
# 2022 NSCA TACTICAL ANNUAL TRAINING

#NSCATactical22

# *CONFLICT OF INTEREST STATEMENT*

I / We have no actual or potential conflict of interest in relation to this presentation.

# Learning Objectives

1. Impact of Respiratory Muscle Power, Exercise Intensity (Critical Velocity/Speed) on Load Carriage Performance.
2. Types of occupational personal protective equipment could influence RMP.
3. Different kinds of Respiratory Muscle Training to improve RMP.

# Respiratory Muscle Power (RMP)

## Load Carriage Performance Factor?

Mark T. White, MS, CSCS, TSAC-F

# Problem / Issue

- Does increased scaling-weight of combat equipment have an impact on RMP?
- How is RMP different for males and females?
- When might RMP negatively impact Load Carriage Performance?


Near a US Marine Corps (USMC) AH-1W Super Cobra attack helicopter, an infantryman with the 15th Marine Expeditionary Unit (MEU) Special Operations Capable (SOC) carries a full combat load, including an FNMI 7.62 mm M240 Machine Gun, while moving into a security position after seizing a forward operating base in support of Operation ENDURING FREEDOM.

DM-SD-06-03033 USMC infantryman at FOB Rhino. https://commons.wikimedia.org/wiki/File:DM-SD-06-03033_USMC_infantryman_at_FOB_Rhino.jpg. By Sergeant Joseph R. Chenelly, United States Marine Corps [Public domain].

# Scientific Construct

# Definitions

## Work of Breathing

- Work of Breath ($W_b$) [1]
  - A quantitative measurement of mechanical work per breath; (Joules; J).

## Respiratory Muscle Power

- Power of Breathing ($P_b$) [1]
  - Rate of $W_{b;}$ expressed per unit time; ($J \cdot min^{-1}$).
  - A quantitative measure of the respiratory muscular power.

1. Cross, T. J., et al. (2021). "A comparison of methods used to quantify the work of breathing during exercise." J Appl Physiol (1985).

# RMP Diagrams & Required Metrics

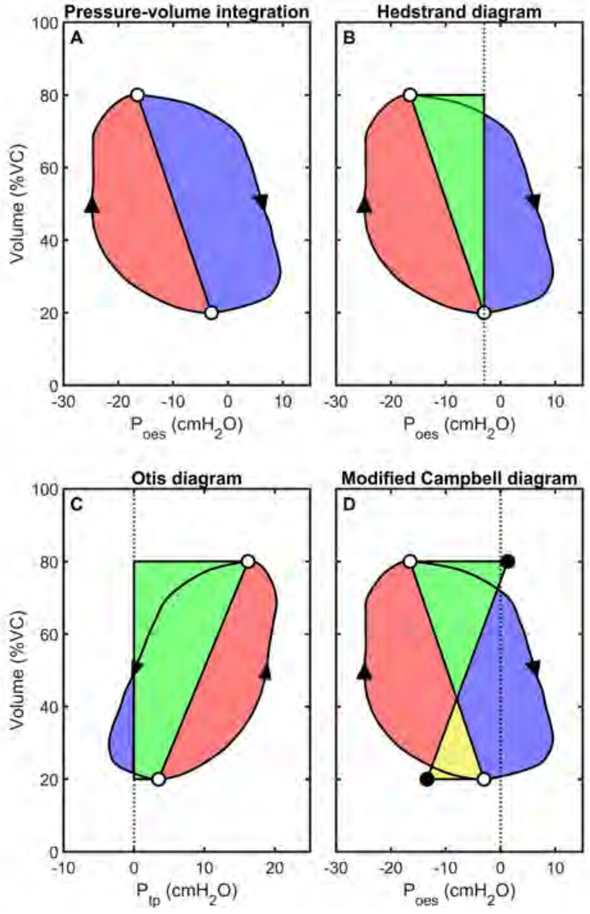



Table 2. Overview of the necessary measurements and the derived components of the mechanical work of breathing (Wb) associated with each method.

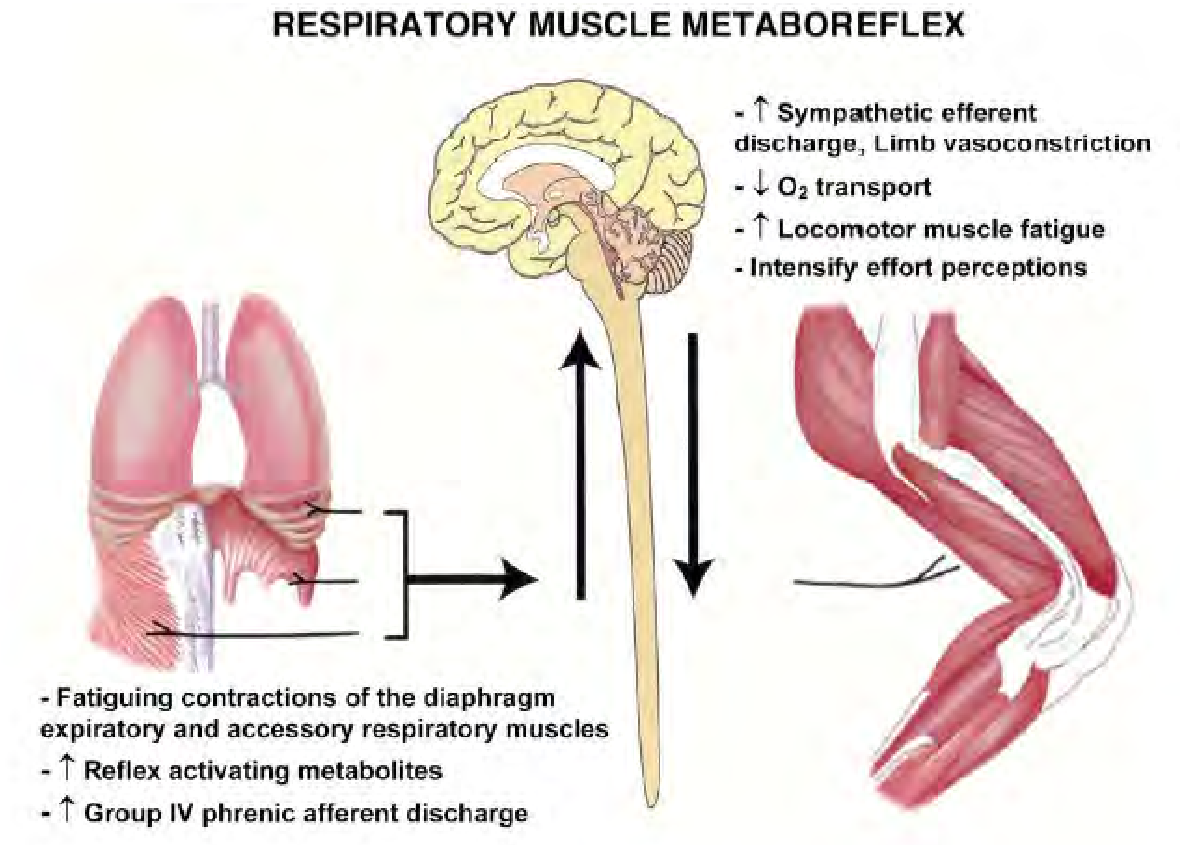
| | PV | Hedstrand | Otis | Campbell |
|---|---|---|---|---|
| *Necessary measurements* | | | | |
| $P_M$ | ✗ | ✗ | ✓ | ✗ |
| $P_{OES}$ | ✓ | ✓ | ✓ | ✓ |
| $C_{dyn,L}$ | ✓ | ✓ | ✓ | ✓ |
| $C_{CW}$ | ✗ | ✗ | ✗ | ✓ |
| EELV | ✗ | ✗ | ✗ | ✓ |
| *Total* | 2 | 2 | 3 | 4 |
| *Derived Wb components* | | | | |
| Inspiratory resistive | ✓ | ✓ | ✓ | ✓ |
| Expiratory resistive | ✓ | ✓ | ✓ | ✓ |
| Inspiratory elastic | ✗ | ✓ | ✓ | ✓ |
| Expiratory elastic | ✗ | ✗ | ✗ | ✓ |
| *Total* | 2 | 3 | 3 | 4 |

$P_M$: mouth pressure; $P_{OES}$: oesophageal pressure; $C_{dyn,L}$: dynamic lung compliance; $C_{CW}$: chest wall compliance; EELV: end-expiratory lung volume. **N.B.:** The PV integration method, and the Hedstrand and modified Campbell diagrams include work performed against external devices/apparatuses in their components of resistive work. The Otis diagram does not include this external resistive component of the Wb.

1. Cross, T. J., et al. (2021). "A comparison of methods used to quantify the work of breathing during exercise." J Appl Physiol (1985).

# Consequence of High RMP

- Respiratory muscle fatigability is a significant limiting factor to performance during heavy-intensity exercise.[2]
- Considerations of hierarchal blood flow between respiratory versus locomotor musculatures during exercise.[3]




2. Dempsey, J. A., et al. (2006). "Consequences of exercise-induced respiratory muscle work." Respir Physiol Neurobiol 151(2-3): 242-250.
3. Sheel, A. W., et al. (2018). "Competition for blood flow distribution between respiratory and locomotor muscles: implications for muscle fatigue." J Appl Physiol (1985).

# Important Internal Factor

## Respiratory Sex-based Difference

- **Anatomical**
  - Airway size
  - Lung size
  - # of alveoli
- **Mechanical**
  - Flow
  - Expiratory Flow Limitation
  - WOB
  - VO2 respiratory muscles
  - Diaphragm Fatigue Resistance
- **Unknowns**
  - Respiratory / Locomotor Blood Flow
  - SaO2
  - Exercise Performance
  - Locomotor Muscle Fatigue
  - Healthy Aging Dyspnoea

4. Sheel, A. W., et al. (2016). "Revisiting dysanapsis: sex-based differences in airways and the mechanics of breathing during exercise." Exp Physiol 101(2): 213-218.

Table 1. Anthropometric and Spirometric Group Values (Modified)

| Characteristic | Men ($n$ = 9) | Women ($n$ = 9) |
|---|---|---|
| Age (Years) | 29 ± 3 | 23 ± 1∗ |
| Height (cm) | 183 ± 2 | 167 ± 2∗ |
| Mass (kg) | 75 ± 3 | 58 ± 2∗ |
| FVC (L) | 5.8 ± 0.2 | 4.0 ± 0.2∗ |
| FVC (% Predicted) | 99 ± 4 | 95 ± 2 |
| FEV1 (L) | 4.7 ± 0.2 | 3.4 ± 0.1∗ |
| FEV1 (% Predicted) | 100 ± 4 | 94 ± 2 |
| FEV1/FVC | 82 ± 2 | 85 ± 1 |
| FEV1/FVC (% Predicted) | 100 ± 2 | 99 ± 2 |

Abbreviations: FEV1, forced expired volume in 1 s; and FVC, forced vital capacity. ∗Significantly different frommen ($P$ < 0.05). Values in this and subsequent tables are means ± SEM.

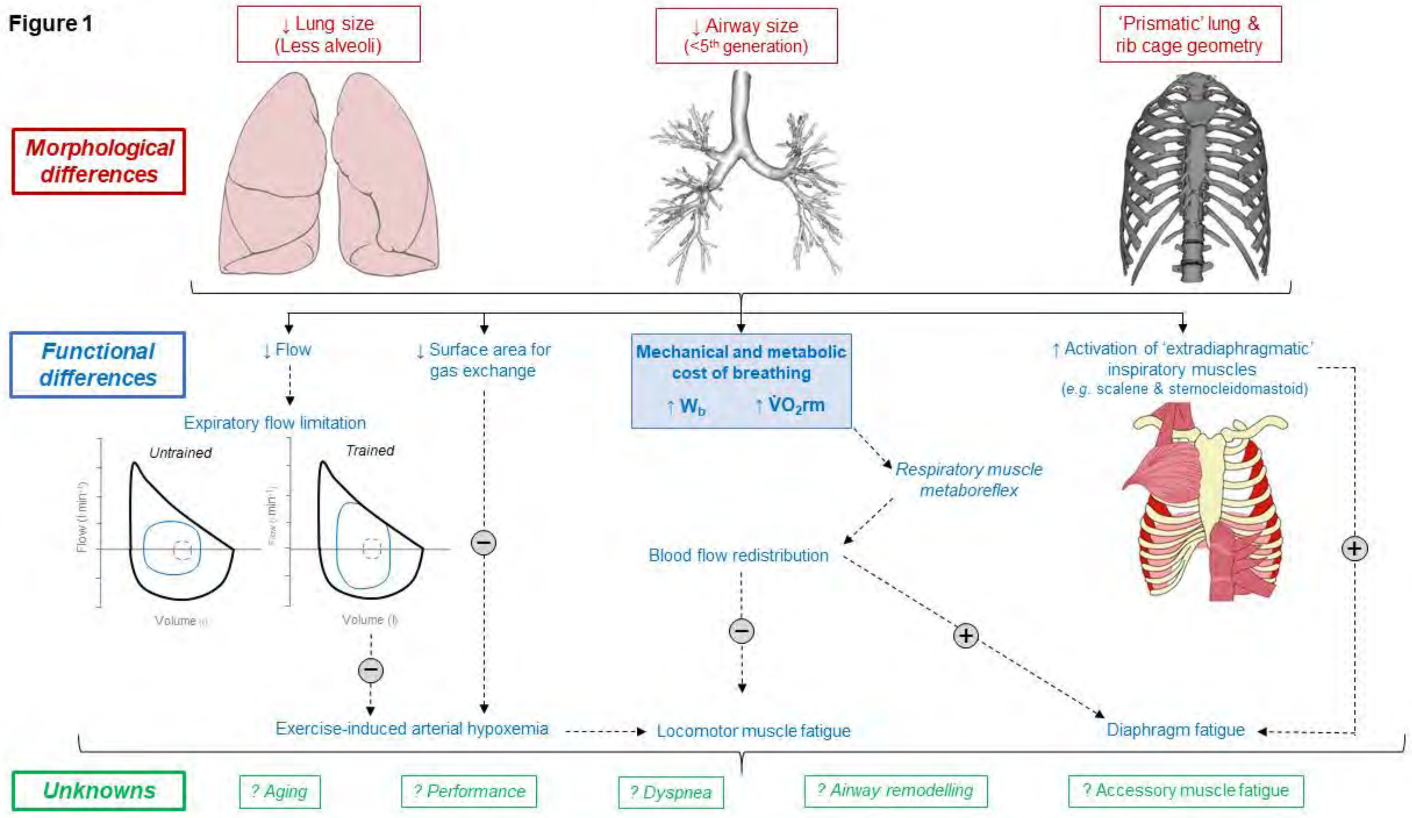
5. Dominelli, P. B., et al. (2015). "Oxygen cost of exercise hyperpnoea is greater in women compared with men." J Physiol 593(8): 1965-1979.

Table 2. Cardiorespiratory Values @ Maximal Exercise (Modified)

| Parameter | Men ($n$ = 9) | Women ($n$ = 9) |
|---|---|---|
| $VO_2$ ($L \cdot min^{-1}$) | 4.4 ± 0.2 | 2.8 ± 0.2∗ |
| $VO_2$ ($ml \cdot kg^{-1} \cdot min^{-1}$) | 58.7 ± 1.9 | 48.1 ± 2.1∗ |
| $VCO_2$ ($L \cdot min^{-1}$) | 4.8 ± 0.2 | 3.0 ± 0.1∗ |
| VT (L) | 3.1 ± 0.1 | 1.9 ± 0.1∗ |
| VE ($L \cdot min^{-1}$) | 173 ± 10 | 114 ± 4∗ |
| $\Delta P_{OE}$ ($cmH_2O$) | 54 ±4 | 46 ± 1∗ |
| WOB ($J \cdot min^{-1}$) | 605 ± 59 | 354 ± 19∗ |
| $PTP_{OE}$ ($cmH_2O\ s^{-1}$ min−1) | 606 ± 35 | 500 ± 30∗ |
| $PTP_{DI}$ ($cmH_2O\ s^{-1}\ min^{-1}$) | 457 ± 44 | 406 ± 75 |
| $PTP_{OE}/PTP_{DI}$ | 0.77 ± 0.07 | 0.84 ± 0.11 |
| VE Cap ($L \cdot min^{-1}$) | 220 ± 15 | 164 ± 9∗ |
| VE / VE Cap (%) | 80 ± 3 | 72 ± 5 |

Abbreviations: $\Delta P_{OE}$, Oesophageal Pressure Swing; $PTP_{OE}$, Oesophageal Pressure–Time Product; $PTP_{DI}$, Diaphragmatic Pressure–Time Product; $VCO_2$ , Carbon Dioxide output; VE, Expired Minute Ventilation; VE Cap, Ventilatory Capacity; $VO_2$ , Oxygen Uptake; VT, Tidal Volume; and WOB, Work of Breathing. ∗Significantly different (P < 0.05).

# Integrative Theory for Sex-based Differences




6. Dominelli, P. B., et al. (2019). "Sex-Differences in the Pulmonary System Influence the Integrative Response to Exercise." Exerc Sport Sci Rev.

| M | Physiological System | F |
|---|---|---|
| | **Central** | |
| ↓ | • Perception of Breathing | ↑ |
| | **Morphological** | |
| ↓ | • Lung size & # of Alveoli | ↑ |
| ↓ | • Surface Gas Exchange | ↑ |
| ↓ | • Central Airway Size | ↑ |
| | **Functional** | |
| ↓ | • Work of Breathing | ↑ |
| ↓ | • O2 Cost of Breathing | ↑ |
| ↑ | • Exercise Diaphragmatic Fatigue | ↓ |
| ↓ | • Activation of extra-diaphragmatic muscles | ↑ |
| ↑ | • Respiratory muscle metaboreflex | ↓ |
| ↑ | • Peripheral muscle sympathetic activity | ↓ |
| ↓ | • Susceptibility to exercise induced arterial hypoxemia | ↑ |
| ↓ | • Locomotor muscle fatigue | ↑ |

**Central Respiratory Control**

- Higher sensory input (mechano- / chemoreceptors)
- Lower respiratory muscle motor output
- Hormone receptors located near chemoreceptors

**Sex Hormones**

- Progesterone respiratory stimulant
- Testosterone increases ventilation sensitivity

7. Archiza, B., et al. (2021). "An integrative approach to the pulmonary physiology of exercise: when does biological sex matter?" Eur J Appl Physiol 121(9): 2377-2391.

# Important External Factors

## Breathing Restrictions

- Pressure, Volume & Flow
  - Inspiratory muscle fatigue & expiratory limitations.[8]
  - Inspiratory resistance lead to diaphragm fatigue.[9]
  - Agonist–antagonist respiratory muscles interactions are important to expiratory loading.

8. McKenzie, D. C. (2012). "Respiratory physiology: adaptations to high-level exercise." Br J Sports Med 46(6): 381-384.
9. Peters, C. M., et al. (2017). "Influence of inspiratory resistive loading on expiratory muscle fatigue in healthy humans." Exp Physiol 102(9): 1221-1233.

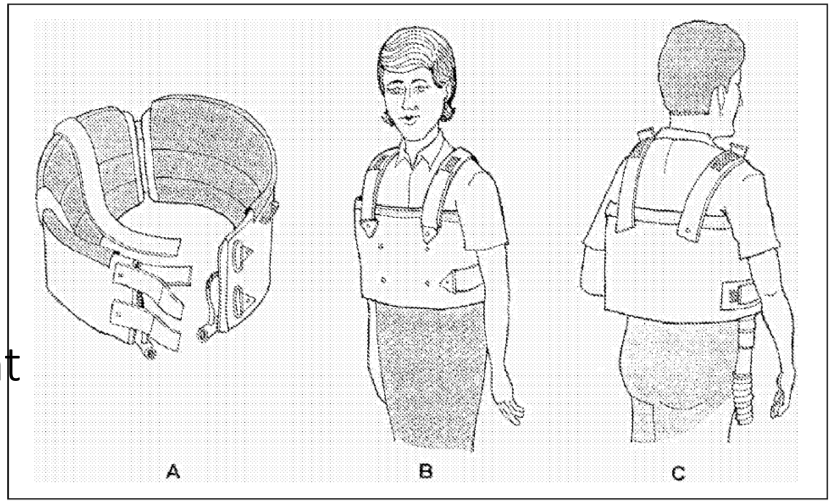



**Fig. 1.** The chest wall-restrictive device. **A** Inside view showing pads, air attachments and fastening. Front (**B**) and rear (**C**) views showing method of placement. Refer to text for specific details.

10. Cline, C. C., et al. (1999). "A chest wall restrictor to study effects on pulmonary function and exercise. 1. Development and validation." Respiration 66(2): 182-187.

## Chest Wall Restrictions

- Diaphragmatic vs. Abdominal
  - Diaphragmatic function not affected with abdominal wall restriction.
  - Limitations to rib cage expansion reduces diaphragmatic endurance during exercise.[11]

11. Hussain, S. N. and R. L. Pardy (1985). "Inspiratory muscle function with restrictive chest wall loading during exercise in normal humans." J Appl Physiol (1985) 58(6): 2027-2032.

# Theoretical Application

# Occupational Relevance

*"The load carried by the soldier…will probably always be a compromise between what is physiologically sound and what is operationally essential"* (1954, RA Medical Corps Officer)

12. Seay, J. F. (2015). "Biomechanics of Load Carriage--Historical Perspectives and Recent Insights." J Strength Cond Res 29 Suppl 11: S129-133.

## SCUBA

(DoD, Public domain, via Wikimedia Commons, FILE: https://commons.wikimedia.org/wiki/File:SEALS_wearing_diving_gear.JPG)

## CBRNE

(DoD, Public domain, via Wikimedia Commons, FILE: https://commons.wikimedia.org/wiki/File:2nd_Maintenance_Battalion_competes_to_find_its_best_130503-M-AR522-038.jpg)

## SCBA

(Public Domain, Self-contained breathing apparatus, https://upload.wikimedia.org/wikipedia/commons/0/02/TFS_SCBA_gear.jpg)

## HAP

(DoD, Public domain, via Wikimedia Commons, File: Capt. David Chace, https://upload.wikimedia.org/wikipedia/commons/d/d6/Soldiers_preparing_for_HAHO_jump.jpg)

## AFE

(DoD, Public domain, via Wikimedia Commons, File:U.S. Air Force Major Kevin Hall, a test pilot, performs a preflight inspection on a F-35A Lightning II aircraft March 14, 2014, before departing from Hill Air Force Base, Utah 140314-F-UT482-113.jpg)

## HAM

(DoD, Public domain, via Wikimedia Commons, File:U-2 new cockpit 2006-06-20 F-8409K-001.jpg – Wikimedia Commons, File:U-2 new cockpit 2006-06-20 F-8409K-001.jpg - Wikimedia Commons)

Occupational / Operational Use-Cases

# Personal Protective Equipment Considerations

## Face / Mouth Restrictions

Sgt Mark Fayloga - USMC
website: http://www.marines.mil/_layouts/imagemeta.aspx?image=http://www.marines.mil/unit/mcbhawaii/PublishingImages/2009/091202-M-1558F-195.jpg. Public Domain, File:M50 gas mask.jpg, Created: 2 December 2009

- Helmets
- Face masks
- Filtration systems

| | | | |
|---|---|---|---|
| Filter Breathing Performance | | | |
| Re-breathed $CO_2$ | 0.80% | | |
| Inhalation resistance | | Mask Only: | Mask & Filters: |
| | 30 L/Min | 2 mm WG | 10 mm WG |
| | 95 L/Min | 8 mm WG | 30 mm WG |
| | 160 L/Min | 12 mm WG | 64 mm WG |
| Exhalation Resistance at: | 85 L/Min | 7 mm WG | |
| | 160 L/Min | 12 mm WG | |

## Chest Wall Restrictions


HighCom Guardian 4S17 (Level IV SA), Hard Armor Rifle Plates; Single Curve, Full, 10” x 12”; Front & Rear. HighCom Guardian 4S17 (Level IV SA) - Armor Express. Accessed 08 AUG 2021.

Base Vest Assembly, IOTV (Improved Outer Tactical Vest), NSN 8470-01-604-XXXX, MultiCam (OCP), GEN III, USGI Issue. IOTV (Improved Outer Tactical Vest) - GEN III - The ArmyProperty Store. Accessed 08 AUG 2021.


Rogue Sandbags, 1000D MILSPEC Cordura brand nylon construction. Rogue Training Sandbags - Weightlifting Sandbags | Rogue Fitness. Accessed 08 AUG 2021.

Mystery Ranch® 3 Day Assault BVS Pack, 3 Day Assault BVS Pack | MYSTERY RANCH Backpacks. Accessed 08 AUG 2021.

Multi-Rifle Magazine Pouch w/ non-ballistic plates 1.6 lbs., Rifle Magazine Pouch Sets | AR500 Armor. Accessed 08 AUG 2021.

- Rucks / Backpacks
- Plate Carriers
- Body Armor Plates

# Exercise Intensity Domains

| Domain | Boundaries | Time | O2 Kinetic Responses |
|---|---|---|---|
| Moderate | Upper: GET | > 4 h | Two components; steady state achieved within 3 min in healthy individuals |
| Heavy | Lower: GET<br>Upper: CP/S | Up to ~3 - 4 h | Three components; slow component evident after primary phase; steady state delayed by 10-20 min; elevated V˙ O2 |
| Severe | Lower: CP/S<br><br>Upper: highest power that elicits VO2max before fatigue | Up to ~30 - 45 min | Two/three components; slow component evident that develops continuously if power below V˙ O2max; no steady state; V˙ O2max attained if sustained |
| Extreme | Lower: highest power eliciting VO2max | < 120 s | Two components; no slow component evident; VO2max not attained |

(NOTE: GET = Gas Exchange Threshold ; CP = Critical Power/Speed)

13. Burnley, M. and A. Jones (2007). "Oxygen uptake kinetics as a determinant of sports performance." European Journal of Sport Science 7(2): 63-79.

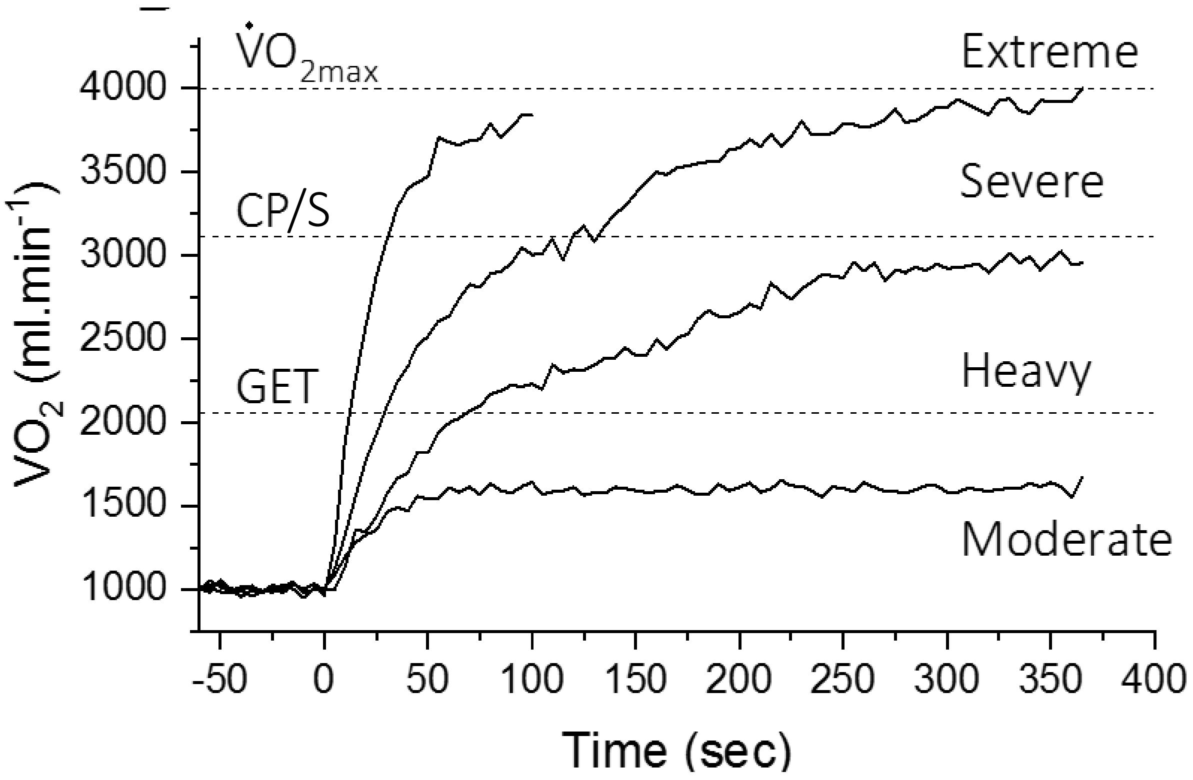



Figure from Dr. Mark Kramer's dissertation (2019), Nelson Mandela University, South Africa

# RMP, Exercise Intensity, & Compensation

- Confirm $P_b$ increases equally with Slow Component ($VO2_{SC}$) during strenuous, constant work.
- First report showing $VO2_{SC}$ rise for $P_b$ is greater for severe- vs. heavy-intensity work rates.

- Evidence that 25 kg thoracic load carriage induces Inspiratory & Expiratory muscle fatigue during sustainment and assault walking.[15]
- To reduce work of breathing, people change breathing mechanics to “shallow and frequent” patterns.[16]

14. Cross, T. J., et al. (2014). "Respiratory muscle power and the slow component of O2 uptake." Med Sci Sports Exerc 46(9): 1797-1807.

15. Faghy, M. A. and P. I. Brown (2014). "Thoracic load carriage-induced respiratory muscle fatigue." Eur J Appl Physiol 114(5): 1085-1093.
16. Phillips, D. B., et al. (2016). "Ventilatory responses to prolonged exercise with heavy load carriage." Eur J Appl Physiol 116(1): 19-27.

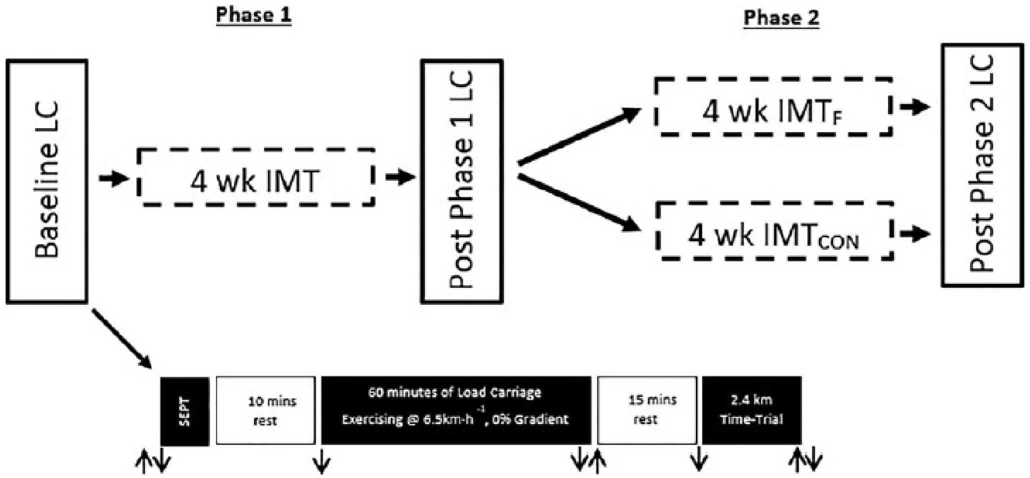
# Load Carriage / Ventilatory Research Findings

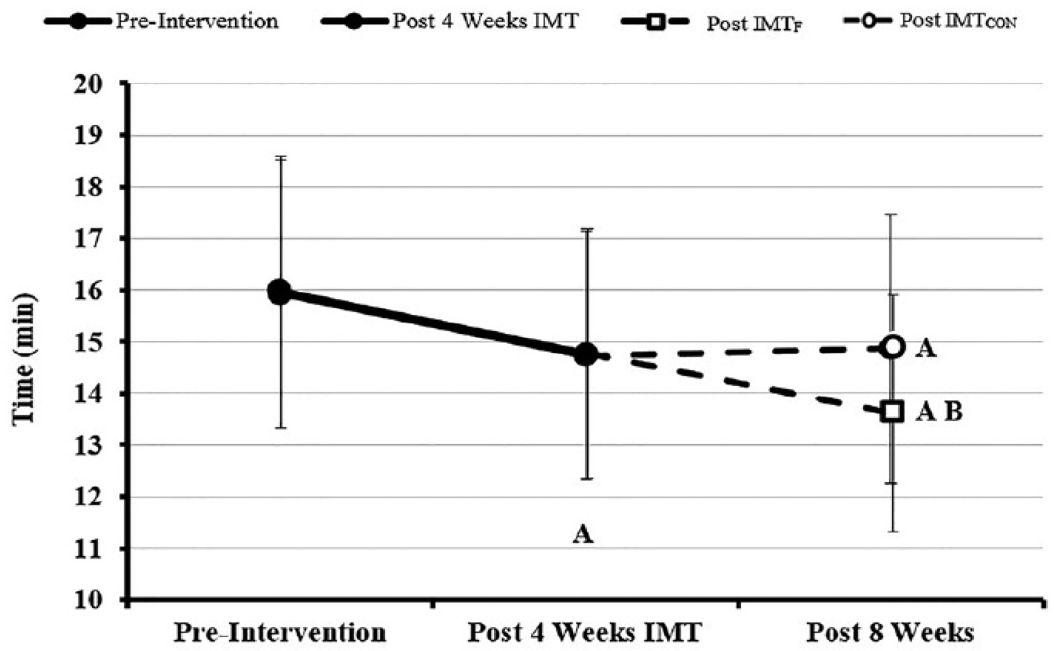
- Inspiratory Muscle Training (IMT) attenuated cardiovascular and perceptual responses to steady-state exercise and improved high-intensity time-trial performance when wearing a 25 kg backpack.[17]
  - Attribute in part to reduced relative work intensity of the inspiratory muscles due to improved inspiratory muscle strength.
- Ergogenic benefit of IMT on load carriage performance.[18]
  - Demonstration that functional IMT provided a greater performance benefit during exercise with thoracic loads.

17. Faghy, M. A. and P. I. Brown (2016). "Training the inspiratory muscles improves running performance when carrying a 25 kg thoracic load in a backpack." Eur J Sport Sci 16(5): 585-594..
18. Faghy, M. A. and P. I. Brown (2019). "Functional training of the inspiratory muscles improves load carriage performance." Ergonomics 62(11): 1439-1449.

# Functional IMT improves Load Carriage Performance[18]

- **Upward arrows:** respiratory pressure & lung volumes measurements.
- **Downward arrows:** physiological & perceptual measurements.
- Inspiratory Muscle Training (IMT)
- Maintenance IMT ($IMT_{CON}$)
- Functional Inspiratory Muscle Training ($IMT_F$)




- **Time:** absolute time for LCTT performance.
- **Solid-lines:** refer to pooled data,
- **Open-circle:** refer to IMTCon
- **Open-square:** refer to IMTF.
- **Points:** A-different from pre-intervention; B-different to post 4 wks. IMT in IMTF ($p<0.05$).

# Training Protocols / Interventions[18]

## Inspiratory Muscle Training (IMT)

- **INTENSITY:** 50% of $PI_{MAX}$
- **VOLUME:** 30 reps (IE, Inspiratory Efforts)
- **FREQUENCY:** 2x daily; 7-days per week
- **DURATION:** 4-weeks
- **MODE:** Handheld Device (HHD)
- **NOTE**: Assessed bi-weekly; re-calibrate device relative intensity

## Control IMT ($IMT_{CON}$)

- **INTENSITY:** 50% of $PI_{MAX}$
- **VOLUME:** 30 reps IE
- **FREQUENCY:** 2x daily, 3x per week
- **DURATION:** 4-weeks
- **MODE:** HHD
- **NOTE:** Assessed weekly; re-calibrate device relative intensity

## Function IMT ($IMT_F$)

- **INTENSITY:** 50% of $PI_{MAX}$
- **VOLUME:** Week 1 = 12 IE reps per exercise in week 1; Week 4 = 18 IE reps (increase 2-breaths per week)
- **FREQUENCY:** 3x sessions weekly
- **DURATION:** 4-weeks
- **MODE:** HHD plus 4 Inspiratory-loaded Core Muscle Training Exercises; 2x per session.
- **INSTRUCTION:** Inhale forcefully through device as body actions initiated from starting position and exhaled slowly when returning to starting position.
- **NOTE:** Assessed weekly; re-calibrate device relative intensity

# Critical Speed (CS)

## Load Carriage Performance Factor?

Robert W Pettitt, PhD, CSCS

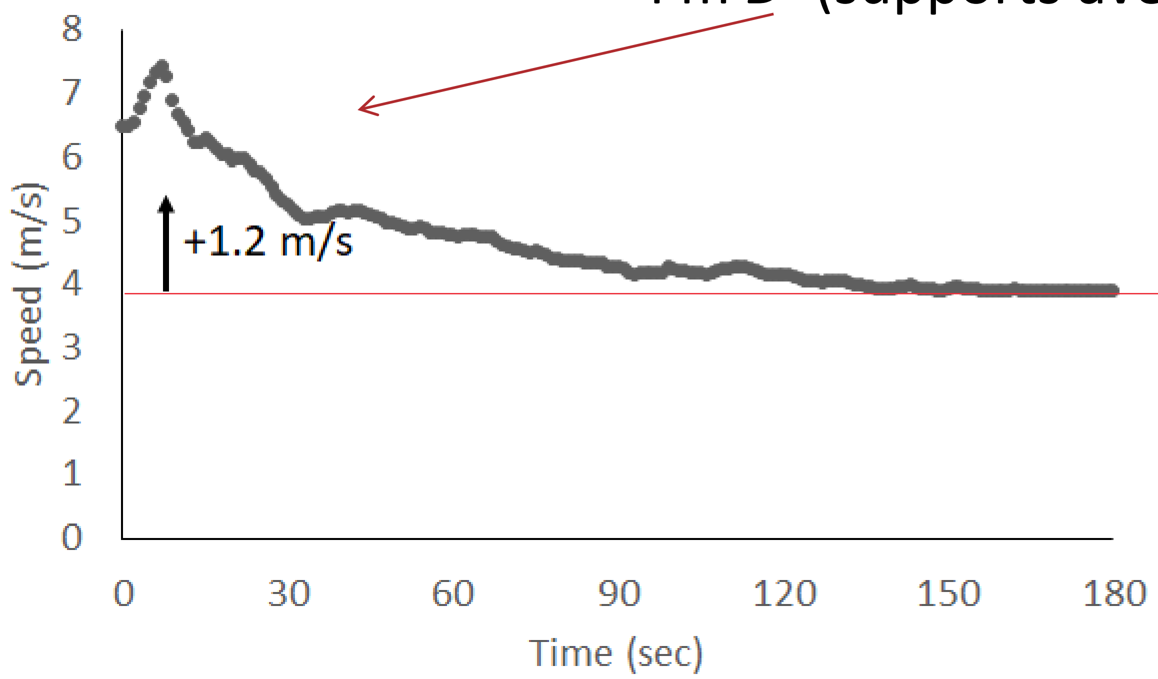
# Conceptual understanding of the 3-min all-out running test


Photo courtesy of Laurence Christie

Pettitt RW, Clark IE, and Jamnick NA. 3-min all-out exercise test for running. *Int J Sports Med 44: 2012*

# Conceptual understanding of the 3-min all-out running test

I'm *D'* (supports average speed >CS = 5.2 m/s)




I'm *CS* = 4 m/s

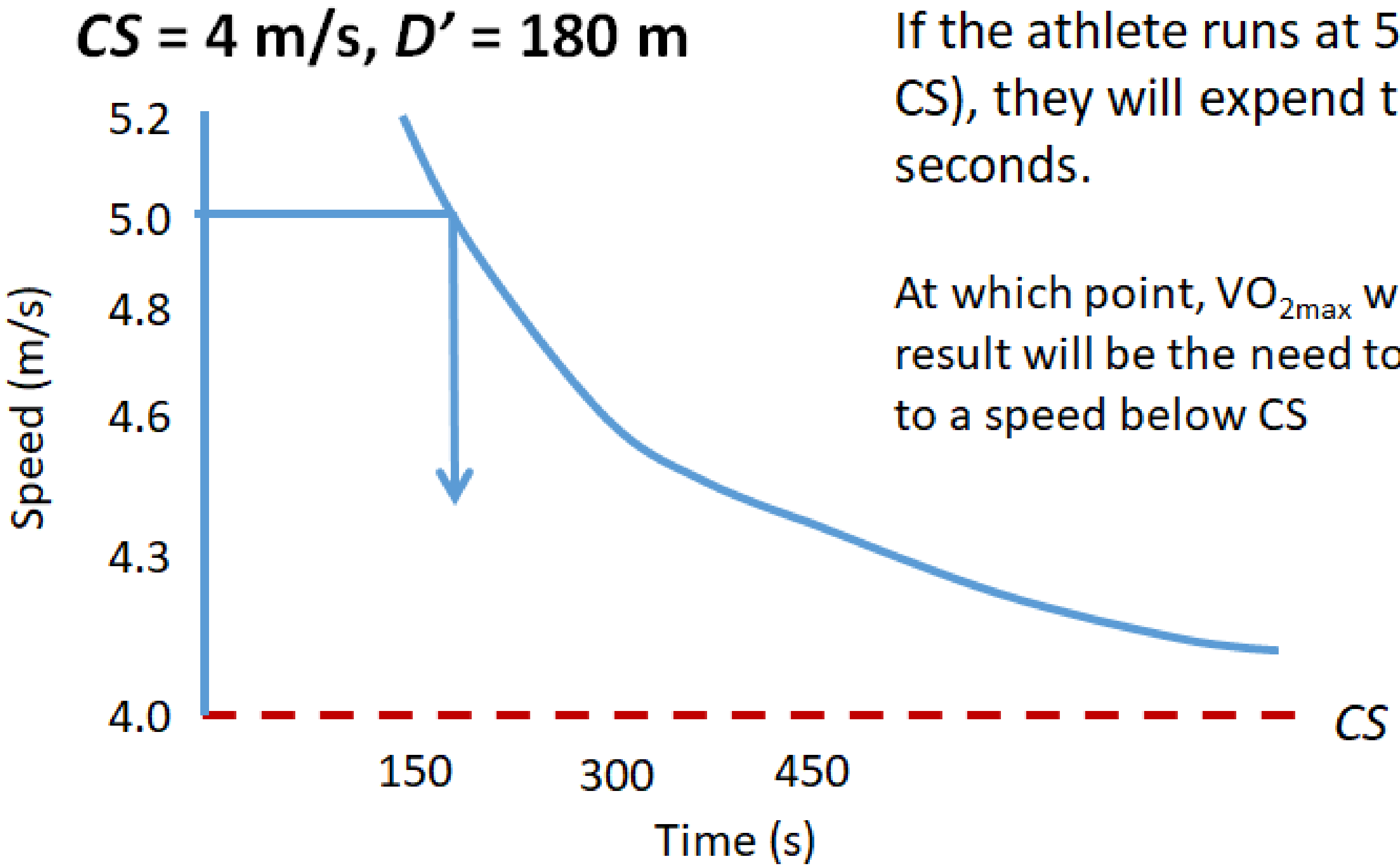
$D' = 150\text{ s }(S_{150s} - CS)$

$D' = 150\ (5.2 - 4)$

$D' = 150 * 1.2$

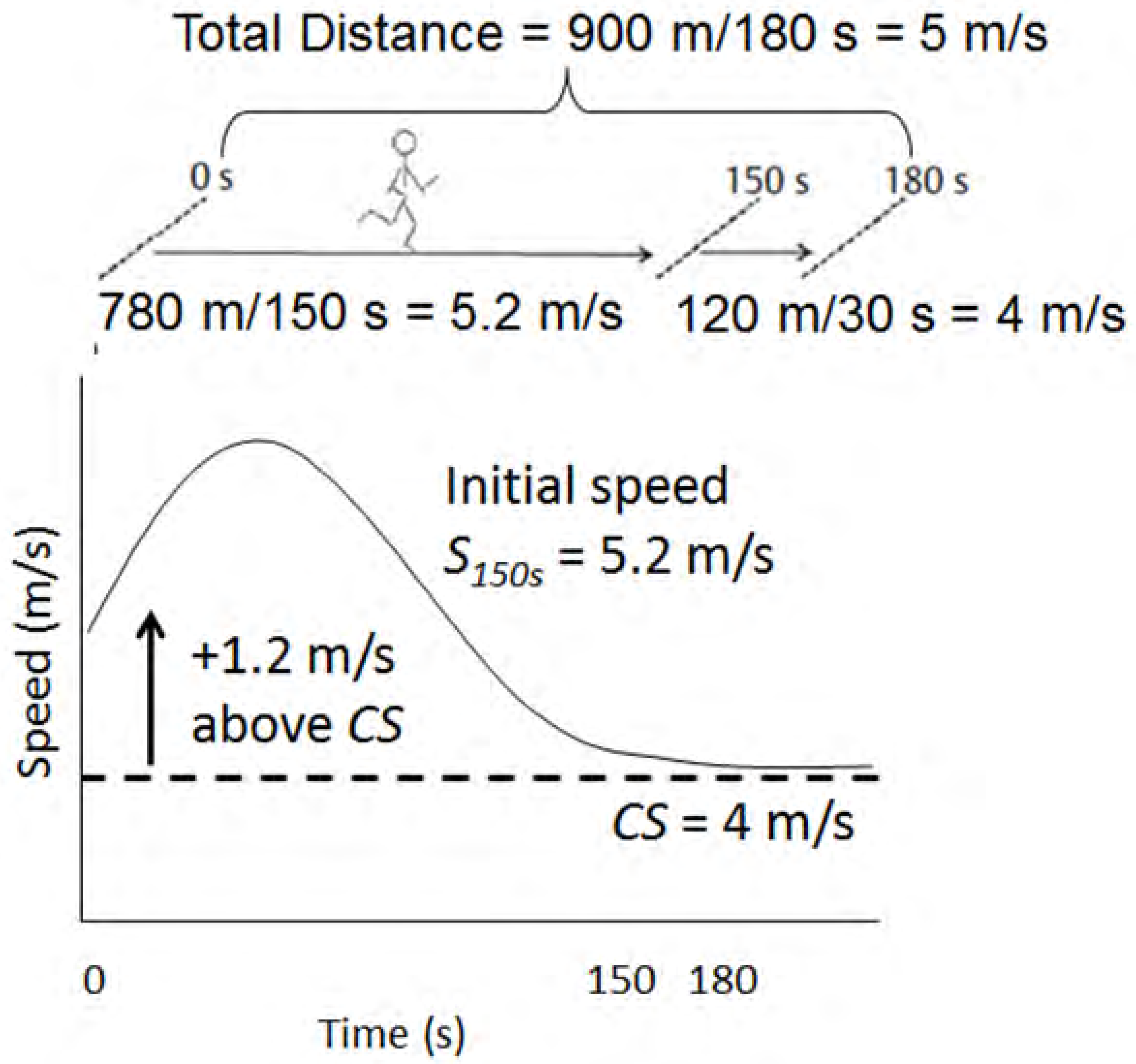
$D' = 180\text{ m}$

# Understanding *D'*

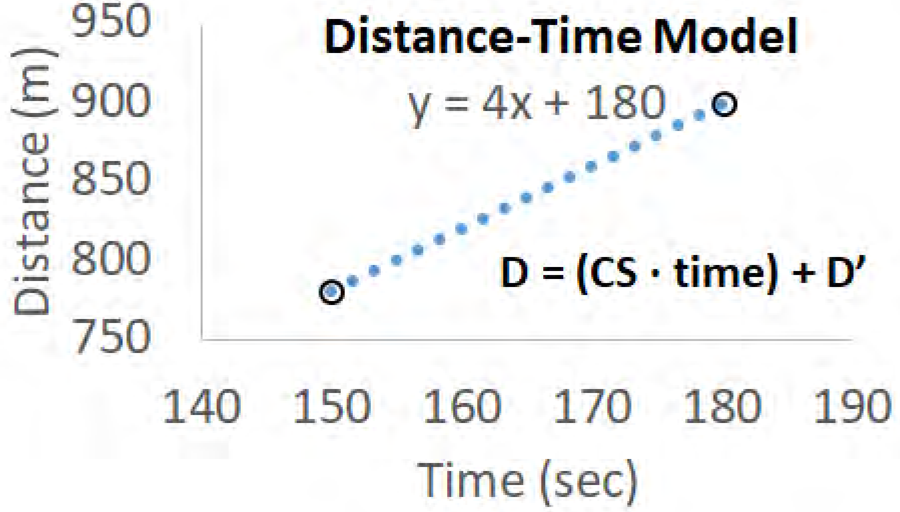



If the athlete runs at 5 m/s (+ 1 m/s above CS), they will expend the D' of 180 m in 180 seconds.

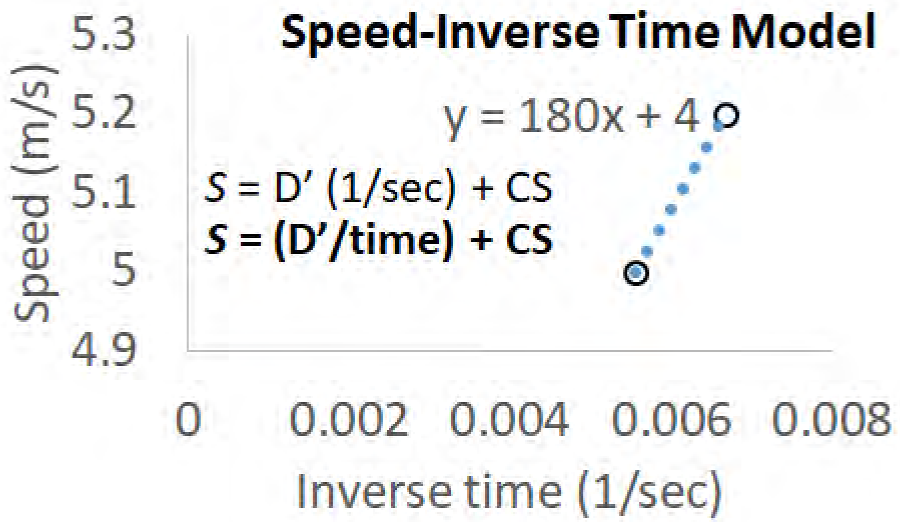
At which point, $VO_{2max}$ will be achieved. The result will be the need to stop or slow down to a speed below CS



Total Distance = 900 m/180 s = 5 m/s
0 s
150 s
180 s
780 m/150 s = 5.2 m/s
120 m/30 s = 4 m/s
Speed (m/s)
Initial speed
$S_{150s}$ = 5.2 m/s
+1.2 m/s
above *CS*
*CS* = 4 m/s
0
150
180
Time (s)

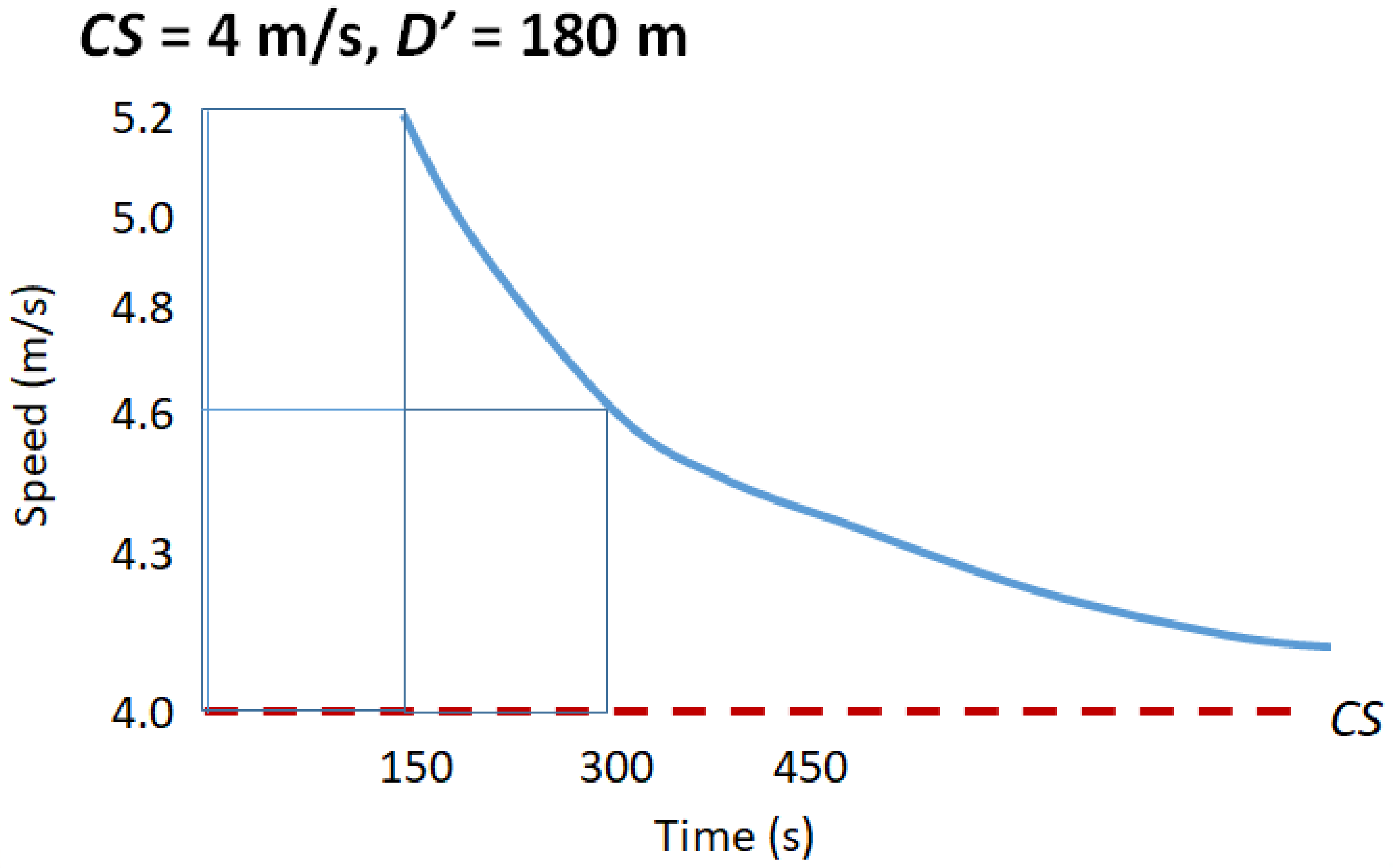



Distance-Time Model
y = 4x + 180
D = (CS · time) + D′
Distance (m)
950
900
850
800
750
140
150
160
170
180
190
Time (sec)

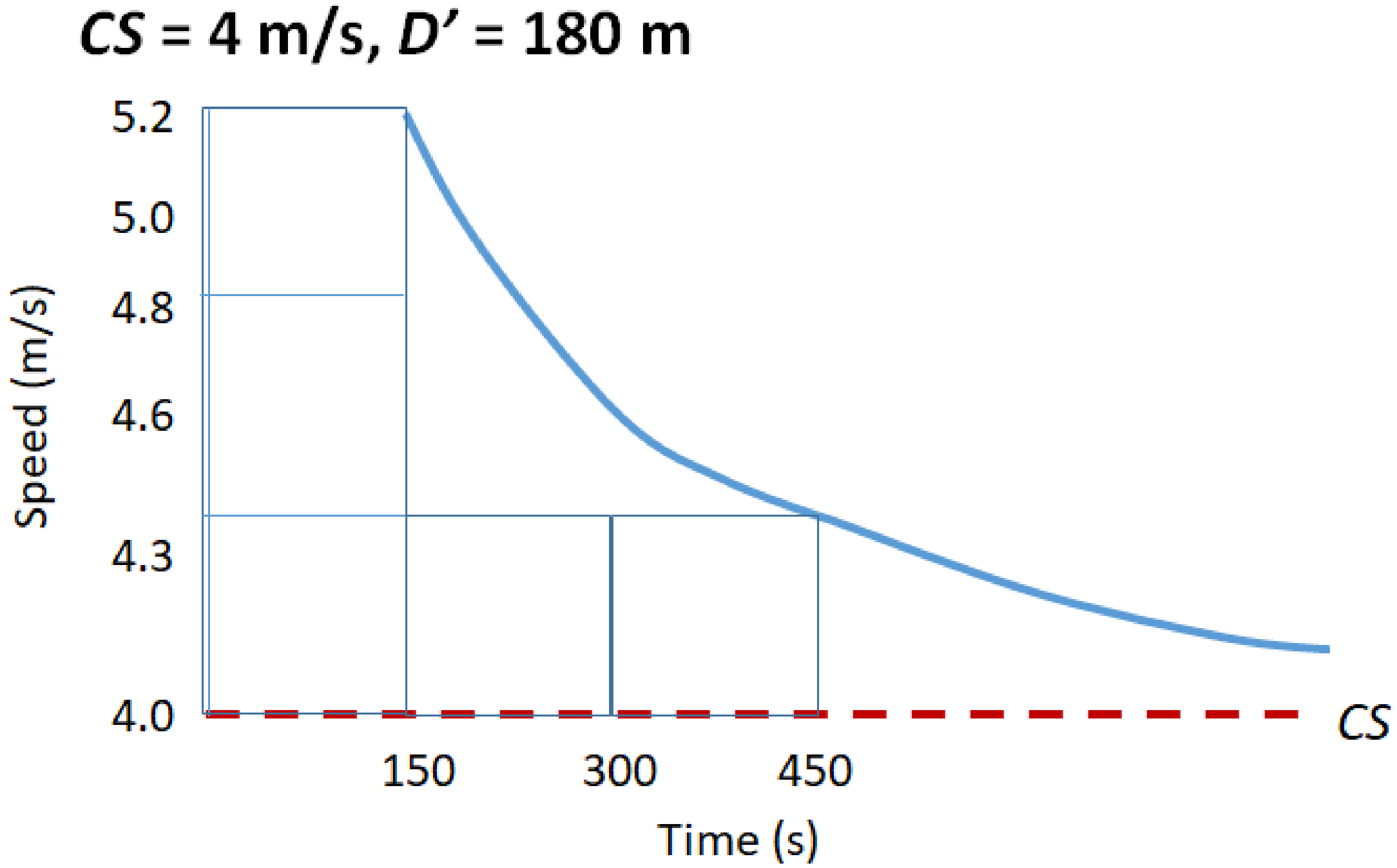



Speed-Inverse Time Model
y = 180x + 4
*S* = D′ (1/sec) + CS
*S* = (D′/time) + CS
Speed (m/s)
5.3
5.2
5.1
5
4.9
0
0.002
0.004
0.006
0.008
Inverse time (1/sec)

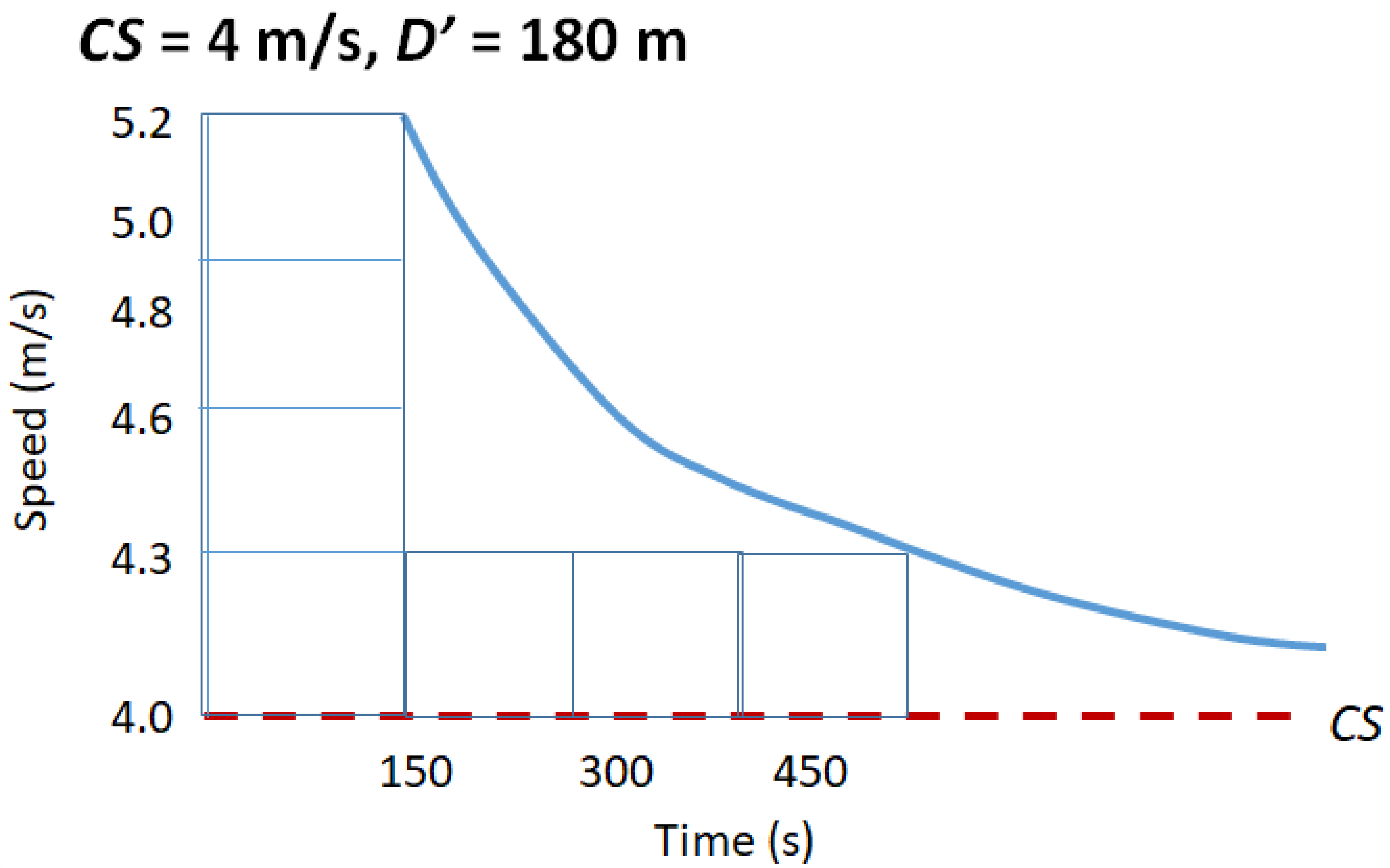
# Proportionate expenditure of *D'*



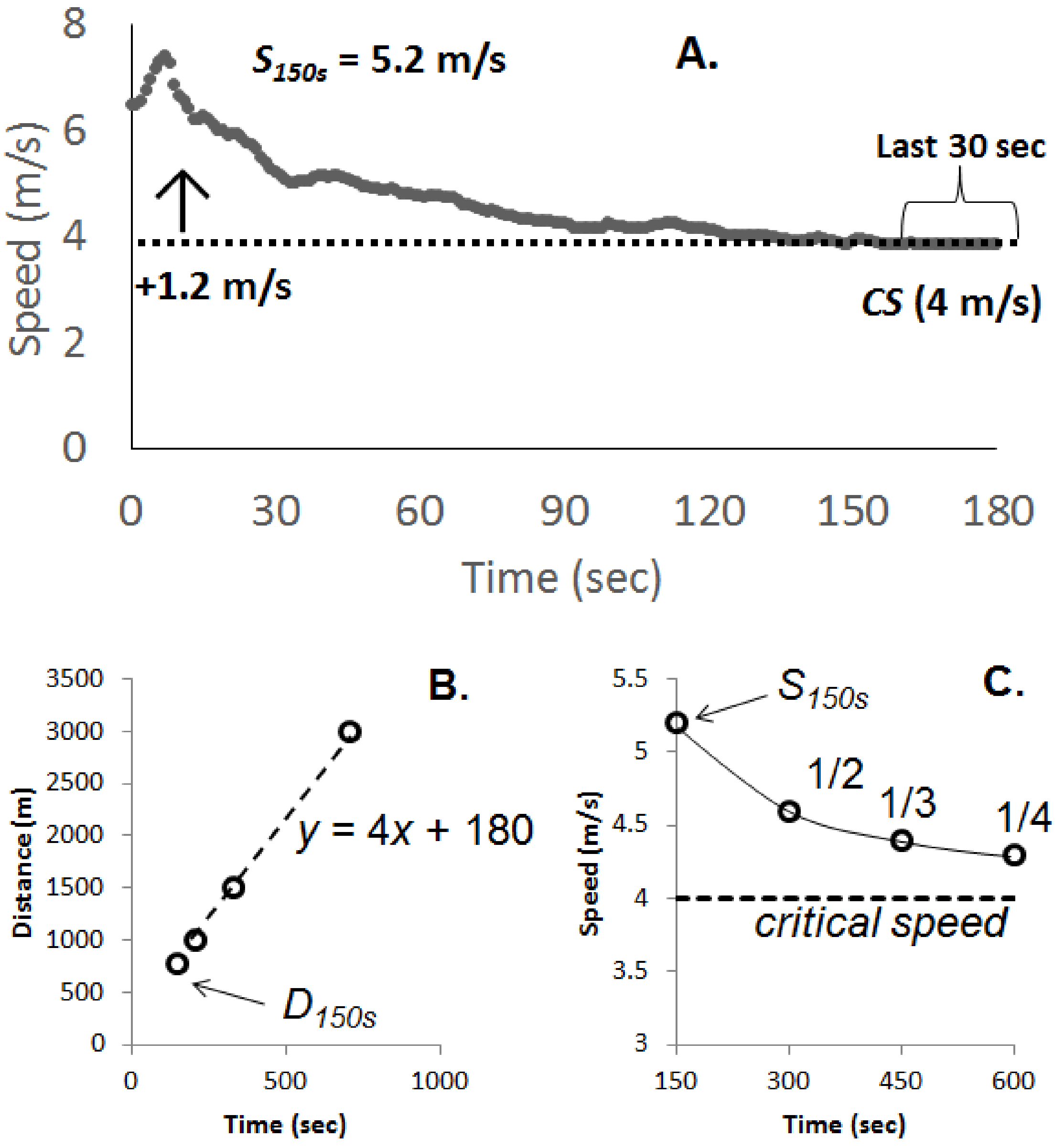
# Proportionate expenditure of *D'*



# Proportionate expenditure of *D'*

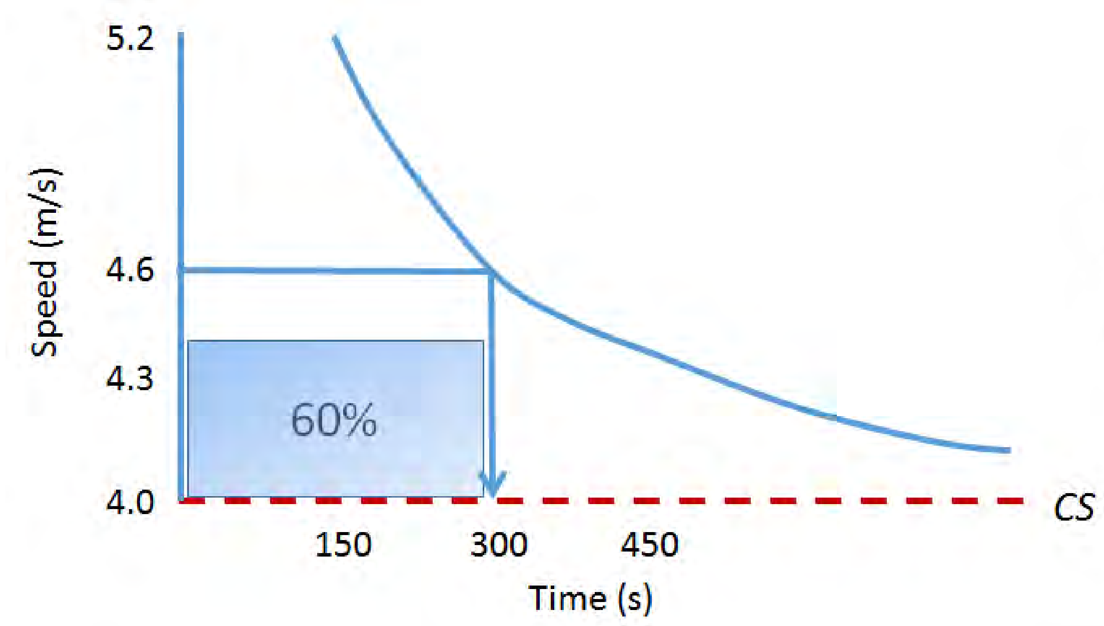


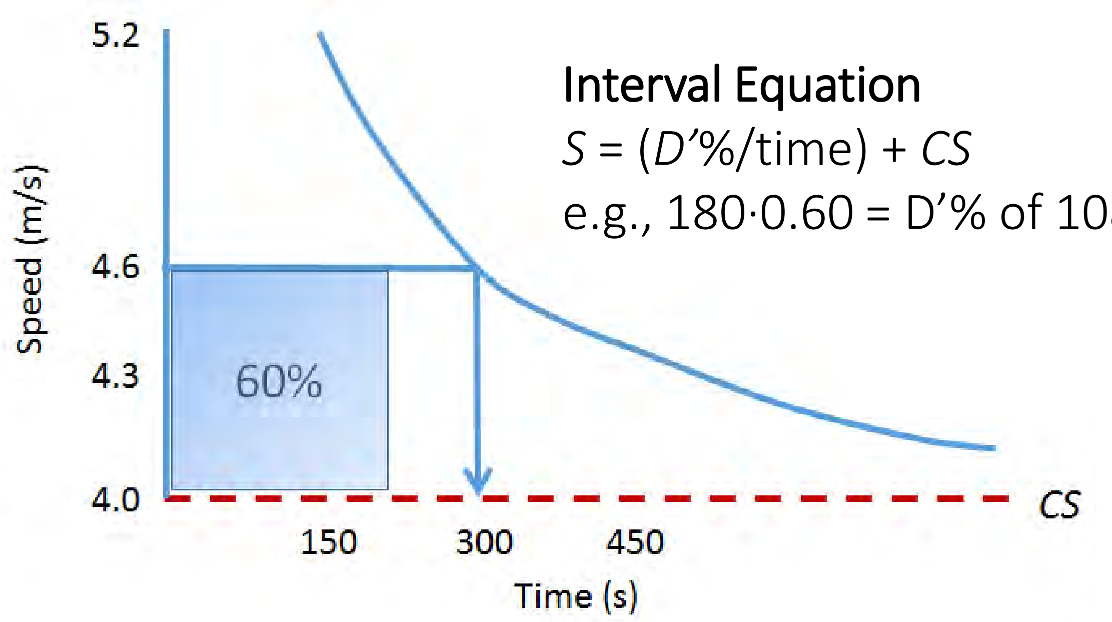
# Review



A.
$S_{150s}$ = 5.2 m/s
Last 30 sec
+1.2 m/s
CS (4 m/s)
Speed (m/s)
Time (sec)
0
2
4
6
8
0
30
60
90
120
150
180
B.
y = 4x + 180
$D_{150s}$
Distance (m)
Time (sec)
0
500
1000
1500
2000
2500
3000
3500
0
500
1000
C.
$S_{150s}$
1/2
1/3
1/4
critical speed
Speed (m/s)
Time (sec)
3
3.5
4
4.5
5
5.5
150
300
450
600

# Original speed-time parameters with HIIT




**Original Speed-Inverse Time Model**

*S* = (*D′*/time) + *CS*

**Interval Equation**

*S* = (*D′*%/time) + *CS*

e.g., 180·0.60 = D′% of 108 m

Pettitt RW. Applying the critical speed concept to racing strategy and interval training prescription. *Int J Sports Physiol Perform 11: 842-847, 2016.*

# Equation for fractional utilization of *D′* with HIIT on a track

**Sample subject: *CS* = 4 m/s, *D′* = 180 m**

**Original Equation**

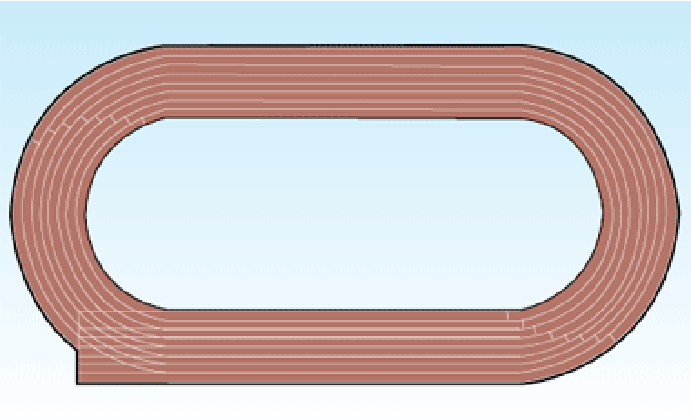
Time (s) = (D – *D′*)/*CS*

205 s = (1000 m–180 m)/4 m/s

**Interval Equation**

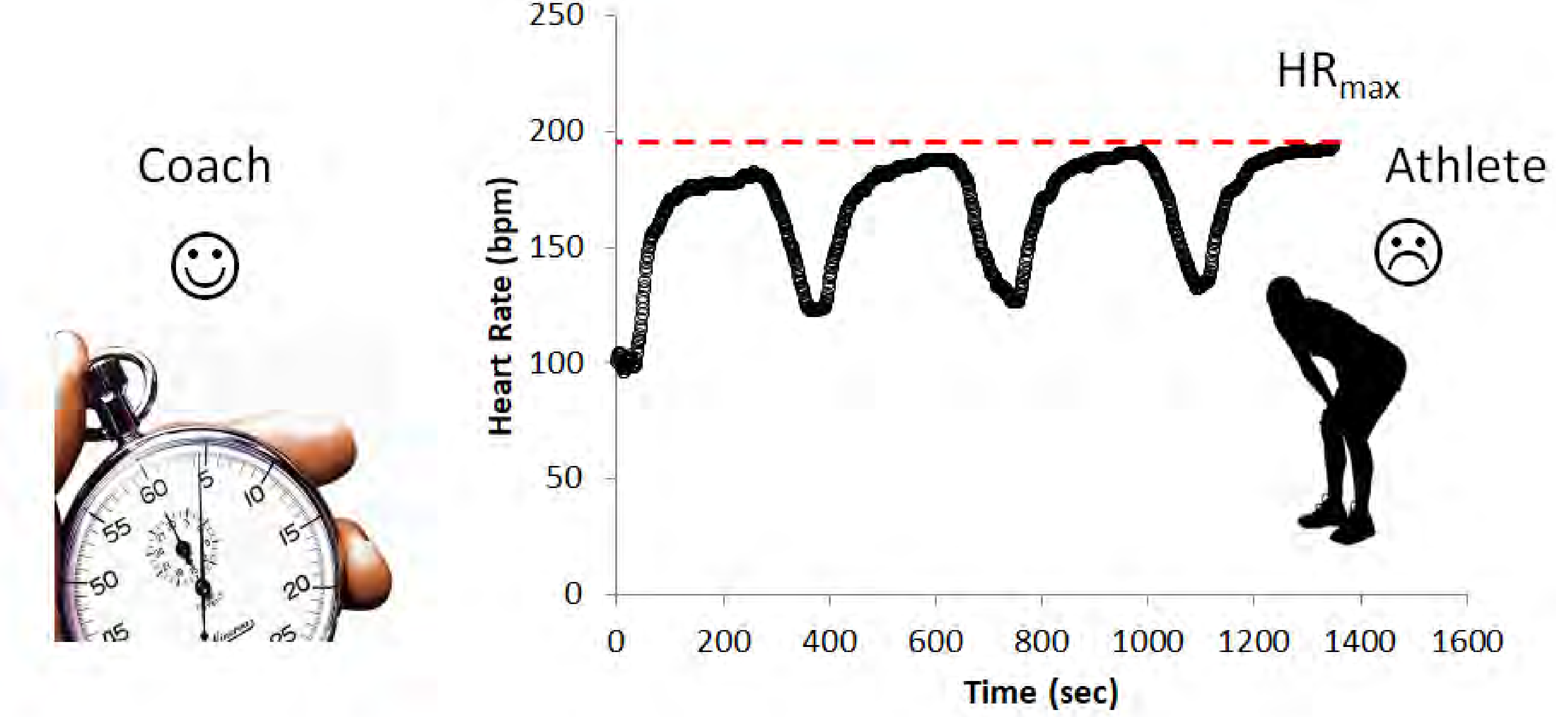
Time (s) = [D – (*D′*·0.60)]/*CS*

223 s = [(1000 m–(180 m·0.60)]/4 m/s



Pettitt RW. Applying the critical speed concept to racing strategy and interval training prescription. *Int J Sports Physiol Perform 11: 842-847, 2016.*

# Original HIIT Study: no load carriage




Clark, I.E., West, B., Reynolds, S., Murray, S.M., Pettitt, R.W. (2013). Applying the critical velocity model for an off-season interval training program. *Journal of Strength and Conditioning Research 27:* 3335-41.

# HIIT Rx.

| Training Goal | Continuous Interval Distance [a] | Interval Time | %D′ Depletion [b] | %$vVO_{2max}$ |
|---|---|---|---|---|
| ↑↑↑CS, ↓D′ | 800-1000 m | 180-300 s | 60-80% | 90-99% |
| ↑CS, ↔D′ | 600 m | 120 s | 60-80% | 100-129% |
| ↔CS, ↑D′ | < 400 m | < 90 s | >80% | >130% |

[a] Shuttle runs proportionately shorter

[b] 60% depletion = 4 intervals; 80 = 3 intervals

Pettitt RW. Applying the critical speed concept to racing strategy and interval training prescription. *Int J Sports Physiol Perform 11: 842-847, 2016.*

# Influence of *Load Carriage* on Running Performance

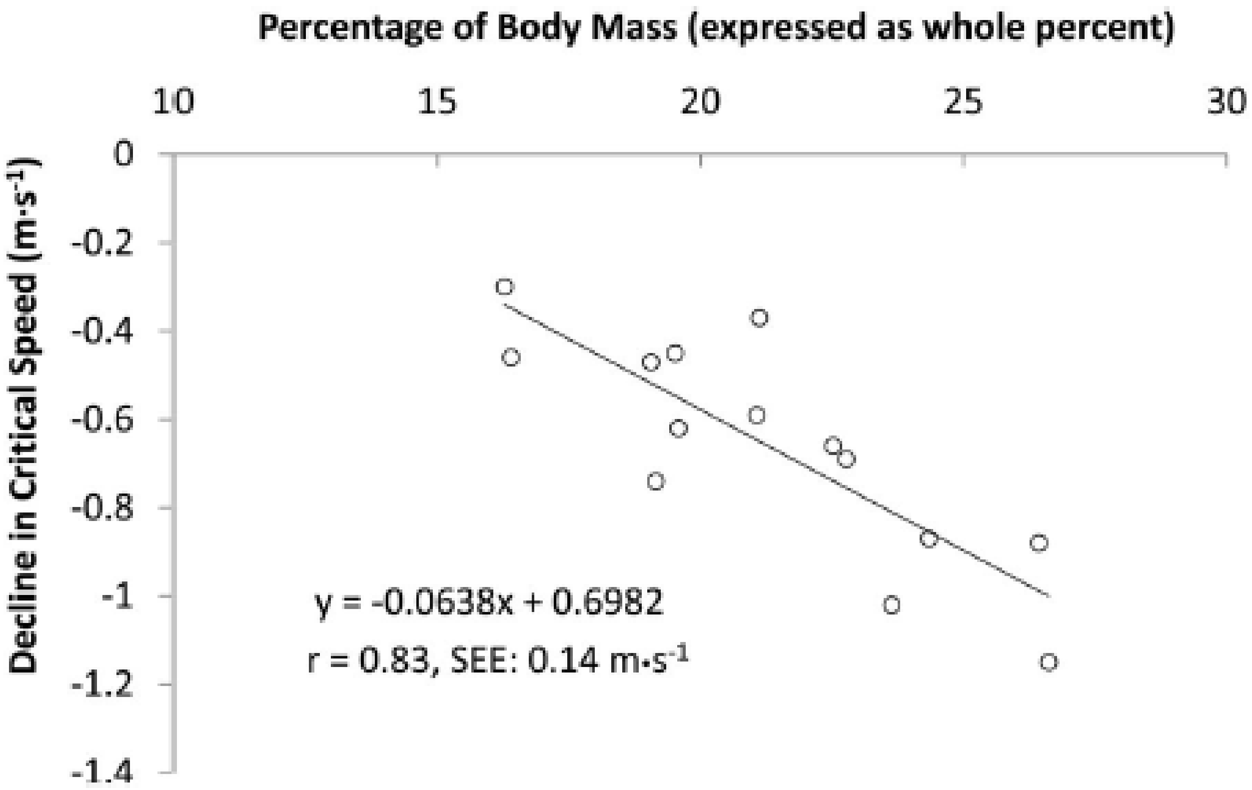
- Examined CS and *D'* from unloaded and loaded trials of the 3MT
- 14 males, various occupational backgrounds (i.e., fire, military, LE)
- Unloaded 3-min all-out running test

| | |
|---|---|
| CS ($m \cdot s^{-1}$): | $3.72 \pm 0.38$ |
| D' (m): | $201.8 \pm 51.54$ |

- Loaded Trial = 18.86 kg Weight vest
  - Declined CS $0.66 \pm 0.24$ $m \cdot s^{-1}$
  - Small decline in *D'*

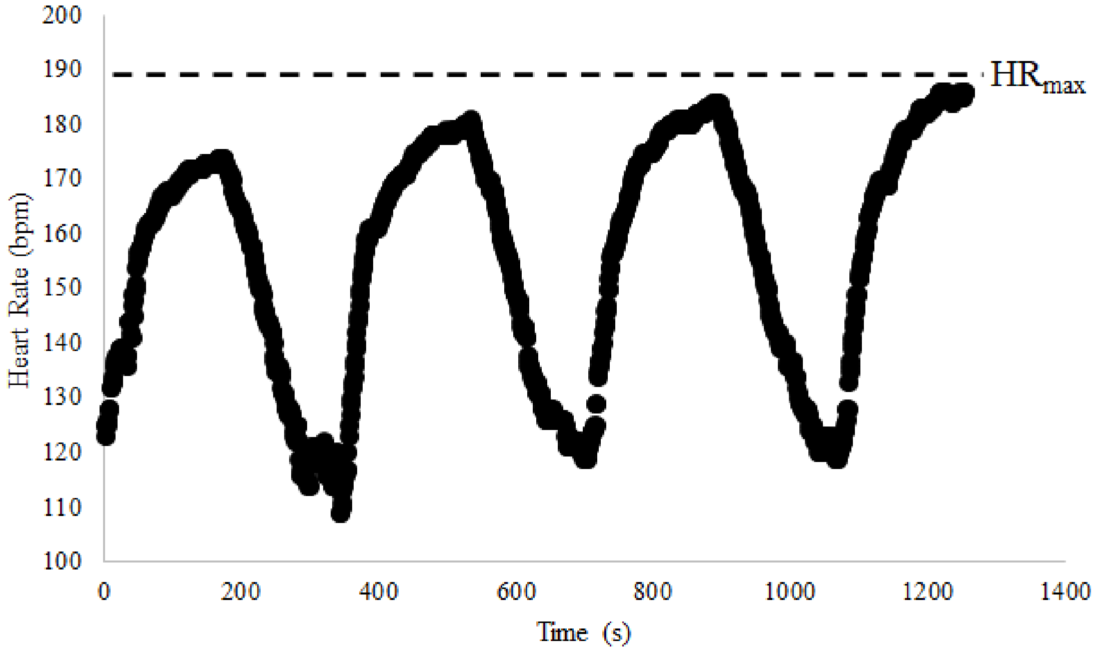
Solomonson et al.(2016). *J Strength Con Res*, *30*(5), 1391-1396.

# Load carriage evokes a linear decline in *CS*

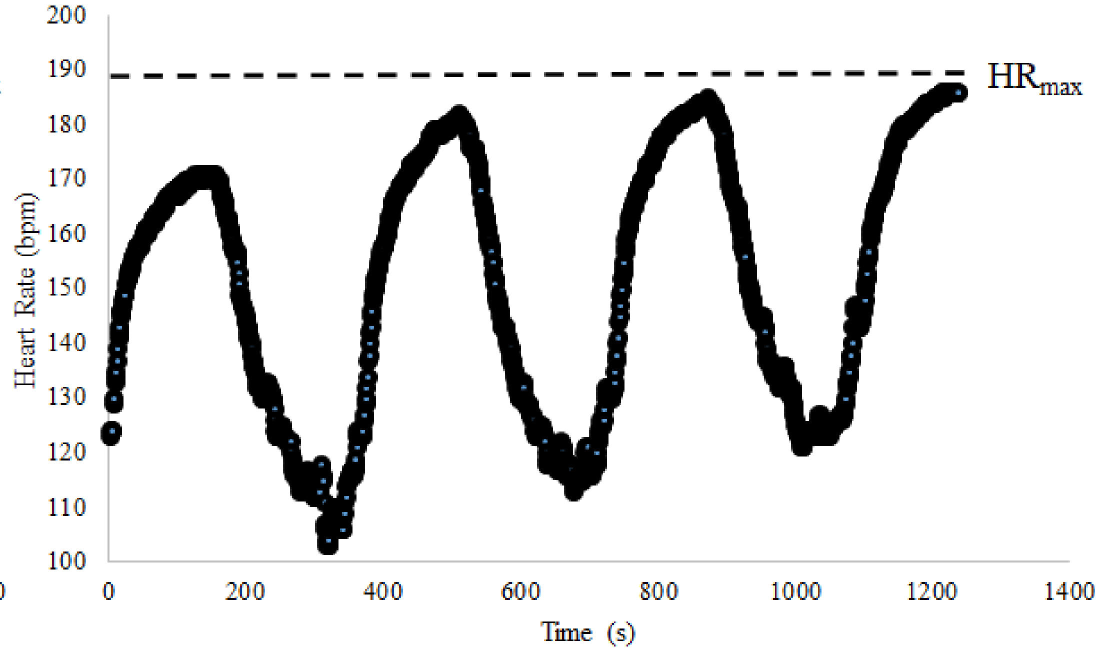



Original Study: Solomonson et al.(2016). *J Strength Con Res*, *30*(5), 1391-1396.
Validation Study: Dicks, N.D., Joe, T.V., Hackney, K.J., Pettitt, R.W. (2018). Validity of critical velocity concept for weighted sprinting performance. *International Journal of Exercise Science 11*: 900-909.

# *Load carriage* and HIIT – Accuracy of Rx




4 x 3 min Intervals at 60% *D'*
15% BM LC (12.3 kg) / 12.87 kph




4 x 2.5 min Intervals at 60% *D'*
21% BM LC (16.7kg)/ 12.71 kph


Dicks, N.D., Mahoney, S., Kramer, M., Lyman, K., Christianson, B., Pettitt, R.W., Hackney, K. (2021). Increased Velocity at VO2max and Load Carriage Performance in Army ROTC Cadets: Prescription Using the Critical Velocity Concept. *Ergonomics 21*:733-743.

# *Load carriage* and HIIT – 2 d·wk$^{-1}$ (4 wk program)

Table 3. Load carriage task completion times pre and post-testing.

| Measure | Pre-test, mean ± SD | Post-test mean ± SD | Cohen's *d* ES | Percent Δ (%) |
|---|---|---|---|---|
| HIT 400 m (s) | 97.4 ± 18.8 | 92.5 ± 18.8* | 0.26 | −5.0 |
| HIT 3200 m (min) | 21.1 ± 4.73 | 19.94 ± 4.63* | 0.24 | −5.4 |
| LCHIT 400 m (s) | 89.5 ± 12.3 | 85.7 ± 10.7* | 0.33 | −4.2 |
| LCHIT 3200 m (min) | 20.38 ± 3.42 | 18.38 ± 2.86* | 0.64 | −9.8 |
| Pooled 400 m (s) | 93.5 ± 16 | 89.1 ± 15* | 0.28 | −4.7 |
| Pooled 3200 m (min) | 20.73 ± 4.03 | 19.16 ± 3.83* | 0.40 | −7.6 |

ES: Effect size, LCHIT: Load carriage high-intensity interval training, HIT: high-intensity interval training.
*Significant differences from pre to post-testing ($p < 0.05$).

# Thank you – want to learn more?

- Open access (aka FREE) article in the journal *Sports*
- Optimization of the Critical Speed Concept for Tactical Professionals: A Brief Review by Nathan Dicks and Robert Pettitt
- https://www.mdpi.com/2075-4663/9/8/106

# Question & Answer Session

## Learning Objectives

1. Impact of Respiratory Muscle Power, Exercise Intensity (Critical Velocity/Speed) on Load Carriage Performance.
2. Types of occupational personal protective equipment could influence RMP.
3. Different kinds of Respiratory Muscle Training to improve RMP.