Interval Training for Health and Application in Cardiometabolic Disease

8ο Συνέδριο Βιοχημείας & Φυσιολογίας της Άσκησης

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Overall Message

Interval training is an infinitely variable form of exercise that elicits physiological adaptations linked to improved health and performance in a time-efficient manner.

Key Introductory Points

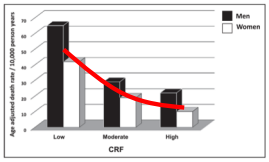
1) Cardiorespiratory fitness is a critical health marker.

2) The role of exercise intensity is underappreciated.

Importance of Assessing Cardiorespiratory Fitness in Clinical Practice: A Case for Fitness as a Clinical Vital Sign

A Scientific Statement From the American Heart Association

Circulation



1-MET ↑ CRF = 13% ↓ mortality

Risk reduction comparable to:
- **7-cm ↓ in waist circumference**
- **5-mm Hg ↓ in systolic BP**
- **1 mmol in ↓ plasma glucose**

(Kodama et al., JAMA, 2009)

Ross R et al. Circulation 134:e653-e699, 2016.

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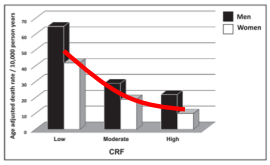

"The routine measurement of CRF in clinical settings is both important and feasible (and) estimates of CRF using nonexercise algorithms have pragmatic importance."

Ross R et al. Circulation 134:e653-e699, 2016.

https://www.worldfitnesslevel.org/#/

Intensity versus duration of cycling, impact on all-cause and coronary heart disease mortality: the Copenhagen City Heart Study

- Observational study of ~5000 adults (21-90 y) over ~20 y period
- Survey data included self-reported daily cycling habits:
  - Duration: <30 min, 30-60 min, >60 min
  - Relative intensity: 'Slow', 'Average', 'Fast'

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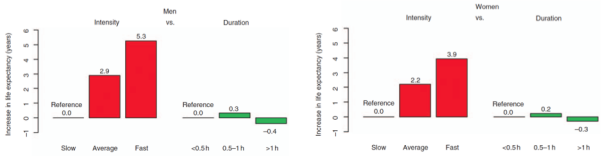
Schnohr P et al. Eur J Cardiovasc Prev Rehab 19: 73-80, 2012.

Intensity versus duration of cycling, impact on all-cause and coronary heart disease mortality: the Copenhagen City Heart Study



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Schnohr P et al. Eur J Cardiovasc Prev Rehab 19: 73-80, 2012.

Intensity versus duration of cycling, impact on all-cause and coronary heart disease mortality: the Copenhagen City Heart Study

"The fast cyclists compared to the slow cyclists were leaner, had lower blood pressure, cholesterol, triglycerides (and) frequency of diabetes."

"Relative intensity, and not the duration of cycling, is of more importance in relation to all-cause and CHD mortality."

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Schnohr P et al. Eur J Cardiovasc Prev Rehab 19: 73-80, 2012.

Separate Effects of Intensity and Amount of Exercise on Interindividual Cardiorespiratory Fitness Response

MAYO CLINIC

121 sedentary obese adults (75 women) aged 53±7 assigned to (1) low amount, low intensity; (2) high-amount, low-intensity or (3) high-amount, high-intensity training, 3x/wk for 24 wk

Amount = 300 or 600 kcal (women: 180 or 360) per bout; Intensity = 50 or 75% of VO_2peak

"our finding that low-intensity exercise performed for about 150 min/wk may not be sufficient to improve CRF for a substantive proportion of adults is reason for concern."

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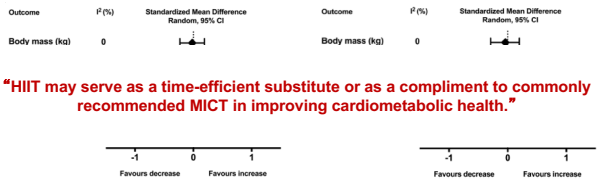
Ross et al. Mayo Clin Proc 90:1506-14, 2015.

Effects of high-intensity interval training on cardiometabolic health: a systematic review and meta-analysis of intervention studies

BJSM The Journal of Sport & Exercise Medicine

65 intervention studies stratified based on BMI



"HIIT may serve as a time-efficient substitute or as a compliment to commonly recommended MICT in improving cardiometabolic health."

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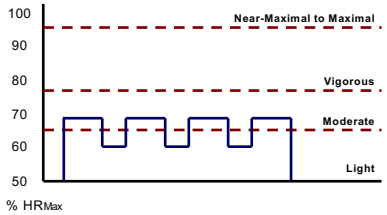
Batacan et al. Br J Sports Med 51:494-503, 2017.

Characterizing Interval Training



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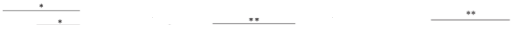
The Effects of Free-Living Interval-Walking Training on Glycemic Control, Body Composition, and Physical Fitness in Type 2 Diabetic Patients

A randomized, controlled trial

N = 32 (age ≈ 60 y, BMI ≈ 30); 60 min/session, 5 d/wk for 4 months

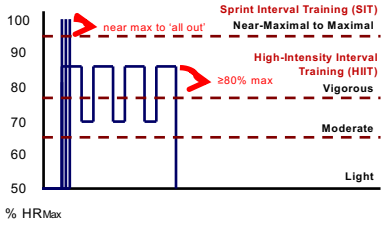
Continuous or Interval Walking (~66% HR_{max}) or non-training Control



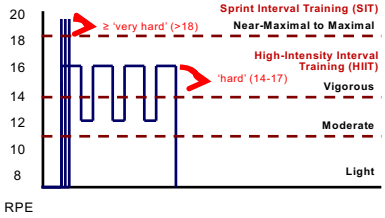
"Interval walking is superior to energy-matched continuous walking (and) may therefore be a good option when considering which type of training…should be offered in primary care."

Karstsoft K et al. Diabetes Care 36: 228-236, 2013.

Characterizing Interval Training



Characterizing Interval Training



Aerobic Interval Training Versus Continuous Moderate Exercise as a Treatment for the Metabolic Syndrome

A Pilot Study

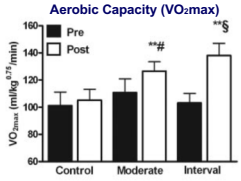
Age ~52 y; VO_2peak ~34 ml/kg/min; treadmill training 3x/wk for 16 wk

Interval = 4 x 4 min at 90% HR_{max} with 3 min recov at 70% HR_{max} (+ warm-up and cool-down = 40 min)

Moderate = 47 min continuous ex at 70% HR_{max} (matched volume)

Control = No training

Aerobic Capacity (VO_2max)



Tjonna et al. Circulation. 118:346-354, 2008.

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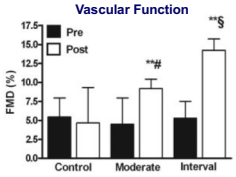
Vascular Function



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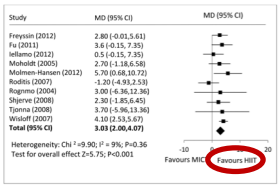
Control = No training

"High-intensity exercise training is superior to moderate-intensity training in reversing risk factors of the metabolic syndrome (including) fasting glucose levels and insulin sensitivity."

Tjonna et al. Circulation. 118:346-354, 2008.

High-intensity interval training in patients with lifestyle-induced cardiometabolic disease: a systematic review and meta-analysis

BJSM The Journal of Sport & Exercise Medicine



"HIIT significantly increases CRF by almost double that of MICT in patients with lifestyle-induced chronic diseases."

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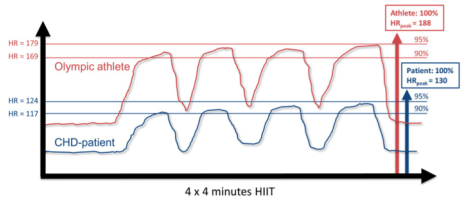
Weston et al. Br J Sports Med 48:1227-1234, 2014.

Absolute Intensity is Relative!



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Karlsen et al. Prog Cardiovasc Dis. 60: 67-77, 2017.

Exercise training in heart failure: recommendations based on current research

KATHARINA MEYER
Swiss Cardiovascular Center Bern, University Clinic, Bern, SWITZERLAND

"The rationale for developing interval training for cardiac patients was to apply a more intense exercise stimuli to the peripheral muscles than that obtainable during steady-state training but without inducing greater cardiovascular stress..."

"This is possible by using short bouts of work phases in repeated sequence, followed by short recovery phases."

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Med Sci Sports Exerc. 33:525-531, 2001.

Cardiovascular Risk of High- Versus Moderate-Intensity Aerobic Exercise in Coronary Heart Disease Patients

Øivind Rognmo, PhD; Trine Moholdt, PhD; Hilde Bakken, BSc; Torstein Hole, MD, PhD; Per Mølstad, MD, PhD; Nils Erling Myhr, BSc; Jostein Grimsmo, MD, PhD; Ulrik Wisløff, PhD

Center	Patients, n	Total Training, h	Moderate Intensity, h	High Intensity, h
Ålesund	775	25 720 (1)	15 232	10 488 (1)
Feiring	2629	85 208 (2)	63 032 (1)	22 176 (1)

"The risk of a cardiovascular event is low after both high-intensity exercise and moderate-intensity exercise."

Myocardial infarction		0	0
Risk of events	1/58 607	1/129 456	1/23 182

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Circulation 126: 1436-1440, 2012.

Circulation

High-Intensity Interval Training in Patients With Heart Failure With Reduced Ejection Fraction

Table 4. Serious Adverse Events

Events*	RRE (n=76), n (%)	MCT (n=73), n (%)	HIIT (n=82), n (%)
Cardiovascular, weeks 1–12	5 (7)	6 (8)	9 (11)
Fatal	0	1	0
Ventricular arrhythmia, life threatening	0	1	1
Ventricular arrhythmia, other	0	0	1
Worsening heart failure	2	3	4
Other nonfatal	3	1	3

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Ellingsen et al. Circulation 135: 839-849, 2017 (top); Gayda et al. Can J Cardiol 32: 485-494, 2016 (bottom).

Circulation

High-Intensity Interval Training in Patients With Heart Failure With Reduced Ejection Fraction

"HIIT was not superior to MCT… and its feasibility remains unresolved in patients with heart failure."

Comparison of Different Forms of Exercise Training in Patients With Cardiac Disease: Where Does High-Intensity Interval Training Fit?

"HIIT should now be more fully and systematically integrated into cardiac rehabilitation programs."

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Ellingsen et al. Circulation 135: 839-849, 2017 (top); Gayda et al. Can J Cardiol 32: 485-494, 2016 (bottom).

High-intensity interval training versus continuous training on physiological and metabolic variables in prediabetes and type 2 diabetes: A meta-analysis ☆

B

Study or Subgroup	Mean Difference	SE	Weight	Mean Difference IV, Random, 95% CI
Karsoft et al. 2013	-0.4	0.75	14.6%	-0.40 [-1.87, 1.07]
Maillard et al., 2016	-0.1	0.82	12.2%	-0.10 [-1.71, 1.51]
Mitranun et al., 2014	-0.06	0.5	32.8%	-0.06 [-1.04, 0.92]
Terada et al., 2013	0.5	0.45	40.5%	0.50 [-0.38, 1.38]
Total (95% CI)			**100.0%**	**0.11 [-0.45, 0.67]**

Heterogeneity: Tau² = 0.00; Chi² = 1.39, df = 3 (P = 0.71); I² = 0%
Test for overall effect: Z = 0.39 (P = 0.70)

Mean Difference IV, Random, 95% CI

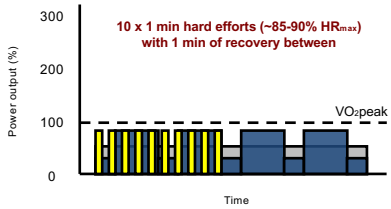
-4 -2 0 2 4
Favours [HIIT] Favours [MICT]

"HIIT induces cardiometabolic adaptations similar to those of MICT in prediabetes and T2D, and provides greater benefits to functional capacity."

De Nardi, Clin Res Diab Prac 137: 149-159, 2018.

A More Practical HIIT Approach?

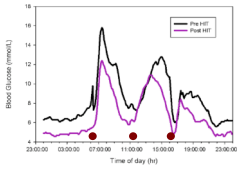
Can you elicit adaptations with reduced time commitment?



Low-volume high-intensity interval training reduces hyperglycemia and increases muscle mitochondrial capacity in patients with type 2 diabetes

n=8 T2D (63±8 y, BMI ≈ 32±6) performed 6 sessions over 2 wk
(1 h of exercise in a 2 h total time commitment)

Medtronic iPro CGMS



Little et al. J Appl Physiol 111: 1554-1560, 2011.

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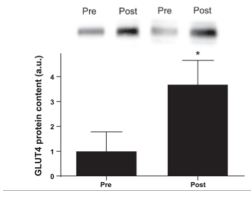
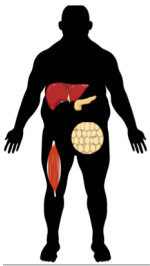


Little et al. J Appl Physiol 111: 1554-1560, 2011.

How Might HIIT Improve Glycemic Control?

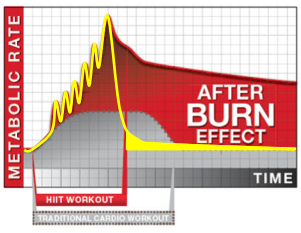
- ↓Hepatic Fat Content (Cassidy et al. *Diabetologia, 2016*; Sargeant et al. *EJAP, 2018*)
- ↑Muscle insulin sensitivity (Karstoft et al. *Diabetologia*, 2014)
- ↑GLUT4 (Gillen et al. *PLoS One*, 2014; Little et al. *JAP*, 2011)
- ↑Mitochondrial content (Little et al. *JAP*, 2011)
- ↓Ceramides (Shepherd et al. *Int J Obes*, 2017)



- ↑Beta-cell Function (Madsen et al. *PLoS One, 2015* Heiskanen et al. *Diabetologia, 2018*)
- ↓Pancreatic Fat Content (Heiskanen et al. *Diabetologia, 2018*)
- ↓Fat Mass (Francois et al. *Front Physiol, 2017*; Gillen et al. *Obesity, 2013*)
- ↑Lean Mass (Francois et al. *Front Physiol, 2017*)

Slide courtesy of Dr. Jenna Gillen, University of Toronto

HIIT and Body Composition?



http://www.liveleanafterburn.com/foundation/

The effects of high-intensity interval training vs. moderate-intensity continuous training on body composition in overweight and obese adults: a systematic review and meta-analysis

"Short-term HIIT and MICT exercise both elicit modest improvements, and of similar magnitude, in body fat levels and waist circumference."

"Considering HIIT shows similar efficacy (with) less time commitment… HIIT can be considered a time-efficient alternative for managing overweight and obese individuals."

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Wewege et al. Obes Rev 18: 635-646, 2017.

Interval Training: What We Know

1) Large improvements in cardiorespiratory fitness, often superior to continuous exercise

2) Modest improvements in other health indices, similar to traditional exercise but in less time

3) Mounting evidence that it is generally safe but 'real world' effectiveness is contentious

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Interval Training: What We Need to Know

1) More practical models?

2) Effect on mortality?

3) Will people do it?

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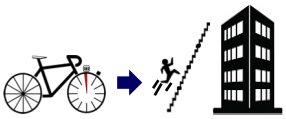
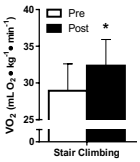
Brief Intense Stair Climbing Improves Cardiorespiratory Fitness

3 x 20-s sprints over 10-min period (RPE ~15/20 or "hard"), 3x/wk for 6 wk





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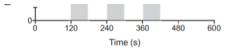
Allison et al. Med Sci Sports Exerc 49: 298-307, 2017.

The effect of brief intermittent stair climbing on glycemic control in people with type 2 diabetes: a pilot study

3 x 60-s vigorously ascending and slowly descending 1 flight of stairs, 3x/wk for 6 wk

"While the protocol was well tolerated by participants, the mean intensity achieved was lower than in our previous study of healthy individuals (and) a higher total volume of exercise is likely needed to alter 24-h glycemic control in people with T2D."



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Godkin et al., Appl Physiol Nutr Metab (in press).

Functional high-intensity exercise training ameliorates insulin resistance and cardiometabolic risk factors in type 2 diabetes

Overweight/obese adults with T2D (53±7 y; BMI 35±4) performed 18 sessions over 6 wk

"short-duration, high-intensity exercise training that combines functional aerobic and resistance exercises lasting 8–20 min improves insulin sensitivity and reduces cardiometabolic risk in individuals with type 2 diabetes."

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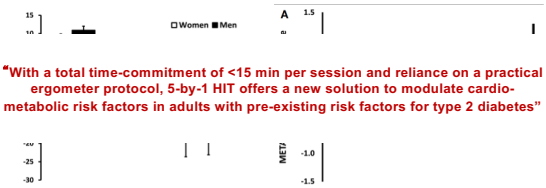
Fealy et al. Experimental Physiology. 103: 985-994, 2018.

frontiers in Endocrinology

A Practical and Time-Efficient High-Intensity Interval Training Program Modifies Cardio-Metabolic Risk Factors in Adults with Risk Factors for Type II Diabetes

5 x (60s at ~100% VO_{2max} , 90s recovery) = <15 min; 3x/wk for 6 wk (n=136)



"With a total time-commitment of <15 min per session and reliance on a practical ergometer protocol, 5-by-1 HIT offers a new solution to modulate cardio-metabolic risk factors in adults with pre-existing risk factors for type 2 diabetes"

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Phillips et al. Front. Endocrinol. 8:229, 2017.

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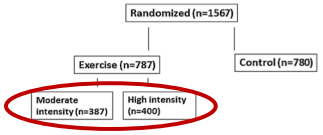
A randomised controlled study of the long-term effects of exercise training on mortality in elderly people: study protocol for the Generation 100 study



"the first study to evaluate the long-term effect of both high-intensity training and moderate intensity on how people age."

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Stensvold et al. BMJ Open. 2015 Feb 12;5(2):e007519; https://www.ntnu.edu/cerg/generation100.

McMaster University

A scoping review of the psychological responses to interval exercise: is interval exercise a viable alternative to traditional exercise?

Matthew J. Stork[a], Laura E. Banfield[b], Martin J. Gibala[c] and Kathleen A. Martin Ginis[a]

"The emerging data support the viability of interval exercise as an alternative to continuous exercise…

While interval exercise may not be ideal or preferred by all, it may provide a viable option for many."

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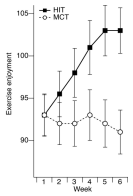
Health Psych Rev 11: 324-344, 2017.

McMaster University

Enjoyment for High-Intensity Interval Exercise Increases during the First Six Weeks of Training: Implications for Promoting Exercise Adherence in Sedentary Adults

Jennifer J. Heisz, Mary Grace M. Tejada, Emily M. Paolucci, Cameron Muir

"The results point to HIT as a promising protocol for promoting exercise enjoyment and adherence in sedentary young adults."



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PLoS One. 2016 Dec 14;11(12)

McMaster University

Take Home Point

There is no single "best" approach to exercise for the promotion of cardiometablic health; interval training offers an almost infinitely variable form that broadens the "menu options" to choose from, but larger and longer randomized controlled trials and translational studies are required to determine effectiveness and adherance in the "real world".

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