)
High	-0.61 (moderate)

(Eihara et al., 2022, *Sports Med Open*, 8:138)

- ➢ Limited data in female-only, youth and master athletes



(Llanos-Lagos et al, 2024b, *Sports Med*, 54:895-932)



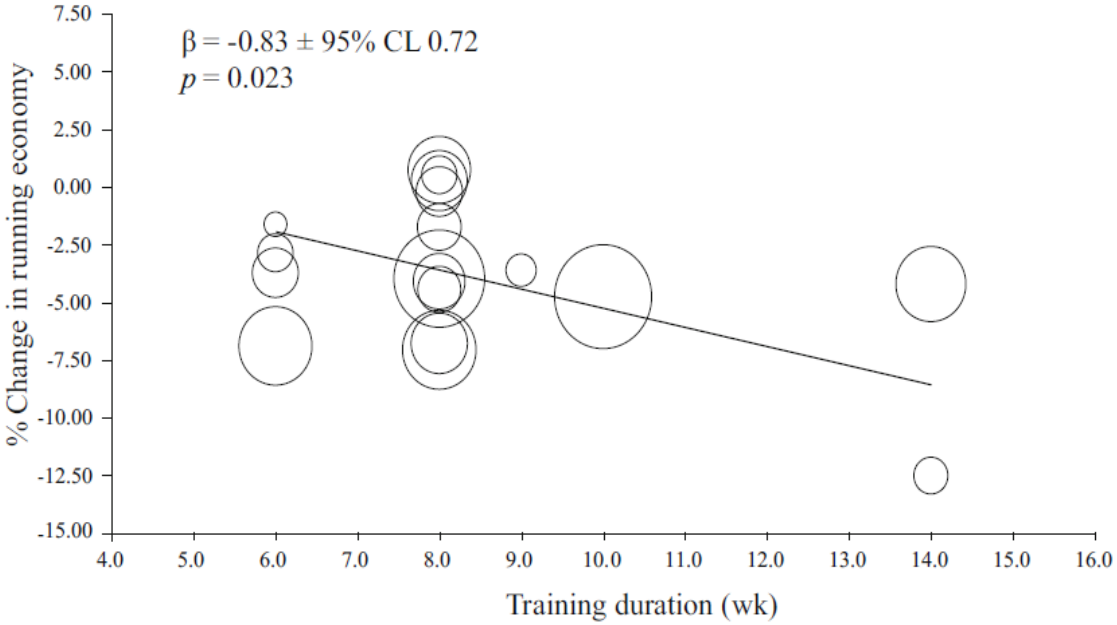
(Llanos-Lagos et al, 2024a, *Sports Med*, 54:1801-33)

- Light-moderate loads (15 reps+ per set) offer less improvement compared to heavy loads (12 reps or less per set)
- Heavy resistance training, explosive/ballistic strength training, and plyometric training all appear to offer benefits
  - ➢ Combined or periodized approach seems to work best for improving performance

- Frequency:
  - ➢ 2-4 sessions per week with no moderating effect for frequency (Llanos-Lagos et al, 2024b, *Sports Med*, 54:895-932)
- Volume per session:
  - ➢ (Heavy and explosive) strength training:

    2-6 exercises, 2-5 sets x 3-10 reps (**6-12 sets per session**)
  - ➢ Plyometrics: 1–6 exercises, 1–6 sets x 4–10 repetitions (**30–228 foot contacts per session**)

- Duration of intervention:



(Denadai et al., 2017, *Sports Med*, 47:545-54)

Neuromuscular preparation	Plyometrics and ballistic training	(Heavy) Resistance training	Specific conditioning
~10 min	*~15 min*	*~25 min*	*~10 min*
• Movement skill • Motor control & proprioception • Dynamic mobilisations • Activation	• Ankle reactivity • Sprint drills • Bilateral jumping • Hopping and bounding	• Bilateral loading • Unilateral loading • Upper limb exercises	• Calf-Achilles complex • Feet • Gluteals • Hamstrings

(Blagrove et al, 2020, *Strength Cond J,* 42:2-11)

Multi-joint, closed kinetic chain exercises:

- Squat
- Hinge
- Step
- Lunge
- (Upper limb pull and push)

Calf complex targeted approach?

Bohm et al. (2021), *Proc R Soc B,* 288:20202784

- 14 weeks of bent-leg calf press
- 3-4 sessions per week
- 5 sets x 4 reps of 3 sec isometric at 90% max
- 4% improvement in running economy

Similar findings for 6-weeks of daily skipping (5-15 x 10 sec) (Engerorff et al., 2023, *Sci Rep*, 13:4167)

- Absence of deceleration phase
- High effort and intent

➢ Medicine ball throwing

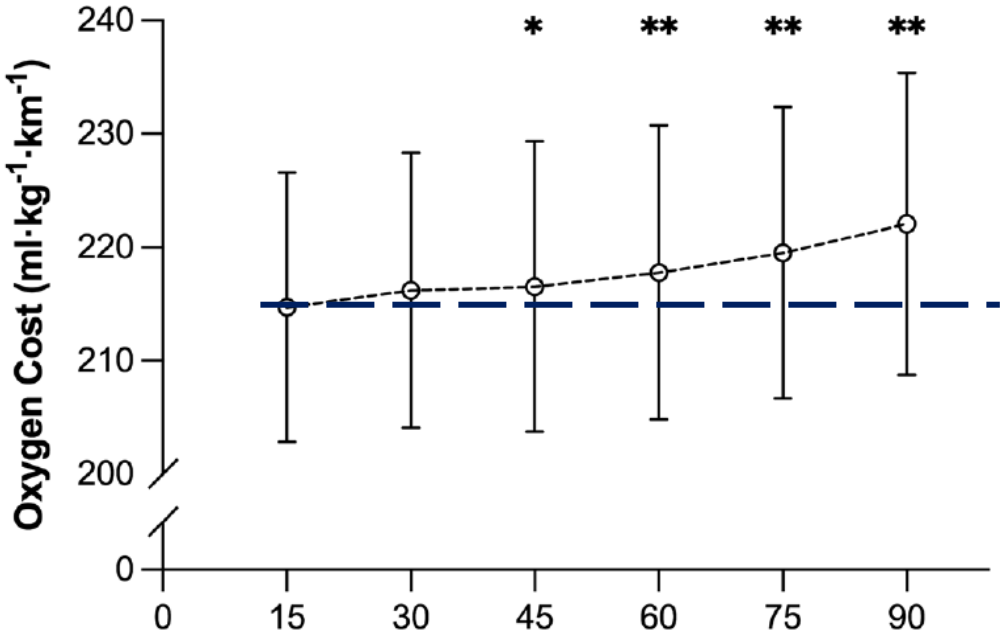
➢ Weightlifting skills

➢ Light load jumping

- Prioritise short ground contact time
- Double to single leg dominance
- Low to higher eccentric demand

A role for strength training in improving running economy durability?

- Studies tend to measure running economy in a relatively unfatigued state
- Running economy significantly deteriorates during prolonged running
- Does strength training improve physiological resilience or durability?



(Zanini, Folland, Blagrove, 2024, *Med Sci Sports Exerc*, 56: 2230-40)

n=28 well-trained male endurance runners

- Strength tests (CMJ, 1RM leg press, MVC plantarflexor)
- Incremental step-test and VO2max test
- 90 min at 10% Δ LT1 – LT2 + TTE

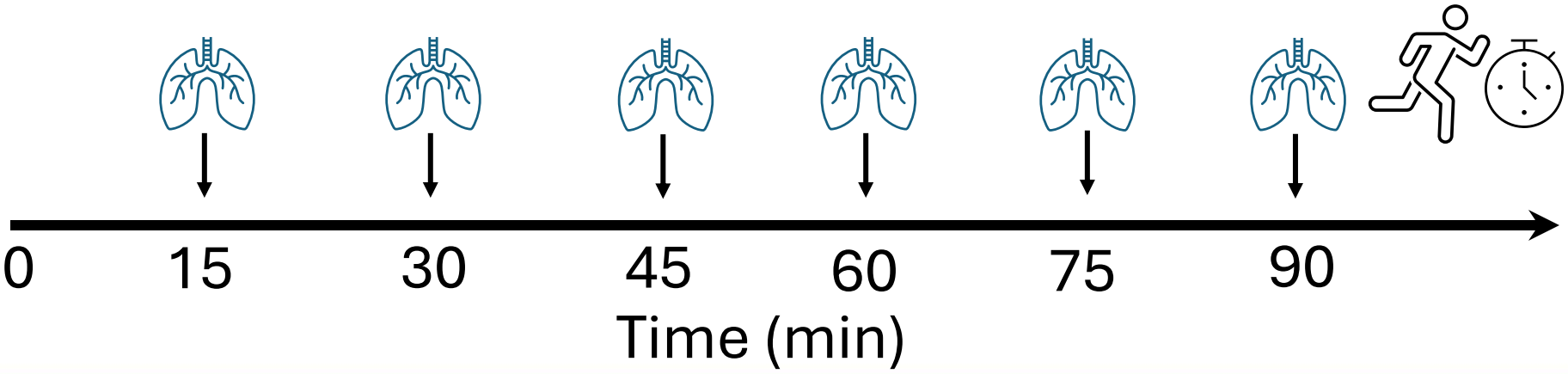
Randomised

n=14 Running + strength training

n=14 Running only

10 weeks

Repeat:
- Strength tests
- 90 min + TTE



Time to exhaustion (TTE) at 95% sVO2max

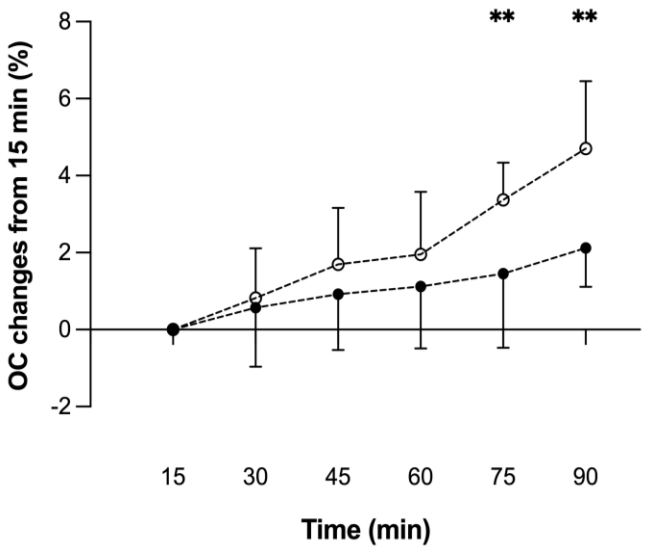
(Zanini et al, 2025, *Med Sci Sports Exerc*, ahead of print)

10 weeks, 2 x per week, each session:

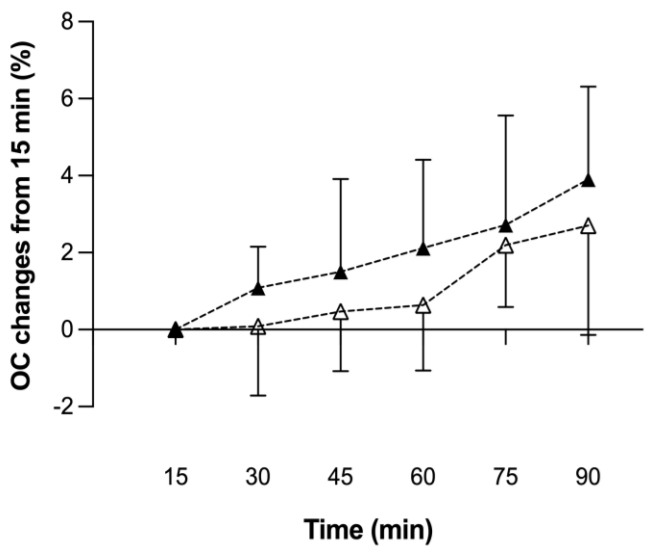
- 2-3 x plyometric exercises
- 1-2 x bilateral (pogo and/or drop jumps)
- 1 x unilateral (hops or bounds)
- 3 x resistance training exercises (3-4 sets x 3-8 reps):
  - Half squat
  - Single leg leg press
  - Iso. single leg calf raise
- **99% adherence rate**

(Zanini et al, 2025, *Med Sci Sports Exerc*, ahead of print)

Running + strength training



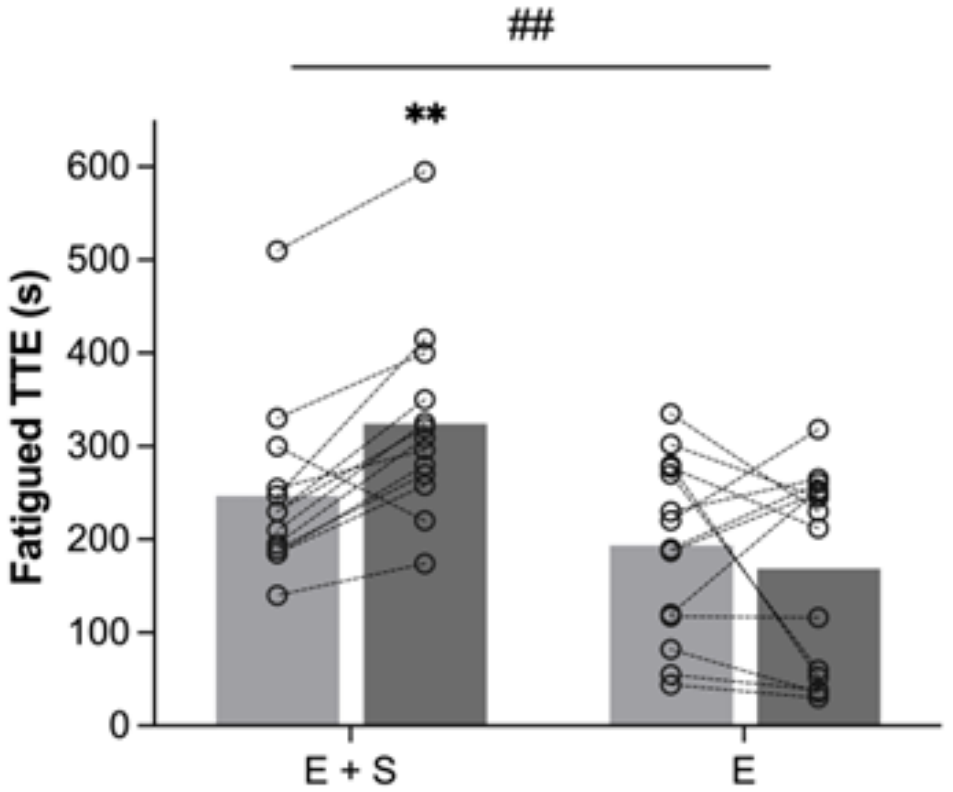
Running only training



(Zanini et al, 2025, *Med Sci Sports Exerc*, ahead of print)

- Unshaded symbols indicate pre-intervention measure, shaded symbols indicate post
- **Significant improvements (p=0.003) in running economy durability beyond 60 min of running following strength training compared to no change in running-only group**

Following the 90 min run, time to exhaustion at 95% sVO_2max showed significant improvements (p=0.004) in the strength training group (35 ± 25%) compared to the change in the running-only group (-8 ± 52%)



(Zanini et al, 2025, *Med Sci Sports Exerc*, ahead of print)

Organisation of the training week

Day	Morning	Afternoon
Monday	Easy 60 min	**S&C**
Tuesday	Easy 30 min	Interval session
Wednesday	Easy 70 min	Easy 30 min
Thursday	**S&C**	Easy 14km
Friday	Tempo run	Easy 30 min
Saturday	-	-
Sunday	Easy 90 min	-

General rules…

- 24 hours separates strength training from hard running sessions
- 6 hours+ between S&C and any running sessions

(Blagrove et al., 2018, 2020)

Polarised design

Day	Morning	Afternoon
Monday	Easy 60 min	Easy 30 min
Tuesday	Interval session	**S&C**
Wednesday	Easy 60 min	-
Thursday	Tempo run	Easy 30 min
Friday	-	-
Saturday	Interval session	**S&C**
Sunday	Easy 90 min	-

- 4-8 hours recovery after hard interval session fine for heavy resistance training (Alves Panissa et al., 2021, *Str Cond J*, 44:46-57)
- However, fatigue from hard running sessions negatively affects explosive strength development (Wilson et al., 2012, *J Str Cond Res*, 26:2293-307)
- Injury risk with plyometric training after hard running?

Micro-dosing or S&C units design

Day	
Monday	Easy 40 min + **resistance training (20-30 min)**
Tuesday	**Plyometric-based warm-up (10 min)** + Interval session
Wednesday	Easy 40 min + **specific conditioning (15 min)**
Thursday	**Plyometric-based warm-up (10 min)** + Tempo run
Friday	Easy 40 min + **resistance training (20-30 min)**
Saturday	-
Sunday	Easy 70 min + **specific conditioning (10 min)**

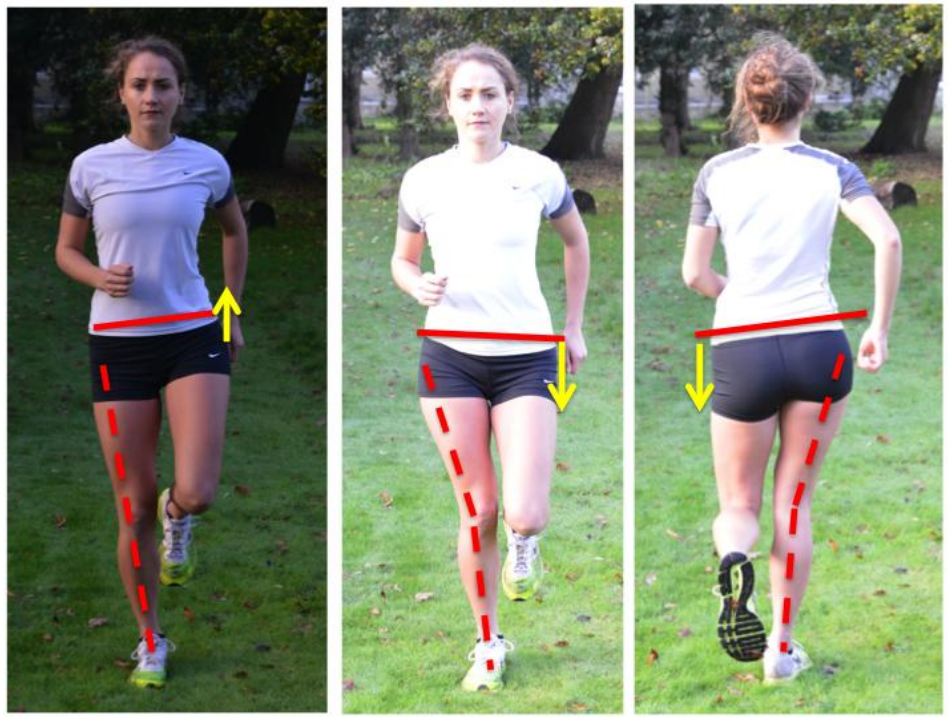
- Shorter bouts can be more manageable
- Brief high-intensity plyometric exercise may acutely potentiate running economy (Blagrove et al., 2018, *J Sci Med Sport*, 22:239-44).

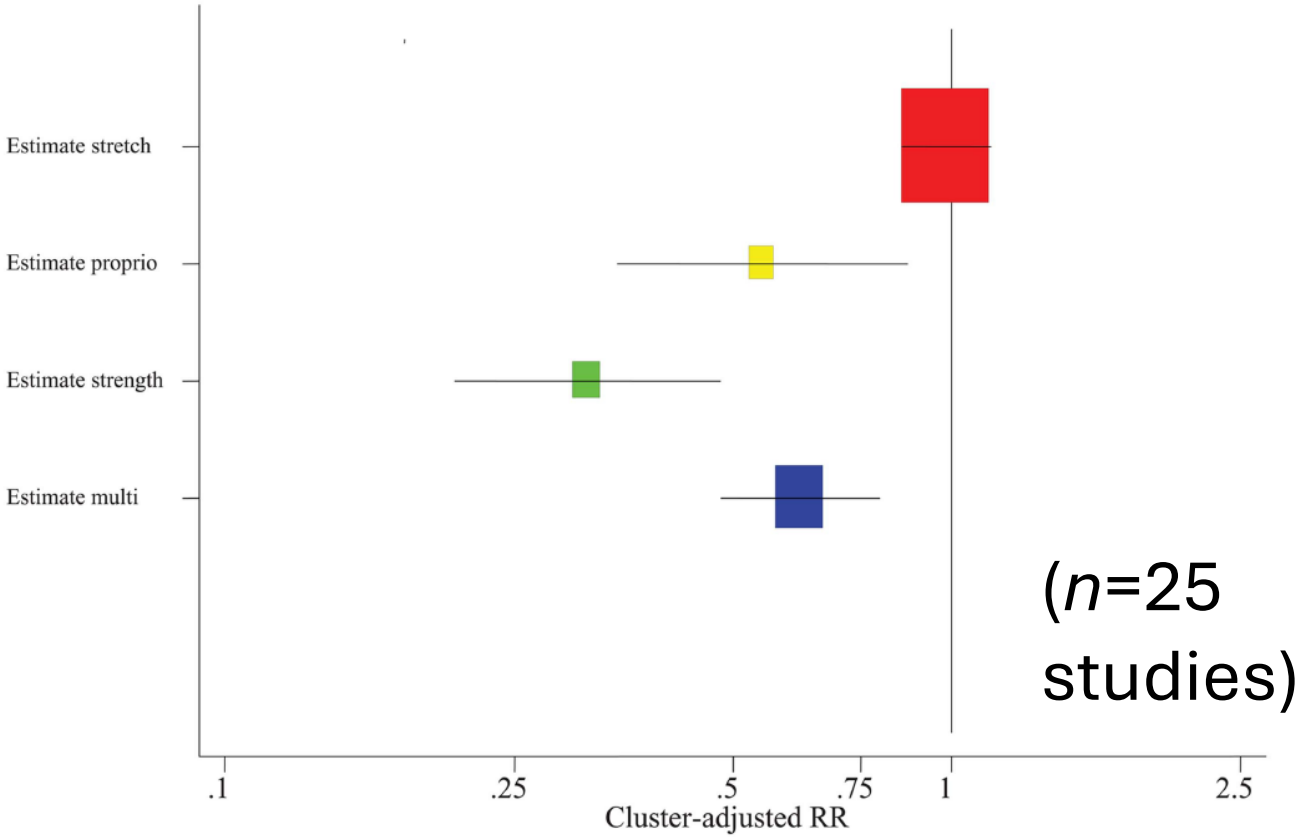
(Blagrove & Hooper, In: Blagrove & Hayes (Eds), 2021, *The Science and Practice of Middle and Long Distance Running*, Routledge: UK)

n=667

(Blagrove et al., 2020, *J Strength Cond Res*, 34:1392-9)

- Weaker hip abductors related to:
  - ➢ Anterior knee pain (Luedke et al., 2015, *Int J Sports Phys Ther,* 10:868-76)
  - ➢ Medial tibial stress syndrome (Becker et al., 2018, *Med Sci Sports Exerc*, 50:2092-100)
- Weaker hip external rotators related to:
  - ➢ Patellofemoral pain (Finnoff et al, 2011, *PM R*, 3:792-801)
- Weaker ankle plantarflexors related to:
  - ➢ Achilles tendon overuse injury (Mahieu et al., 2006, *Am J Sports Med,* 34:226-35)





(*n*=25 studies)

The effectiveness of exercise interventions to prevent sports injuries: a systematic review and meta-analysis of randomised controlled trials

Jeppe Bo Lauersen,[1] Ditte Marie Bertelsen,[2] Lars Bo Andersen[3,4]

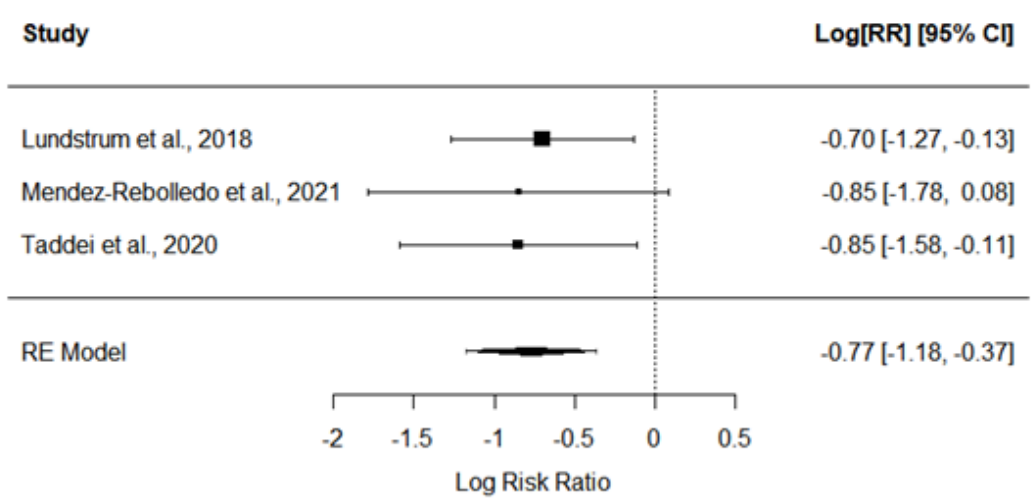
- Strength training reduces injury occurrence by 66% (95% CI: 52% to 76%).
- Evidence largely from soccer, throwing sports, military and acute injuries

Sports Medicine
https://doi.org/10.1007/s40279-024-01993-7

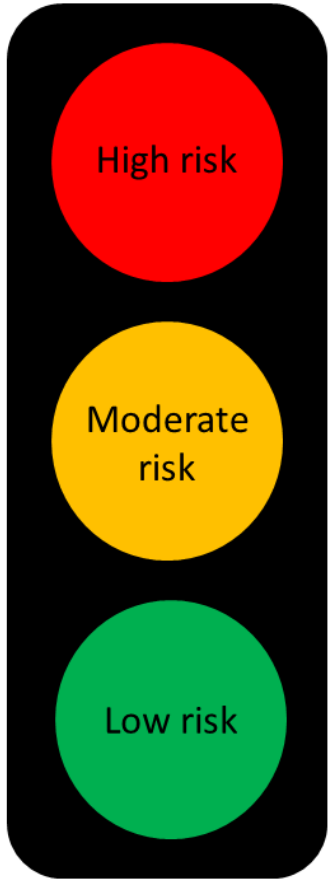
SYSTEMATIC REVIEW

Do Exercise-Based Prevention Programs Reduce Injury in Endurance Runners? A Systematic Review and Meta-Analysis

Han Wu[1] · Katherine Brooke-Wavell[1] · Daniel T. P. Fong[1] · Max R. Paquette[2] · Richard C. Blagrove[1]



- 9 studies have used S&C injury prevention in endurance runners (*n*=1,904)
- No effect on injury risk or injury rate ($p>0.05$)
- Post-hoc analysis of supervised trials showed positive effect (RR – 0.77, $p<0.001$)
  - ➢ Adherence to the programme was higher
  - ➢ Coaching helps movement skill and effort?
  - ➢ Those with high compliance may exhibit other ‘healthy behaviours’?



High risk

- Regularly injured previously with loss of strength/capacity
- Large increase in volume and/or intensity of running (or new to running)
- Major change in running environment (or footwear) for most of training
- Rapid recent weight loss
- Excessive 'tightness' or soreness
- Absence of menstrual cycles >3 months
- Poor sleep quality and quantity (<7 hours)
- Modification of running technique
- Highly stressful lifestyle events or low mood or high anxiety status
- Single and old pair of running shoes
- No S&C work
- 'Risky' biomechanics linked to previous injuries

Moderate risk

- Some injuries and niggles rehabilitated previously
- Increase in volume and/or intensity of running
- Change in footwear and/or running terrain/surface for some of training
- Steady weight loss over last few months and/or poor quality diet
- Some mild 'tightness' or soreness
- Irregular menstrual cycles
- Irregular sleep quality and/or quantity (<7 hours)
- Stressful lifestyle events or reduced mood or anxiety
- Single pair of running shoes for training
- Subtle modification of running technique
- Inconsistent use of S&C
- 'Risky' biomechanics linked to niggles/tightness

Low risk

- No injuries previously
- Little change in running volume/intensity or environment compared to previous month
- Sufficient energy intake to meet lifestyle demand; body mass consistent
- Sound nutrition and eating habits
- Regular menstrual cycles
- 7+ hours of quality sleep per night
- Manageable lifestyle stresses, positive mood, and no feelings of anxiety
- Rotate several pairs of running shoes
- Regular use of S&C

Importance of a holistic approach to injury prevention in endurance runners

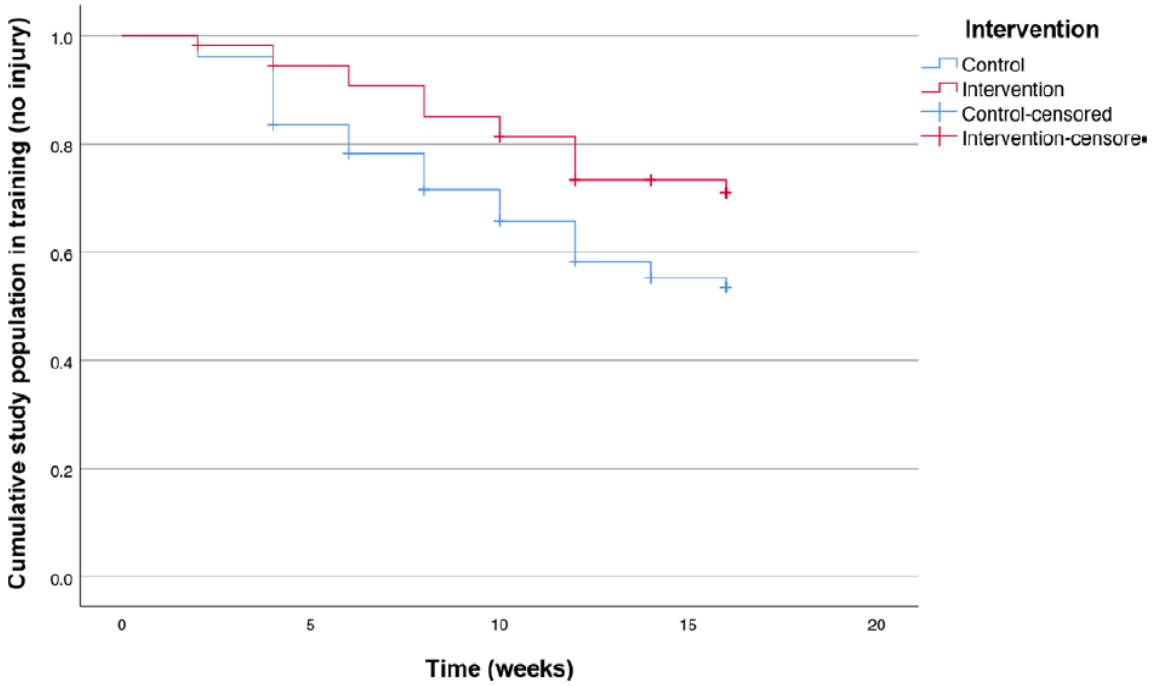
(Blagrove, 2024, In: Reuter, B. (Ed.) *NSCA Developing Endurance, 2nd ed.*)

Universal prevention through a digital health platform reduces injury incidence in youth athletics (track and field): a cluster randomised controlled trial

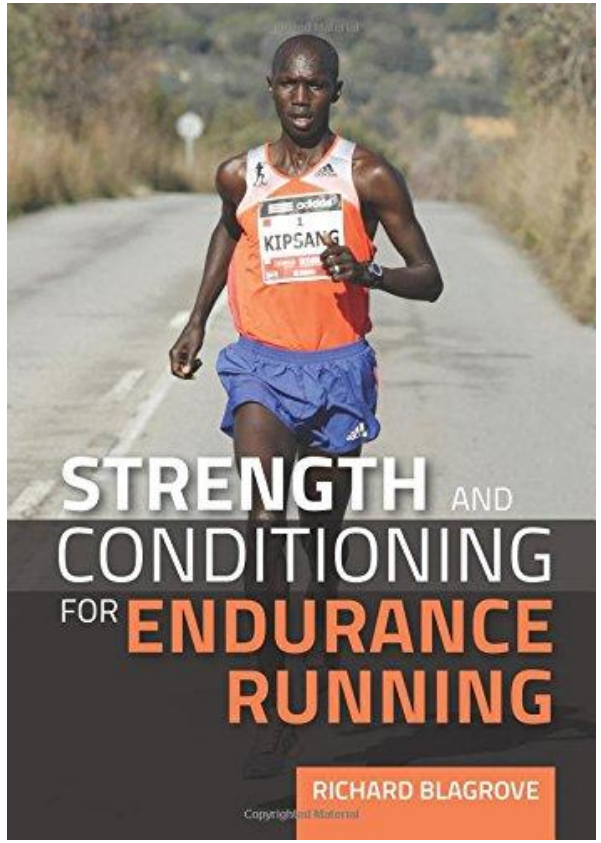
Jenny Jacobsson [1], Jan Kowalski,[2] Toomas Timpka [3,4], Per-Olof Hansson,[5] Armin Spreco,[6] Orjan Dahlstrom [7]

- 12-15 year old T&F athletes
- Intervention, *n*=63; control, *n*=79
- 4 month study period
- Digital health education - training planning, growth and puberty, recovery strategies (nutrition and sleep), injury prevention advice, avoiding injuries and illnesses, mental health

- Compliance: digital health platform was accessed from 113 digital devices in 233 sessions (ave. 5 min/session)



- Strength training activities provide small improvements in running economy, durability, and anaerobic qualities (eg maximal speed), which translates to enhancements in endurance running performance without increasing body mass.
- Endurance runners should perform strength training sessions on at least two occasions per week for periods of at least 6 weeks to obtain benefits.
- When S&C programmes are supervised (and thus adherence high), there may be a small reduction in the risk of runners sustaining an overuse injury, however a holistic approach to injury prevention is likely crucial.



Thank you!
Grazie!

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