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Understanding Interval Training: Chasing Zatopek

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What is Interval Training?

- **Method for improving fitness by breaking up a period of work into work & rest.**
- **Manipulates 4 variables:**
  - **time (or distance) of each work period**
  - **intensity of each work period**
  - **time of each recovery period**
  - **# of repetitions**

History of Interval Training

- Originated in Europe in 1930s to develop fitness in competitive runners.
- First studied by German coach Woldemar Gerschler & physiologist Hans Reindell of University of Freiburg.
  - believed that primary stimulus for cardiovascular improvement occurs during recovery intervals between work periods rather than during periods of activity, as heart rate decreases from elevated value.
  - placed emphasis of workout on recovery interval, prompting them to call it an *interval workout* or *interval training.*
- Original method consisted of running periods of 30-70 sec at intensity that elevated heart rate to 170-180 beats/min, followed by sufficient recovery to allow heart rate to decrease to 120 beats/min.

History of Interval Training

- In late 1940s/early 1950s, interval training popularized by Emil Zatopek of Czechoslovakia (only runner to win 5,000 meters, 10,000 meters, & marathon in same Olympics).
- Hungarian coach Mihaly Igloi developed concept of sets of short distances run quickly.
  - His coaching centered on large amounts of interval training, believing that large amount of speed training built stamina.
- In 1960s, physiologist Per-Olaf Åstrand discovered that by breaking up a set amount of work into smaller segments, you can perform more work at higher intensity.
  - You can run 5 x 1,000 meters faster than 5,000 meters
  - You can run 10 x 500 meters faster than 5 x 1,000 meters
  - You can run 20 x 250 meters faster than 10 x 500 meters

Performance Benefits of Interval Training

- Improves fitness quickly
- Time-efficient strategy to induce skeletal muscle remodeling toward a more oxidative phenotype (Cochran et al. 2014)
- Interval workouts (e.g., 4 min total work @ 170% VO_2max) induces comparable muscle fiber changes as continuous exercise (e.g., 30 min @ 65% VO_2max) (Scribbans et al. 2014)
- Turns on signaling cascade that leads to synthesis of mitochondria (Gibala et al. 2009)
- Increases skeletal muscle enzyme activity (Gibala et al. 2006; MacDougall et al. 1998; Talanian et al. 2007)

Types of Interval Workouts

- **Acidosis (lactate) threshold intervals**
- **VO_2max intervals**
- **Anaerobic capacity intervals**
- **Anaerobic power intervals**

Acidosis Threshold Intervals

- **Acidosis threshold refers to fastest pace that is still aerobic, before anaerobic metabolism begins to play significant role.**
- **Work periods lasting 5-25 min with short recovery intervals < time of work periods.**
- **Adaptations include:**
  - **increase aerobic system (Krebs cycle & electron transport chain) enzyme activity**
  - **increase lactate clearance from muscle**
  - **increase acidosis threshold to faster pace, making what was an anaerobic pace now high aerobic**

Acidosis Threshold Pace

- **Slower, recreational runners:**
  - **~10-15 sec/mile slower than 5K race pace (~10K race pace)**
  - **~75-80% max HR**
- **Highly-trained:**
  - **~25-30 sec/mile slower than 5K race pace (~15-20 sec/mile slower than 10K race pace)**
  - **85-90% max HR**
- **Subjectively feels 'comfortably hard' (7-7.5 on scale of 1-10)**

Acidosis Threshold Intervals

- **AT Intervals**
  - **short runs @ AT pace with short rest periods**
  - **4 x 1 mile @ AT pace with 1:00 rest**
  - **8 x 1,000 meters @ AT pace with 1:00 rest**
- **AT+ Intervals**
  - **shorter runs @ slightly faster than AT pace with short rest periods**
  - **2 sets of 4 x 1,000 meters @ 5-10 sec/mile faster than AT pace with 45 sec rest & 2:00 rest between sets**
- **AT Run**
  - **continuous run @ AT pace**
  - **3 to 4 miles (~20-25 min) @ AT pace**
- **AT/LSD Combo Run** (for half-marathon & marathon)
  - **long, easy distance runs with portion run @ AT pace**
  - **12-16 miles with last 2-4 miles @ AT pace**
  - **2 miles easy + 3 miles @ AT pace + 6 miles easy + 3 miles @ AT pace**

VO2max Intervals

- **VO2max is maximum volume of O2 muscles consume per minute.**
- **Intense work periods lasting 3-5 min with recovery intervals ≤ time of work periods.**
  - **target improvements in aerobic power by using aerobic system at its fastest rate**
- **One of best methods to improve cardiovascular conditioning (heart's ability to pump blood & oxygen to active muscles)**
- **Adaptations include:**
  - **increase enzyme activity in aerobic system (Krebs cycle & electron transport chain)**
  - **increase VO2max**
  - **increase max stroke volume & cardiac output**
    - **left ventricular hypertrophy**
    - **heart contractility**
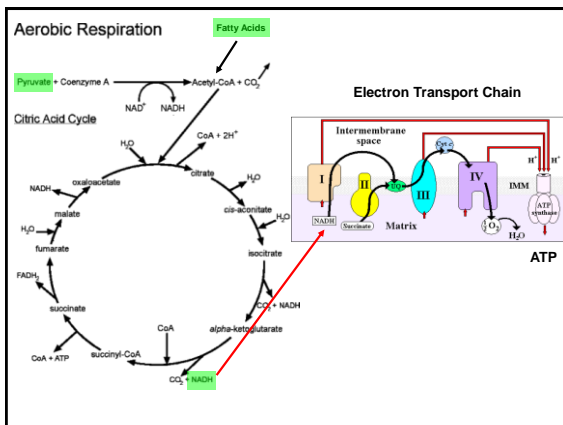
VO2max Training

$$VO_2 = SV \times HR \times (\text{a-v } O_2 \text{ difference})$$

$$VO_2 = CO \times (\text{a-v } O_2 \text{ difference})$$

Cardiac factors

Peripheral factors

VO₂max Intensity

- Intensity that elicits VO₂max
- Fastest speed that can be maintained for about 7-10 min
- 95-100% max HR
- Slower/recreational runners:
  - 1 to 1½-mile race pace
- Highly-trained/competitive runners:
  - 2-mile race pace
- Subjectively feels 'hard but manageable' (9 on scale of 1-10)

VO₂max Intervals

- 4 x 1,000 meters @ VO₂max pace w/ 1:≤1 work:rest ratio
- 6 x 800 meters @ VO₂max pace w/ 1:≤1 work:rest ratio
- 16 x 400 meters @ VO₂max pace w/ 1:<1 work:rest ratio

If you can run 1½ miles in 10:00 (=6:40 mile pace):

- 4 x 1,000 meters in 4:10 w/ 3:00 jog recovery
- 6 x 800 meters in 3:20 w/ 2:30-3:00 jog recovery
- 16 x 400 meters in 1:40 w/ :50 jog recovery

Although tempting to run faster when intervals are shorter, pace should be same for all 3 workouts since goal is same — to improve VO₂max. As runners progress, make workouts harder by adding more reps or decreasing recovery intervals rather than by running faster. Only increase speed of work periods once races have shown that the runner is indeed faster.
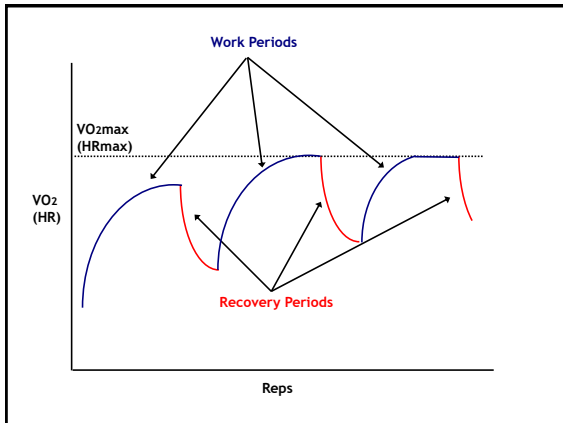
Anaerobic Capacity Intervals

- Anaerobic capacity refers to ability to regenerate energy (ATP) through glycolysis.
- Intense work periods lasting 30 sec to 2 min with recovery intervals 2-4 times as long as work periods.
  - target improvements in anaerobic capacity by using anaerobic glycolysis as predominant energy system
- Adaptations include:
  - increase muscle glycolytic enzyme activity
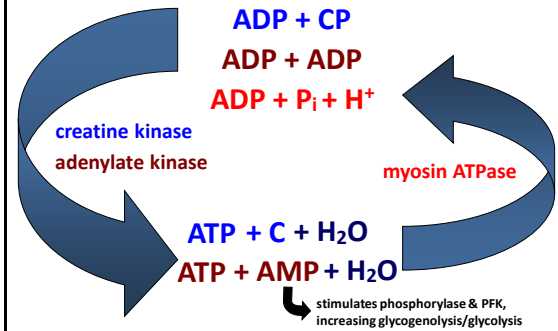 - improve buffering capacity of muscle acidosis
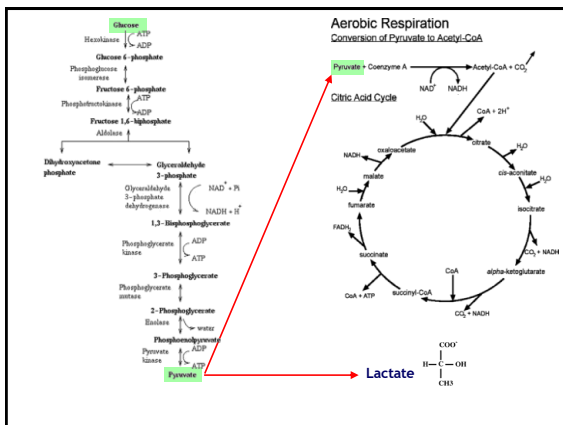
Anaerobic Capacity Intervals

- 6-8 x 400 meters @ mile race pace w/1:2 work:rest ratio
- 2 sets of 3-4 x 300 meters @ 800-meter race pace w/1:3 work:rest ratio & 5:00 rest between sets
- 4 x 600 meters @ 85% 400-meter pace w/1:2 work:rest ratio
- Exact # reps doesn't matter; what matters is causing fatigue

Anaerobic Power Intervals

- **Anaerobic power refers to ability to regenerate ATP through phosphagen system.**
- **Very intense work periods lasting 5-15 sec with 3- to 5-min recovery intervals.**
  - **target improvements in anaerobic power by using phosphagen system as predominant energy system**
  - **long recovery allows for near-complete replenishment of creatine phosphate in muscles**
- **Adaptations include:**
  - **increase fast-twitch motor unit activation**
  - **increase activity of creatine kinase, the enzyme responsible for breaking down creatine phosphate**

Phosphagen System

ADP + CP
ADP + ADP
ADP + P$_i$ + H$^+$

creatine kinase
adenylate kinase

myosin ATPase

ATP + C + H$_2$O
ATP + AMP + H$_2$O

stimulates phosphorylase & PFK, increasing glycogenolysis/glycolysis

Anaerobic Power Intervals

- **10 x 20 meters @ max speed w/3-5 min rest**
- **10 x 50 meters @ max speed w/3-5 min rest**
- **4 x 150 meters @ near max speed w/3-5 min rest**

Final Thoughts

- **Intervals are a great way to burn calories & get VERY fit fast.**
- **You can improve aerobic fitness more than anaerobic fitness.**
- **It takes longer to improve endurance than speed & power.**
- **Fatigue matters more than specific # of reps.**
- **Always run at the *slowest* speed to cause the desired adaptation.**