

Introduction to Exercise Physiology

- Training Principles



Learning Objectives

- Understand the terms associated with training principles
- Be aware of the physiological processes involved in training the associated body systems
- To know the baseline types of exercise modality available for training individuals with specific varying needs

Task

- Discuss in groups of 4-5 some of the components of Health in relation to Physical Fitness
- Present your results back to the rest of the team

Components of Health



Terminology: Muscular Strength

- Strength: maximal force that a muscle or muscle group can generate
 - Isometric – Static
 - Isotonic – Muscle shortening or lengthening under tension
 - Isokinetic – constant rate of motion
- 1 repetition maximum (1RM): maximal weight that can be lifted with a single effort
 - Start with proper warm-up
 - Add weight until only 1 repetition can be performed

Terminology: Muscular Power

- Muscular power: rate of performing work
 - Explosive aspect of strength
 - $\text{Power} = \text{force} \times (\text{distance}/\text{time})$
- Power more important than strength for many activities
- Typically measured with electronic devices
 - Tendo units
 - Accelerometers

Terminology:

Muscular Endurance

- Endurance: capacity to perform repeated muscle contractions (or sustain a single contraction over time)
- Number of repetitions at given % 1RM
- Increased through
 - Gains in muscle strength
 - Changes in local metabolic, cardiovascular function

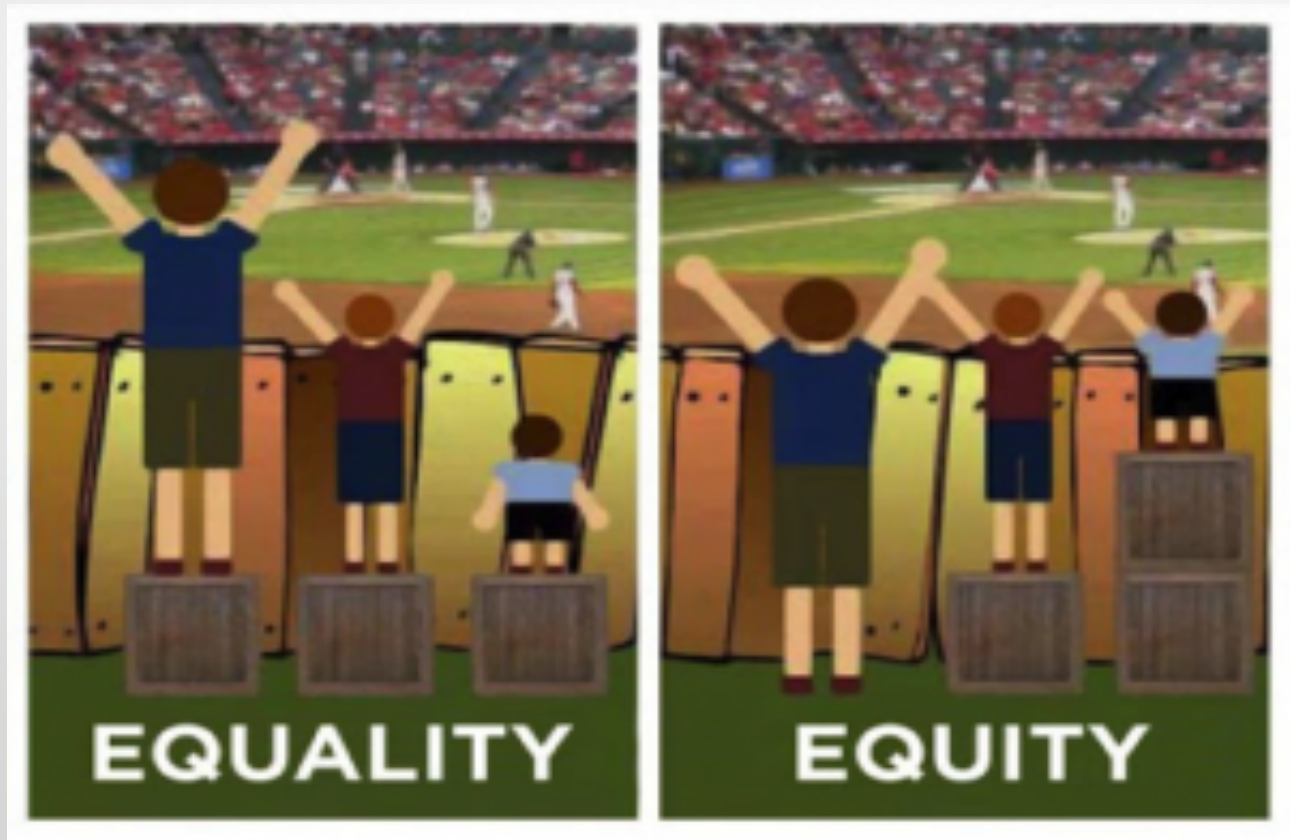
Terminology: Aerobic Power

- Aerobic power: rate of energy release by oxygen-dependent metabolic processes
- Maximal aerobic power: maximal capacity for aerobic resynthesis of ATP
 - Synonyms: aerobic capacity, maximal O_2 uptake, VO_{2max}
 - Primary limitation: cardiovascular system
 - Can be tested in submaximally or in a full lab test.

Terminology: Anaerobic Power

- Anaerobic power: rate of energy release by oxygen-independent metabolic processes
- Maximal anaerobic power: maximal capacity of anaerobic systems to produce ATP
 - Also known as anaerobic capacity
 - Maximal anaerobic running test
 - Wingate anaerobic test

Based on these the picture how might you change a training program to ensure optimal results?



General Principles of Training:

Principle of Individuality

- Equity versus Equality
- Genetics affects performance
- Variations in cell growth rates, metabolism, and cardiorespiratory and neuroendocrine regulation
- Explains high versus low responders

General Principles of Training:

Principle of Progressive Overload

- Must increase demands on body to make further improvements
- Muscle overload: muscles must be loaded beyond normal loading for improvement
- Progressive training: as strength ↑, resistance/repetitions must ↑ to further ↑ strength

Magnusson, Langberg and Kjaer, 2010

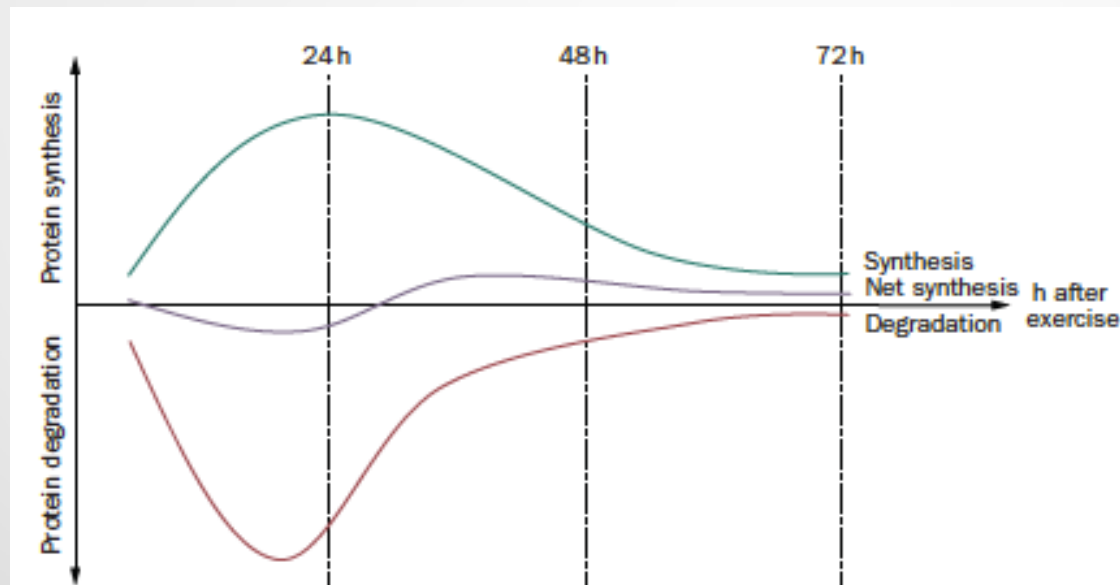


Figure 2 | Schematic representation of collagen synthesis and degradation. Acute exercise in humans is followed by an increase in both the synthesis and degradation of collagen. Over the first 24–36h, this response results in a net loss of collagen, but is followed by a net synthesis 36–72 h after exercise. Repeated training with rest periods that are too short can result in a net degradation of the matrix and lead to overuse injury.^{65,66,111}



GROUP TASK –

How might this article and the principle of overload effect the way you exercise or advise about exercise?

General Principles of Training:

Principle of Specificity

- Exercise adaptations specific to mode and intensity of training
- Training program must stress most relevant physiological systems for given health or sport related target
- Training adaptations highly specific to type of activity, training volume, and intensity

General Principles of Training:

Principle of Reversibility

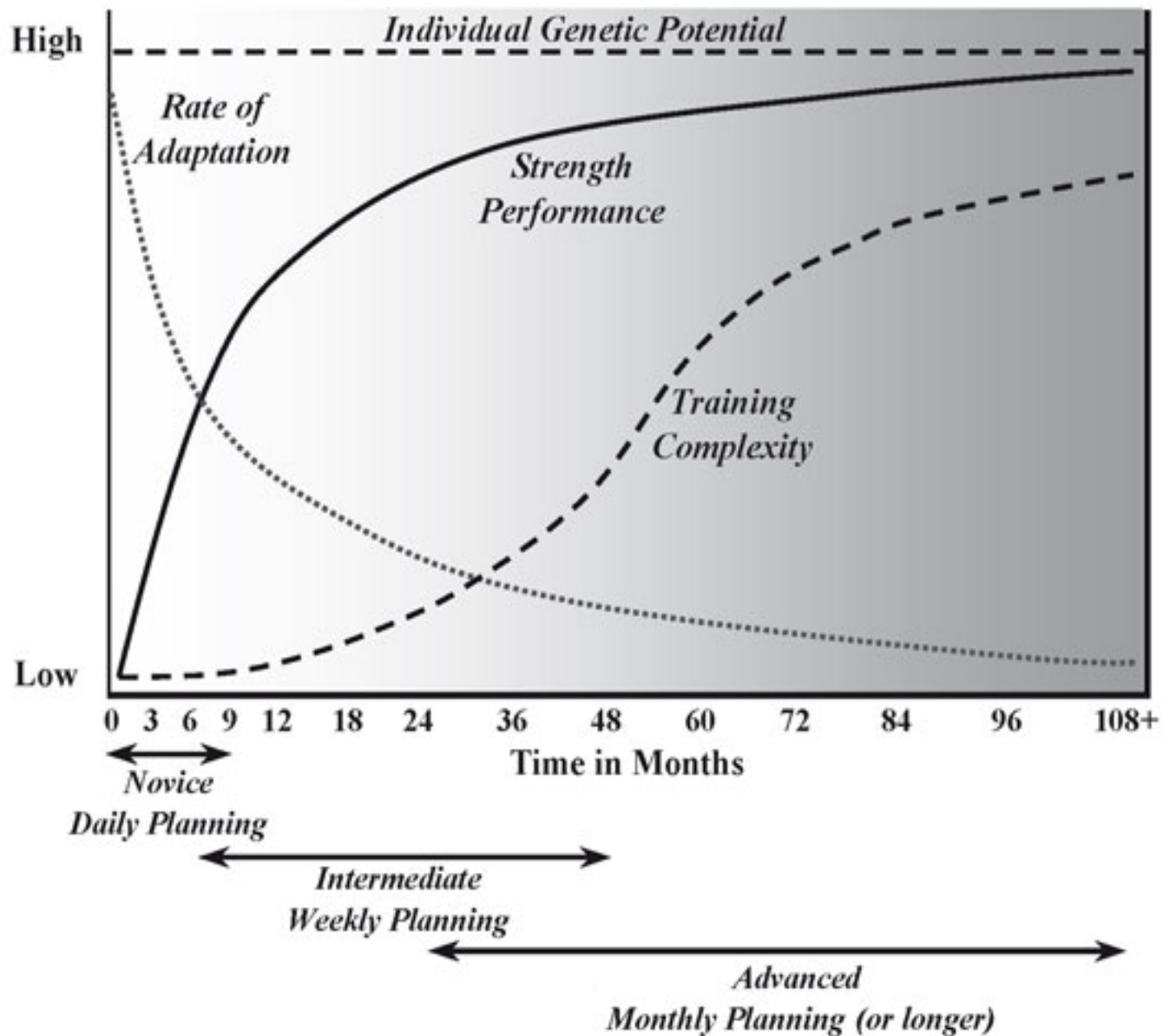
- Use it or lose it
- Training → improved strength and endurance
- Detraining reverses all gains



General Principles of Training:

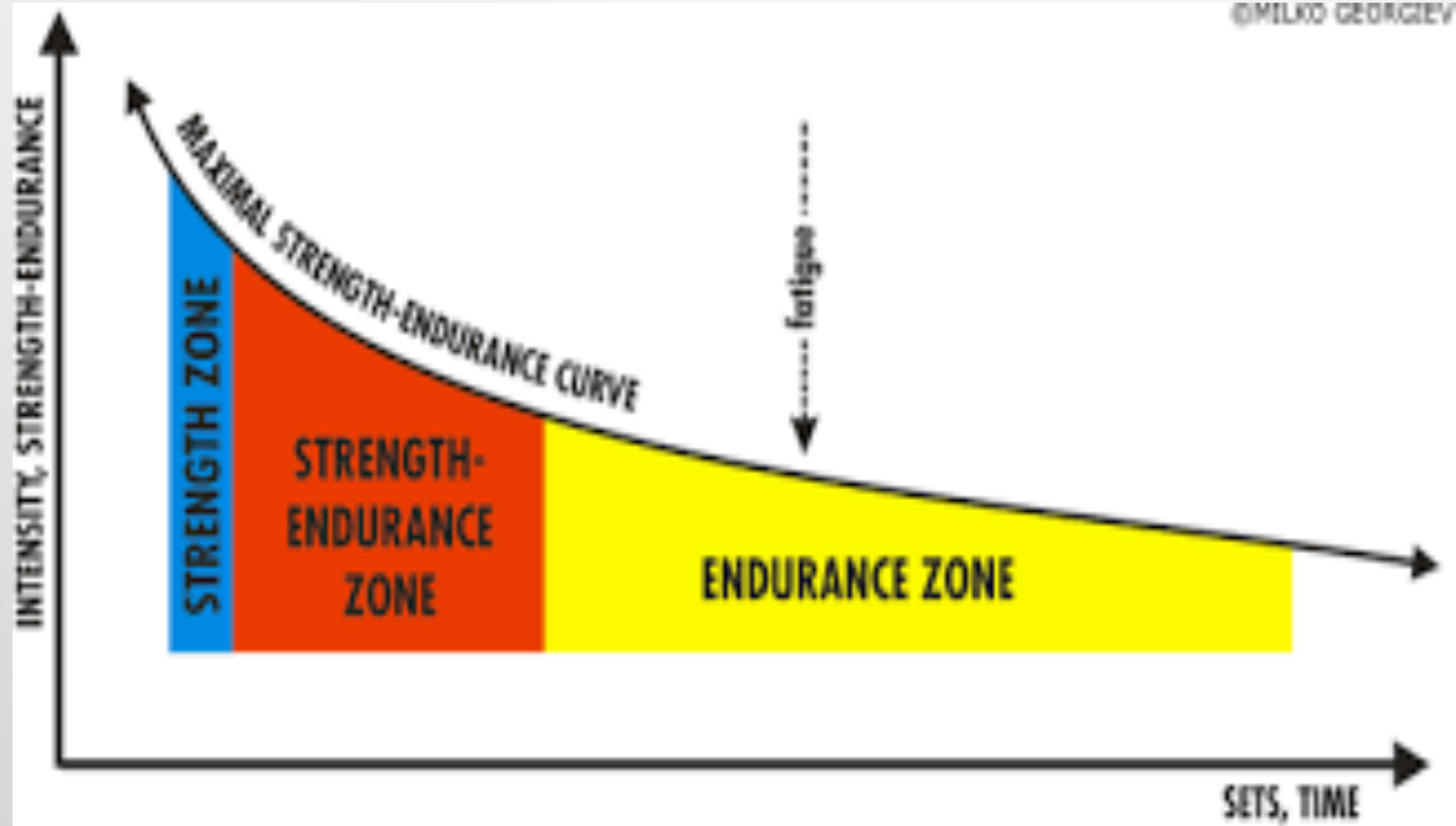
Principle of Variation

- Also called principle of planning for health or periodisation
- Systematically changes one or more variables to keep training challenging
 - Intensity, volume, and/or mode
 - ↑ Volume/↓ intensity
 - ↓ Volume/↑ intensity
- Macrocycles - One or two years
- Mesocycles – Two to eight weeks
- Microcycle – Less than seven days



Resistance Training Programs: Training Needs Analysis

- First appropriate step in designing and prescribing appropriate resistance training program identifies
 - Muscle groups to target
 - Type of training
 - Energy system to stress
 - Injury prevention needs
- Specifics of resistance training program design based on needs analysis



Resistance Training : Free Weights Versus Machines

- Free weights (constant resistance)
 - Tax muscle extremes but not midrange
 - Recruit supporting and stabilizing muscles
- Machines
 - May involve variable resistance
 - Safer, easier, more stable, better for novices?!
 - Limit recruitment to targeted muscle groups

Resistance Training Programs: Variable-Resistance Training

- Resistance ↓ in weakest ranges of motion, ↑ in strongest ranges
- Muscle works against higher percentage of its capacity at each point in range of motion



Resistance Training Programs: Plyometrics

- Also known as stretch-shortening cycle exercise
 - Uses stretch reflex to recruit motor units
 - Stores energy during ECC, released during CON
 - Example: deep squat to jump to deep squat
- Proposed to bridge gap between speed and strength training

TABLE 9.2 American College of Sports Medicine's Recommendations for Resistance Training Programs^a

Primary goal of resistance training program	Training level	Loading	Volume	Velocity	Frequency (times per week)
Strength development	Novice	60-70% 1RM	1-3 sets, 8-12 reps	Slow, moderate	2-3
	Intermediate	70-80% 1RM	Multiple sets, 6-12 reps	Moderate	3-4
	Advanced	80-100% 1RM	Multiple sets, 1-12 reps	Unintentionally slow to fast	4-6
Muscle hypertrophy	Novice	70-85% 1RM	1-3 sets, 8-12 reps	Slow, moderate	2-3
	Intermediate	70-85% 1RM	1-3 sets, 6-12 reps	Slow, moderate	4
	Advanced	70-100% 1RM; emphasis on 70-85%	3-6 sets, 1-12 reps	Slow, moderate, fast	4-6

(continued)

TABLE 9.2 (continued)

Primary goal of resistance training program	Training level	Loading	Volume	Velocity	Frequency (times per week)
Development of muscle power	Novice	0-60% 1RM—lower body; 30-60% 1RM—upper body	1-3 sets, 3-6 reps	Moderate	2-3
	Intermediate	0-60% 1RM—lower body; 30-60% 1RM—upper body	1-3 sets, 3-6 reps	Fast	3-4
	Advanced	85-100% 1RM	3-6 sets, 1-6 reps, various strategies	Fast	4-5
Increased local muscular endurance	Novice	Light	1-3 sets, 10-15 reps	Slow—moderate reps Moderate—high reps	2-3
	Intermediate	Light	1-3 sets, 10-15 reps	Slow—moderate reps Moderate—high reps	3-4
	Advanced	30-80% 1RM	Various strategies, 10-25 reps or more	Slow—moderate reps Moderate—high reps	4-6

^aThese recommendations also include the type of muscle action (eccentric and concentric), single-joint versus multiple-joint exercises, order or sequence of exercises, and the rest intervals. See text for further information.

^bPeriodized—see text for explanation of periodization.

Adapted from ACSM, 2009.

Anaerobic and Aerobic Power Training

- Train sport-specific metabolic systems
- Programs designed along a continuum from short sprints to long distances
 - Sprints: ATP-PCr (anaerobic)
 - Long sprint/middle distance: glycolytic (anaerobic)
 - Long distance: oxidative system (aerobic)

Anaerobic and Aerobic Power Training: Interval Training

- Repeated bouts of high/moderate intensity interspersed with rest/reduced intensity
 - More total exercise performed by breaking into bouts
 - Same vocabulary as resistance training: sets, repetitions, time, distance, frequency, interval, rest
- Example
 - Set 1: 6 x 400 m at 75 s (90 s slow jog)
 - Set 2: 6 x 800 m at 180 s (200 s jog-walk)

Anaerobic and Aerobic Power Training: Distance of Interval

- Determined by requirements of activity
- Sprint training: 30 to 200 m (even 400 m)
- Distance training: 400 to 1,500+ m

Anaerobic and Aerobic Power Training: Continuous Training

- Training *without* intervals
- Targets oxidative, glycolytic systems
 - Can be high or low intensity
 - High intensity near race (85 to 95% HR_{max})
 - Low intensity: LSD training

Anaerobic and Aerobic Power Training: LSD Training

- Long, slow distance
- Train at ~60 to 80% HR_{max} (50 to 75% VO_{2max})
 - Popular, safe
 - However, must train near race pace, too
- Main objective: distance, not speed
 - Up to 10 to 20 mi/day, 60 to 100 mi/week
 - Less cardiorespiratory stress
 - Can be greater joint/muscle stress, overuse injuries.

Based on the information presented how what exercise would be suitable for:

- 68 year old lady with a heart valve issue who is awaiting an operation?
- 24 year old sportsman who has been inspired by the recent Olympics to take up sprint cycling?
- 45 year old bank account manager who has recently seen his GP and told to improve his lifestyle?