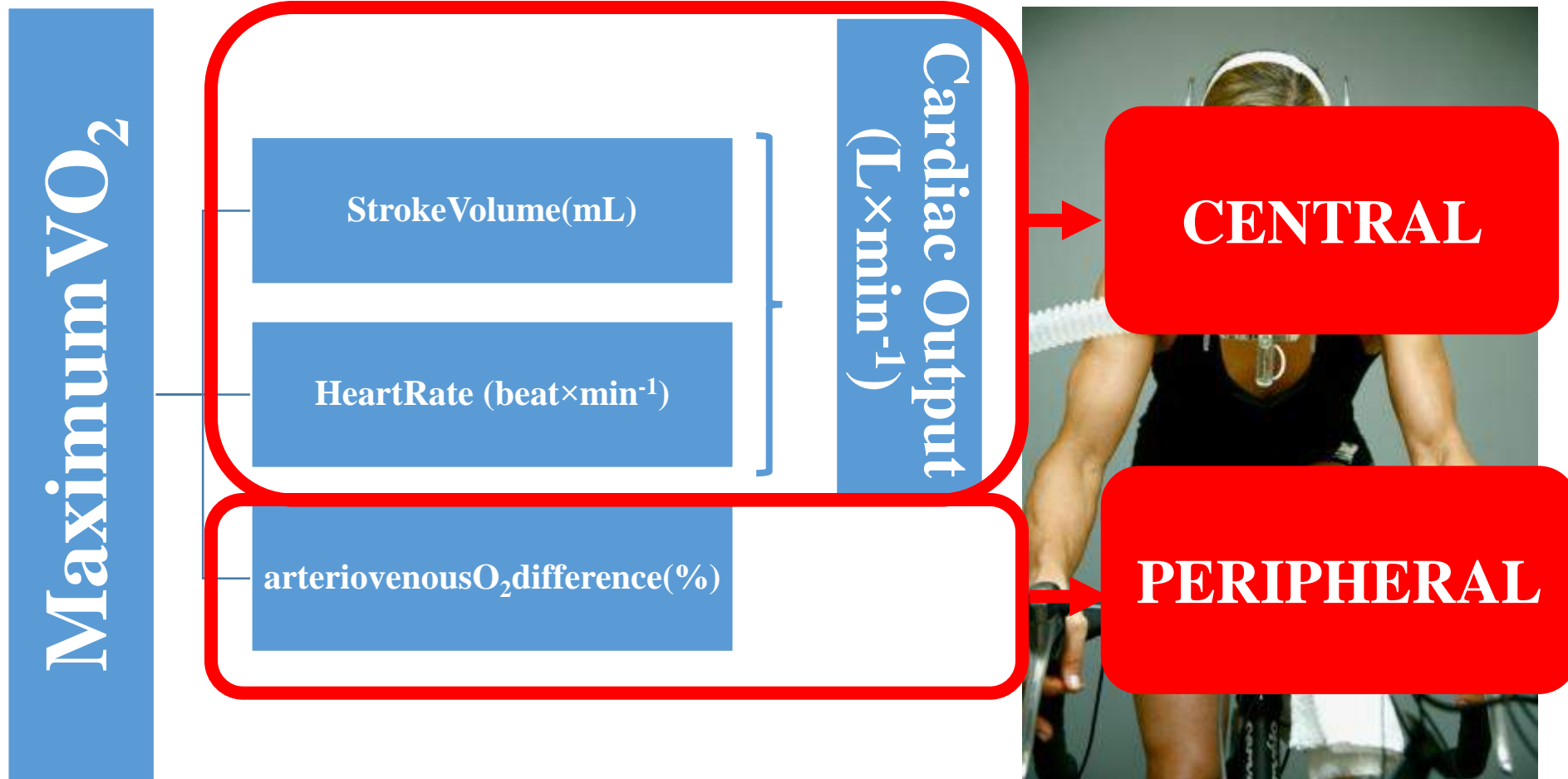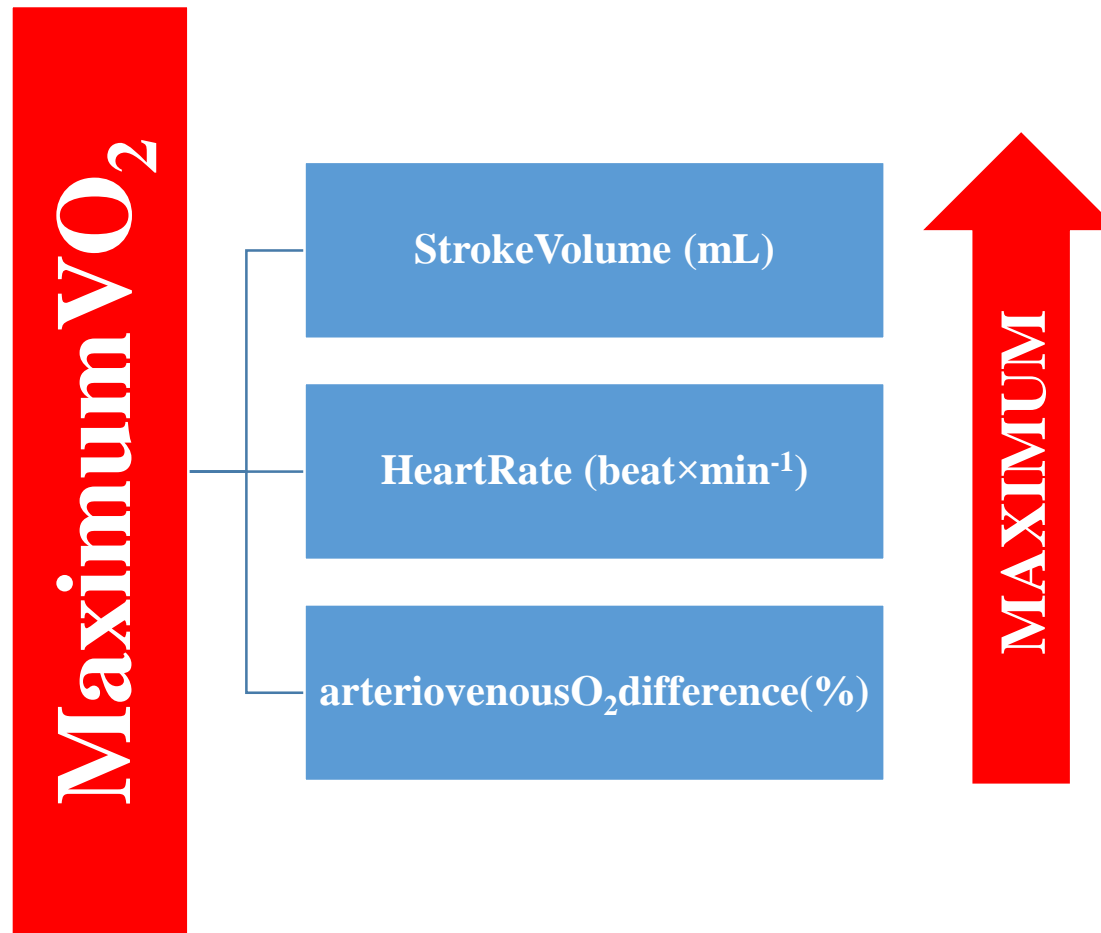# *Effects of high intensity continuous and intermittent training strategies used for endurance development on cardio-vascular responses*

*Research Assistant
Görkem Aybars BALCI*

1

MAXIMUM O$_2$ CONSUMPTION (VO$_{2max}$)

Maximum VO$_2$

StrokeVolume(mL)

HeartRate (beat×min^{-1})

arteriovenousO$_2$difference(%)

Cardiac Output (L×min^{-1})

CENTRAL

PERIPHERAL

MAXIMUM O$_2$ CONSUMPTION (VO$_{2max}$)

Maximum VO$_2$

- StrokeVolume (mL)
- HeartRate (beat×min^{-1})
- arteriovenousO$_2$difference(%)

MAXIMUM

MAXIMUM O$_2$ CONSUMPTION (VO$_{2max}$)

Maximum VO$_2$:

>

>

SV (ml)

×

HR

×

a-vO$_{2\_diff}$

5:30-6:00

Time (s.in)

Buchheit M, Laursen PB. High-intensity interval training, solutions to the programming puzzle: Part I: Cardiopulmonary emphasis. Sports Medicine [Internet]. 2013 May 29 [cited 2017 Apr 3];43(5):313–3
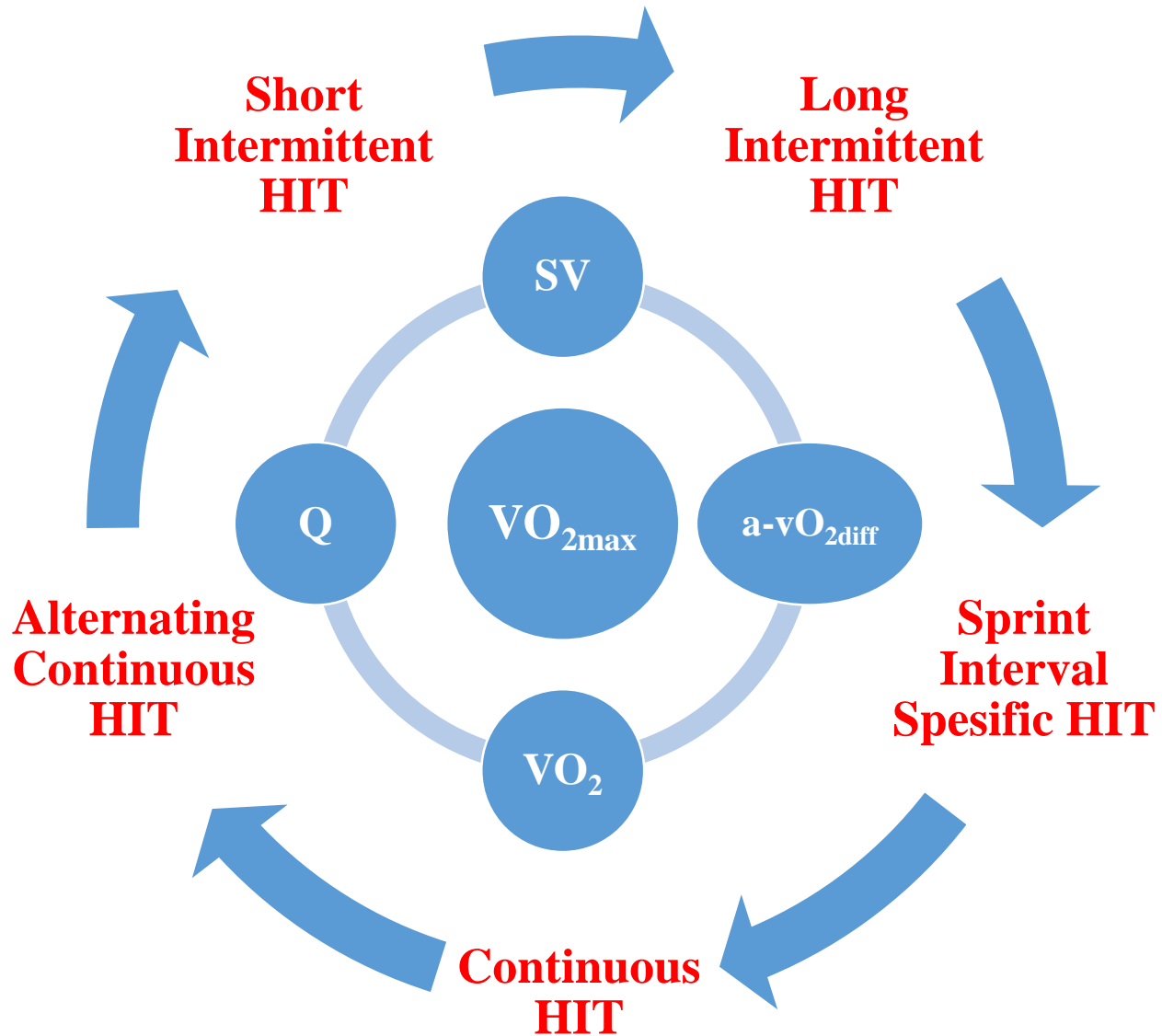
MAXIMUM O$_2$ CONSUMPTION (VO$_{2max}$)

>90% Q$_{max}$

>90% SV$_{max}$

>90% a-vO$_{2diff\_max}$

Buchheit M, Laursen PB. High-intensity interval training, solutions to the programming puzzle: Part I: Cardiopulmonary emphasis. Sports Medicine [Internet]. 2013 May 29 [cited 2017 Apr 3];43(5):313–3

What is the Problem?

Q, SV ve a-vO$_{2\text{diff}}$

Rest periods

Iso-efor, Iso-time

24 – 25 minutes
>19 RPE
maximal exercise

PILOT STUDY FOR 6 MONTHS

PURPOSE OF THIS STUDY

	Workload	Modality	w/r ratio	Type of modality	Total Time
HIT-1	$\sim\%110$ VO_{2max}	45-sec × 16 rep.	1:1	intermittent	24-min

Procedures

Familiarization sessions (4 × 5-min)

Submaximal VO$_2$ Test (4 × 5-min)

VO$_{2peak}$ Test (3 – 5 × 2-min)

VO$_{2max}$ Verification Tests (97-100-103% of VO$_{2peak}$)

Individual Q$_{max}$, SV$_{max}$ and a-vO$_{2diff\_max}$ (40-110%VO2max)

5 HIT Sessions
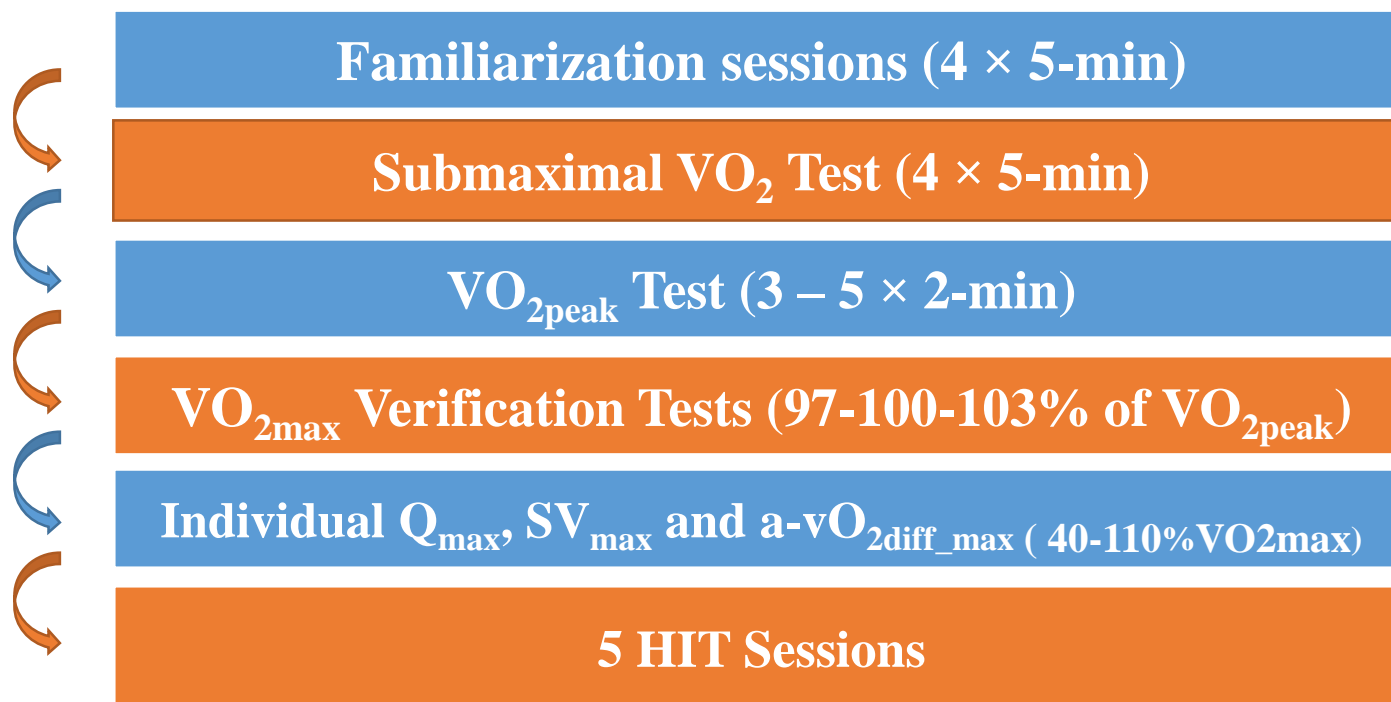
16 - 18 test days

~35 - 40 days

N$_2$O$_{RB}$ MEASUREMENTS
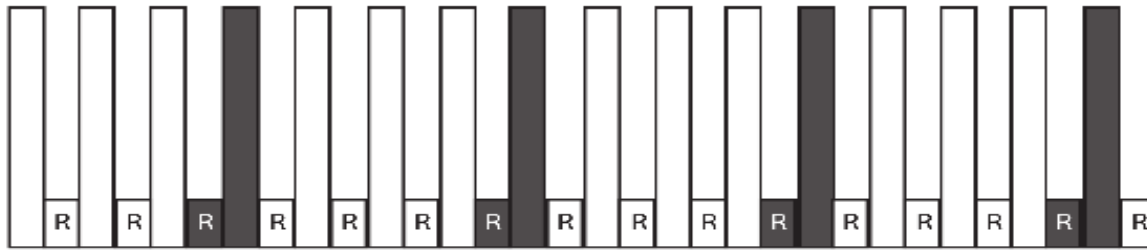
HIT-1
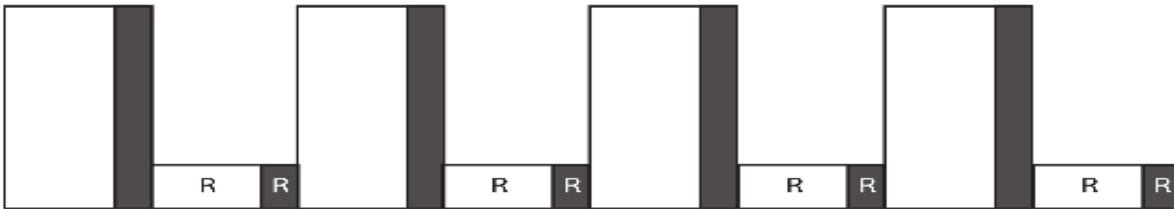
HIT-2
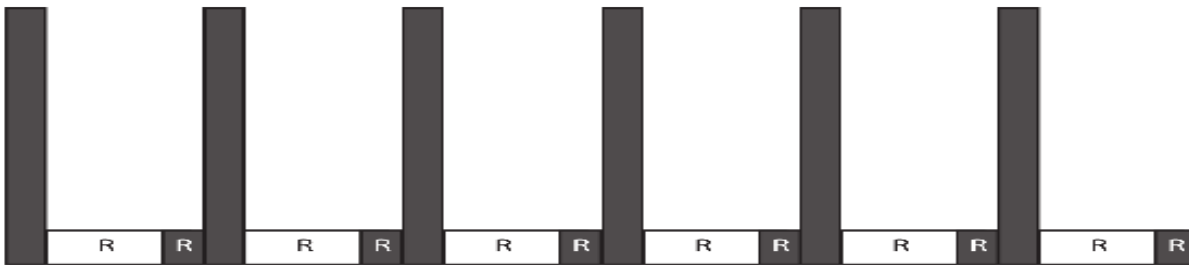
HIT-5

N$_2$O$_{RB}$@EXERCISE

R N$_2$O$_{RB}$@REST
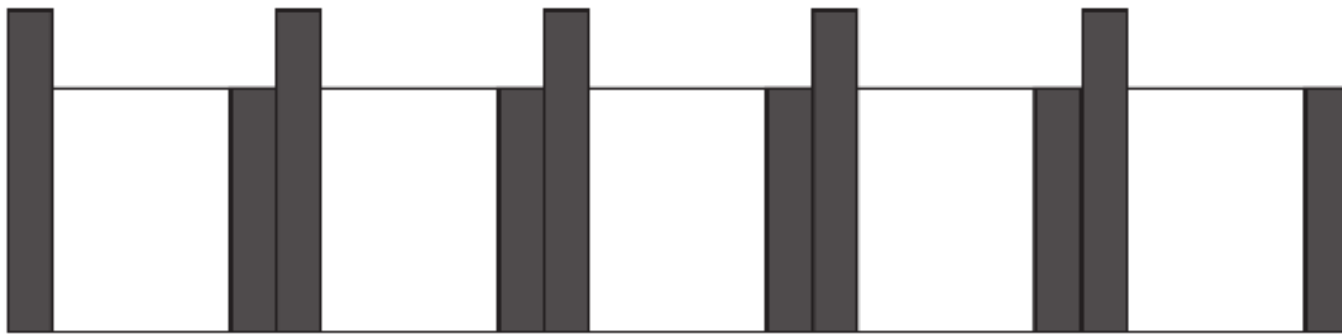
EXERCISE

R REST

HIT-3

HIT-4

N$_2$O$_{RB}$@EXERCISE

R N$_2$O$_{RB}$@REST

EXERCISE

R REST

STATISTICAL ANALYSIS

- SPSS (SPSS 20 Inc., Chicago, USA)
- Skewness ve Kurtosis
- Shapiro-Wilk
- Repeated analysis of variance
- K-Related Samples/Friedman
- LSD, Wilcoxon
- Effect Size
- $p \leq 0.05$, ES > 0.5: medium, > 0.8: large effect

RESULTS

Descriptives Statistic

Parameters	Mean ± SS	%CV	Min	Max
Age (year)	22.1 ± 3.1	14.2	18	28
Height (cm)	175.4 ± 5.2	3.0	170	183
Body mass (kg)	66.2 ± 8.5	12.9	55	78.5
Body Fat (%)	7.2 ± 1.1	15.3	5.9	9.2
VO_{2max} (mL·min·kg^{-1})	64 ± 5.6	8.8	58.1	74.1
p@VO_{2max} (W·kg^{-1})	5.5 ± 0.3	6.3	5	6.1
AnE@%VO_{2max}	78.4 ± 3	3.8	74.5	83.1
p@AnE (W·min^{-1})	4 ± 0.4	13.5	76.4	87
p@SV_{max} (W)	273.5 ± 71.7	26.2	124	350
Q_{max} (L·min^{-1})	25 ± 2.7	10.8	20.3	28.2
SV_{max} (mL)	147 ± 21	14.3	113.2	171.6
a-vO_{2diff_max} (%)	89 ± 6.3	7.11	81	99
HR_{max} (beat·min^{-1})	188.1 ± 7.2	3.8	177	198
SV_{max}@%VO_{2max} (%)	82.5 ± 18.3	22.2	40	100

RESULTS

T_{spent} above 90% of VO_{2max}
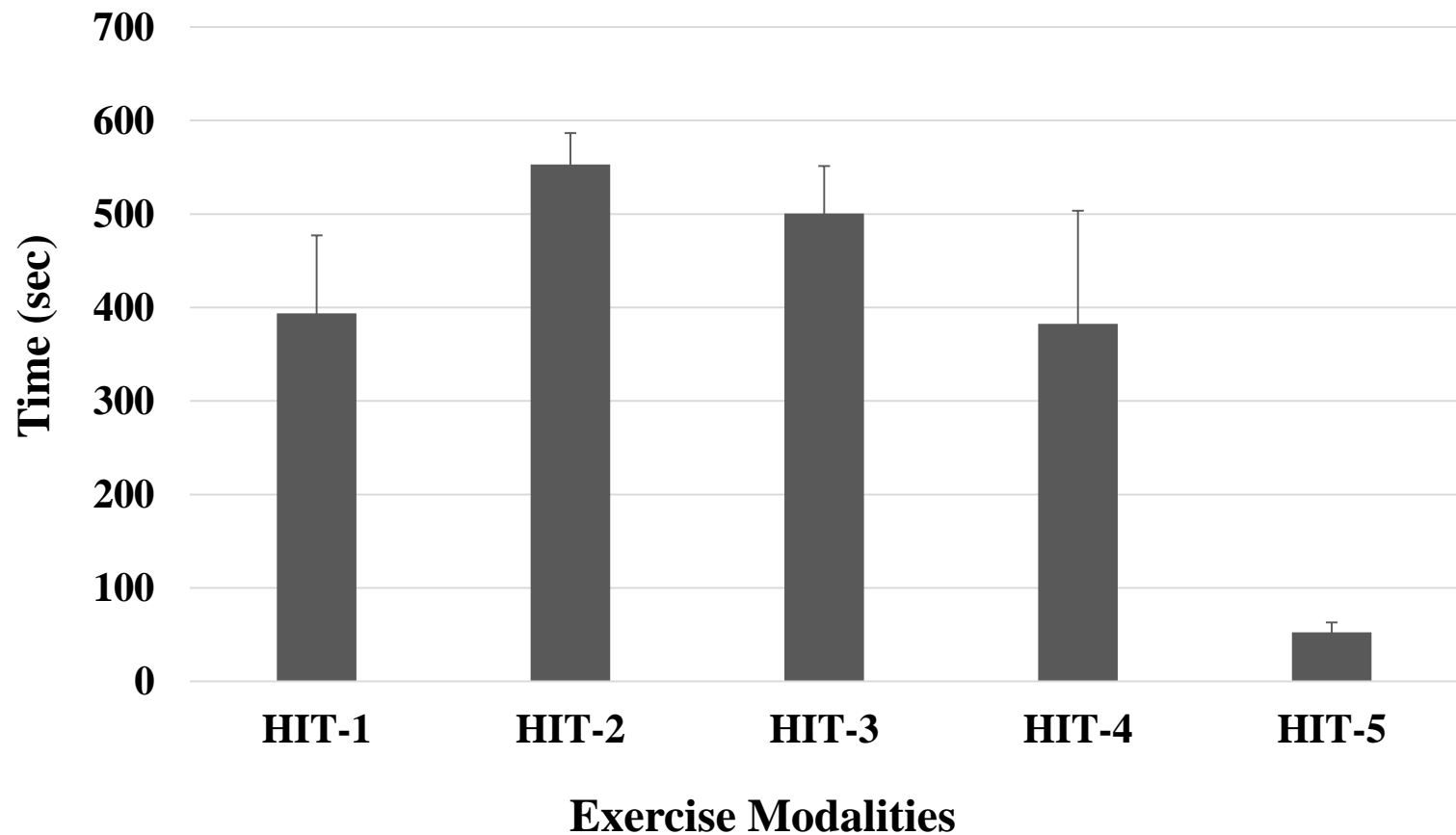
RESULTS

T_{spent} above 95% of VO_{2max}
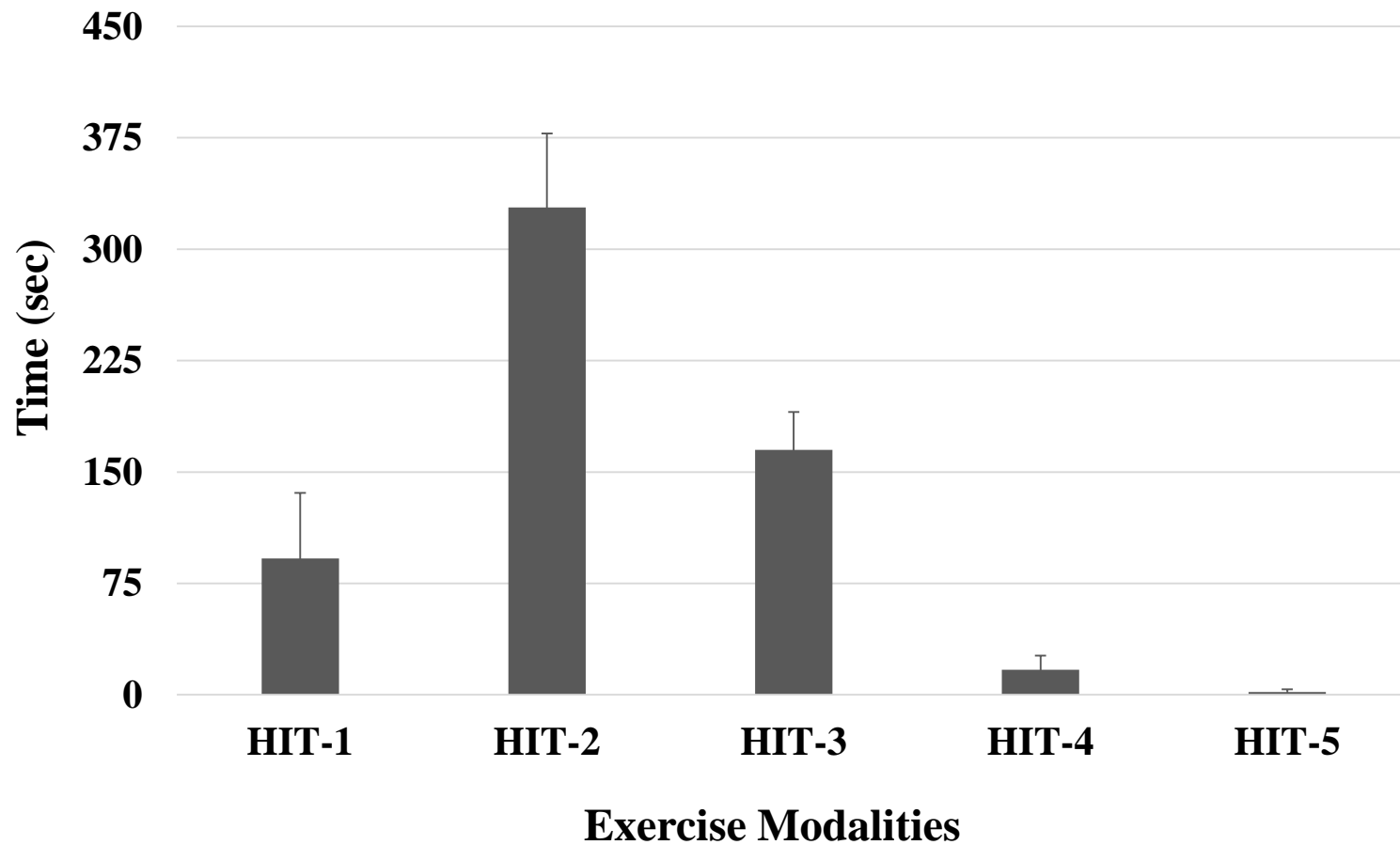
RESULTS

T_{spent} above 90% of Q_{max}
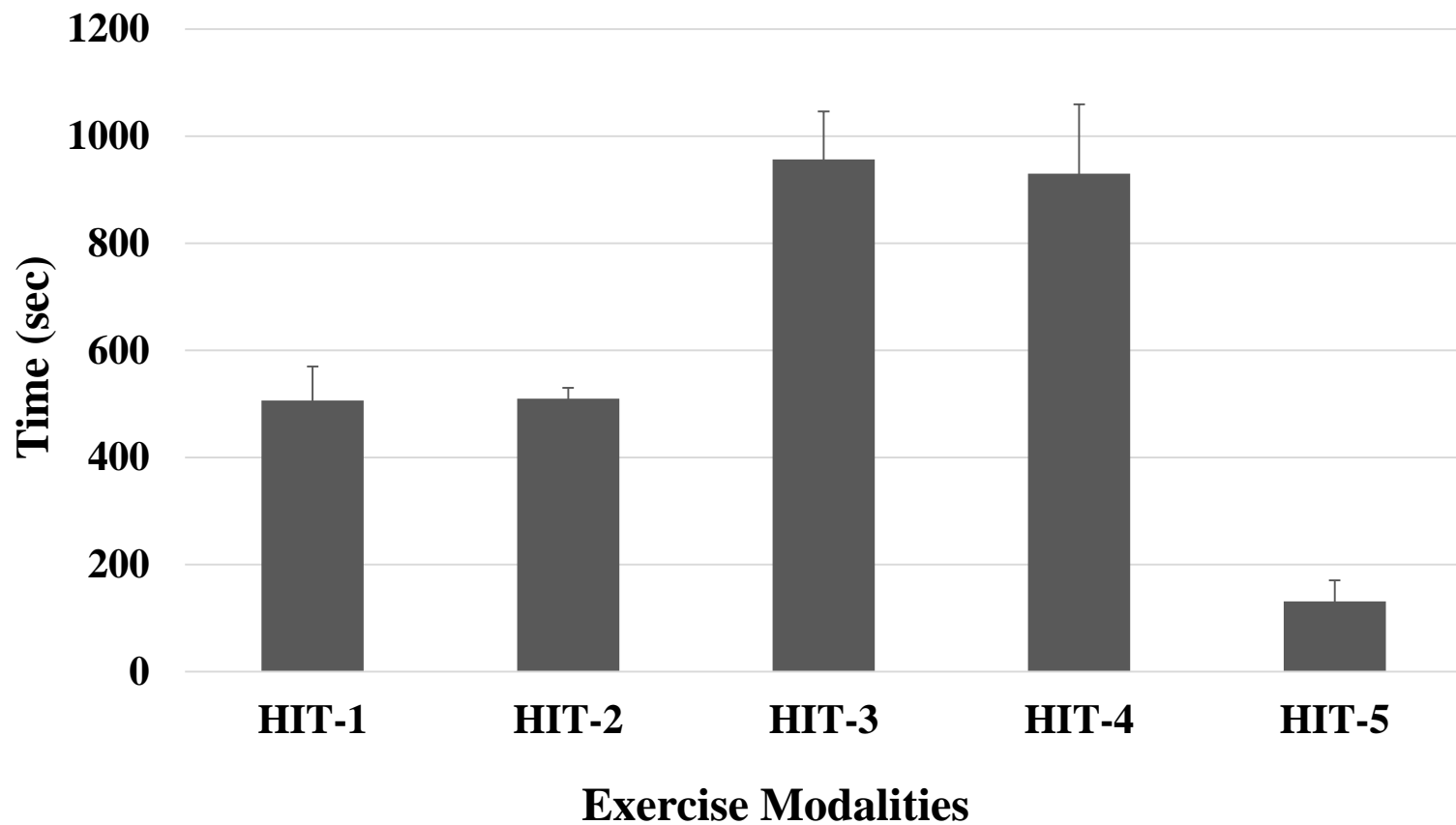
RESULTS

T_{spent} above 90% of SV_{max}
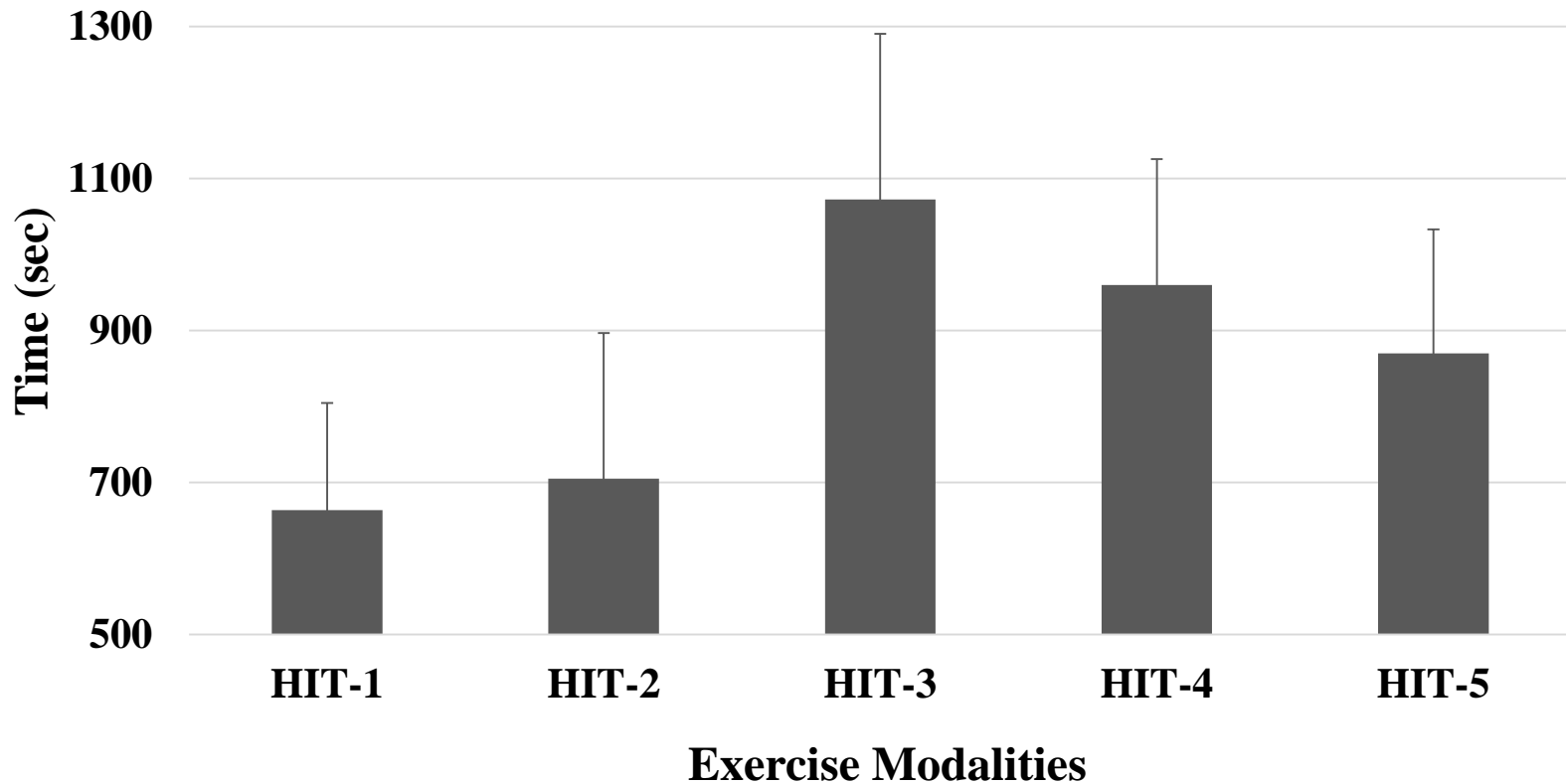
RESULTS

T_{spent} above 90% of HR_{max}
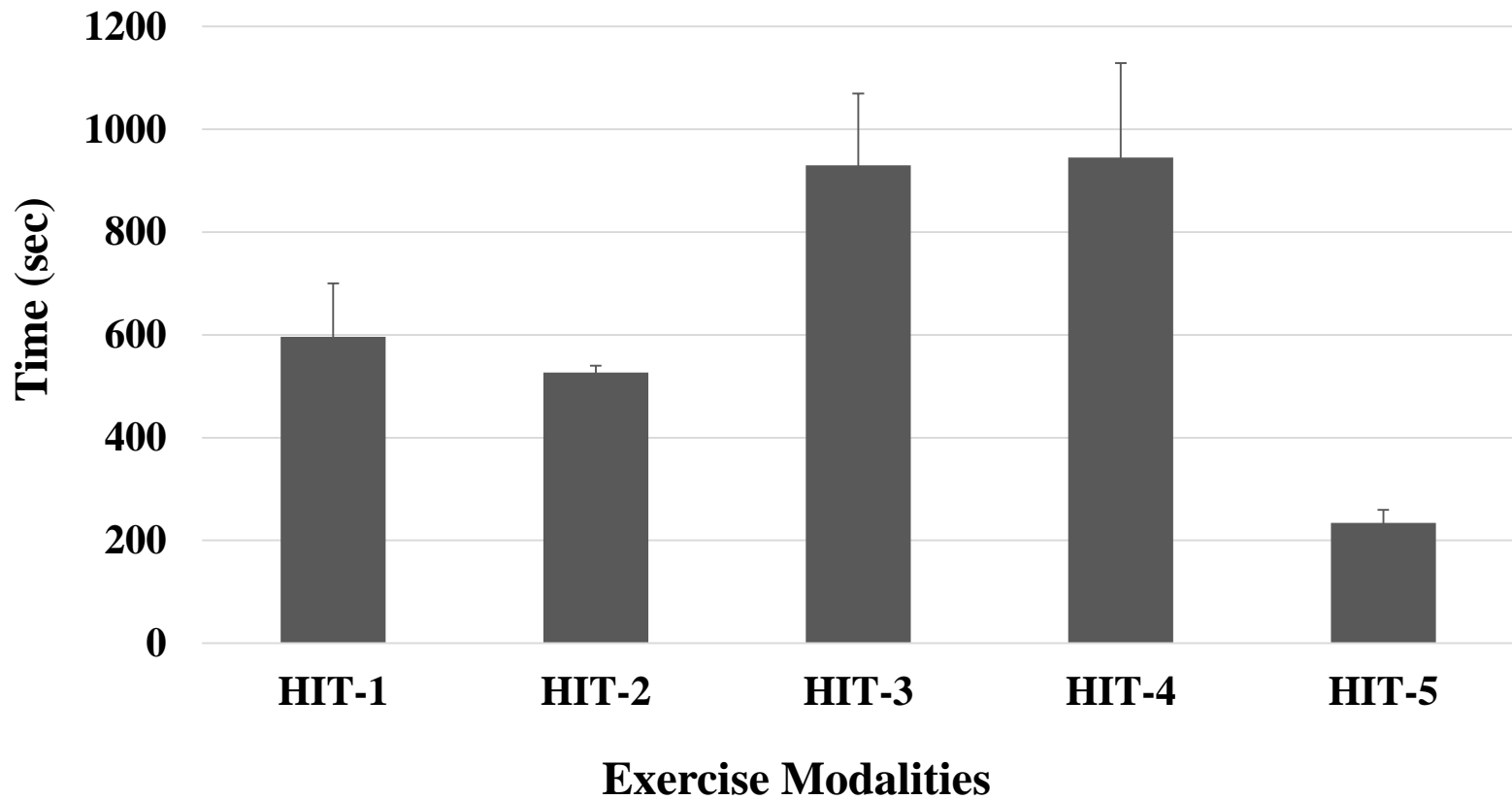
RESULTS
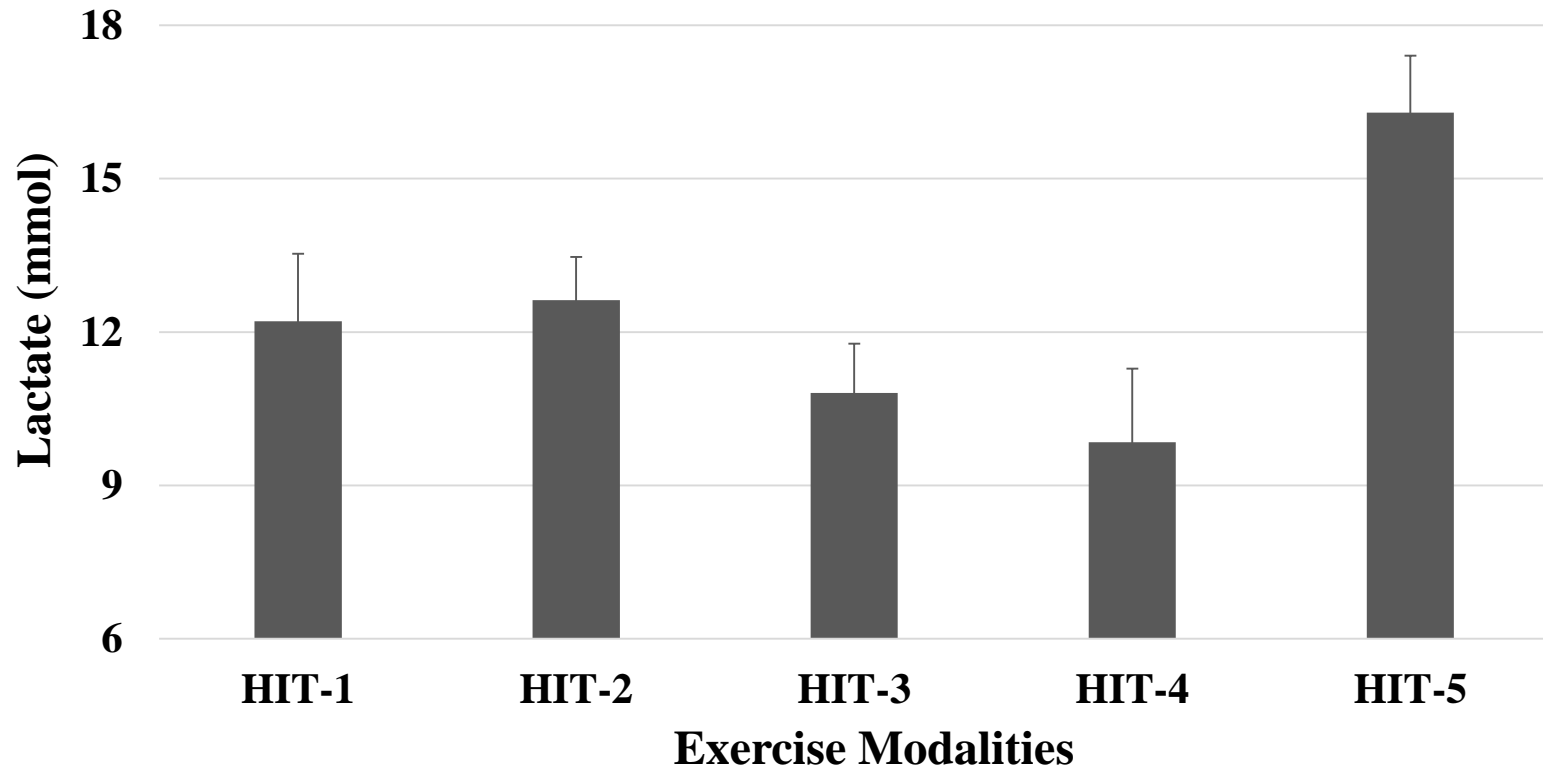

T_{spent} above 90% of a-vO$_{2\_diff\_max}$
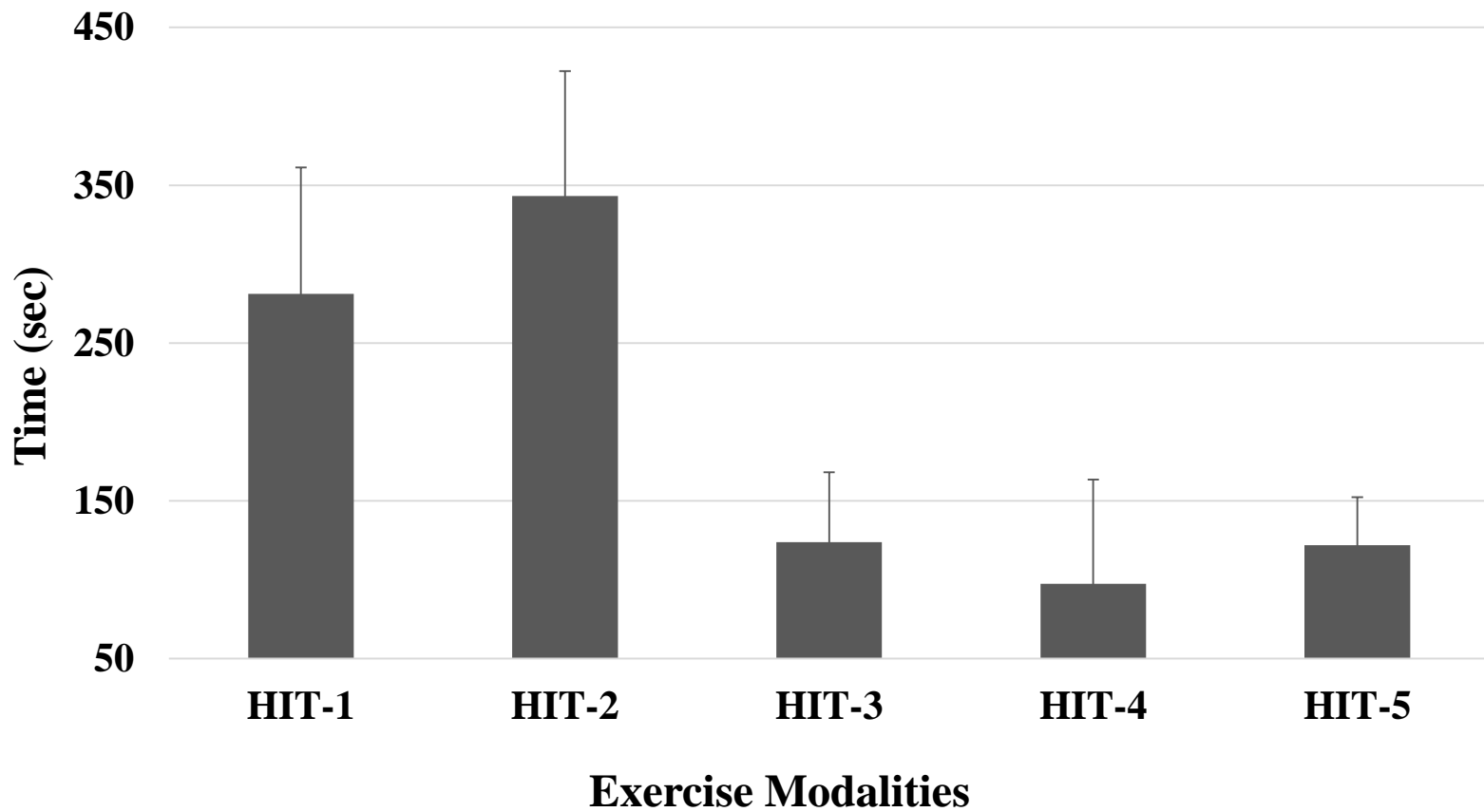
RESULTS

Post Exercise Fat Oxidation (2-h)
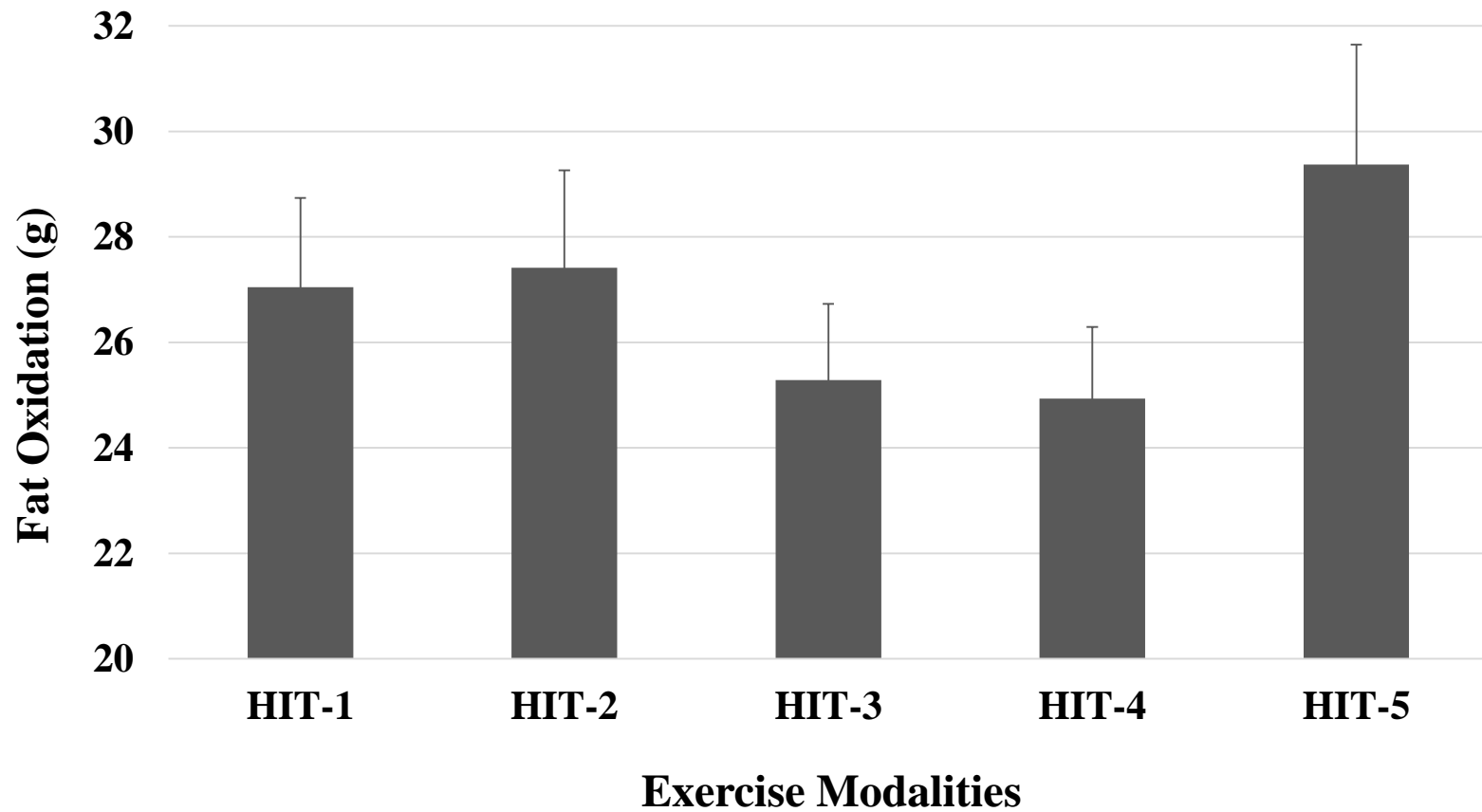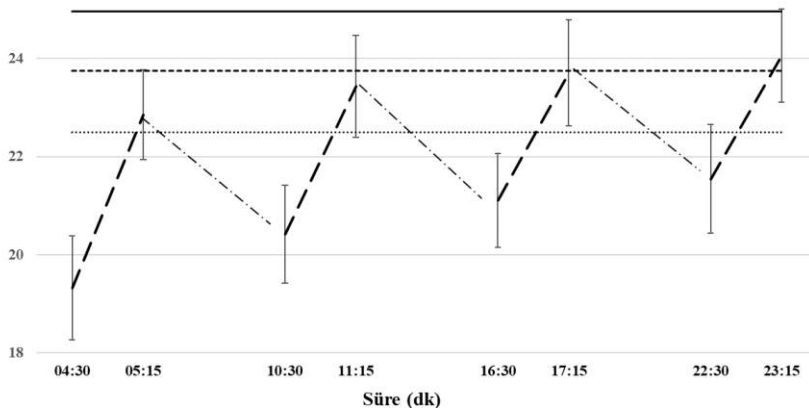
RESULTS

Maximal lactate values of HIT sessions
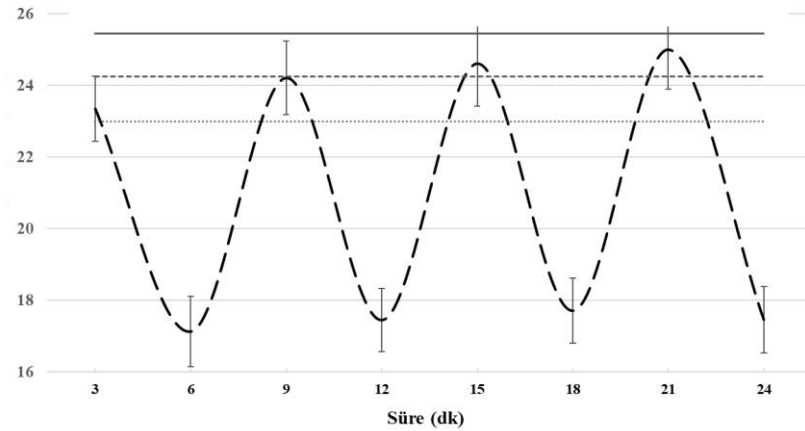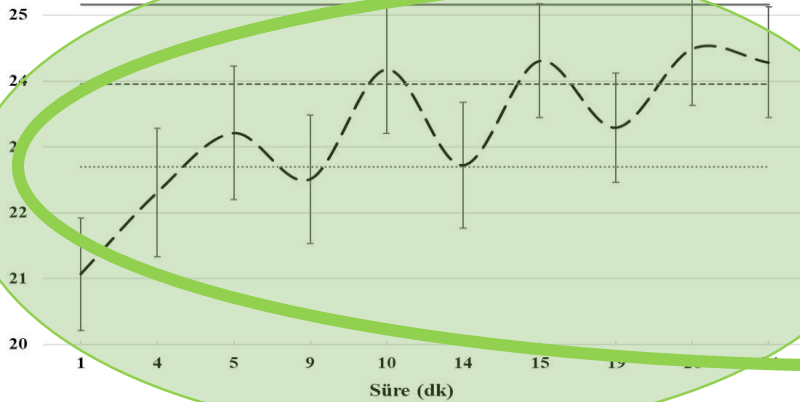
DISCUSSION

DISCUSSION – Q RESPONSES
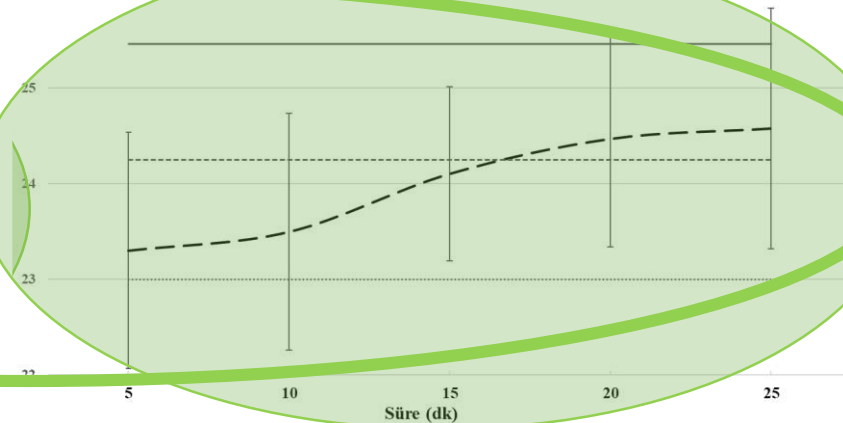
DISCUSSION - SV RESPONSES
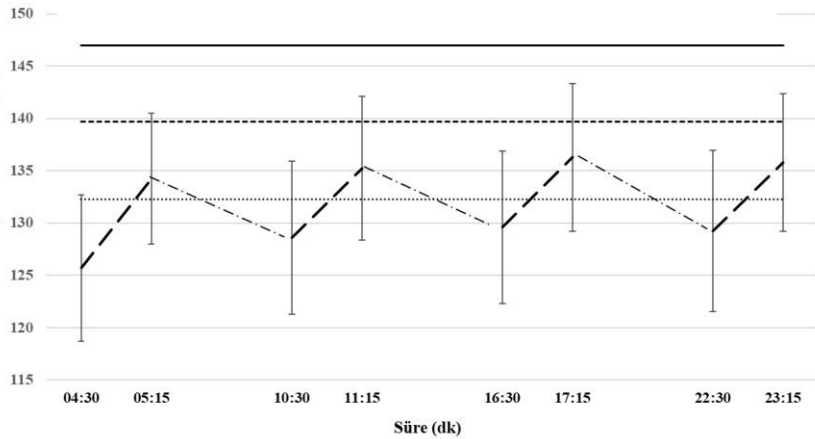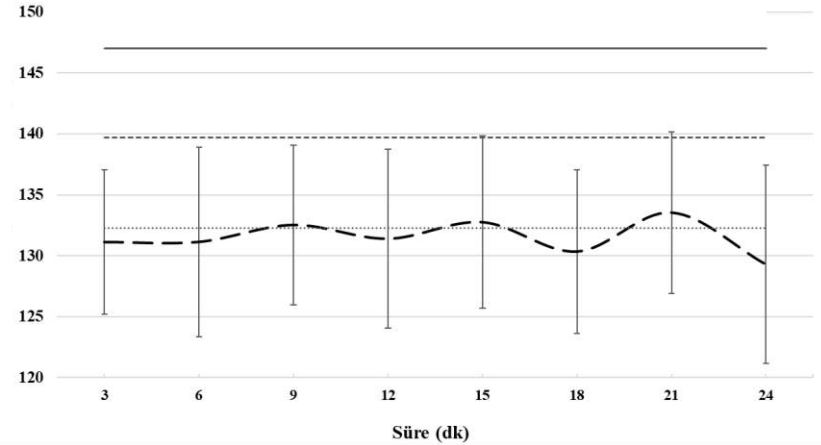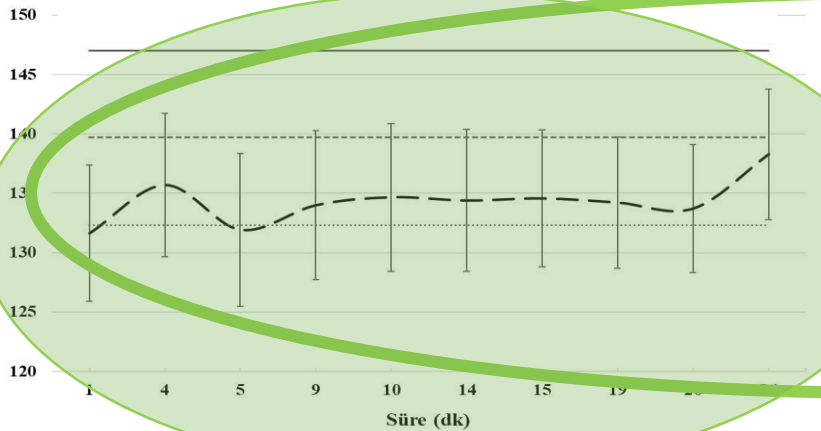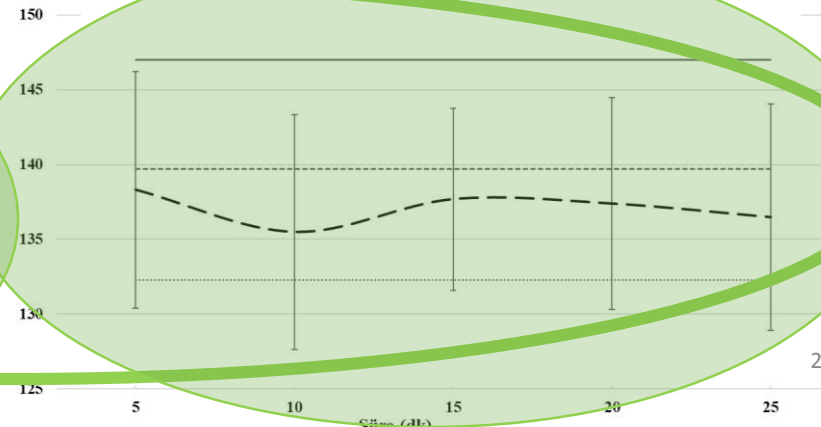
DISCUSSION – A-vO$_{2\_DIFF}$ RESPONSES
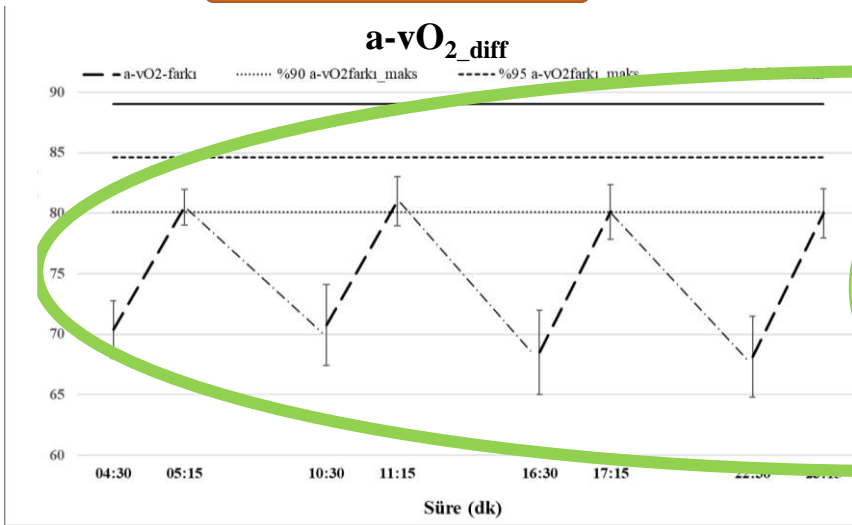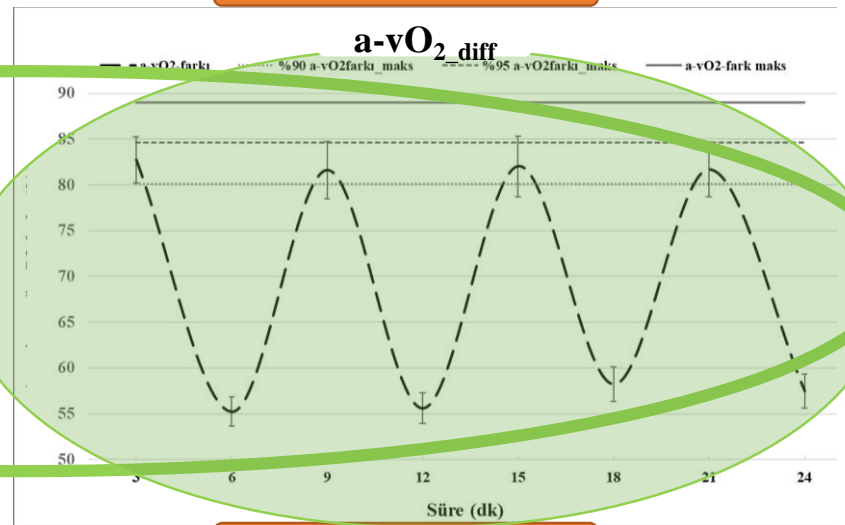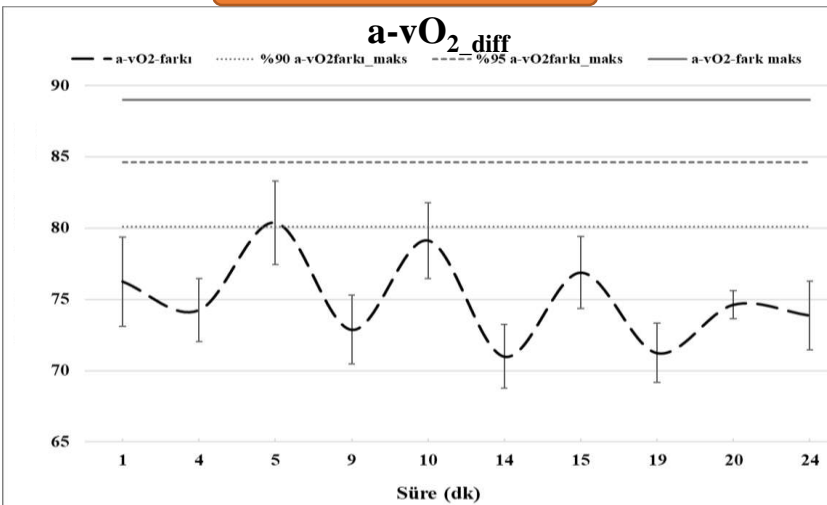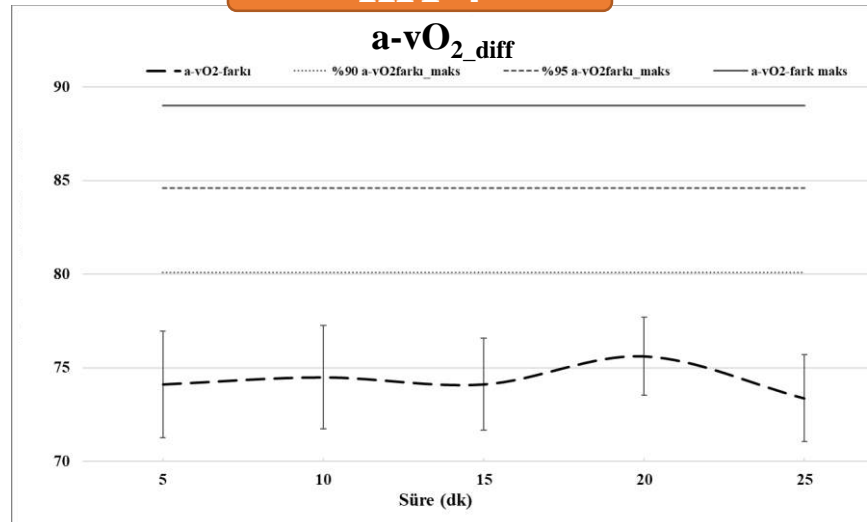
DISCUSSION - HR RESPONSES
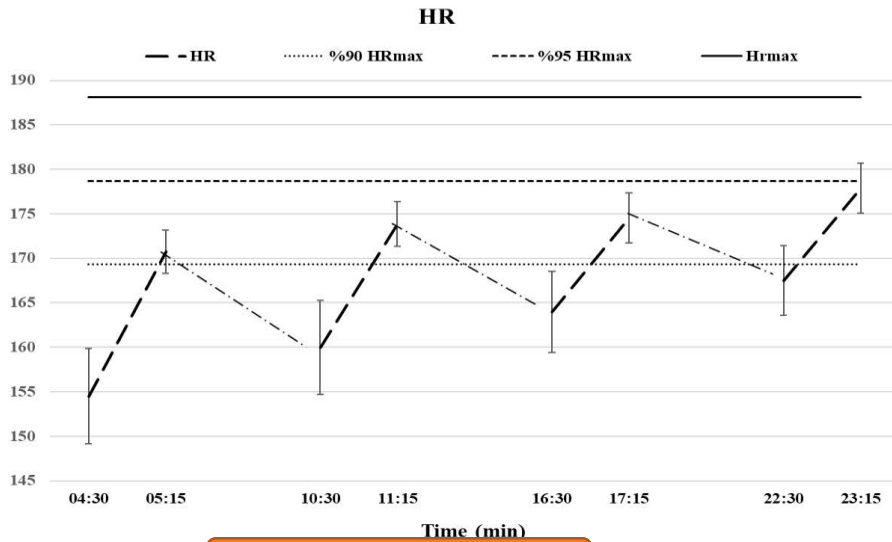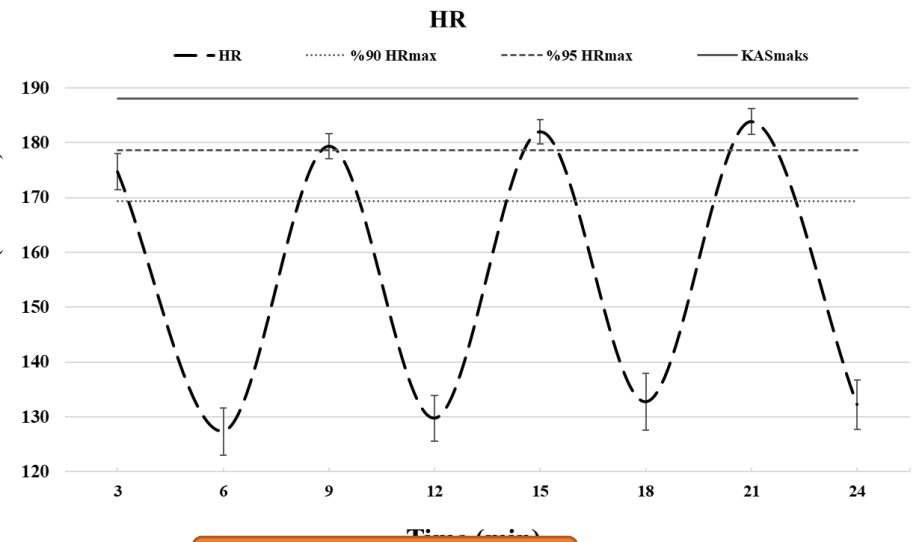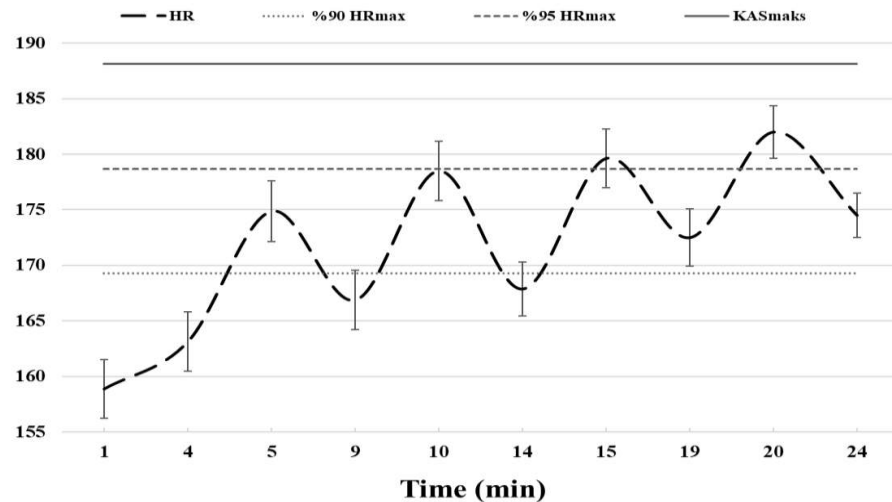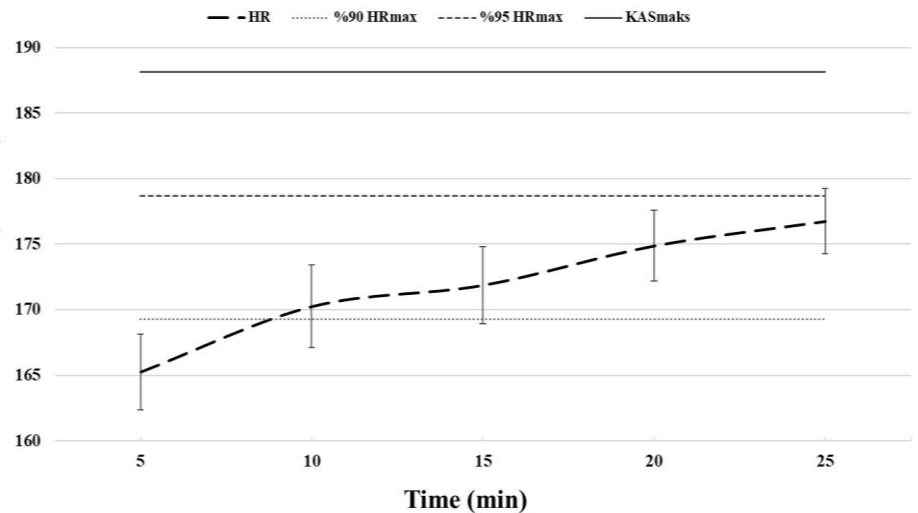
CONCLUSION

Long Inverval (3-min) HIT

VO_{2max}

Continuous HIT

Central

Component
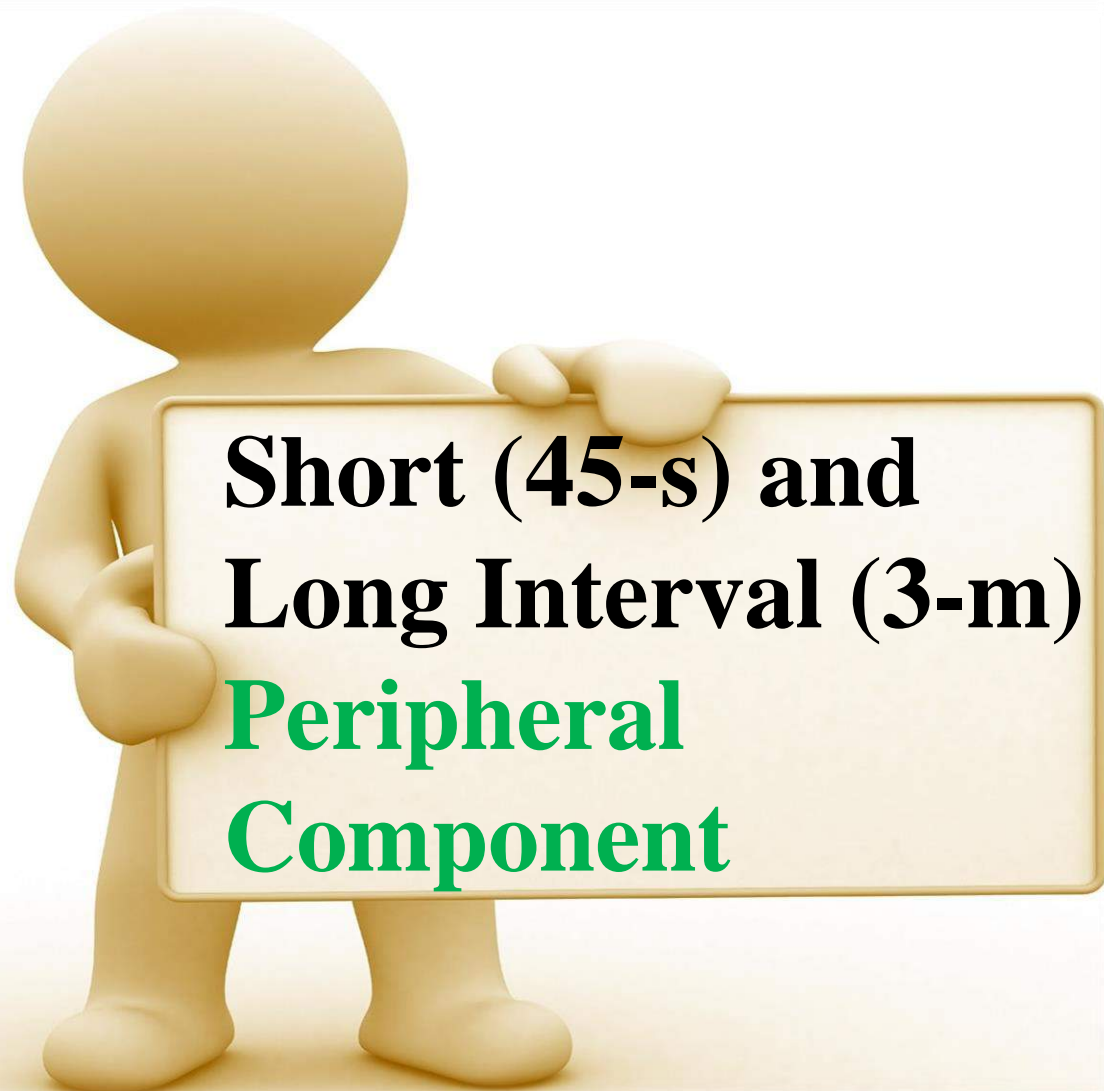
Short (45-s) and Long Interval (3-m) **Peripheral Component**

Sprint Spesific HIT (all-out)
SV, Anaerobic

Thank You...

Nitrous Oxide Rebreathing

MAXIMAL EXERCISE

a-vO$_{2diff}$

Cardiac Output (Q)

Stroke Volume (SV)
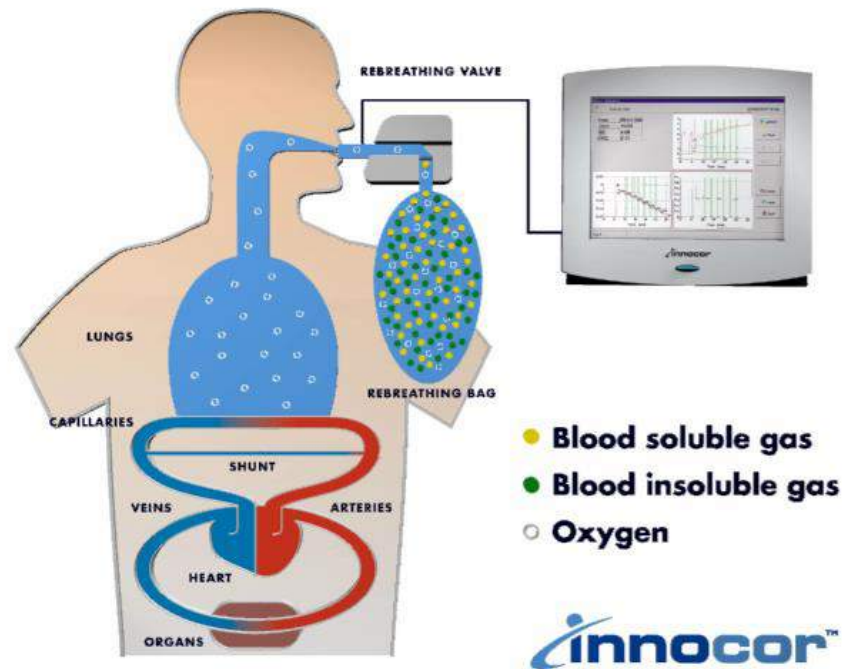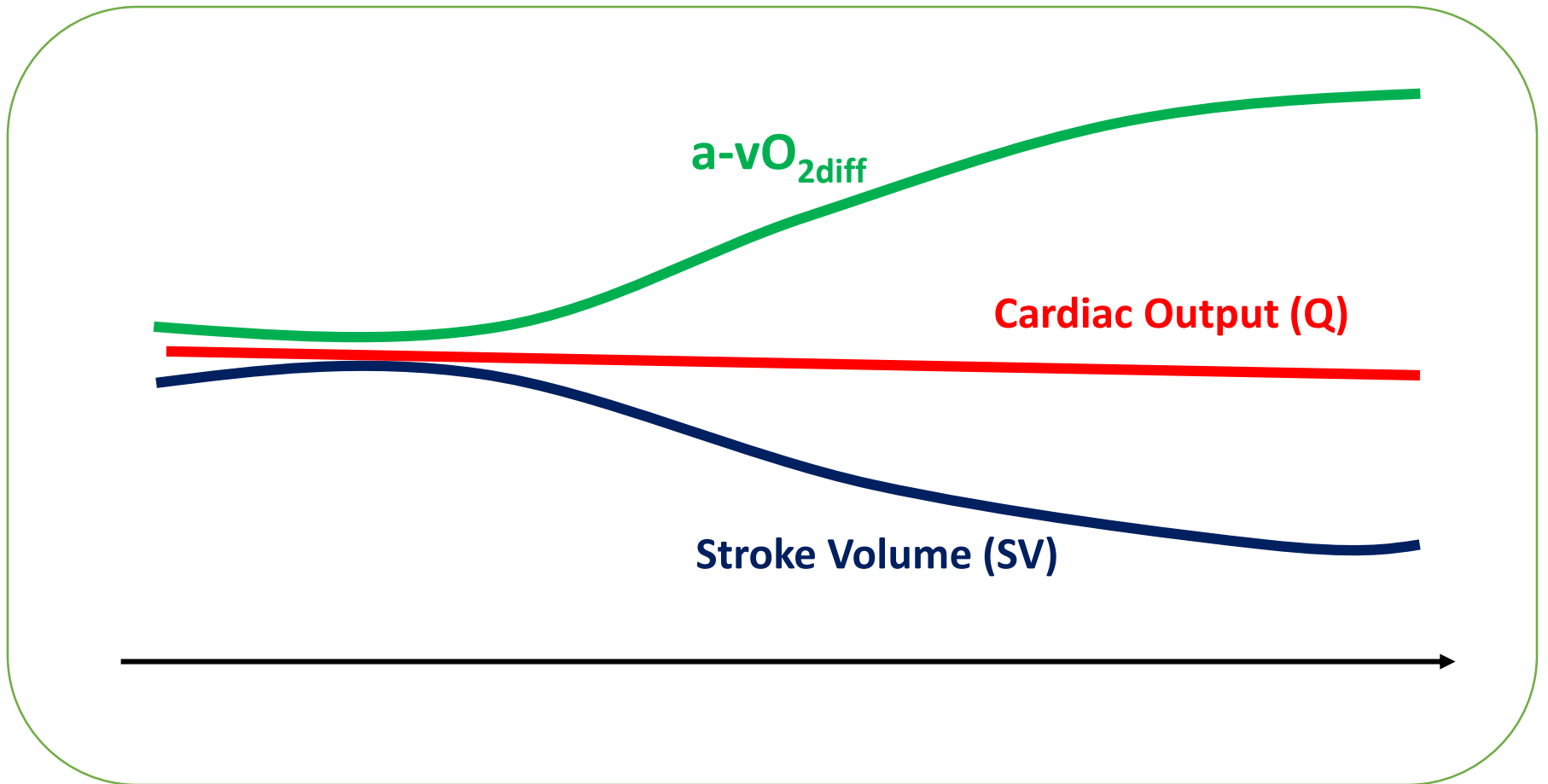
Table 12. Typical duration and intensity combinations used in training sessions by elite endurance athletes.

	Duration[a] (min)	Intensity (%VO2max)	Total VO2[b] (L)	Training load[c] (RPE.min)
Basic endurance	120	60	360	240-360
Threshold training (lactate ~3-4 mM)	60 (4x15)	85	293	375
90 % intervals (lactate ~5-7 mM)	40 (5x8)	90	218	375-425
VO2max intervals (lactate ~6-10 mM)	24 (6x4)	95	152	300-350

[a]Warm-up not included.
[b]Oxygen consumption calculations based on a male athlete with 5 L.min^{-1} VO2max and include 15 min warm up at 50 %VO2max for threshold and interval sessions. Examples are based on a manageable accumulated duration at different interval training intensities, and drawn from the training diaries of elite athletes.
[c]Session rating of perceived exertion x duration (Foster et al., 1996; Seiler et al., 2007).

Seiler ve ark., 2009

Minimal Training workload/speed

%75 VO$_{2max}$

MacDougall D, Sale D. Continuous vs. interval training: a review for the athlete and the coach. Can J Appl Sport Sci [Internet]. 1981 Jun [cited 2018 Jan 22];6(2):93–7
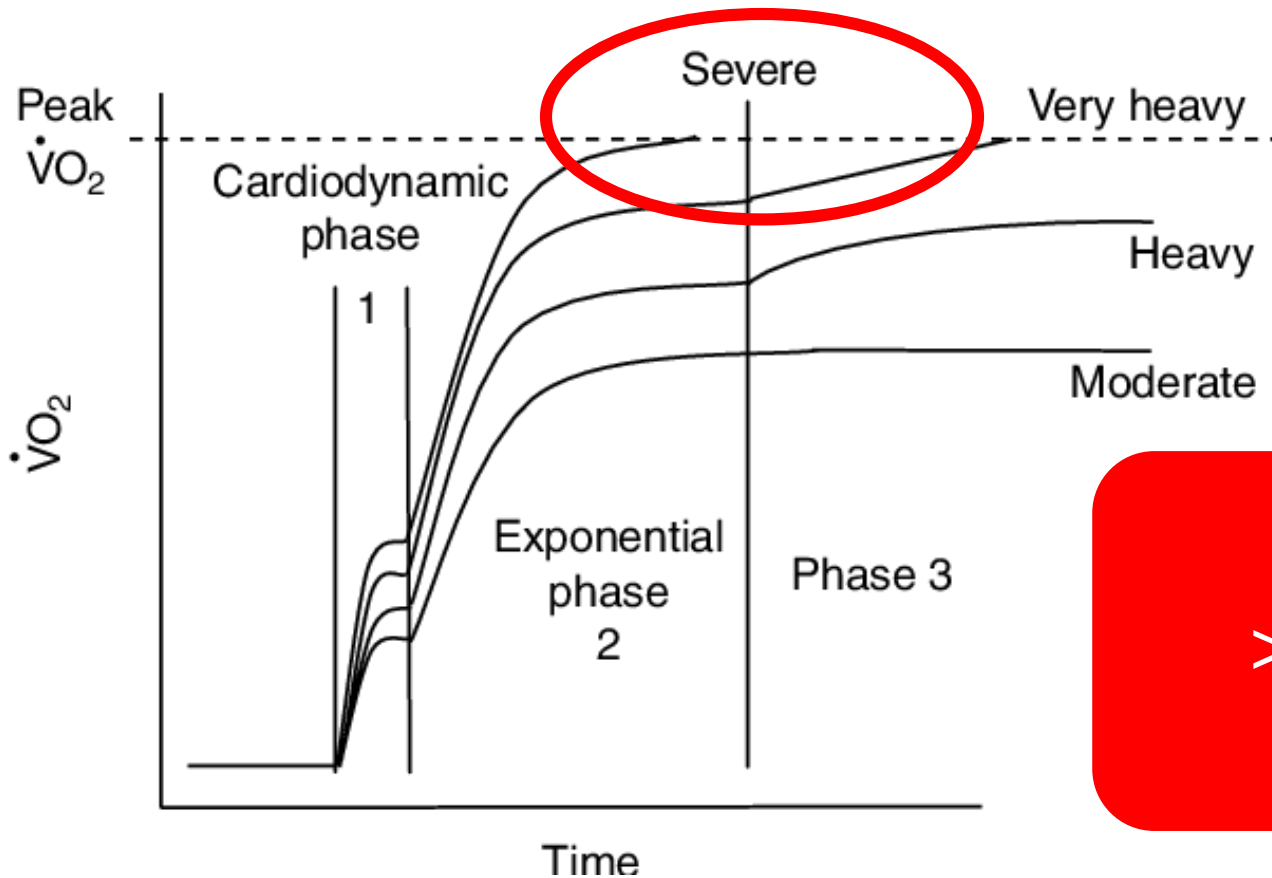
Minimal Training workload/speed

$>\%80\ VO_{2max}$

Stone NM, Kilding AE. Aerobic Conditioning for Team Sport Athletes. Sports Medicine [Internet]. 2009 Aug [cited 2018 Feb 6];39(8):615–42.
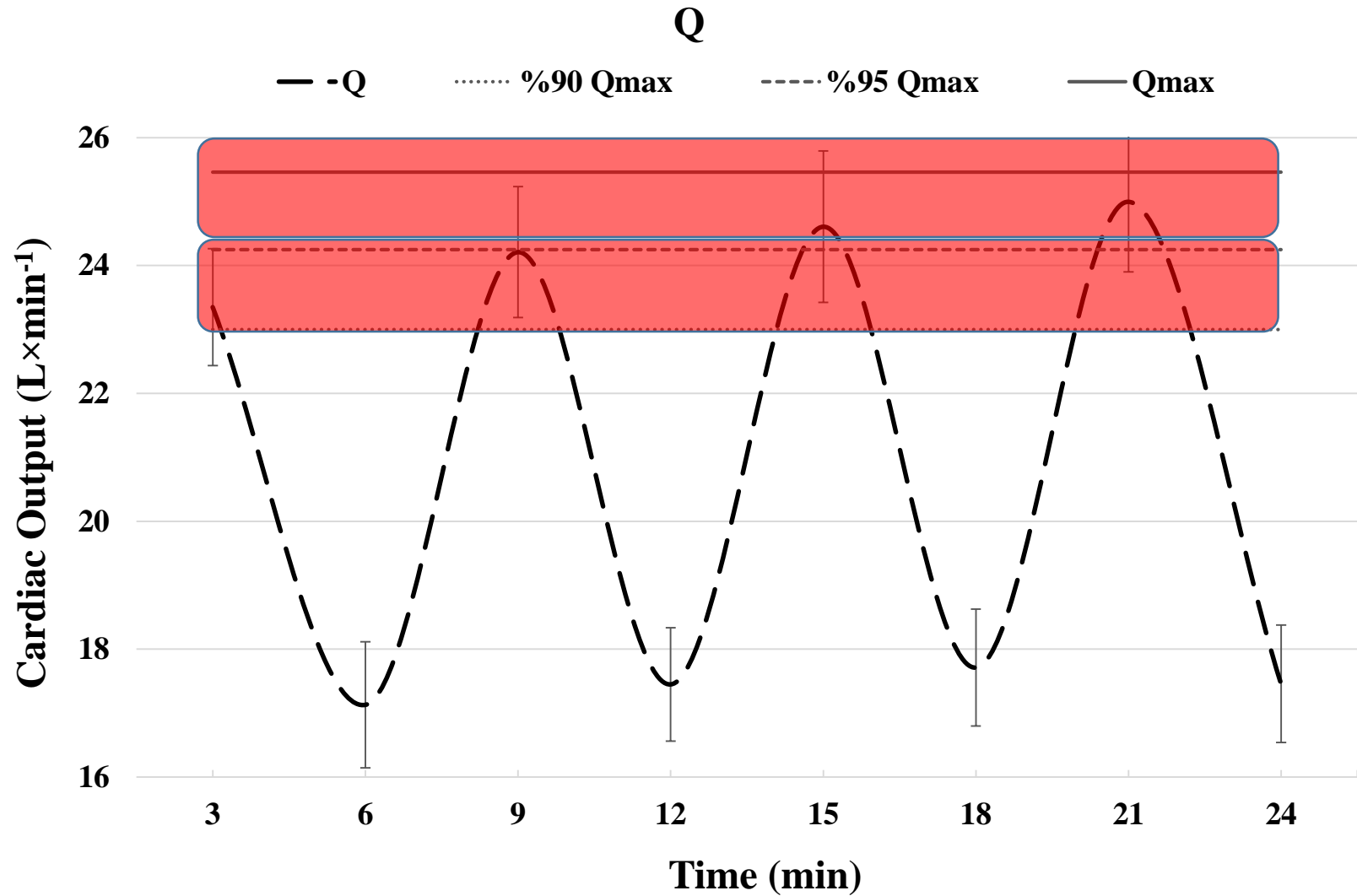
> **> MLSS/AnE**

Jones AM, Vanhatalo A, Burnley M, Morton RH, Poole DC. Critical power: Implications for determination of VO2max and exercise tolerance. Medicine and Science in Sports and Exercise
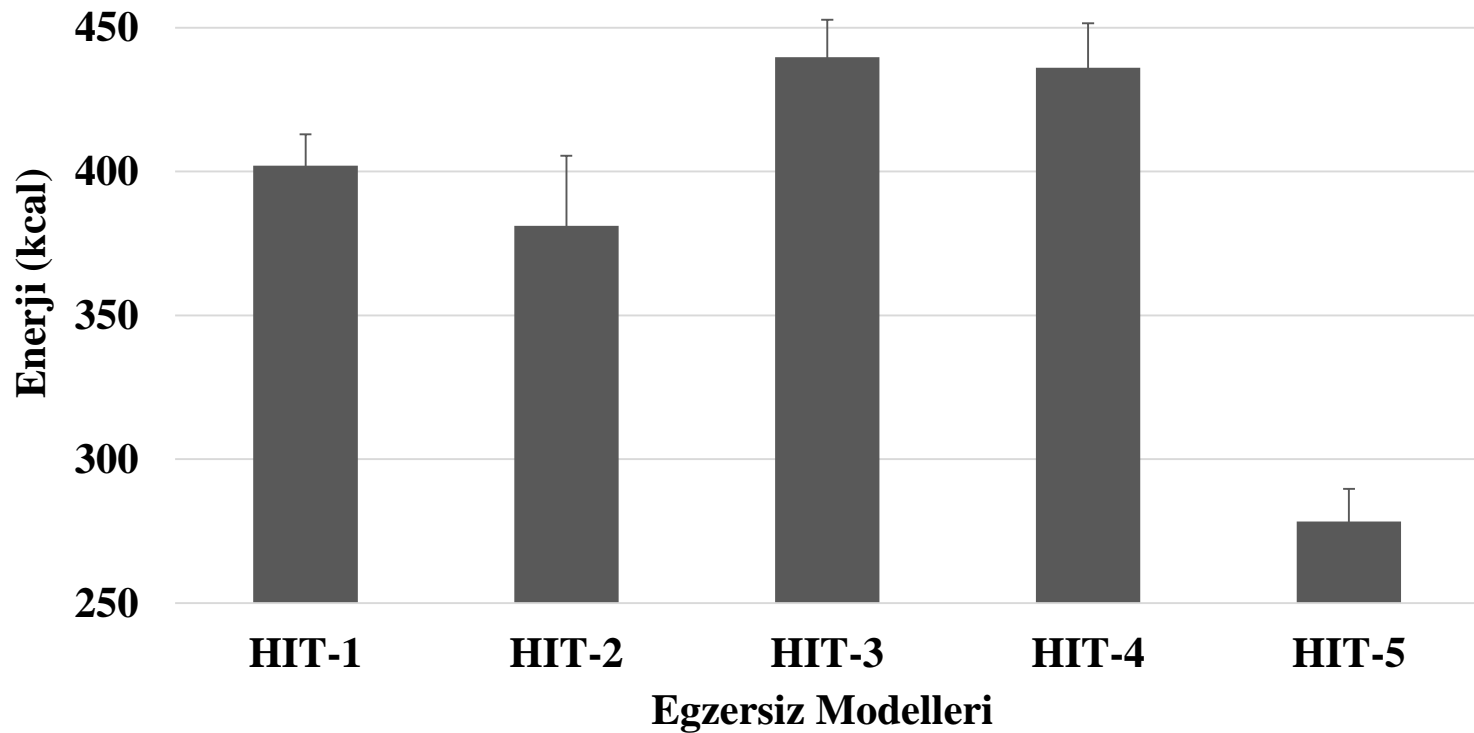
RESULTS

Mean power of HIT sessions

Exercise modalities	Loading (Mean ± SS)	Recovery (Mean ± SS)	Ortalama (Mean ± SS)
HIT$_1$ (W)	399.4 ± 44	108.3 ± 10.7	253.8 ± 27.4
HIT$_2$ (W)	337.8 ± 41.8	108.3 ± 10.7	223 ± 26.3
HIT$_3$ (W)	351.3 ± 36.9 and 265.6 ± 38.9	-	282.8 ± 38.5
HIT$_4$ (W)	288.8 ± 35.6	-	288.8 ± 35.6
HIT$_5$ (W)	640.2 ± 79.2	108.3 ± 10.7	174.8 ± 12.7

RESULTS

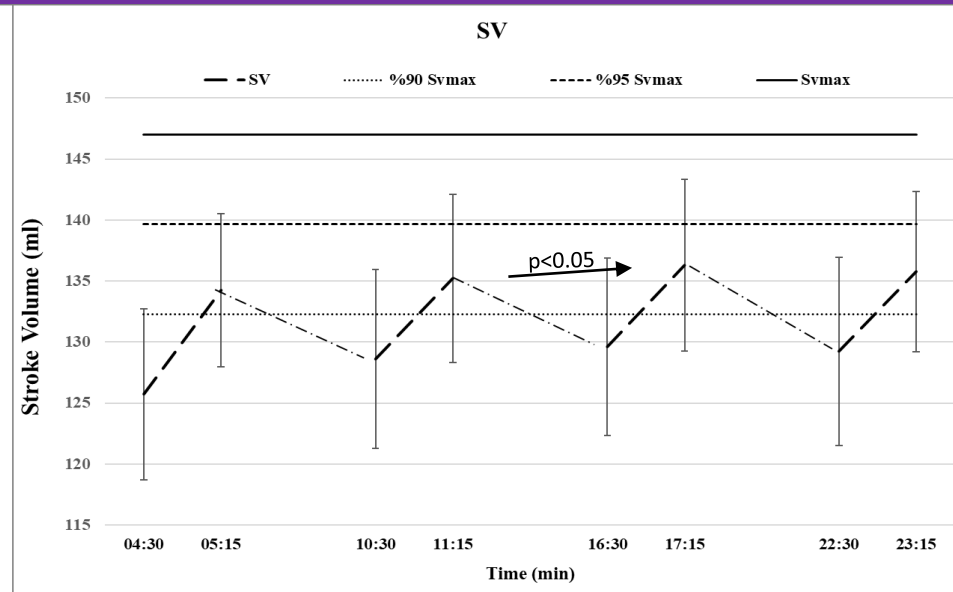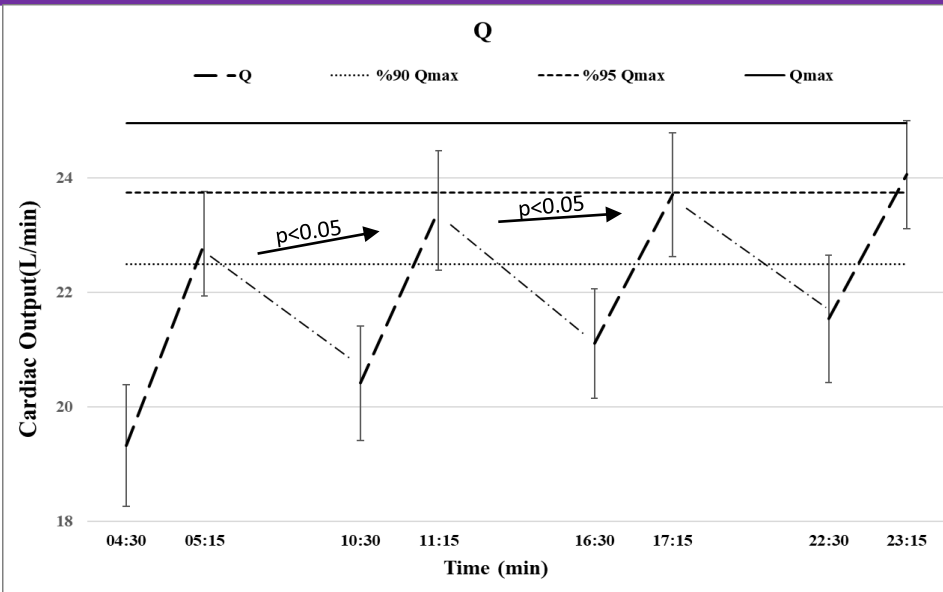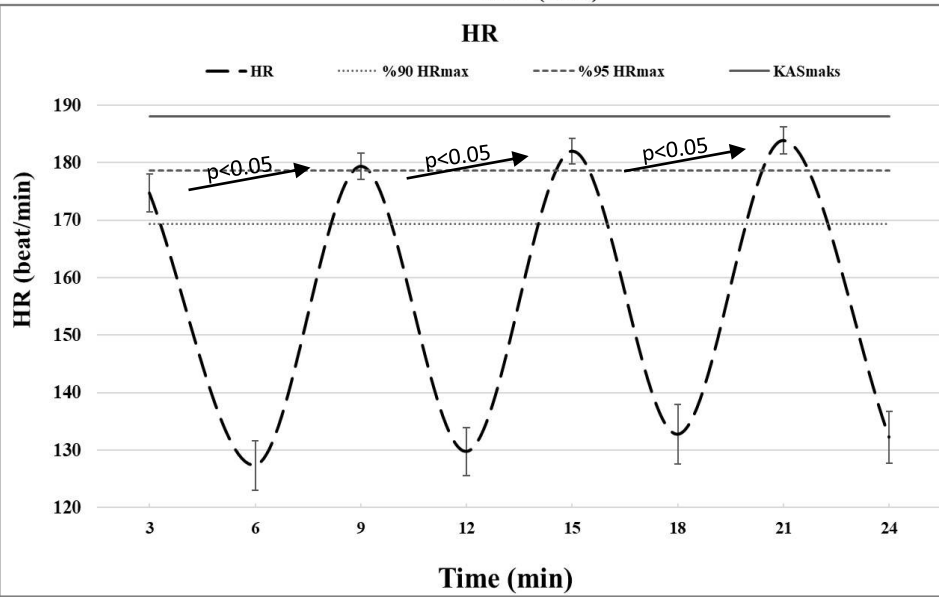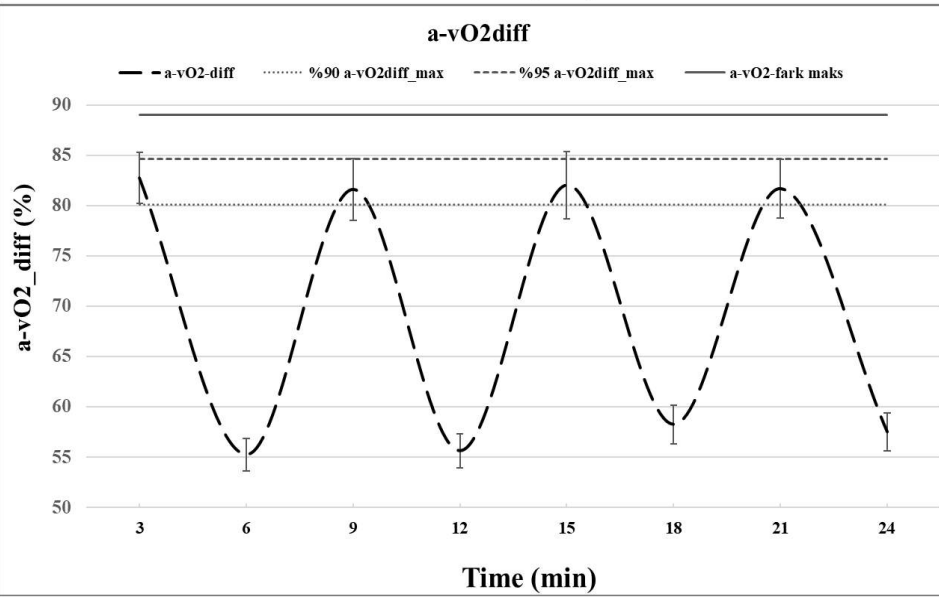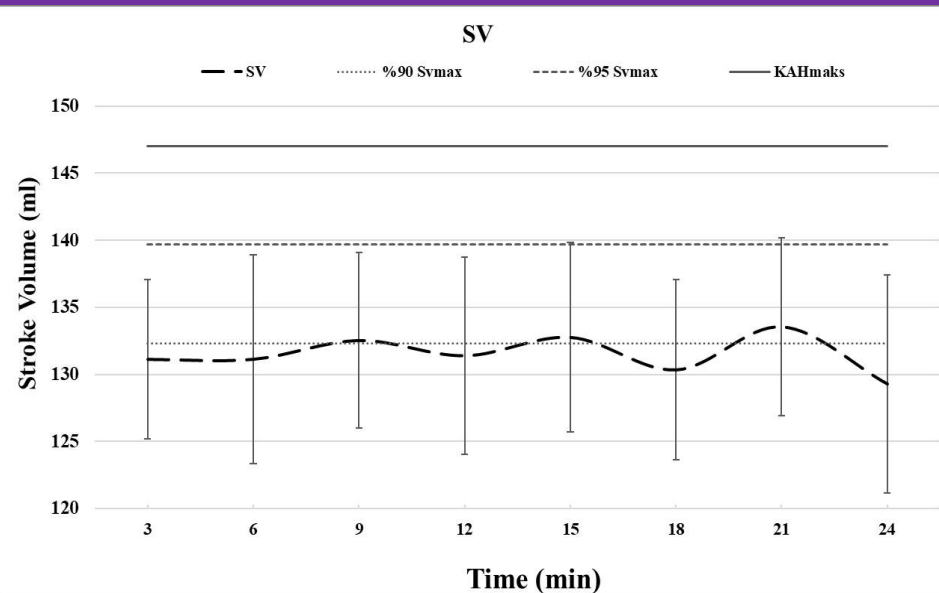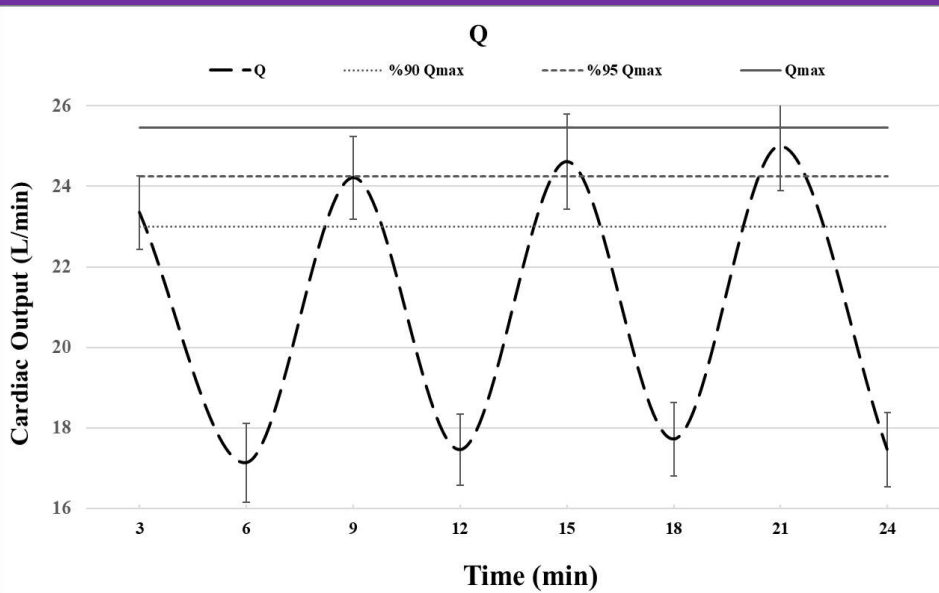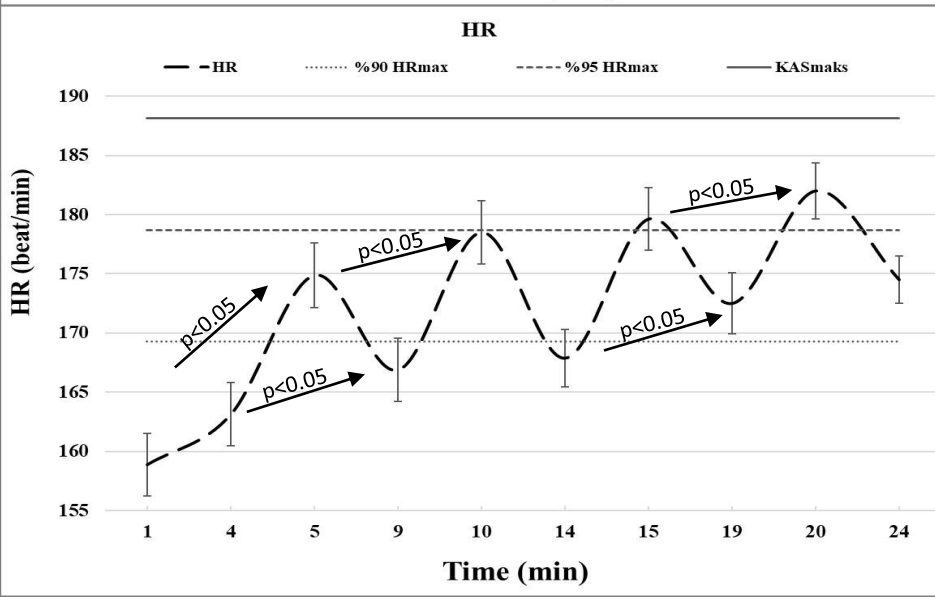**Total Energy Consumption During Exercises**

RESULTS

Post Exercise Energy Consumption Values
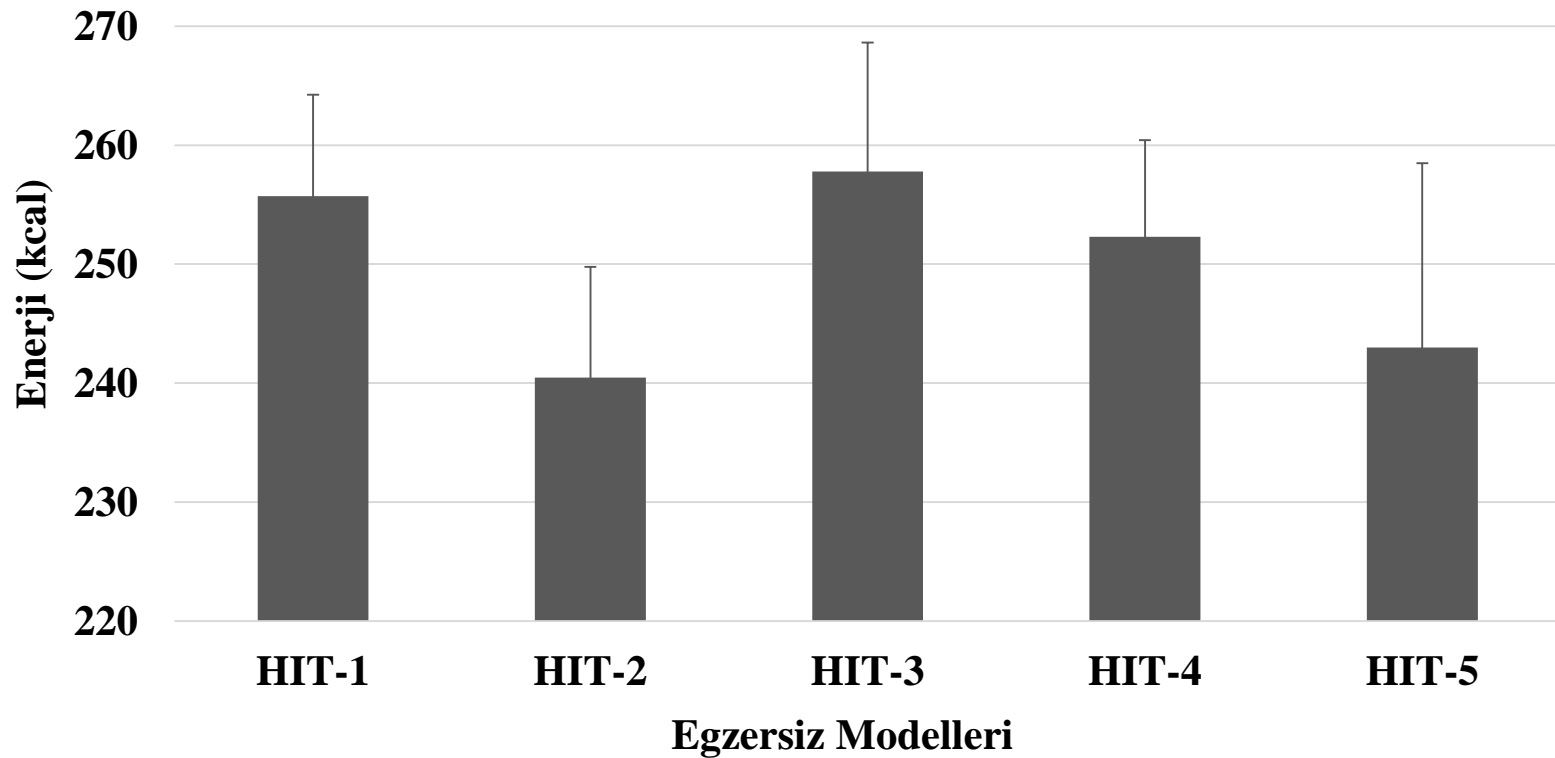
RESULTS - *HIT₁: (45″ × 16 rep.@~%110VO₂max)*
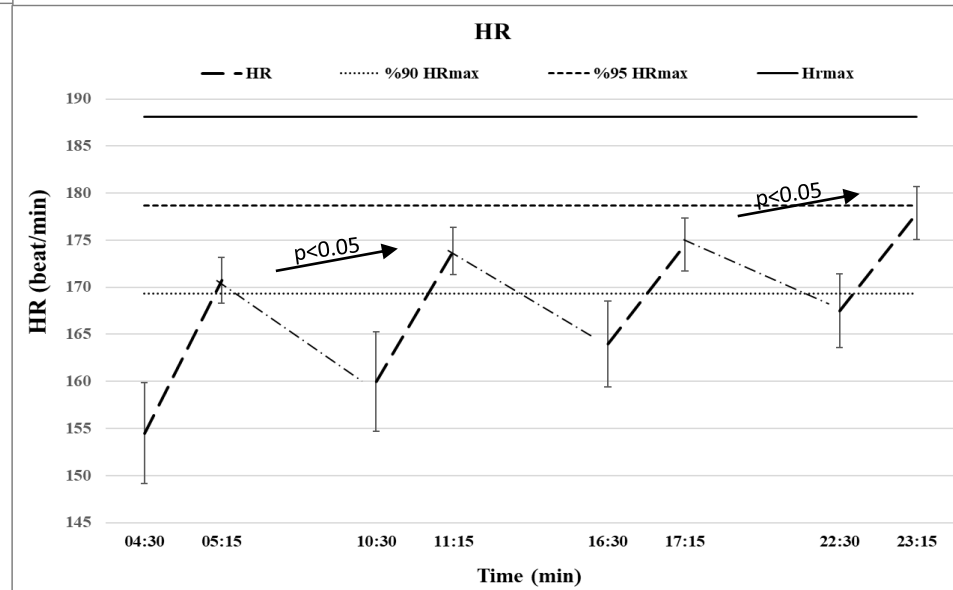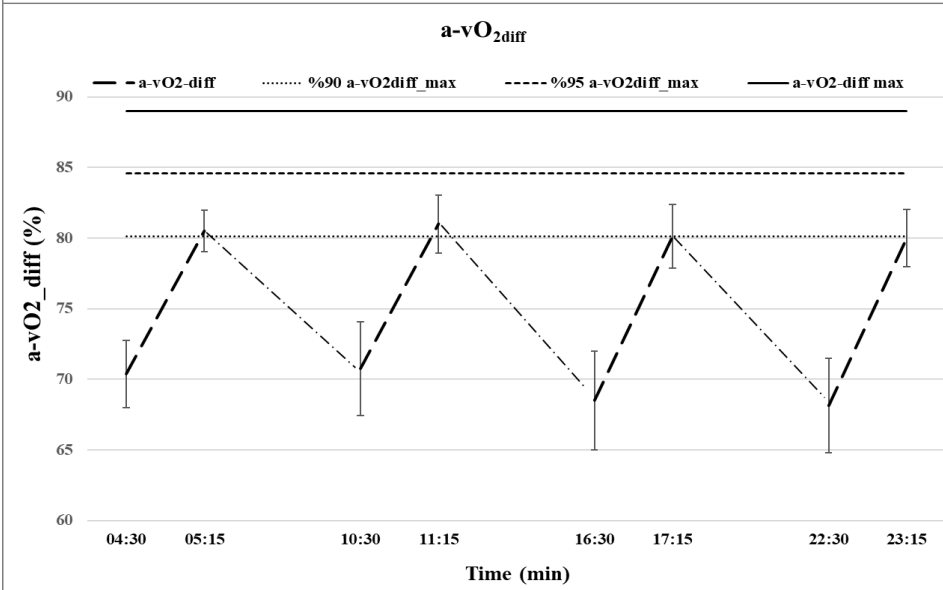
RESULTS - *HIT₂: (3' × 4 rep. p@~%93VO₂ₘₐₓ)*

RESULTS - *HIT₃: (1' p@~VO₂ₘₐₓ + 4' p@AnE × 5 rep.)*
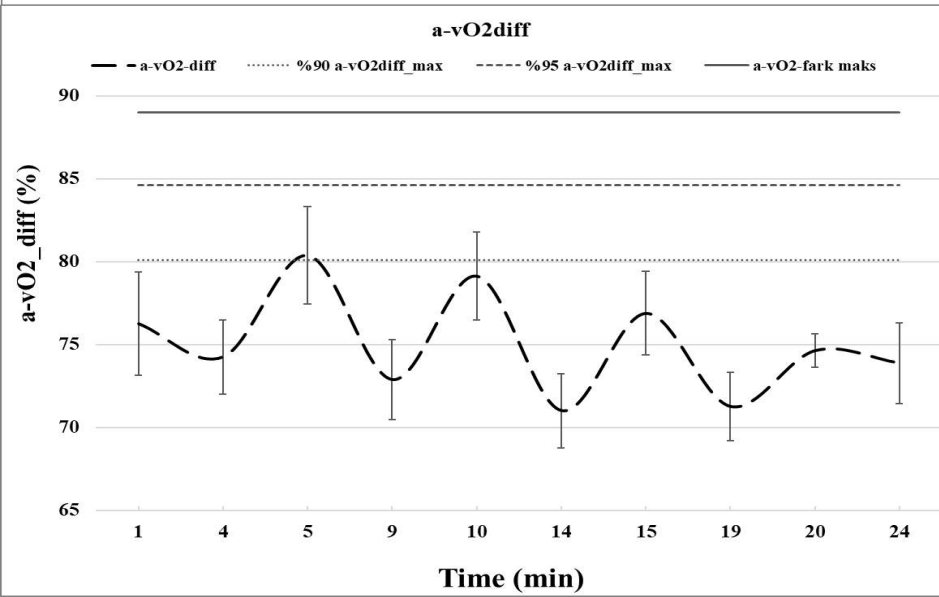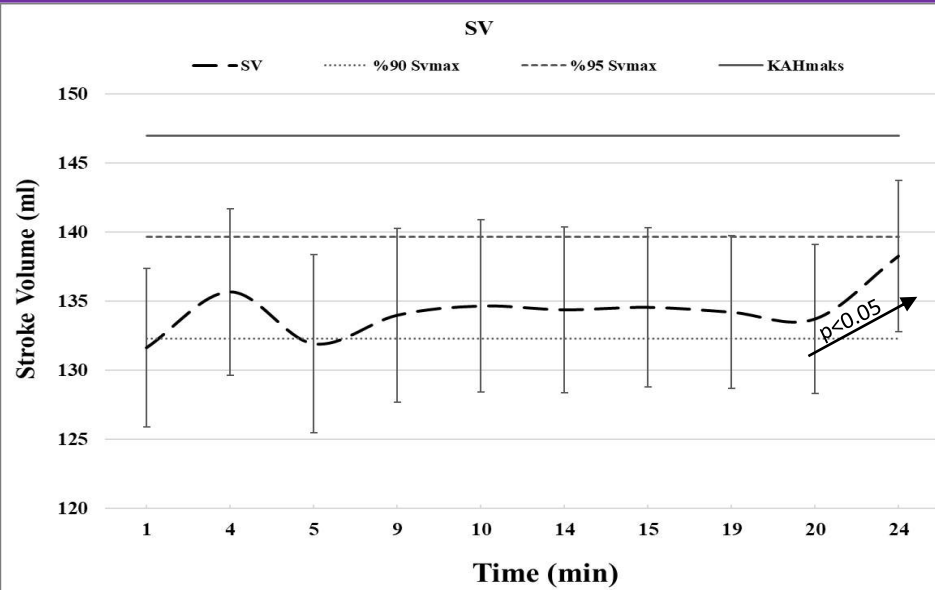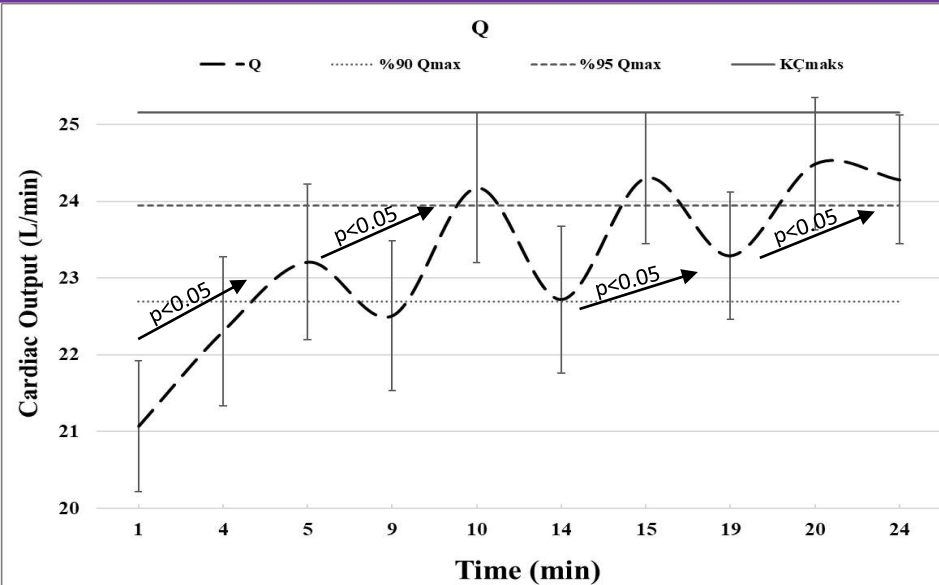
RESULTS - *HIT$_4$: (25' p@~%80VO$_{2max}$)*

23-dk

14-dk

10-dk

30-sn, p_{-min}@VO_{2maks}, 2:1 y/t
~3-dk; %50T_{maks}
~4,5-dk; %80T_{maks}

Maksimal efor

30-sn

12-dk

%90 KAH_{maks}

3-dk ·-dk

8,5-dk
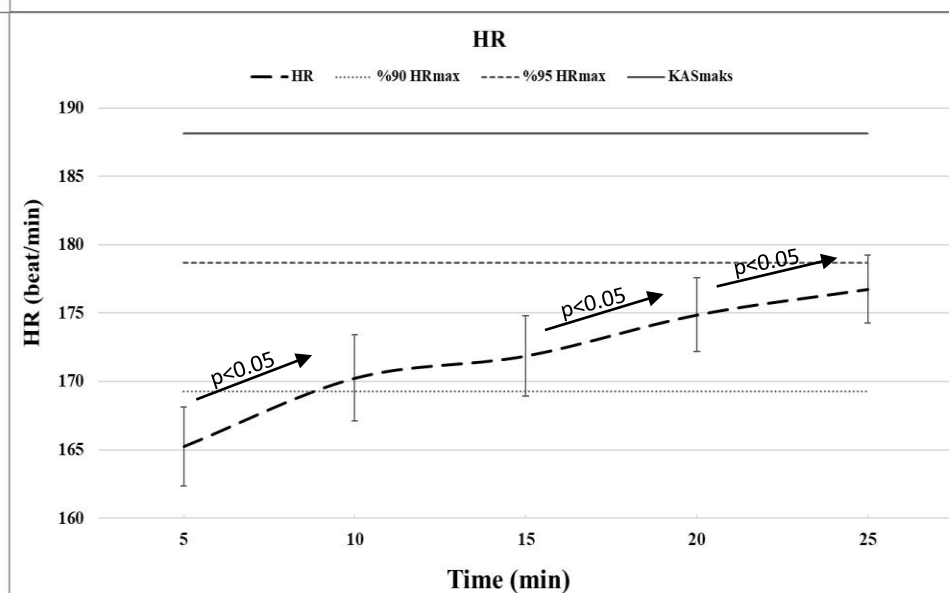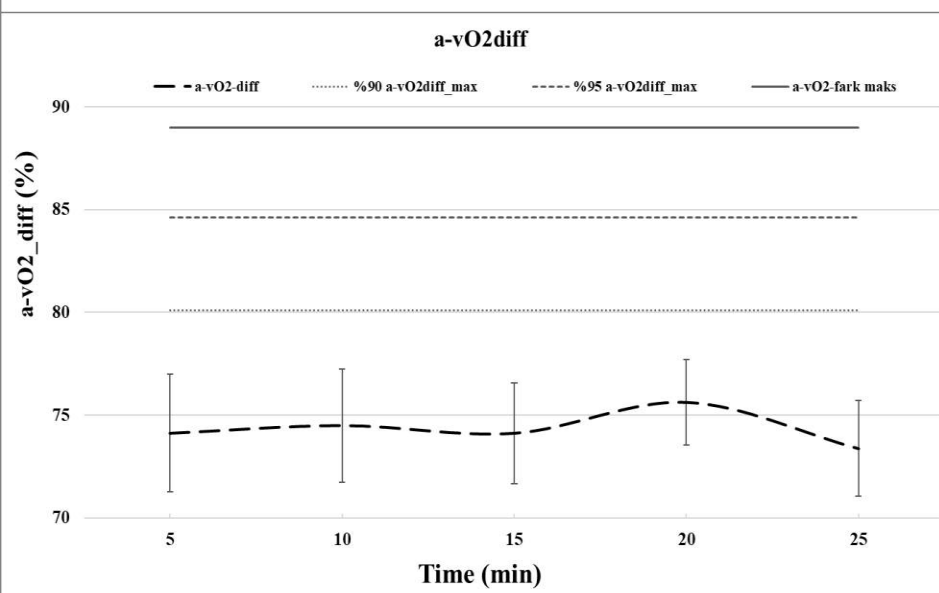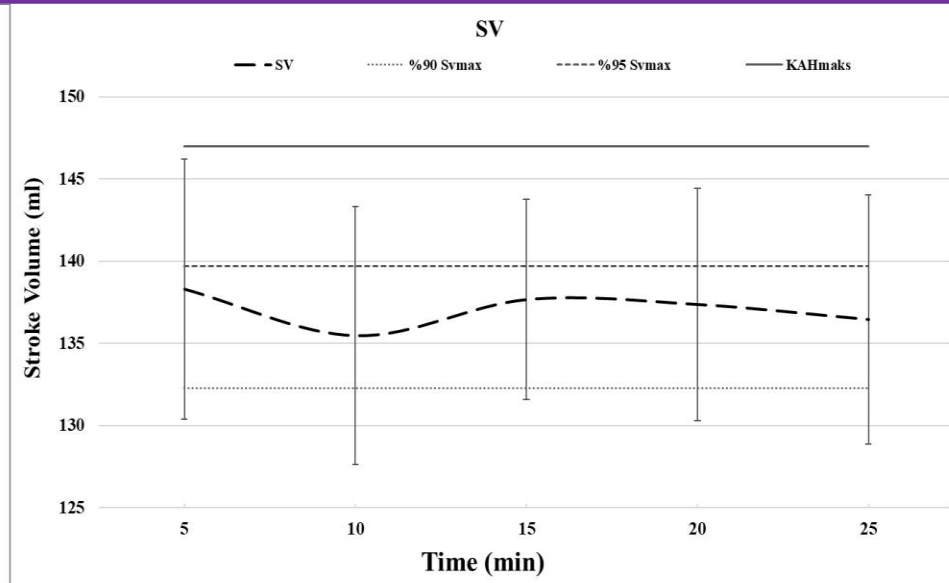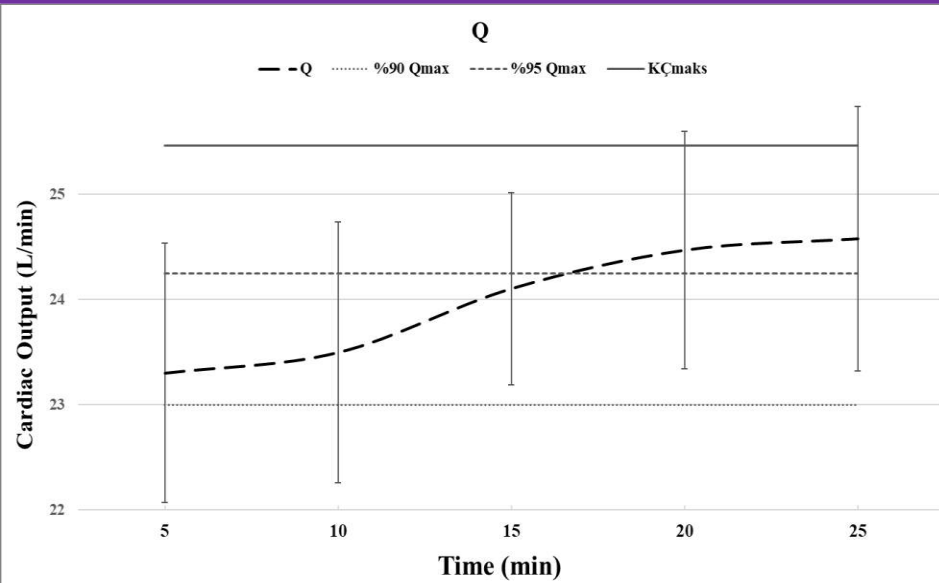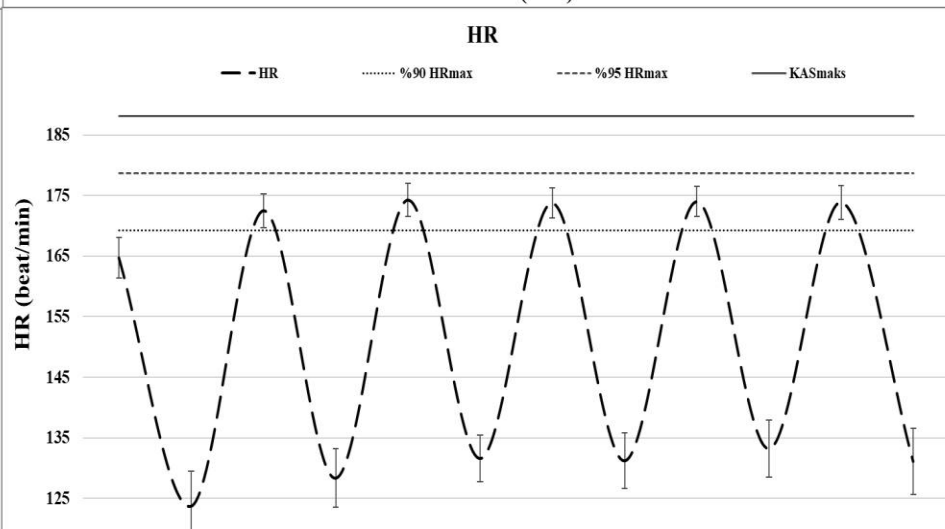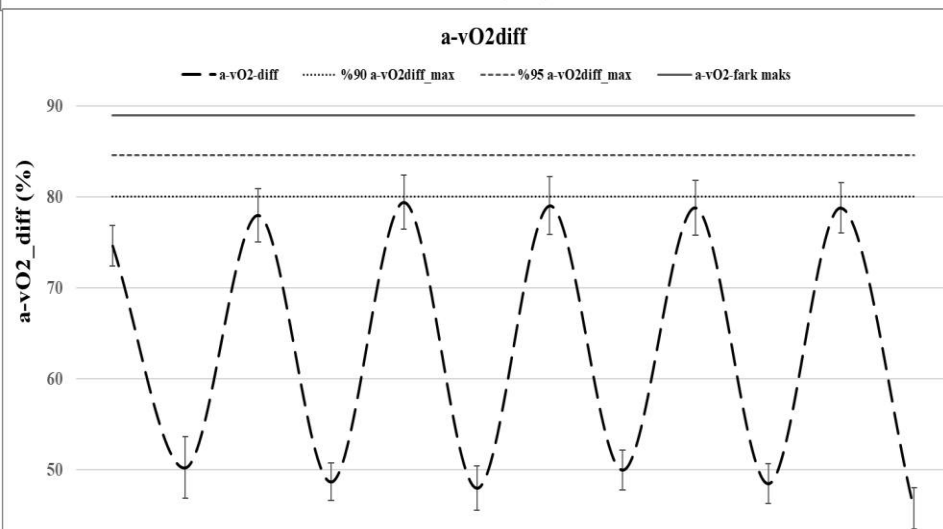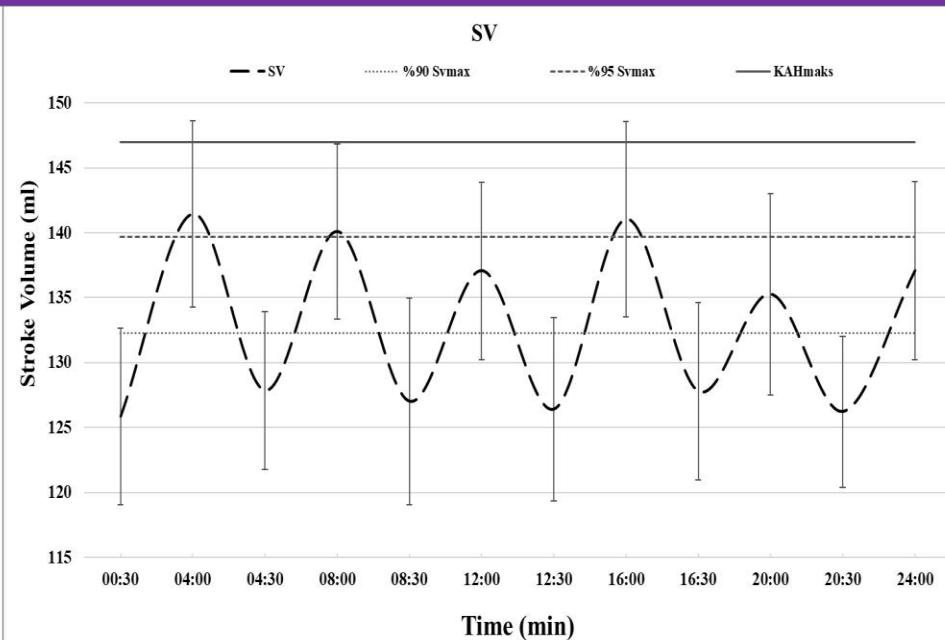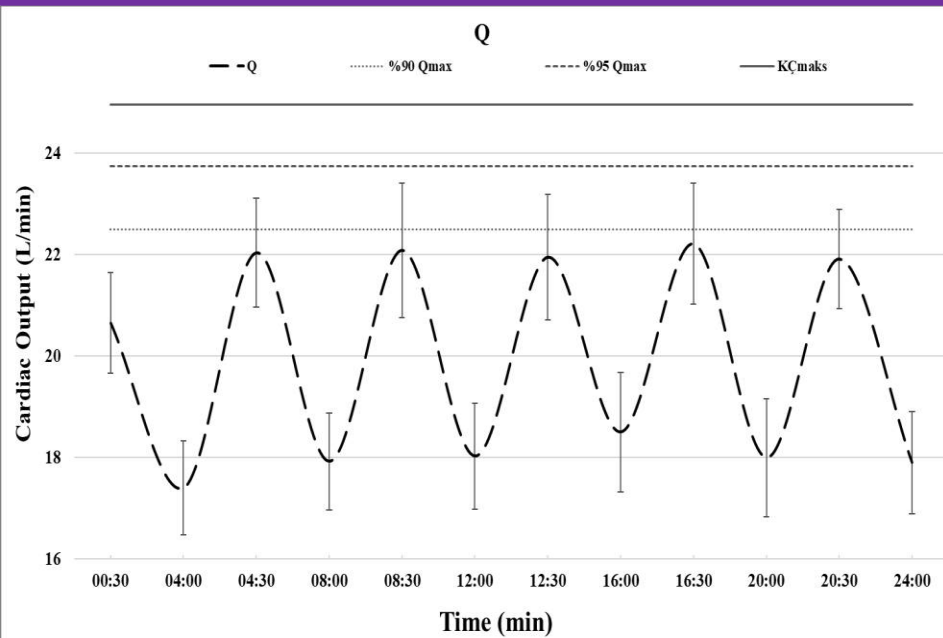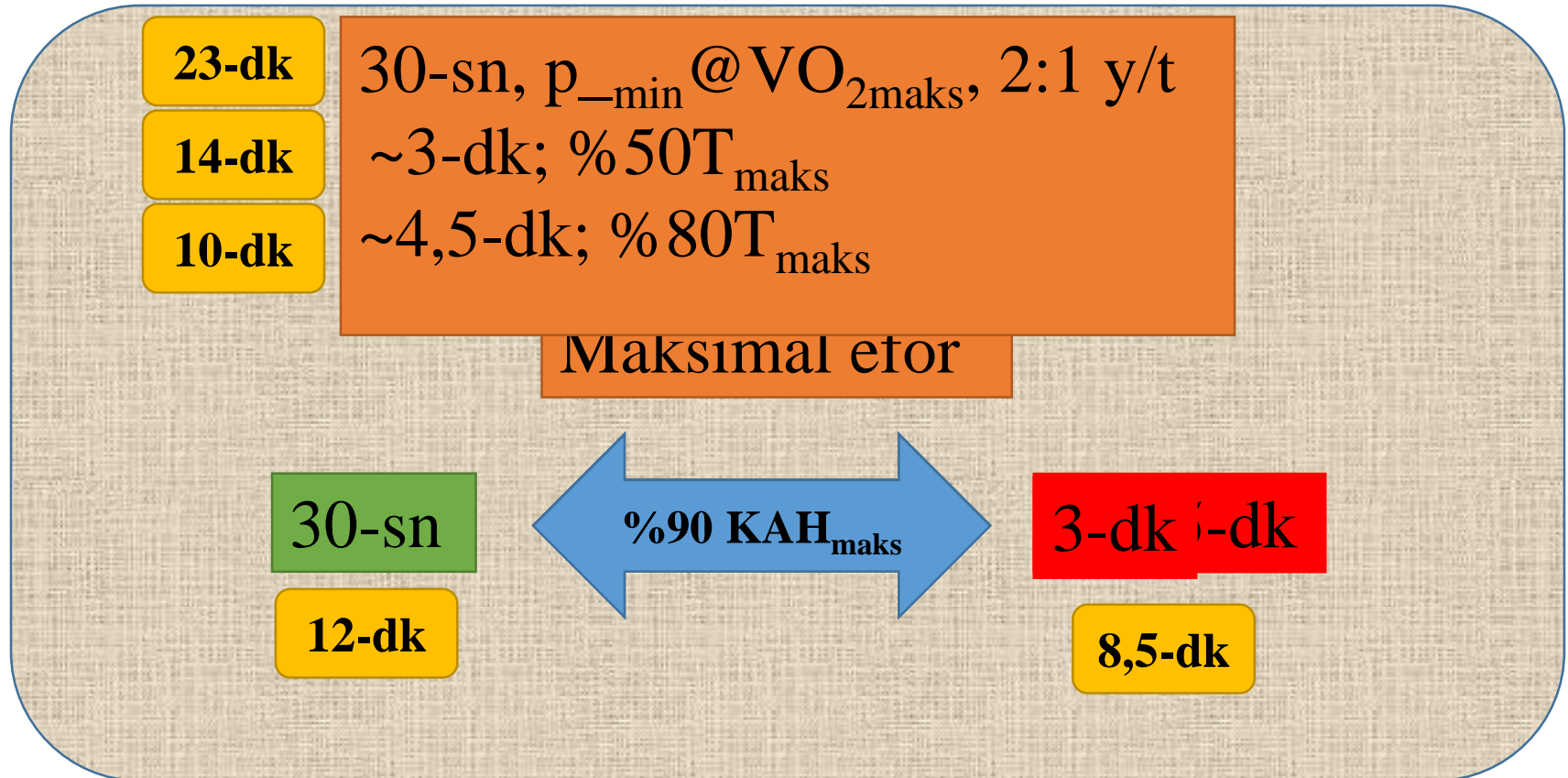
Rønnestad BR, Hansen J. Optimizing Interval Training at Power Output Associated with Peak Oxygen Uptake in Well-Trained Cyclists. Journal of Strength and Conditioning Research [Internet]. 2016 Apr 1 [cited 2018 Feb 6];30(4):999–1006.

TARTIŞMA

Kesintisiz %83 VO_{2maks}
30-sn %110 VO_{2maks} 1:1y/t
3-dk %95 VO_{2maks} 1:1y/t

14 dakıka, KAS%97'ye kadar

Uzun HIT

%90 VO_{2maks}

Zafeiridis A, Rizos S, Sarivasiliou H, Kazias A, Dipla K, Vrabas IS. The extent of aerobic system activation during continuous and interval exercise protocols in young adolescents and men. Applied Physiology, Nutrition, and Metabolism [Internet]. 2011 Jan [cited 2018 Feb 10];36(1):128–36.

DISCUSSION

Yüklenme / Toparlanma Oranı

Pasif / %50 VO$_{2maks}$

%30 / 60 VO$_{2maks}$

% 35 VO$_{2maks}$

Dodd S, Powers SK, Callender T, Brooks E. Blood lactate disappearance at various intensities of recovery exercise. Journal of Applied Physiology [Internet]. 1984 Nov [cited 2018 Jan 27];57(5):1462–5.

DISCUSSION

Sprint Özellikli HIT'ler

% 7,5   VO$_{2maks}$

VO$_2$

KAH

KÇ

Laktat

a-vO$_{2farkı}$

Yağ Oksidasyonu

DISCUSSION

Cummings (1972)

Takashi ve ark. (2000)

Goldberg ve Shephard (1980)

Horn ve ark. (2016)

DISCUSSION

HIT_3: $(1'\ p@\sim VO_{2max} + 4'\ p@AnE \times 5\ rep.)$

$\Delta 50\ \Delta 75$, VO_{2max} and $110\%\ VO_{2max}$

$90\%\ VO_{2max}$

15-sec, 90 – 80%, 100 – 70% and 110 – 60% VO_{2max}

100 - 70

VO_{2max}

DISCUSSION

HIT_{3-4}

75% VO$_{2max}$ – myocardial stress
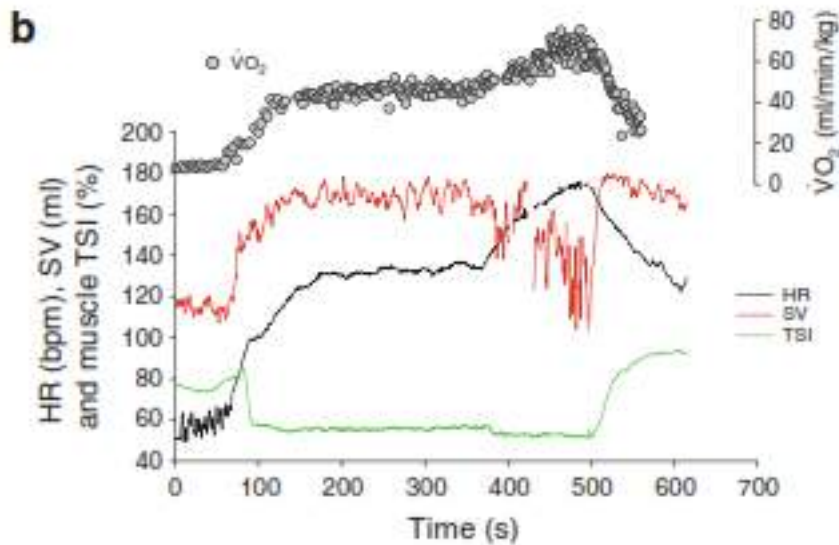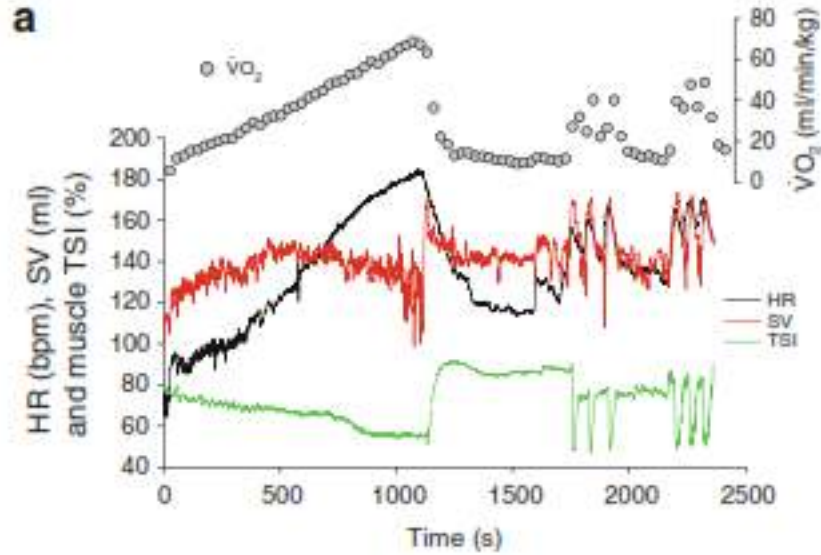
Maximal Stroke Volume

Q$_{max}$

273,5' and 288,8 W

273,5'and 265,6 W

SV$_{max}$

High-Intensity Interval Training, Solutions to the Programming Puzzle

Part I: Cardiopulmonary Emphasis

Martin Buchheit · Paul B. Laursen