Der Nachbrenneffekt – Turbo oder eher „Effektchen“?

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PDF

@sportsandscience

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Inhalt heute

1. Warm-up: Was ist der Nachbrenneffekt?
2. Was muss bei der Messung beachtet werden
3. Überblick: Aktuelle Studienlage
4. Zusammenfassung

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Warm-Up

Ein paar Informationen zum Nachbrenneffekt

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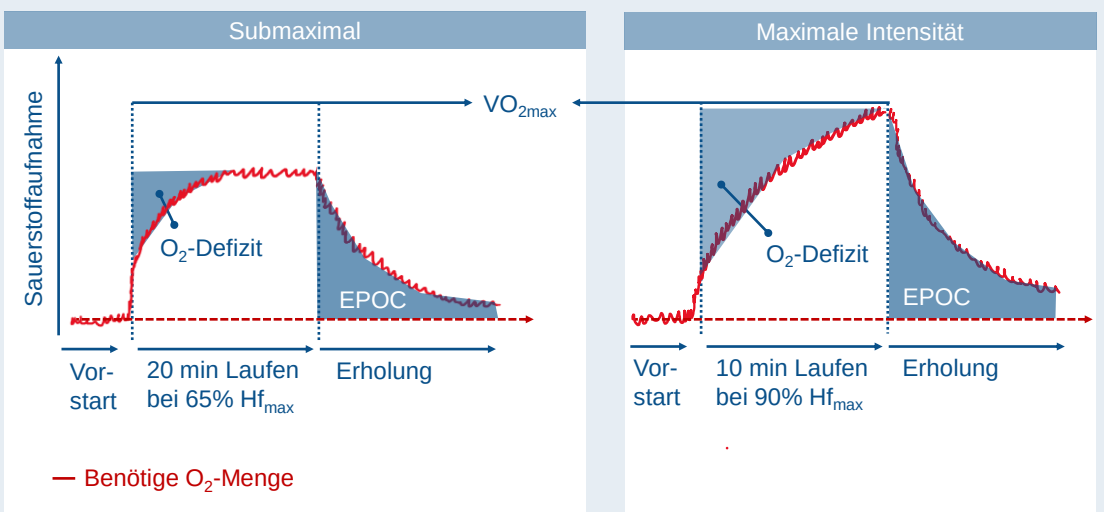
Einordnung – EPOC (Excess post-exercise oxygen consumption)



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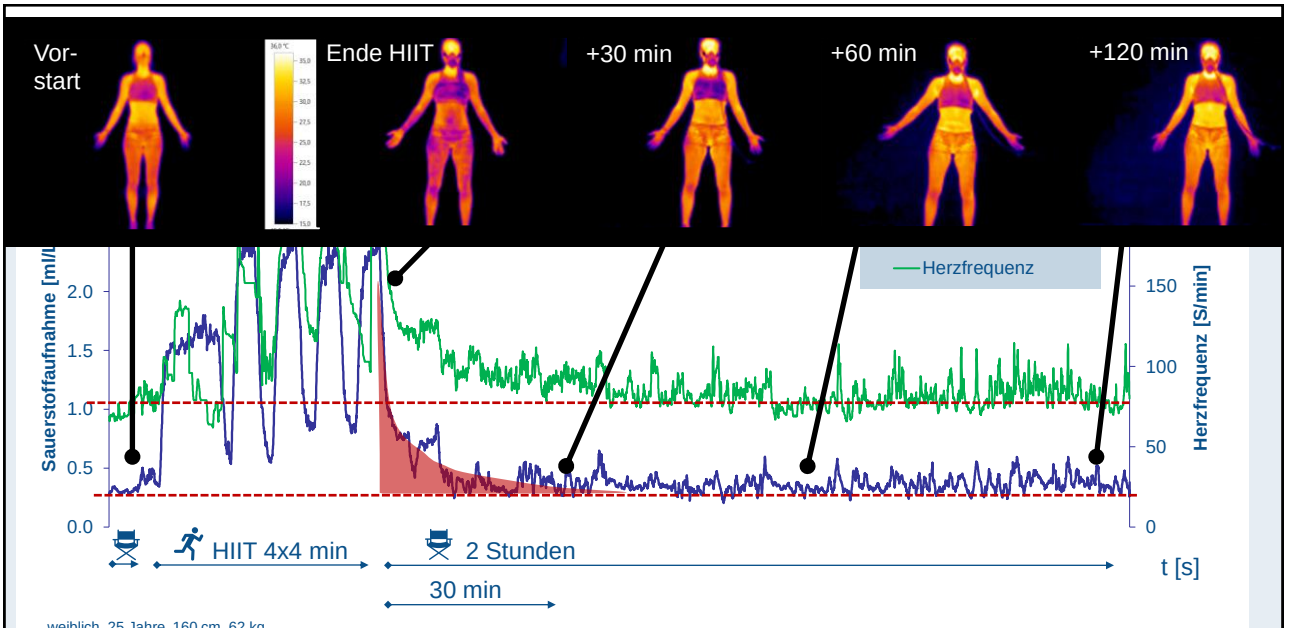

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Energiebilanz Sauerstoff

- 1 kcal: Energie um 1L Wasser um 1°C zu erwärmen
- **Kalorie** (cal) und Kilo-Kalorie (kcal) sind **veraltete Maßeinheiten: 1 kcal = 4.186,8 Joule**

Verstoffwechslung von 1L Sauerstoff &

- CHO: 5.01 kcal
- Fetten: 4.70 kcal
- Protein: 4.60 kcal
- Mittleres energetisches Äquivalent: **4.825 kcal / Liter O_2**

Merke: 1L Sauerstoff => ca. 5 kcal

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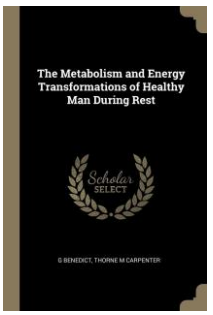
Frühe Befunde

1910



Benedict/Carpenter 1910:
N=2
+11.1% Ruheumsatz 7-13h nach intensiver körperlicher Arbeit

1926

(Aus der II. Med. Klinik der Charité, Berlin [Direktor: Geh.-Rat Prof. Dr. *Kraus*] und der Deutschen Hochschule für Leibesübungen in Berlin [Rektor: Geh.-Rat Prof. Dr. *Bier*].)

Spätwirkungen erschöpfender Muskelarbeit auf den Sauerstoffverbrauch.

Von

H. Herxheimer, E. Wissing und **E. Wolff.**

(Eingegangen am 17. Mai 1926.)

I. Versuche im Tiefland.

2. Bei im ganzen 5 untrainierten V.-P. trat nach einer erschöpfenden Anstrengung eine Steigerung des O_2-Verbrauchs von durchschnittlich etwa 10% auf, die 36—48 Stunden anhielt, und dann auf die Norm zurückging.

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EPOC – Zwei zeitliche Komponenten

REVIEW ARTICLE

Effect of Exercise Intensity, Duration and Mode on Post-Exercise Oxygen Consumption

Elisabet Børsheim and *Roald Bahr*

Norwegian University of Sport and Physical Education, Oslo, Norway

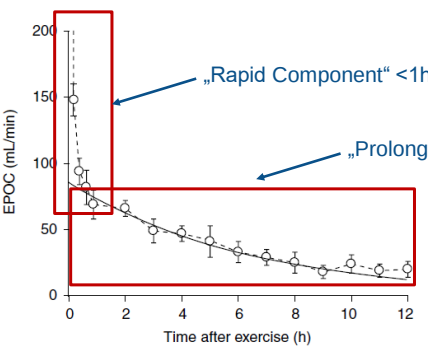

Fig. 1. Time plot of excess post-exercise oxygen consumption (EPOC) after exhaustive submaximal exercise (71–80 minutes at 69–78% of maximal oxygen uptake; n = 12). The solid line shows the prolonged EPOC component (reproduced from Bahr,[7] with permission).

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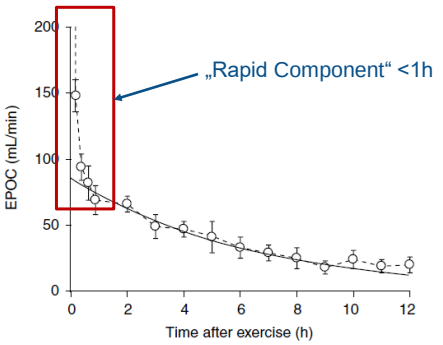
Schnelle/Frühe Komponente



a) Sauerstoffbedarf im Blut und Gewebe
b) Resynthese von ATP und CrP
c) Verwertung Blutlaktat
d) H^+-Pufferung => Regulation Säure-Basen Haushalt
e) Erhöhte muskuläre Temperatur
f) O_2-Bedarf der Atemmuskultur
g) etc.

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EPOC der Arbeitsmuskulatur

Journal of Physiology (1991), **434**, *pp.* 423–440
With 6 figures
Printed in Great Britain

SUBSTRATES FOR MUSCLE GLYCOGEN SYNTHESIS IN RECOVERY FROM INTENSE EXERCISE IN MAN

By J. BANGSBO, P. D. GOLLNICK, T. E. GRAHAM AND B. SALTIN
From the August Krogh Institute, Universitetsparken 13, DK-2100 Copenhagen Ø, Denmark

Intensive Kniestreckbewegung für 3 min bis zur Ausbelastung (n=7):

Bein-VO_2 (= Arbeitsmuskulatur) macht nur 1/3 von 60-minütigem EPOC aus!

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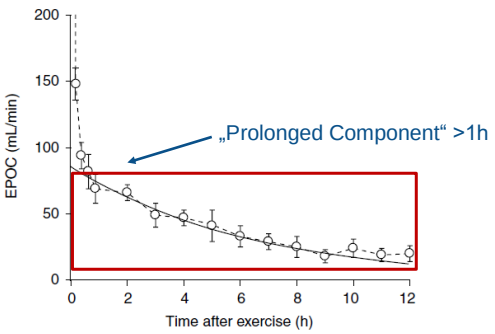
Langsame EPOC-Komponente



a) ↑ Atemantrieb, Stoffwechsel und Thermoregulation benötigen O_2 (wahrscheinlich aber <1L)
b) ↑ Oxidation von Fettsäuren => Shift von CHO zu Fetten => ca. 10-15% von EPOC
c) ↑ Adreanlin/Noradrenalin => Stimuliert Stoffwechsel
d) ↑ Katecholamine
e) ↑Sympatikoadrenerge Aktivität

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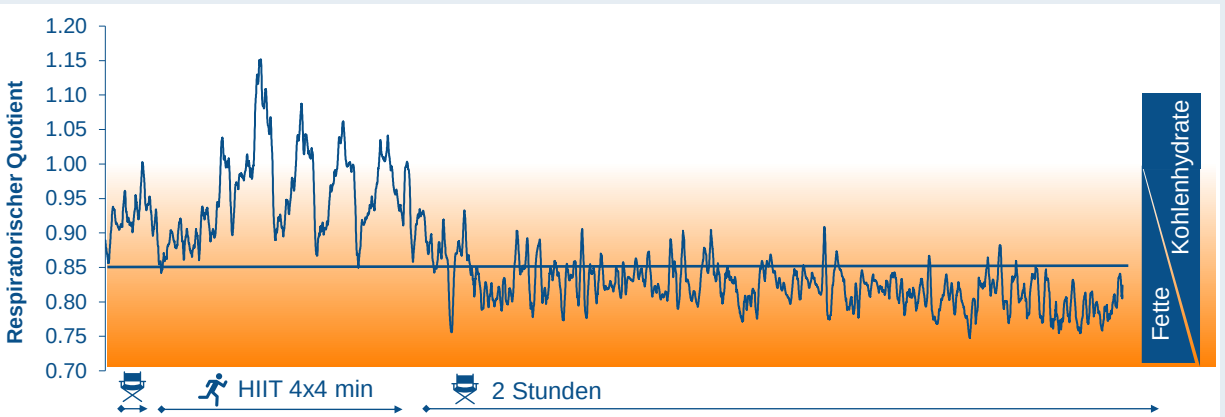
EPOC & Stoffwechsel



weiblich, 25 Jahre, 160 cm, 62 kg

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Methodik

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EPOC – Studiendesign

Baseline-Messung:
=> Wann und wie lange?
⇒ Anfahrt ins Labor
⇒ Schlaf im Labor?
⇒ Nüchtern?

Aktivität:
=> Vergleichsmessung => Isokalorisch?

EPOC-Messung:
⇒ z.B.: 12h EPOC-Messung => mit/ohne Ernährung?
⇒ Lagerung: sitzend, liegend, “free-living“

Isokalorischer Vergleich

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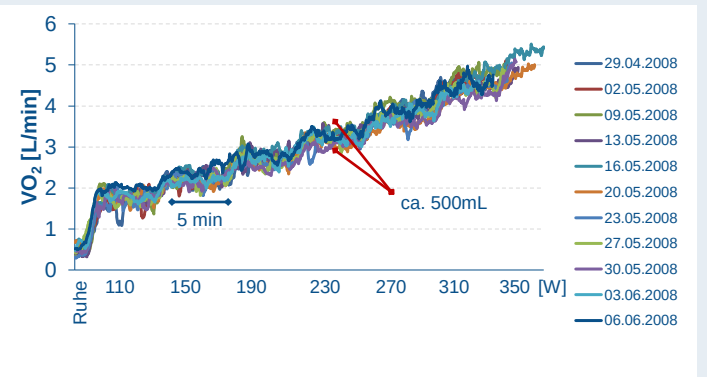
Atemgasanalyse – Reliabilität & Validität

Atemgasanalyse:
Häufig keine Angabe bezgl. Reliabilität & Validität



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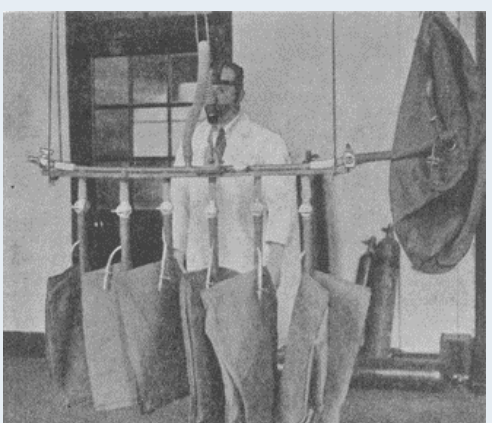
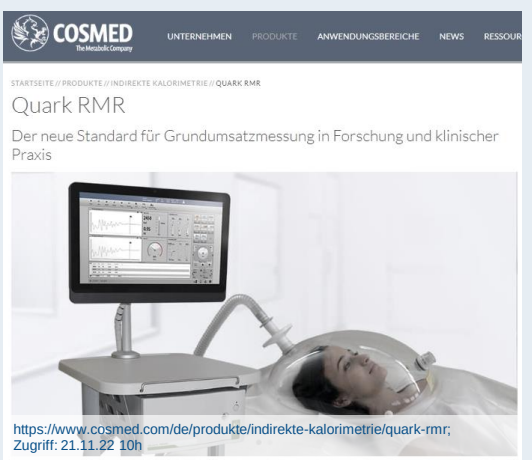
Analyseverfahren



Aus: Shephard 2017 Eur J Appl Physiol



https://www.cosmed.com/de/produkte/indirekte-kalorimetrie/quark-rmr; Zugriff: 21.11.22 10h

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Studien

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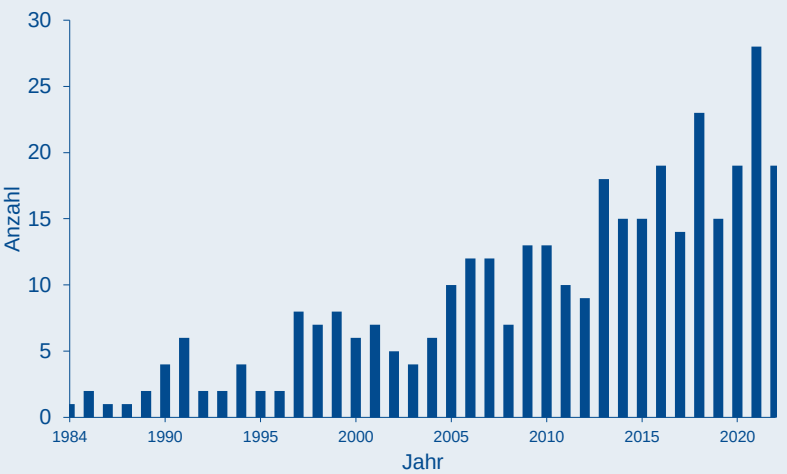
Aktuelle Studienlage „EPOC & exercise“

PubMed.gov

n=39 (systematic) reviews



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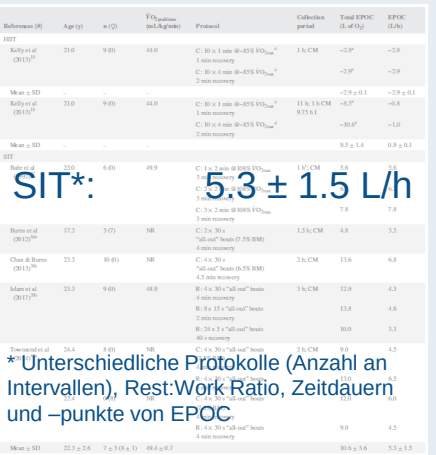
EPOC <3h: Sprint-Intervalltraining (SIT)


Mechanistic and methodological perspectives on the impact of intense interval training on post-exercise metabolism

Sara C. Moniz[1] | Hashim Islam[2] | Tom J. Hazell[1]

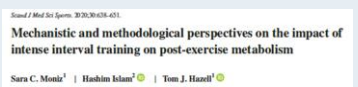
"Klassiker":
4 × 30 s "all-out" bouts
4 min recovery

SIT*: 5.3 ± 1.5 L/h



* Unterschiedliche Protokolle (Anzahl an Intervallen), Rest:Work Ratio, Zeitdauern und –punkte von EPOC

EPOC <3h: Sprint-Intervalltraining vs MICT (moderate-intensity continous training)


Mechanistic and methodological perspectives on the impact of intense interval training on post-exercise metabolism

Sara C. Moniz[1] | Hashim Islam[2] | Tom J. Hazell[1]

SIT*: 6.3±4.5 L/h

MICT*: 3.8±2.5 L/h

TABLE 3 Characteristics of studies examining EPOC following SIT vs MICT

References [#]	Age (y)	n (♀)	$\dot{V}O_{2peak/max}$ (mL·kg·min)	SIT protocol	MICT protocol	Collection period	EPOC magnitude (L of O_2) SIT	EPOC magnitude (L of O_2) MICT	EPOC magnitude (L/h) SIT	EPOC magnitude (L/h) MICT
0.5 - 3 h post-exercise										
Islam et al (2018)[40,a]	23.0	8 (0)	51.2	R: 4 × 30 s "all-out" bouts 4 min recovery periods	30 min @ 65% $\dot{V}O_{2max}$	2 h; I	10.0	6.0	5.0	3.0
Matsuo et al (2012)[25]	24.0	10 (0)	52.0	C: 3 × 30 s bouts @ 120% $\dot{V}O_{2max}$ R: 15 s recovery periods	40 min @ 70% $\dot{V}O_{2max}$	1 h; I	6.8	2.9	2.3	1.0
Metcalfe et al (2015)[42]	26.0	8 (0)	51.0	C: 2 × 20 s "all-out" bouts 5 min recovery periods (60 W)	50 min @ 50% $\dot{V}O_{2max}$	1.5 h; I	5.1	4.1	3.4	2.7
Schaun et al (2018)[33]	22.3	0 (11)	38.2	C: 4–6 × 30 s bouts @ 130% $\dot{V}O_{2max}$ R: 4 min recovery periods	30 min @ 70% $\dot{V}O_{2max}$	1.5 h; I	4.2	4.6	8.3	9.1
Townsend et al (2013)[34a]	23.3	6 (0)	40.2	C: 3 × 30 s "all-out" bouts[b] 4 min recovery periods	30 min @ 55% $\dot{V}O_{2max}$[c]	0.5 h; CM	7.5	1.8	15.0	3.6
Tucker et al (2016)[26,a]	24.0	10 (0)	45.9	C: 6 × 30 s "all-out" bouts (7.5% BM) 4 min recovery periods (60% HR_{peak})	30 min @ 70% $\dot{V}O_{2max}$[d]	3 h; CM	22	12.8	7.3	4.3
Williams et al (2013)[32,a]	23.6	18 (0)	41.0	C: 4 × 30 s "all-out" bouts (7.5% BM) 4.5 min active recovery periods	60 min @ 65% $\dot{V}O_{2peak}$	3 h; I	8.1	8.8	2.7	2.9
Mean ± SD	23.7 ± 1.4	10.0 (−) ± 4.2 (−)	45.6 ± 5.9	-	-	-	9.1 ± 6.0	5.9 ± 3.8	6.3 ± 4.5	3.8 ± 2.5
9 h post-exercise										
Laforgia et al (2012)[46,a]	21.2	8 (0)	69.2	R: 20 × 1 min bouts @ 105% $\dot{V}O_{2max}$ 1 min recovery periods	30 min @ 70% $\dot{V}O_{2max}$[e]	9 h; CM	15.0	9.0	1.7	1.0
21-24 h post-exercise										
[illegible] (2012)[46,a]	[illegible]	[illegible]	[illegible]	C: [illegible] bouts (10% BM) 4 min recovery periods	30 min @ 70% $\dot{V}O_{2max}$	24 h; I	62.8	12.4	2.6	0.5

* Unterschiedliche Protokolle (Anzahl an Intervallen), Rest:Work Ratio, Zeitdauern und –punkte von EPOC

EPOC <3h HIIT vs MICT (moderate-intensity continous training)

Scand J Med Sci Sports. 2020;30:638–651.

Mechanistic and methodological perspectives on the impact of intense interval training on post-exercise metabolism

Sara C. Moniz[1] | Hashim Islam[2] | Tom J. Hazell[1]

Meistens
4 x 4 min + 3 min Rec
3 x 3 min + 2 min Rec
80-90%VO_{2max}

MICT:
30-60 min @ 65%VO_{2max}

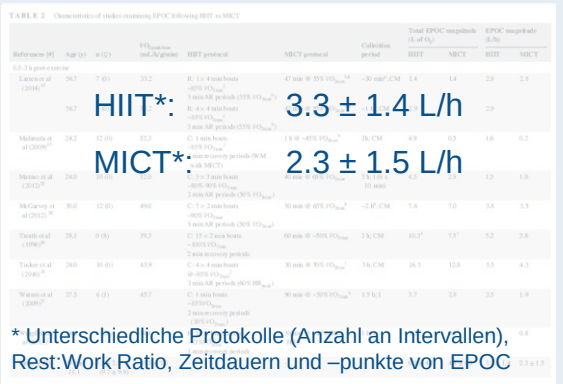


TABLE 2 Characteristics of studies examining EPOC following HIIT vs MICT

References [#]	Age (y)	n (♀)	VO_{2peak} (mL/kg/min)	HIIT protocol	MICT protocol	Collection period	Total EPOC magnitude (L of O_2) HIIT	Total EPOC magnitude (L of O_2) MCT	EPOC magnitude (L/h) HIIT	EPOC magnitude (L/h) MICT
0.5–3 h post-exercise										
Larsen et al (2016)[37]	56.7	7 (0)	33.2	R: 3 × 4 min bouts @85% VO_{2peak} 3 min AR periods (55% VO_{2peak})	47 min @ 55% VO_{2peak}	~30 min[a]	1.4	1.4	2.8	2.8
	56.7			R: 4 × 4 min bouts @85% VO_{2peak} 3 min AR periods (55% VO_{2peak})					2.9	
Malatesta et al (2009)[41]	24.2	12 (0)	52.3	C: 1 min bouts @95% VO_{2max} 1 min recovery periods (WM = 10 MCT)	1 h @ ~45% VO_{2max}	3h; CM	4.9	0.5	1.6	0.2
Meiano et al (2012)[38]	24.0			C: 3 min bouts @85–90% VO_{2max} 2 min AR periods (50% VO_{2max})					1.5	1.0
McGarvey et al (2012)[39]	30.0	12 (0)	49.0	C: 7 × 2 min bouts @90% VO_{2max} 5 min AR periods (50% VO_{2max})	30 min @ 65% VO_{2max}	~2 h; CM	7.6	7.0	3.8	3.5
Trinity et al (1996)[36]	28.1	0 (8)	39.3	C: 15 × 2 min bouts @105% VO_{2max} 2 min recovery periods	60 min @ ~50% VO_{2max}	2 h; CM	10.3*	7.5*	5.2	3.8
Tucker et al (2018)[40]	24.0	10 (0)	45.9	C: 4 × 4 min bouts @~85% VO_{2max} 3 min AR periods (60% HR_{max})	30 min @ 70% VO_{2max}	3 h; CM	16.5	12.8	5.5	4.3
Warren et al (2009)[35]	27.3	6 (0)	45.7	C: 1 min bouts @95% VO_{2max} 2 min recovery periods (50% VO_{2max})	90 min @ ~50% VO_{2max}	1.5 h; I	3.7	2.8	2.5	1.9
										0.8
										1.3 ± 1.5

HIIT*: 3.3 ± 1.4 L/h

MICT*: 2.3 ± 1.5 L/h

* Unterschiedliche Protokolle (Anzahl an Intervallen), Rest:Work Ratio, Zeitdauern und –punkte von EPOC

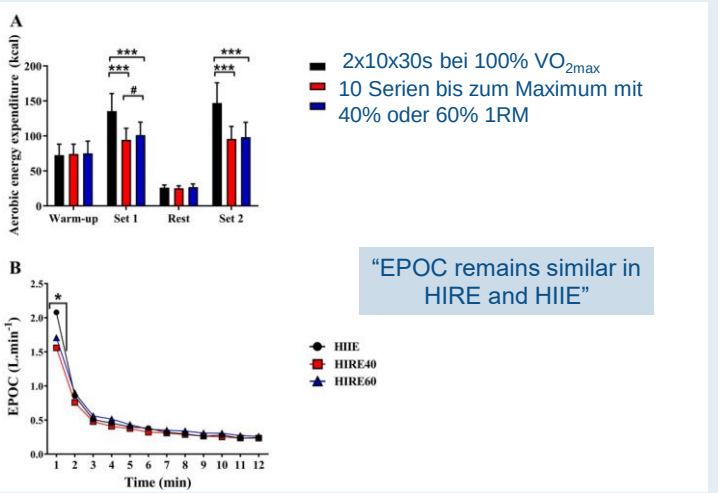
HIIT vs Krafttraining

European Journal of Applied Physiology (2022) 122:459–474
https://doi.org/10.1007/s00421-021-04849-4

ORIGINAL ARTICLE

High-intensity resistance exercise is not as effective as traditional high-intensity interval exercise for increasing the cardiorespiratory response and energy expenditure in recreationally active subjects

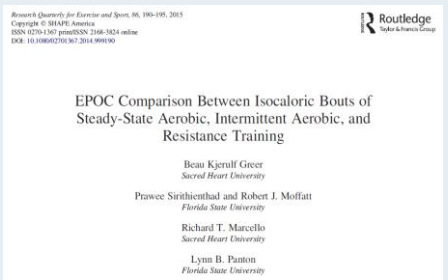
Laura Järvinen[1] · Sofi Lundin Petersdotter[1] · Thomas Chaillou[1]



2x10x30s bei 100% VO_{2max}
10 Serien bis zum Maximum mit 40% oder 60% 1RM

"EPOC remains similar in HIRE and HIIE"

Isokalorischer Vergleich Kraft- vs. Ausdauertraining



EPOC Comparison Between Isocaloric Bouts of Steady-State Aerobic, Intermittent Aerobic, and Resistance Training

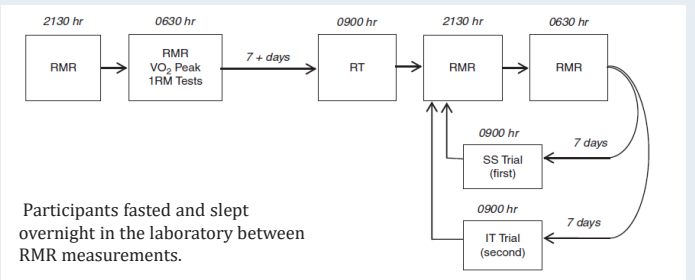
Beau Kjerulf Greer
Sacred Heart University

Prawee Sirithienthad and Robert J. Moffatt
Florida State University

Richard T. Marcello
Sacred Heart University

Lynn B. Panton
Florida State University

"Both resistance training and HIIT increased EPOC to a greater degree than did moderate-intensity steady-state work, indicating that either mode may be more effective at increasing total daily caloric expenditure than moderate-intensity steady-state aerobic exercise."



Participants fasted and slept overnight in the laboratory between RMR measurements.

	Baseline	Krafttraining	HIIT	Dauermethode
Sauerstoffaufnahme [ml/min]	251±30	284±40	267±30	248±30
Energieverbrauch in 30 min [kcals]	38±3	45±4	45±10	39±6

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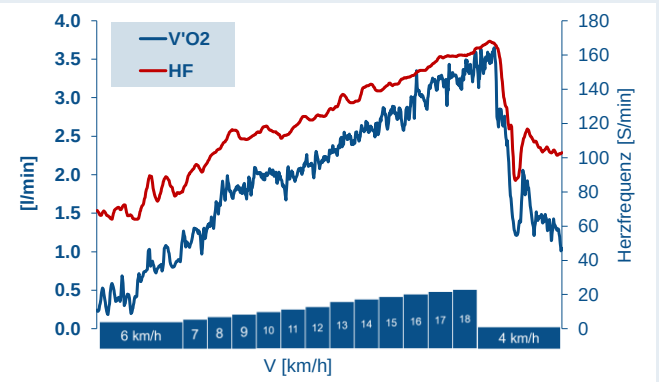
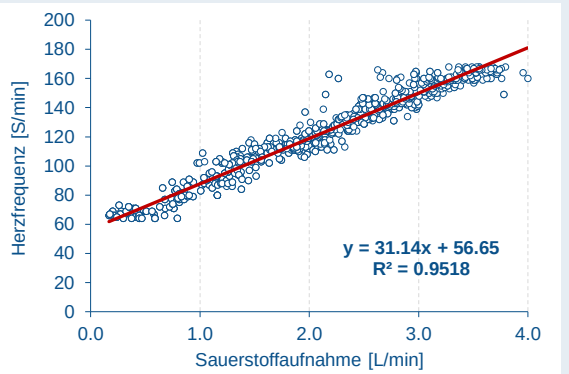
Ausblick & Zusammenfassung

Zusammenhang Sauerstoffaufnahme & Herzfrequenz





Es besteht ein (enger) Zusammenhang zwischen VO_2 und HF.

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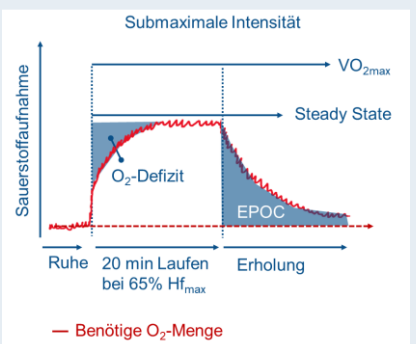
Zusammenfassung - EPOC



- Abschätzung und Vergleich von EPOC: komplex => Messtechnik, -fehler und –zeitpunkte, Lagerung, Ernährung und andere Einflussfaktoren
- Metaanalytische Datenlage recht heterogen:
  - EPOC (<3h) metaanalytisch : ca. +2-6 LiterO_2/h => 10-30 kcal/h
  - SIT > HIIT = Krafttraining > MICE
- Wenige Studien zu Krafttraining & EPOC
- Wenige Untersuchungen mit Frauen

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Vielen Dank!

/billysperlich

INTEX
LEHRSTUHL FÜR INTEGRATIVE UND EXPERIMENTELLE TRAININGS- UND BEWEGUNGSWISSENSCHAFT

Julius-Maximilians-
UNIVERSITÄT WÜRZBURG