Endurance and strength training: Are they incompatible?

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The ‘endurance’ or ‘strength’ phenotype is the outcome of the cumulative effects of multiple acute exercise bouts.
The ‘classic’ study of the potential for strength and endurance training to amplify the endurance phenotype

“These data do not demonstrate any negative performance effects of adding heavy-resistance training to ongoing endurance-training regimens. They indicate that certain types of endurance performance, particularly those requiring fast-twitch fiber recruitment, can be improved by strength training supplementation.”

The physiological demands of team sports require both strength/power and aerobic fitness.
Myofibrillar versus mitochondrial proteins

Myofibrillar protein

Mitochondrial protein

Specificity of training adaptation

The ‘training adaptation continuum’

Mitochondrial biogenesis
- LKB1
  - AMPK
  - PGC-1α

Muscle hypertrophy
- Akt
  - mTOR
  - p70S6k

Specificity of training adaptation
The AMPK (endurance) and Akt (resistance) ‘master switch’ mediates mode-specific adaptations to training

Effects of heavy resistance exercise undertaken after cycling on early signaling events in skeletal muscle

*Test protocol A*  Endurance exercise (E)

- Cycling
  - 1h
- Rest
  - 1h
- Rest
  - 2h
- 1h Post
- 3h Post

*Test protocol B*  Endurance followed by resistance exercise (ER)

- Cycling
  - 15min
- Rest
  - ~25min
- Leg press
  - ~20min
- Rest
  - 1h Post
- Rest
  - 2h
- 3h Post

Fig. 1. Schematic of the experimental protocol. Endurance exercise (E) was performed as cycling at 65% of maximal oxygen uptake (\(\dot{V}O_2_{max}\)), and resistance exercise (ER) as leg press at 70–80% of 1 repetition maximum with 15 repetitions or until failure. Pre, preexercise; Post, postexercise.

Heavy resistance exercise amplifies the acute ‘endurance’ signal in human skeletal muscle

And also preserves the acute ‘myogenic’ signal in human skeletal muscle

A novel finding in the present study is that resistance exercise performed after endurance exercise resulted in enhanced expression of genes involved in the signaling cascade of mitochondrial biogenesis/oxidative metabolism, as well as enhanced activation of proteins involved in the regulation of muscle protein synthesis. These results challenge the current view of how to optimize endurance training adaptation.

Overall effect sizes for strength, endurance and concurrent strength and endurance training

All endurance sports are not created equal: Endurance running versus cycling and strength training
Overall effect sizes for running plus strength, cycling plus strength, and strength only training

Dose response effect size for the average duration of endurance sessions on muscle strength, size, and power

Can nutrient provision attenuate some of the concurrent training-induced ‘interference’ on muscle proteins?
Effects of protein ingestion on muscle protein synthesis following consecutive resistance and endurance exercise

Camera DA et al. (Unpublished observations)
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“Concurrent training promotes anabolic responses and increases in metabolic/oxidative pathways in skeletal muscle. Protein ingestion after combined resistance and endurance exercise enhances myofibrillar protein synthesis and attenuates markers of muscle catabolism. Protein ingestion may therefore promote and/or protect muscle mass and reduce the potential interference effect of endurance exercise on hypertrophy.”

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Summary and practical implications: Are endurance and strength training incompatible?

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- The principle of ‘specificity of training adaptation’ rules!
Factors affecting the variability in the training response/adaptation

Biochemical
- ATP
- ADP+Pi
- AMP

Mechanical
- Ca$^{2+}$
- Ca$^{2+}$
- Ca$^{2+}$

Electrochemical
- ATP
- ADP+Pi
- AMP

AMPK
- PGC-1

CaMK
- CREB
- MEF2
- HDAC

mTOR
- Akt

Training history
- Training modality
- Fibre type

Training intensity
- Training diet
- Gender

TRAINING ADAPTATION
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