

## Session 4408: HIIT Training Unleashed

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- I. Historical roots of HIIT and other notable achievements, (Veronique Billat. (2001) Sports Medicine)
  - A. Pavo Nurmi, 1920-1930; Olympic Champion from Finland, won 9 Gold medals in 1,500m, 3,000m, 5,000m, 10,000m, and Steeplechase; used interval training (6 repetitions, 400m, 24km/hr or 14.88mph, did this workout within 10km-20km (6-12mile) runs, introduced short (400m) intervals; HVIT High Volume Interval Training ( $\geq 60$  min)
  - B. Siegfried Hermann 1950-1960's; German world champion 1500m and 3000m, did 4 sets of six x 200m runs; 98%-118% of 1500m speed; 50-60sec rest between 200m bouts and 8min between sets; VIIT Variable Intensity Interval Training
  - C. Gordon Pirie, 1950-1960 (Great Brittan), 5 world records (5,000m/10,000m); 216,000 miles in 40 yrs.
  - D. Emil Zatopek, 1948-1955 (Czechoslovakia), Triple gold medalist in 1952 Olympics in 5,000, 10,000 and Marathon, repeated up to 100 x 400m repetitions/day interspersed by 200m of recovery run, would train in any weather, including snow, would often wear heavy work boots as opposed to run shoes.
  - E. Greta Waitz, 1978-1988, Nine-time winner of New York Marathon. Two world records in the 3,000m and World Champion in the marathon in 1983. She utilized a combination of Fartlek, short intervals, long intervals, tempo training and distance runs. First marathon was a lark encourage by husband.
  - F. Paula Radcliffe, 1990 -2011 (Great Britian), 3-time winner of London Marathon, 3-time NYC Marathon champion. Fastest female marathoner of all time. 2:15:25 in 2003, 145 miles/week (very consistent), trained at or above lactate threshold, 8-day cycle with 2 long runs, a hard session ever other day and rest; does core exercises every night; "Never set limits, go after your dreams, don't be afraid to push the boundaries. And laugh a lot-it's good for you!" "I can't imagine living and not running."
  - G. First scientific publication on HIIT in 1959 by Reindell and Roskamm
  - H. Saltin, B. and Astand, P., 1960. Swedish physiologists who began intense study of interval training. Introduced intervals as % of  $VO_2$ max and % speed of  $VO_2$ max
  - I. Metabolic adaptations, 1970's. Researchers around world begin study of metabolic adaptations of interval training. Muscle enzymes of interest include ATPase, creatine kinase, adenylate kinase. Jonas Bergstrom and introduction of biopsy needle made metabolic research a viable science.
  - J. HIIT in 2000 to 2019. More sport application (tennis, handball, soccer, rugby, American football, etc.). Clinical application (COPD, cardiac patients, diabetes). Molecular research focused on solving questions on metabolism and bioenergetic effects of HIIT.
- II. HIIT and Cardiovascular (CV) Physiology (Overview of the CV system anatomy): Video ([www.chop.edu](http://www.chop.edu))
  - A. Take-Home Message #1: The higher your  $VO_2$ max the healthier you are (Weston et al., 2014)
  - B. Maximal oxygen consumption ( $VO_2$ max): The maximal rate of consumption, distribution and utilization of oxygen in ml oxygen/kg/min. 4% to 46% increase in studies up to 24 weeks (Boutcher 2011)

- C. Low cardiorespiratory fitness is a sounder predictor of death than risk factors such as hypertension, smoking, diabetes (Booth et al., 2012)
- D. A one met (3.5 ml/kg/min) increase equals 13-15% decrease in risk of CV disease and all causes of mortality (JAMA 2009)
- E. Take Away: Encourage clients to keep improving their aerobic fitness. High aerobic fitness = optimal cardioprotection
- F. John F. Kennedy, "Physical fitness is the basis for all other forms of excellence."
- G. Relative left ventricle mass is 35% greater in trained vs. untrained individuals
- H. "High-intensity interval training (HIIT) is a more potent stimulus than moderate-intensity continuous training (MICT) in enhancing vascular function. HIIT has a positive influence on cardiorespiratory fitness (CRF) and biomarkers associated with vascular function than MICT." (Ramos et al., 2015)
- I. Common program to improve CV function: 5-10min warm-up; alternate 4-min bouts of high intensity (85% of max heart rate {MHR}) with 3-min recovery periods (60-70% of MHR); 4 intervals on any mode, 3x/week; workout is 28 minutes (plus warm-up and cool-down)
- J. Stroke volume (SV): Blood pumped beat by each heart ventricle. Average at rest from 70ml-80ml each beat. EDV represents end-diastolic volume (describing the filling of the ventricles). ESV represents end-systolic volume (describing blood left in ventricles after ejection)  $SV=EDV-ESV$
- K. Helgerud study (2007). 40 fit males in 4 grps, 3x/week for 8 weeks of running in 4 groups; steady state group 70% of HRmax for 45 min, lactate threshold group 85% of HRmax for 24 min, 15/15 interval group 15 sec (90-95% HRmax) with 15 sec (70% HRmax) for 24 min, 4/4 interval group 4 min (90-95% HRmax) with 3 min (70% HRmax) for 28 min. RESULTS VO<sub>2</sub>max no change in steady state or lactate threshold group but 15/15 group had 6% increase and 4/4 group had 9% increase; RESULTS Stroke Volume no change in steady state or lactate threshold group but 15/15 group had 9% increase and 4/4 group had 9% increase
- L. What influences stroke volume during exercise? Venous blood return enhances EDV (ventricle filling), ventricular stretch (capacity to enlarge leads to better ejection of blood), ventricular contractility (signal from brain to contract harder), enhanced dilation of arteries (greater blood flow in aortic and pulmonary arteries)
- M. Peak power: The maximal power output measured in watts. Typically performed on a cycle ergometer. Increase by 19.4% with HIIT programs (Weston et al 2014)
- N. Anaerobic power as measured by Wingate 30sec power test: 5% to 28% increase (Boutcher 2011)
- O. E.P.O.C. represents the Excess Post-Exercise Oxygen Consumption (called the 'exercise after burn'). Factors that E.P.O.C. include creatine phosphate (CrP) replenishment, metabolism of lactate, temperature recovery, hormones recovery. The oxygen consumed to bring physiological variables (above) to pre-exercise. Research shows that HIIT programs have very high E.P.O.C. Kravitz 'blender' explanation 'Why'.
- P. Capillary density: a proliferation of capillaries in skeletal muscle (>15%) (Kenny et al. 2015)

### III. HIIT and clinical exercise physiology variables

- A. HIIT exercise increases 'sensitivity to insulin' 23% to 58%; glucose transporters (GLUT4) (Kessler et al 2012; Boutcher 2011)
- B. Insulin resistance: insulin no longer binds to the insulin protein receptors on muscle cell; pancreas overload
- C. HIIT and blood pressure (BP): systolic BP reduce 12mmHg; diastolic reduced 8mmHg, Molmen-Heansen 2012 (12-week study training 3x/week)
- D. HIIT and fat loss; Short Sprint Training from Australia; 8 seconds (80-90% HR peak; 120-130 rpm) sprint and 12 seconds recovery (40 rpm) with same load on cycle ergometer; 3x week for 12 weeks; up to 20 minute sessions; no change in body mass; % body fat (-6%); abdominal fat (-8.5%); visceral fat (-17%); VO2max (+15%). (Heydari 2015)
- E. HIIT and HDL-C (good cholesterol); has been shown to improve 18% in 8 weeks; 36 untrained men (21-36 yrs); 4x800m at 90% age-predicted heart rate max; rested passively equal time they ran (Musa 2009)

#### V. Metabolic adaptations of HIIT

- A. Where is fat completely oxidized in cells? Mitochondria (think of it as a fat burning fireplace)
- B. With cardiovascular and HIIT training mitochondrial density increases: the mitochondria get 35% bigger and can reproduce up 15-50% more (Kenney et al 2015)
- C. Metabolic model diagram: In this model calcium-calmodulin kinase (CaMK) and adenosine monophosphate kinase (AMPK) are signaling pathways that activate peroxisome proliferator-activated receptor-g coactivator-1 $\alpha$  (PGC-1 $\alpha$ ). PGC-1 $\alpha$  is like a "master switch" that is believed to be involved in promoting the development of the skeletal muscle function (increase in fat oxidation, increase in GLUT4 and glycogen, increase in mitochondrial density, increase in slow-twitch muscle fibers oxidative capacity. High-volume training appears more likely to operate through the CaMK pathway and HIIT appears more likely to signal via the AMPK pathway.
- D. HIIT improves mitochondrial dysfunction. Mitochondrial dysfunction is central to most chronic diseases and could play a vital role in reduced cardiorespiratory fitness. HIIT has been shown to significantly increase PGC-1 $\alpha$ , increasing mitochondrial biogenesis (Weston et al 2014). Mitochondrial biogenesis is essential to maintain the integrity of skeletal muscle. The fluctuation in ATP turnover in interval training (not seen in steady state training) activates signaling pathways, which increase PGC-1 $\alpha$  (Daussin et al 2008)

#### VI. HIIT Conditioning programs: Special suggestion: to prevent overuse and overtraining, complete programs on different modes of exercise

##### 1) HVIT: High Volume Interval Training (Perry et al., 2008)

**Protocol:** Subjects completed 10 exercise intervals lasting 4 minutes interspersed with 2-minute rest intervals (option; no exercise or self-selected light exercise).

**Intensity:** The subjects in this study were at 95% of their actual heart rate max during the 4-minute intervals, which would be analogous to a 17-18 on the RPE scale. (Reminder, modify intensity appropriately for clients.)

**Duration:** This total workout takes close to one hour to complete.

## **2) SIT: Sprint Interval Training** (Burgomaster et al. 2008)

**Protocol:** Subjects did 4-6 sprint intervals lasting 30 seconds interspersed with 4.5 min self-selected pace recovery

**Intensity:** The subjects in this study performed at an all-out effort, which would suggest about a 18-20 RPE rating. Reminder, this workout involves a very forceful effort bout which can easily be modified to a much less vigorous exertion for clients not prepared for that rigorous of a stimulus. Self-selected 4.5 minute recovery 8-9 RPE

**Duration:** This total workout takes 20 to 30 minutes for the 4-6 sprint intervals, respectively.

## **3) HITT with Variable Recovery** (Seiler & Hetlelid, 2005).

**Protocol:** The subjects did 4-minute bouts of exercise (can do on any mode) at near maximal intensity with alternating recovery intervals of 1, 2 and 4 minutes

**Intensity:** Near-maximal interval hard to very hard, or 17-18 on the RPE scale. The recovery is self-selected

## **4) Combination HIIT & CV Conditioning** (Adapted from Lausen, 2010).

Interval: 30 sec of sprinting on any mode; Rest period of 120 sec. Work/Rest ratio 1-to-4. Duration for up 8 min. Next, complete 20-30 minutes of slow cycle at 50-65% HRmax (on any mode). Modify by completing on multiple modes (cycling, elliptical training, running, rowing, stair stepping, etc)

## **5) Long Duration Interval Cycling Plus Running** (Sandbakk et al, 2012)

**Protocol:** The subjects did two 10-minute intervals at cycle race pace with 5 to 7-min recovery; After completion of two intervals subjects did a 20 to 30 min low intensity treadmill run

**Intensity:** The near-maximal interval was hard to very hard, or around 17-18 on the RPE scale. The recovery interval self-selected. **Duration:** This total duration can vary to individual goals

## **6) Explosive Single Leg Jumps with Hill Sprints** (Paton et al., 2005 & 2009)

**Protocol:** 20 single leg jumps each leg; then 30 sec sprints (any mode) with 30 sec rec.

**Intensity:** Sprints are at a hard to very hard intensity and recovery is self-selected.

**Duration:** Repeated the entire bout up to 4 times

## **7) Weighted Vest Workout: Elliptical or Treadmill** (Tiumil, 2011)

**Protocol:** Five, 1-min bouts on treadmill followed by 2-min recovery walking while wearing 5-7% body weight vest; then did a 30-min jog with no vest

**Intensity:** Sprints are very hard intensity; recovery is very light; 30-min jog is 60% HRmax

**Duration:** With intervals and continuous jog this is a 45-min workout

## **8) 30/30 HIIT Training** (Moriarty et al. 2017)

Warm-up: 5-10 min of light intensity exercise; Mode: Treadmill with no grade

Work: 30 seconds at 90% VO<sub>2</sub>max (RPE =Very Hard); Relief Interval: 30 seconds at 35-40% VO<sub>2</sub>max (Walk, RPE=Light); Work/Rest Ratio: 1 to 1 ratio.

## **9) Step-Wise 30/30 HIIT Training** (Kravitz et al. 2017)

After each interval increase treadmill grade 2-3% and keep for work and relief interval

Can complete on any mode increasing work with each interval

## **10) Supramaximal HIIT with Variable Recovery** (Adapted from Laforgia 1997)

Warm-up: 5-10 minute of light intensity exercise; Mode: any mode

6-10 Supramaximal exercise bouts (105%VO<sub>2</sub>max) {all out sprints} for 1 minute

Self-selected intensity relief as long as client needs

**Fabulous Feats:** The longest certified road race in the world is the 3,100 mile Self-Transcendence Race in NYC.

The longest bicycle race is the Tour d'Afrique, which is 12,000 km (7500 miles) and 120 days traveling from Cairo, Egypt to Cape Town, South Africa. One of the longest swims ever was recorded by Martin Strel in 2009.

The Slovenian man swam the length of the Amazon River (3,272 miles) in 66 days. Who holds the marathon record for Women and for Men?

**Kenyan and Ethiopian Runners: What Makes Them So Good (International Journal of Sports Physiology and Performance, 2012)**

- (1) genetic predisposition (heart and lung capacity)
- (2) a high VO<sub>2</sub>max as a result of extensive walking and running at an early age
- (3) high hemoglobin and hematocrit
- (4) good metabolic "economy/efficiency" based on somatotype and lower limb characteristics
- (5) favorable skeletal-muscle-fiber composition (slow twitch)
- (6) traditional Kenyan/Ethiopian diet (77% CHO; 10% protein, 13% fat)
- (7) living and training at altitude
- (8) motivation to achieve economic success

**Thank You for Coming to this Session!**