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Combined Training

Evidence-Based Strength & Conditioning Programming

Amy Ashmore, Ph.D

Learning Objectives 1 and 2

Discuss interference theory and how it relates to combined training

Explain what combined training is and how it relates to avoiding interference

Learning Objectives 3 and 4

Develop effective combined training sessions to increase muscle performance

Organize mode, frequency, duration, volume, and intensity of training to design sessions and programs that maximize muscle performance

Evidence-Based Practice (EBP)

What is EBP?

"EBP is making decisions for practice based on research evidence."

Evidence Based *Programming*

"EB Programming is making exercise programming decisions based on the latest research evidence."

What is Combined Training?

"Combined training is using multiple modes of exercise (strength, cardiovascular, and flexibility) to achieve multiple goals (strength, power, muscle and cardiovascular endurance, and flexibility) in one session or same day sessions."

Why Study Combined Training?

- Combined training is popular.
- It is necessary in most athletic training settings.
  - Because it combines multiple modes of training like muscle strength, power, and endurance along with cardiovascular and flexibility training into one session or separate sessions in one day.

What is the Problem?

Combined training can be counterproductive because multiple modes of training compete with one another and can cancel each other out!

Finding the Solution

Using the PICO formula a clinical question is posed to determine the efficacy of combined training outcomes based on multiple research studies.

CONTINUED

The Clinical Question

*"Does combined training decrease **muscle force generation capacity (MFGC)** and thus decrease performance in college-aged and adult professional athletes?"*

CONTINUED

Muscle force generation capacity (MFGC)

A direct measurement of muscular strength.

The PICO Formula

- Population (P)
- Intervention (I)
- Comparison (C)
- Outcome (O)

PICO Breakdown of Our Clinical Q

- **P**opulation: college-aged and adult professional athletes.
- **I**ntervention: strength and conditioning training programming (mode, frequency, duration, volume, intensity, and rest).

PICO Breakdown, continued

- **C**omparison: currently used combined training programming models.
- **O**utcome: increased muscle force generation capacity (MFGC; a measure of performance) – intended to optimize performance, decrease the risk of injury, and improve rehabilitation outcomes.

Research

Interference Theory

Interference Theory Defined

The scientifically backed idea that the long-term adaptations associated with muscle growth, strength, and power versus muscle endurance and cardiovascular gains compete during workout sessions and cancel one another out.

"Endurance training works against muscle strength."

Docherty and Sporer, 2000

"Strength gains are negatively impacted by high-intensity cardiovascular training."

Doma and Deakin, 2013; Jones et al 2017

Clinical Summary

- The accepted direction of interference is that **endurance training reduces the quality of strength training** sessions.
- Endurance training reduces the likelihood of muscle growth, strength, and power improvements, creating a serious dilemma in athletic performance training.

Muscle Confusion

Muscle Confusion Defined

- Muscles get confused when multiple modes of work are performed during the same training session (or even day).
- How? The mechanisms of strength and power gains get canceled out by endurance work.

Muscle Confusion

- It is interference theory at a microscopic level.
- It is the core scientific dilemma behind combined training.
- It is the molecular explanation for why endurance training interferes with strength training.

Muscle Confusion Is Not…

- Cross-training.
- Doing different exercises for the same muscle group within a session.
  - ❖These are pop culture terms that do not accurately reflect the scientific definition of muscle confusion.

Clinical Summary

- Molecular mechanisms compete when different modes of exercise are done within the same session or close together (within 24 hours in some cases).
- Common combined training methods can cause muscle confusion and competition at the molecular level.

Clinical Summary, cont'd

- The mechanisms that are responsible for muscle growth, strength, power, and endurance compete and cancel each other out rendering training sessions ineffective.

Competing Mechanisms

Competing Mechanisms

- Muscle contractility.
- Delayed-onset muscle soreness.

Competing Mechanisms

- Testosterone levels.
- Cortisol and blood lactate levels.

Muscle Contractility

- Muscle contractility is a structural or morphological change that impacts muscle's ability to elicit the desired effects during strength training.
- Prolonged endurance training interferes with a muscle's ability to contract during strength training.

Muscle Contractility, cont'd

- Doing endurance training before strength training adversely impacts MFGC (the ability of a muscle to produce force).
- Decreases the likelihood of positive muscle growth, strength, and power outcomes.

Delayed-Onset Muscle Soreness (DOMS)

- DOMS cause a series of events, including microscopic damage to muscle fibers that prevent strength and power gains.
- Prolonged muscle work associated with DOMS causes substrate depletion and increased protein breakdown, both of which hinder strength and power gains.

Testosterone Levels

- Combined strength and cardiovascular training can decrease testosterone levels.
- Testosterone is essential to muscle development and growth.
- Therefore, decreases muscle growth, strength, and power gains.

Cortisol and Blood Lactate Levels

- Doing endurance training before strength training increases blood lactate and cortisol levels.
- However, both need to be **lowered** for muscle growth, strength, and power gains.
- Therefore, endurance training works against muscle growth, strength, and power gains via cortisol and blood lactate channels.

Clinical Summary

- Prolonged endurance work like jogging can interfere with strength gains.
- Delayed-onset muscle soreness can interfere with strength gains.
- Doing strength and cardiovascular training together can decrease testosterone levels which decrease strength gains.
- Doing endurance training before strength training increases blood lactate and cortisol levels which can hinder strength gains.

Patterns of Muscle Activation

Pattern of Muscle Activation

- How a muscle is used for a particular exercise.
- Varies with different exercises for the same muscle or muscle group.
  - Contrast a squat with a seated leg press.

Patterns of Muscle Activation

- Push-ups

VS

- Plyometric push-ups

Programming Foundations

Programing Variables

Programming Variables

- Mode (type of training)
- Frequency (recurrence of sessions; recovery lengths)
- Duration (length of program, each session total, and session components)

Programming Variables

- Volume (how much; sets and reps; distance and time)
- Intensity (how hard; heart rate; MFGC or output)

Mode (type of training)

- Cardiovascular
- Strength or resistance
- Flexibility

Frequency (how often)

- Days per week
- Within days (one or more sessions/day)
- Accounting for recovery periods
- Accounting for activity- rest cycles

Duration (time)

- Entire program (weeks to months to a year)
- Each session
- Each session component (i.e., cardiovascular, resistance, flexibility)

Volume (amount)

Strength and Flexibility

- Sets
- Repetitions
- Time

Volume (amount)

Cardiovascular

- Distance
- Time

Intensity (how hard)

Strength/Resistance

- External weight
- Body weight

Speed (of contraction or on a cardio machine)

Incline (cardio example)

Programming Principles

Programming Principles

- Wolff's Law
- Specificity
- Overload
- Progression
- Measurements

Wolff's Law

"Those things subject to a force will respond by growing stronger."

Specificity

"The muscles worked during an exercise will respond according to the specific training demands."

A New Twist On Specificity

Specific training demands include mode of training like endurance and strength and how they are arranged in a program relative to one another.

Overload

"Muscles must be subjected to mechanical stress that cause them to respond physiologically."

A New Twist On Overload

- Overload is not just increasing volume and intensity to make workouts "harder".
- Can lead to overtraining.
- Overload is the thoughtful use of timing of programming variables to avoid interference of competing mechanisms and still reach training objectives.

Overtraining

Too much training and/or preparation.

Overtraining

- Breaks down the body's natural defenses **over time**.
- It is counterproductive.
- It can be dangerous and lead to injury and even death.

Symptoms of Overtraining

- Fatigue.
- Depression.
- Loss of motivation.
- Anxiety.
- Increased blood pressure.
- Increased heart rate.
- Increased rate of injury.
- Chronic muscle soreness.
- Delayed Recovery.
- Poor sleep.
- Insomnia.
- Decreased ability to concentrate.

Acute Rhabdomyolysis

- In contrast to overtraining – which is over time.
- Acute – one time over exercising to the point of exhaustion.
- Causes the breakdown of muscle tissue that causes the release of muscle fiber contents into the blood.
- Can cause kidney damage!

Rhabdomyolysis Example

- Five sets of five back squats with a heavy external load at 85% maximum 1RM (one repetition maximum).

VS.

- One set of 100 back squats as quickly as possible with a light load or body weight only.

Restorative Sleep

Using a regularly scheduled exercise program with well-designed rest and recovery periods, sleep enhances muscle strength and endurance outcomes while preventing overtraining.

Sleep and Athletes

- Sleep and recovery are vital to performance.
- However, athletes and anyone that regularly exercises at high-intensity are vulnerable to poor sleep.

Sleep Disturbances

When over 1600 studies were analyzed to determine the quality of sleep among athletes, athletes were shown to have:

- Longer sleep latencies (transition times).
- Increased sleep fragmentation (cannot stay asleep).
- Non-restorative sleep.
- Excessive daytime fatigue.

Solutions

Strategic combined programming can help to resolve issues related to poor sleep in athletes by providing clear activity-rest cycles and avoiding overtraining related to high-intensity training.

Progression

"In order for Wolff's Law to stand the test of time, workouts must be get more difficult over time."

Common Ways to Progress

- Change modes of training
- Increase volume
- Increase intensity
- Increase duration
- Increase frequency
- Decrease *intra-set* rest periods

Contemporary Progression

Accounts for the timing, intensity, and volume of modes of exercise and make up of sessions relative to the use of the five key programming variables.

Measurements

"Measurements are as important to programming as design and implementation."

Sample Strength Workout

Exercise	Reps	Resistance	Rest Between Sets
Alternating Lunge	10 - 15	65 – 85% of 1RM	20 – 60 seconds
Back Squat	10 - 15	65 – 85% of 1RM	20 – 60 seconds
Alternating Lunge	10 - 15	65 – 85% of 1RM	20 – 60 seconds
Back Squat	10 - 15	65 – 85% of 1RM	20 – 60 seconds
Alternating Lunge	10 - 15	65 – 85% of 1RM	20 – 60 seconds
Back Squat	10 - 15	65 – 85% of 1RM	20 – 60 seconds

Recovery Maximums

Length of recovery should not exceed **96 hours**. After 96 hours detraining occurs.

Combined Programming for Strength Gains

Goals

- Avoid interference.
- Maximize muscle strength.
- **While including endurance/cardiovascular training**.

Cardiovascular Programming

Programming Variables

- Type of endurance exercise (i.e., jogging or cycling); mode
- Length of recovery time (rest cycles); frequency of sessions

Programming Variables, cont'd

- Intensity of each mode (strength and cardiovascular)
- Volume (duration) of endurance training

Mode

- Cycling is recommended.
- Running decreases strength more than cycling when used in a combined training program.

Duration

Limit endurance training sessions where strength gains are the primary training goal to 20 – 30 minutes max.

Length of Recovery

Muscles need to rest for **at least 48 hours** after high-intensity exercise (greater than 85% maximum capacity) to return to baseline strength levels.

❖*Note: rest can be an active recovery that includes cardiovascular activity at a lower intensity of training*.

Frequency

- Schedule endurance and strength training on alternating days.
- Limit endurance training to three or fewer times per week.

Why Is Frequency Critical?

Scheduled training sessions teach muscles when to click on the molecular actions associated with muscle strength, size, power, or endurance gains that avoid interference and improve performance.

Intensity

- Direct relationship between intensity of endurance exercise and strength decrements.
- For best results (avoid interfere with strength gains), low to moderate cardiovascular work is recommended.

Sample Cardiovascular Workout

Mode	Frequency	Intensity	Duration
Cycling	1 - 3 times per week	Low to moderate 45 – 75% max heart rate	20 minutes ideally to 30 minutes maximum

*The sample workout above is for a program focused on strength gains.

Programming Summary

- Limit endurance training to three or fewer times per week.
- Use cycling versus running as the cardiovascular training exercise.

Programming Summary

- Use low-intensity endurance sessions.
- Keep endurance session durations to between 20 and 30 minutes.

Chronotype Programming

What is a Chronotype?

Chronotype is defined as a person's individual natural predisposition for sleep-wake patterns.

How Does It relate?

Accounts for timing of different types of training on an individual basis.

What Do Chronotypes Do?

- Chronotypes account for the time of day that a person is the most alert and perform their best.
- Chronotypes are important in exercise programming because sleep-wake cycles and time of day a person is most alert influence performance.

Discover Your Chronotype

CONTINUED

Question #1

1. **If you were entirely free to plan your evening and had no commitments the next day, at what time would you choose to go to bed?**

a. 8:00 p.m. - 9:00 p.m..... 5 points
b. 9:00 p.m. - 10:15 p.m..... 4 points
c. 10:15 p.m. - 12:30 a.m..... 3 points
d. 12:30 a.m. - 1:45 a.m..... 2 points
e. 1:45 a.m. - 3:00 a.m..... 1 point

CONTINUED

Question #2

2. **You have to do 2 hours of physically hard work. If you were entirely free to plan your day, at what time would you choose to do the work?**

a. 8:00 a.m. - 10:00 a.m.... 4 points
b. 11:00 a.m. - 1:00 p.m. ... 3 points
c. 3:00 p.m. - 5:00 p.m. ..... 2 points
d. 7:00 p.m. - 9:00 pm. ..... 1 point

CONTINUED

Question #3

3. **You have gone to bed several hours later than normal, but there is no need to get up at a particular time the next morning. Which of the following is most likely to occur?**

a. Will wake up at the usual time and not fall asleep again ... 4 points
b. Will wake up at the usual time and doze thereafter ..... 3 points
c. Will wake up at the usual time but will fall asleep again .... 2 points
d. Will not wake up until later than usual ..... 1 point

CONTINUED

Question #4

4. **You have to take a 2-hour test you know will be mentally exhausting. If you were free to choose, when would you take the test?**

a. 8:00 p.m. - 9:00 p.m..... 5 points
b. 9:00 p.m. - 10:15 p.m..... 4 points
c. 10:15 p.m. - 12:30 a.m..... 3 points
d. 12:30 a.m. - 1:45 a.m..... 2 points
e. 1:45 a.m. - 3:00 a.m..... 1 point

Question #5

5. **If you had no commitments the next day and were entirely free to plan your own day, what time would you get up?**

a. 5:00 a.m. - 6:30 a.m. ..... 5 points
b. 6:30 a.m. - 7:45 a.m. ..... 4 points
c. 7:45 a.m. - 9:45 a.m. ..... 3 points
d. 9:45 a.m. - 11:00 a.m. .... 2 points
e. 11:00 a.m. - 12:00 a.m... 1 point

Question #6

6. **A friend has asked you to join him twice a week for a workout in the gym. The best time for him is between 10 p.m. - 11 p.m. With nothing else in mind other than how you normally feel in the evening, how do you think you would perform?**

a. Very well .....1 points
b. Reasonably well ... 2 points
c. Poorly ..... 3 points
d. Very poorly ..... 4 points

CONTINUED

Question #7

7. We hear about 'morning' and 'evening' types of people. Which of these types do you consider yourself?

a. Definitely morning type ..... 6 points
b. More a morning than an evening type ... 4 points
c. More an evening than a morning type ... 2 points
d. Definitely an evening type ..... 0 points

CONTINUED

Results

Add your scores together to get your total and compare your score with the table below to get your chronotype:

Definitely morning type ..... 32 - 28 points
Moderately morning type ... 27 - 23 points
Neither type ..... 22 - 16 points
Moderately evening type ... 15 - 11 points
Definitely evening type ..... 10 - 6 points

Individual Variability

- Regardless of individual chronotype, some things won't change like when circulating levels of testosterone peaks.
- The key is to remember that even if testosterone levels are high, if someone is tired because they have been up since 5 am or worked an eight hour day prior to getting to the gym fatigue is a factor.

Individual Variability

- If fatigued, coordination could be impacted making heavy weight lifting dangerous.
  - In that case, midday strength training may be a better choice.
- Focus to time workouts to the best of your ability taking all individual and programming factors into consideration.

Chronotype Programming

- Endurance and stamina peak first thing in the morning.
- **Early to mid-morning** is the best time for cardiovascular training.

Chronotype Programming

- Cognition is greatest around midday.
- **Midday** is the best time to do sport specific and mental training.

Chronotype Programming

- Muscle strength is greatest for most people between 4 and 6 pm.
- Muscle speed is maximized between 4 and 6 pm.
- Testosterone levels peak between 4 and 6 pm.
- Strength, mass, and power training will be maximized **between 4 and 6 pm**.

Chronotype Programming

- Muscle pliability peaks between 4 and 6 pm.
- Flexibility training will be easiest and most comfortable **between 4 and 6 pm**.

Quiz Resource

Horne, JA, Östberg O. 1976. "A self-assessment questionnaire to determine morningness-eveningness in human circadian rhythms". International Journal of Chronobiology. 4 (2): 97–110.

Flexibility Training for Athletes

Avoiding Interference

Flexibility training, if not programmed correctly, can lead to muscle performance decrements.

❖Most specific to performance is that stretching can adversely impact muscle power.

Flexibility Programming

- Combined training must include flexibility training.
- The ability of a muscle to lengthen is a factor to strength and power output.
- The general rule is to avoid static stretches and go with dynamic stretching prior to performance.

Programming Recommendations

- If used before events, keep static stretches to less than **30 seconds**.
- If static is used before events, provide at least **five minutes** of dynamic activity between stretching and performance.

Programming Recommendations

- Use dynamic stretching before events.
- Do static stretches where each stretch is held longer than 30 seconds after training and/or competition.

Wrap-up

The Clinical Question

*"Does combined training decrease **muscle force generation capacity (MFGC)** and thus decrease performance in college-aged and adult professional athletes?"*

Summary

- Combined training is an effective and common way to train.
- However, endurance training does interfere with strength and power gains critical to performance.
- Follow programming recommendations outlined in the strength gains section to avoid interference.

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Thank you!

~ Dr. Amy