HSS

Lessons Learned From 25 Years of Combining Endurance Sport in the Office and in the Field:

Top 10 Changes Over Time

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Hospital for Special Surgery

Special thanks to:

Brett Toresdahl MD

Josh Goldman MD

Polly DeMille, CSCS

Have been at this for a minute….

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2000

2024

10 Evidence-Based Changes That Have Helped ….

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1. Training Patterns
2. Nutrition
3. Cadence
4. Strength Training (Age-related sarcopenia)
5. Social Networking (Motivation)
6. Intensity Training
7. Recovery Matters
8. Electrolytes
9. Shoe Wear
10. Just Showing Up (Goals)

Training Patterns

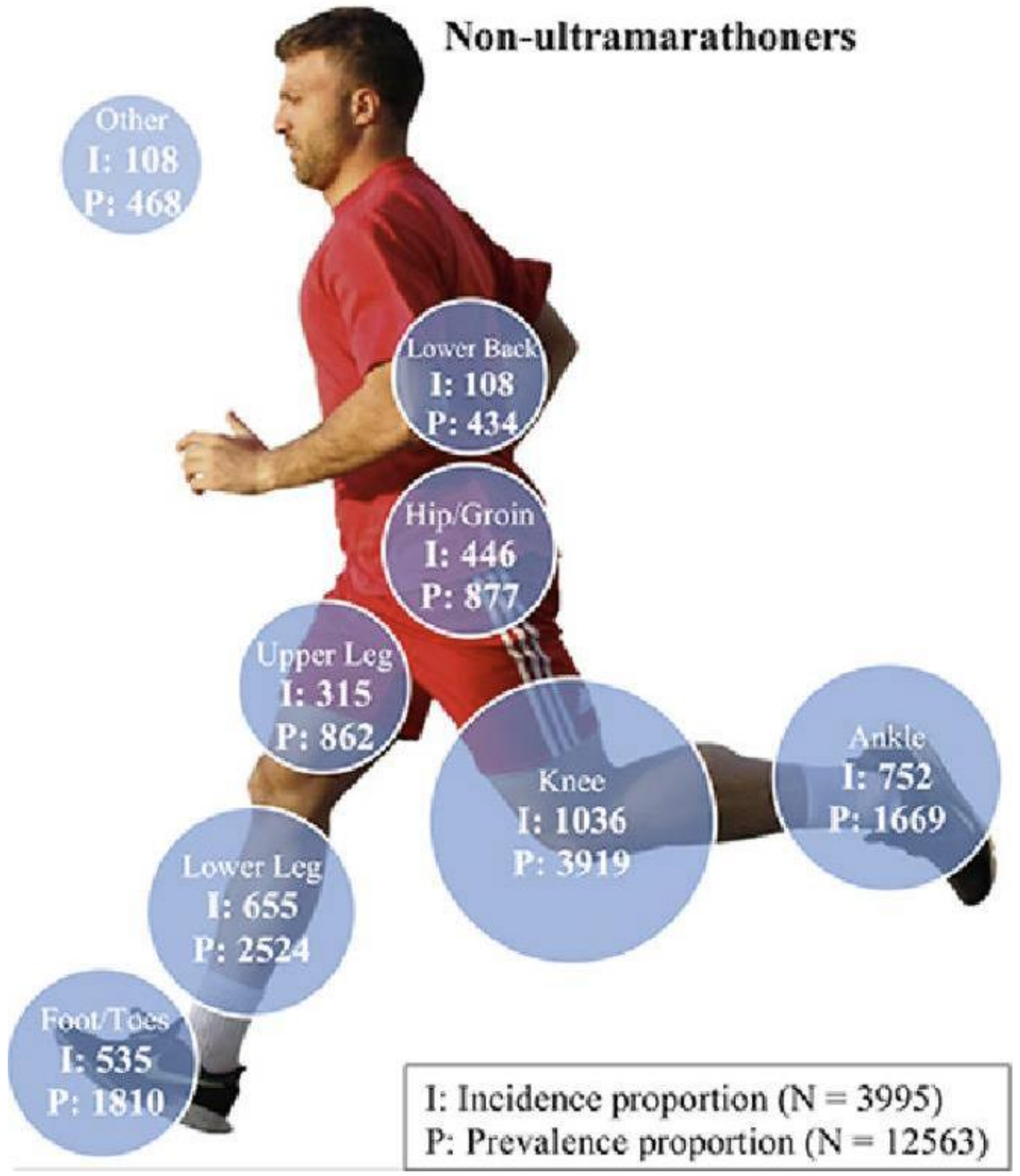
1999 – Run, run, play soccer, run, run

2024 – Training patterns are a major determinant of running related injury

What role do training programs have in the development of RRI?

What injuries do we see in Adult Runners?

Location	Prevalence proportion (*n* (%))	Range (%)	Studies	Incidence proportion (*n* (%))	Range (%)	Studies
Knee	3919 (31.2)	11.6–48.0	9, 28, 31, 34, 44, 45, 47–60	1036 (26.2)	14.3–36.4	20, 21, 23–39
Ankle	1669 (13.3)	6.1–34.2	9, 28, 31, 34, 44, 47–60	752 (19.0)	7.7–28.6	20, 21, 23–25, 27–39
Lower leg	2524 (20.1)	7.8–35.0	9, 28, 31, 34, 44, 45, 47–60	655 (16.6)	5.1–38.8	20, 21, 23–39
Foot/toes	1810 (14.4)	5.2–34.9	9, 28, 31, 34, 44, 45, 47–60	535 (13.5)	2.9–36.1	20, 21, 23–39
Hip/groin	877 (7.0)	4.0–14.5	9, 31, 34, 44, 45, 47, 48, 51, 53–55, 57–60	446 (11.3)	3.5–18.4	20, 23–27, 29–39
Thigh	862 (6.9)	1.5–32.0	9, 28, 31, 34, 44, 45, 47–49, 51, 53–60	315 (8.0)	2.0–14.3	20, 21, 23–38
Lower back	434 (3.5)	2.2–11.5	28, 44, 45, 47–49, 51, 54, 55, 58–60	108 (2.7)	1.5–15.2	20, 23–28, 32, 35, 36, 38
Other	468 (3.7)	2.6–47.8	28, 34, 44, 51, 52, 55–58, 60	108 (2.7)	2.1–19.0	21, 23, 25, 26, 28, 32, 34, 36, 38



Kakouris et al. *J Sport Health Sci*. 2021.

Diagnosis	Prevalence proportion (*n* (%))	Range (%)	Studies	Incidence proportion (*n* (%))	Range (%)	Studies
Patellofemoral pain syndrome	1776 (16.7)	2.2–32.0	44–52, 59	35 (6.3)	1.5–10.2	20–23
Medial tibial stress syndrome	968 (9.1)	3.7–35.0	44–47, 50–52	52 (9.4)	3.4–19.0	21–23, 39
Plantar fasciitis	838 (7.9)	2.2–17.4	44–47, 49–52	34 (6.1)	3.9–21.6	20–23, 39
Iliotibial band syndrome	836 (7.9)	2.2–17.4	44–50, 52, 59	28 (5.1)	3.4–15.7	20, 22, 23, 39
Achilles tendinopathy	705 (6.6)	2.2–18.6	44–47, 49–52	57 (10.3)	7.1–15.0	20–23, 39
Stress fracture/fracture (tibia, fibula, fifth metatarsal, navicular, and calcaneus)	605 (5.7)	1.7–16.0	44–52, 59	22 (4.0)	0.5–9.1	20, 22, 23, 39
Ankle sprain	603 (5.7)	0.8–27.4	44–47, 49–51,59	32 (5.8)	2.8–19.0	20–23
Quadriceps/hamstring tendinopathy	378 (3.6)	0.7–12.7	44, 47, 51	–	–	–
Patella tendinopathy	305 (2.9)	4.2–12.3	45–48	19 (3.4)	1.5–22.7	22, 23, 39
Meniscal injury	181 (1.7)	3.5–5.0	44, 46, 49	24 (4.3)	0.5–9.1	22, 23
Anterior knee pain	135 (1.3)	15.8	51	21 (3.8)	10.2	23
Gluteal strain/tendinopathy	123 (1.2)	1.3–3.5	45, 46	25 (4.5)	1.0–9.8	20, 22, 23
Tibialis posterior tendinopathy	114 (1.1)	0.5–16.0	45–47, 59	2 (0.4)	0.5–2.0	20, 23
Calf strain	104 (1.0)	1.3–2.2	45–47, 49	23 (4.2)	2.0–4.7	20, 22, 39
Quadriceps/hamstring strain	100 (0.9)	1.2–6.7	45–47, 49	19 (3.4)	3.1–7.8	20, 22, 23
Adductor strain	69 (0.6)	1.1–2.2	45–47, 49	–	–	–

Kakouris et al. *J Sport Health Sci*. 2021.

Running Medicine HSS

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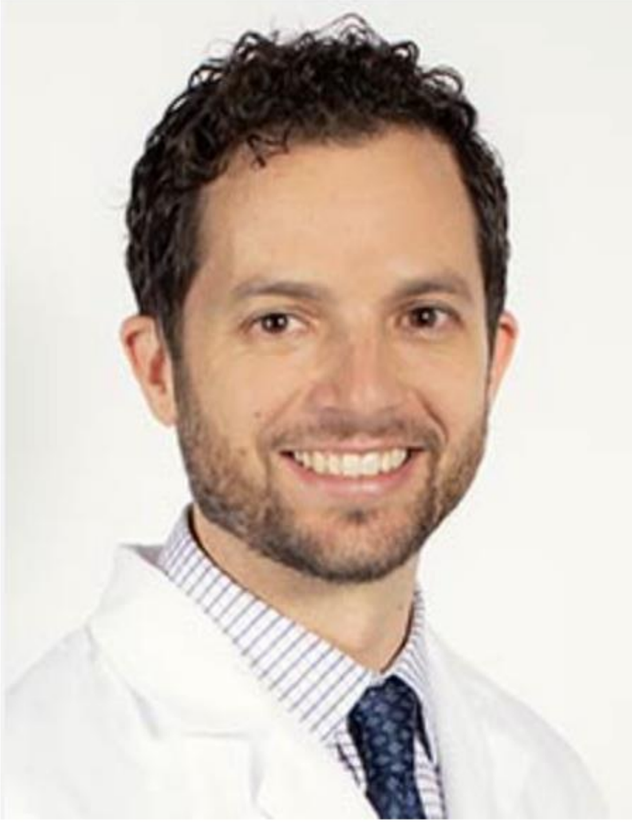

Brett Toresdahl, MD

NYRR NEW YORK ROAD RUNNERS

STRAVA

History of NYC Marathon + HSS

NYC Marathon

- NYRR founded in 1958
- First race 1970 in Central Park with 55 finishers
- Largest marathon in world with >53,000 finishers

HSS Partnership

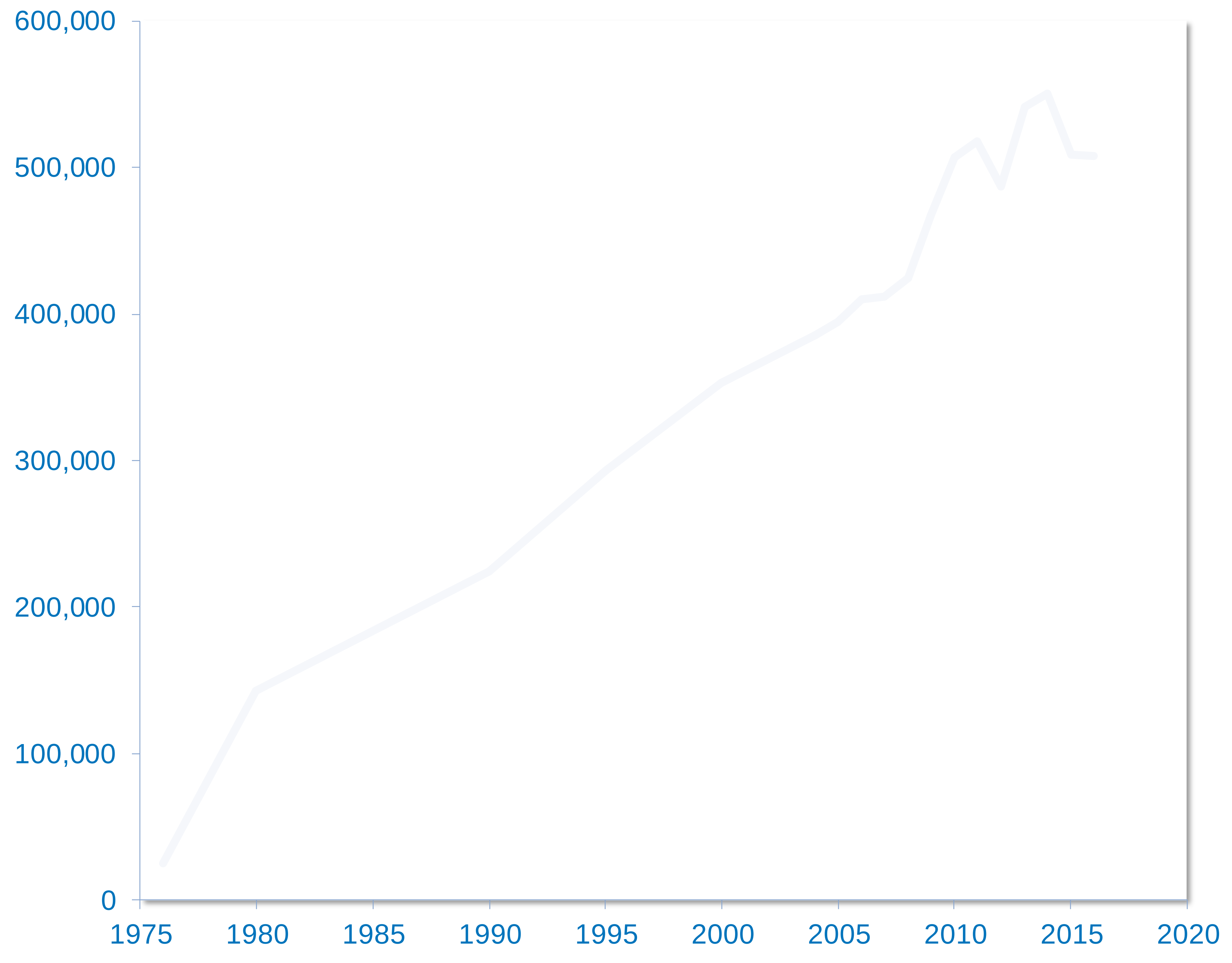
- Began in 2009
- Educational programming
- HSS Recovery Zone
- Research

Background

-Marathon finishers
in the United States

-Existing research on marathon
running-related injuries

- Primarily based on race day medical events
- Few prospective studies of injuries in runners training for a marathon

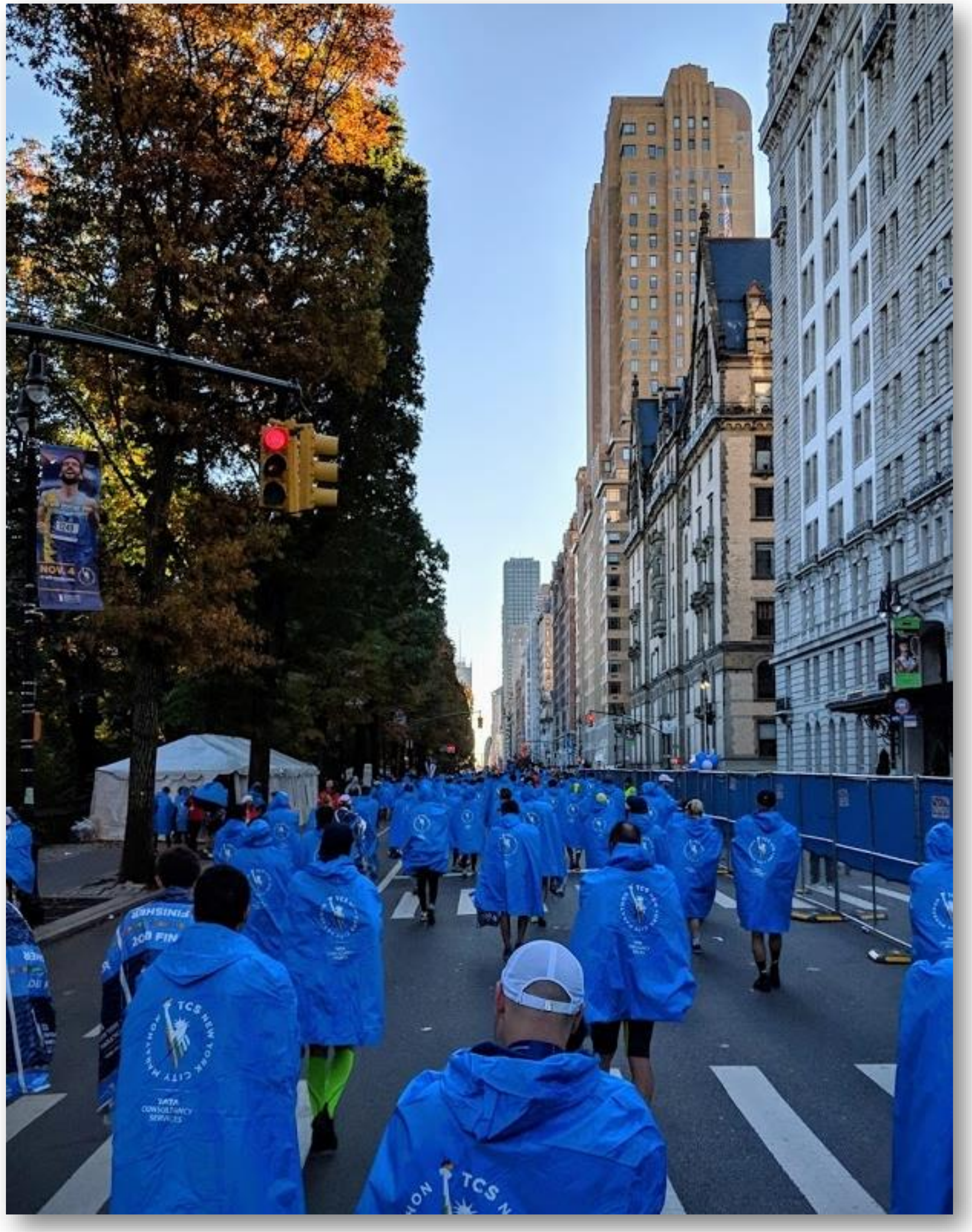


Source: Running USA (2016)

Background

- TCS New York City Marathon
  - Largest marathon in the world
  - 52,813 finishers in 2018

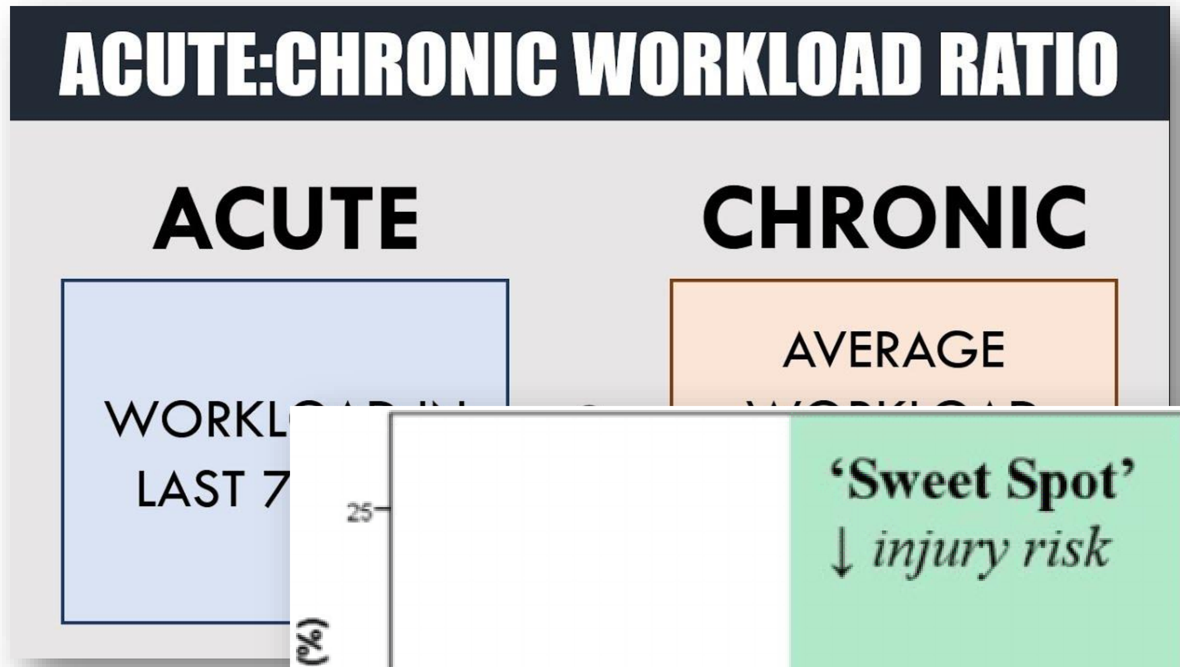
2019 Marathon Study



2019 Marathon Study

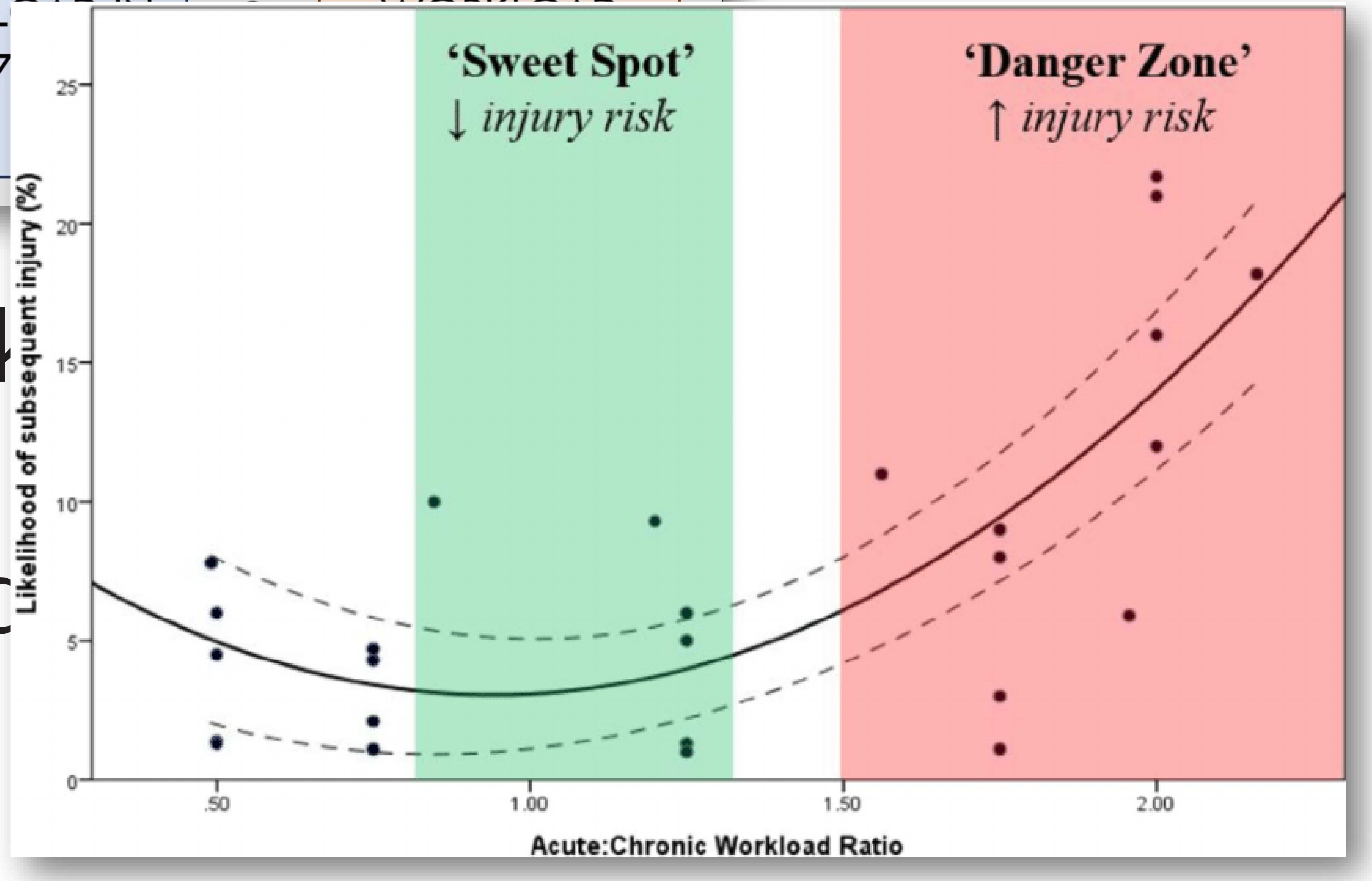
Purpose

Evaluate the association between training patterns and injury/illness in runners training for the marathon



Methods

- Recruited runners of all experience levels
  - Age ≥18 years, no current injury
- Pre-race surveys every 4 weeks starting 16 weel
- Post-race survey
- Received training data from Strava at end of stuc



STRAVA

2019 Marathon Study

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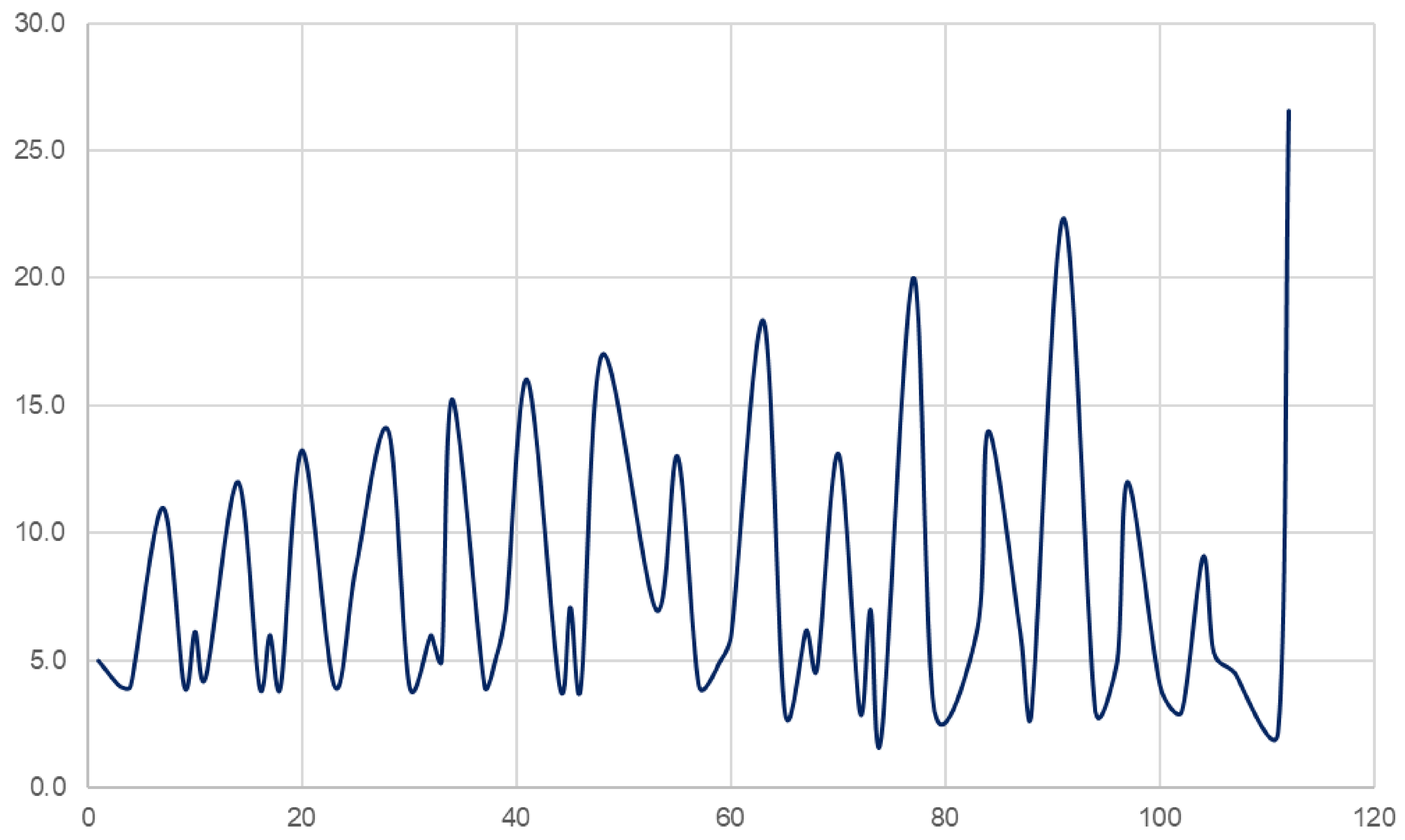
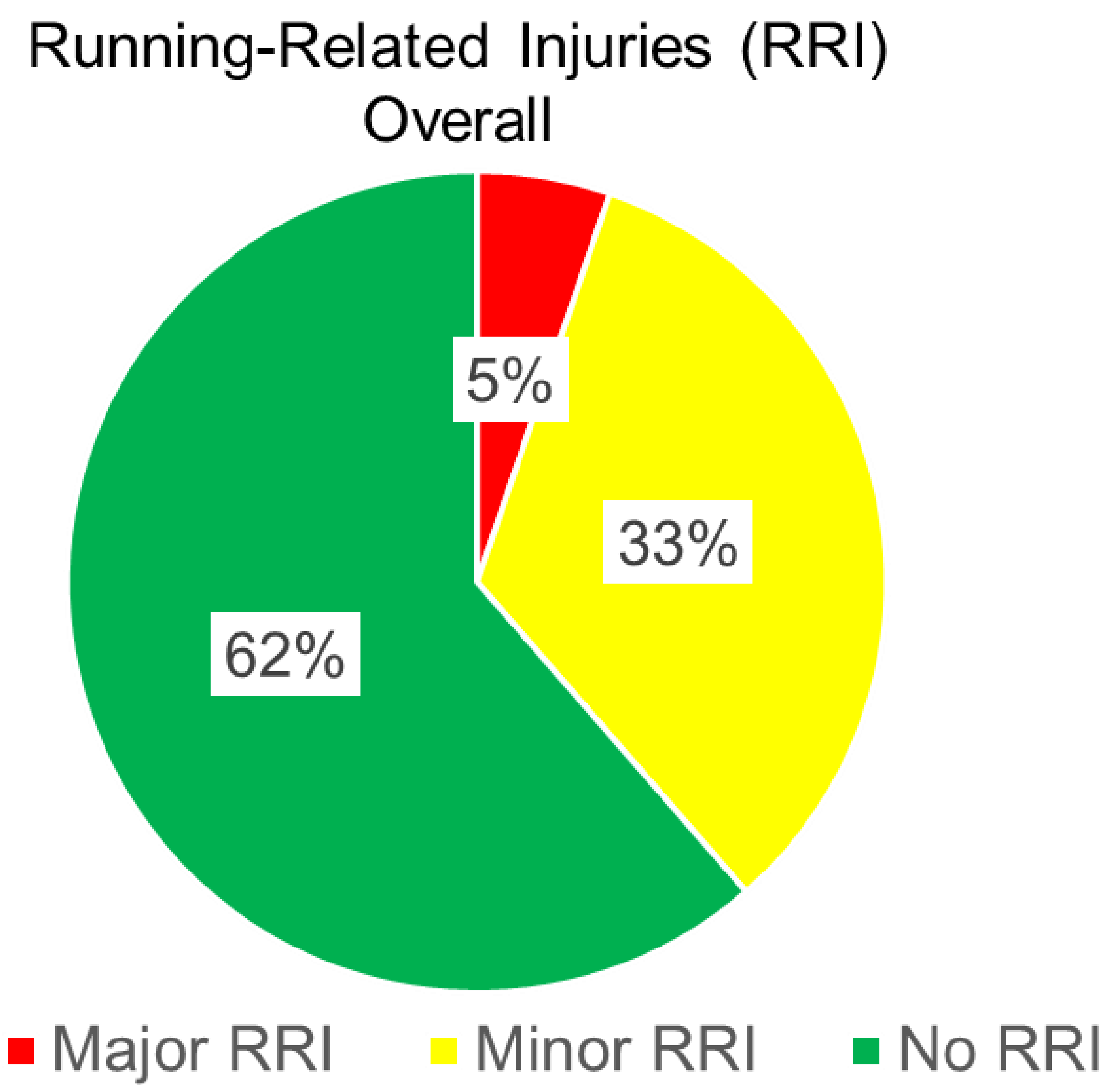
Results
- 1090 participated
- 49% female
- Mean age 42

Marathon completion
- 907 started the race
  - 99% completed the race
- Average finishing time
  - 4 hours 27 minutes

Strava data
- 57,546 training runs logged





2019 Marathon Study

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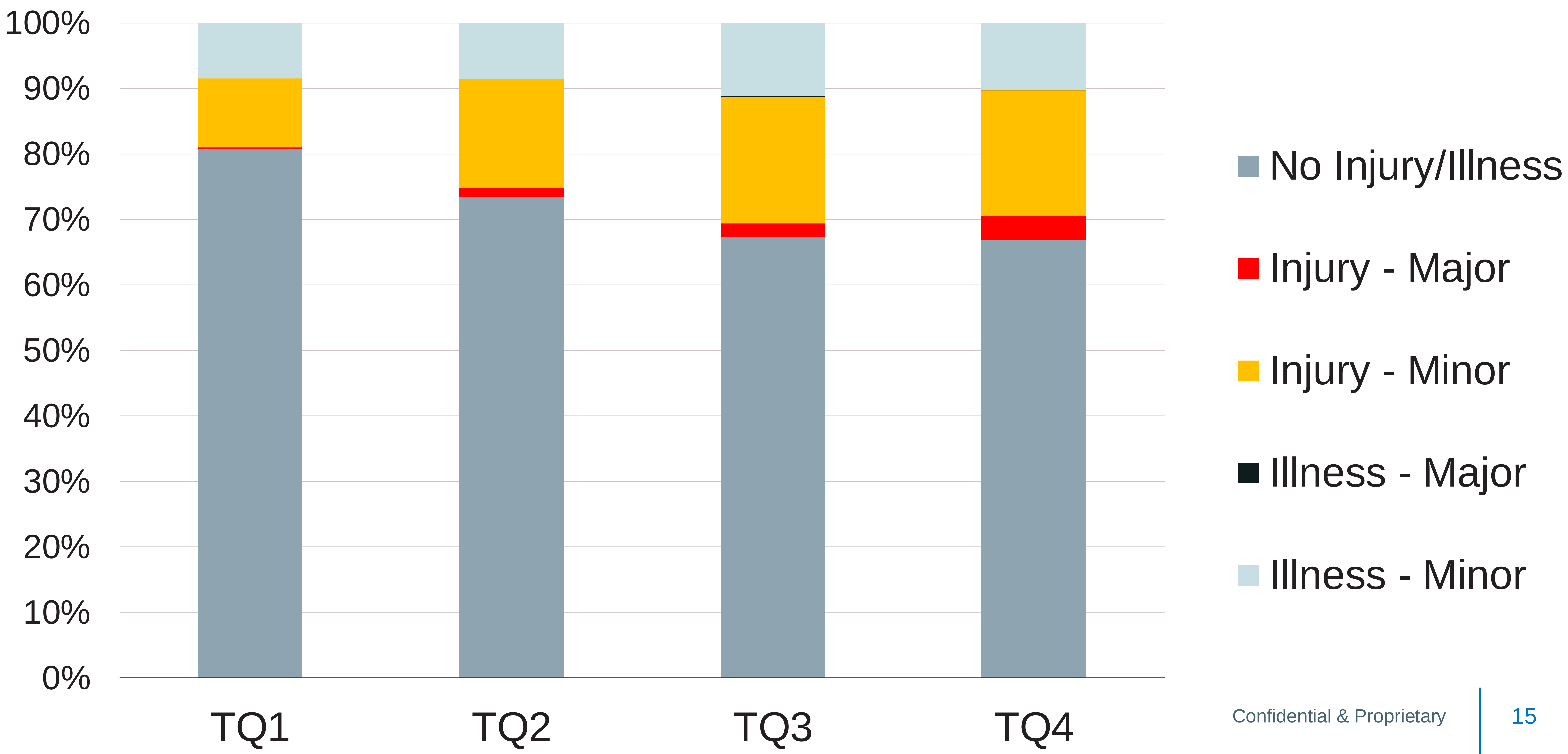
Table 2 Training patterns of runners without injury or illness as collected by Strava

Training quarter	TQ1 (n=594)	TQ2 (n=540)	TQ3 (n=495)	TQ4 (n=490)
Days per week running, median (IQR)	3.8 (3–4.8)	4 (3–5)	4 (3–5)	3.7 (3–4.7)
Distance per week (miles), mean (SD)	27.6 (13.9)	32.0 (14.7)	33.9 (15.3)	29.7 (14.2)
Longest run (miles), mean (SD)	14.2 (4.7)	17.3 (6.2)	22.2 (7.0)	18.5 (5.5)
No of weeks when exceeded '10% rule', median (IQR)	2 (1–2)	1 (1–2)	2 (1–2)	1 (1–2)
No of days when ACWR ≥1.5, median (IQR)	0 (0–1)	0 (0–2)	0 (0–2)	0 (0–0)
No of days when ACWR ≥1.3, median (IQR)	1 (0–5)	3 (1–7)	2 (0–7)	0 (0–0)

ACWR, acute:chronic workload ratio; TQ, training quarters.

2019 Marathon Study



2019 Marathon Study

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Table 7 Association of injuries during TQ4–TQ1 with demographics, running experience and training patterns

	Injury† (n=294)	No injury† (n=441)	Univariable OR (95% CI)	Multivariable OR (95% CI)
Age	41.1 (10.7)	41.0 (10.7)	1.00 (0.99 to 1.02)	1.01 (0.99 to 1.02)
Sex				
Female	131 (44.6%)	207 (46.9%)	Reference	Reference
Male	163 (55.4%)	234 (53.1%)	1.10 (0.82 to 1.48)	1.11 (0.66 to 1.86)
Body mass index	23.7 (3.5)	23.3 (2.9)	1.04 (0.99 to 1.09)	1.02 (0.98 to 1.07)
Marathon finishing time goal (minutes)	240.8 (47.4)	237.2 (42.8)	1.00 (1.00 to 1.01)	1.00 (1.00 to 1.00)
Running distance/week in the month before the study (miles)	30.7 (41.9)	30.8 (26.9)	1.00 (1.00 to 1.00)	1.00 (1.00 to 1.01)
Running days/week running in the month before the study	4 (3, 5)	4 (3, 5)	0.97 (0.88 to 1.08)	1.04 (0.94 to 1.15)
No of half marathons completed	10 (4, 15)	10 (5, 19)	0.98 (0.96 to 1.00)	0.99 (0.96 to 1.01)
No of marathons completed	2.5 (1, 7)	3 (1, 8)	0.97 (0.93 to 1.01)	0.99 (0.94 to 1.04)
No of weeks per TQ when exceeded 10% rule	1 (0, 2)	1 (1, 2)	0.88 (0.76 to 1.02)	0.88 (0.76 to 1.02)
No of days per TQ when ACWR ≥1.5	0 (0, 2)	0 (0, 1)	1.06 (1.03 to 1.10)**	1.06 (1.02 to 1.10)**

Lesson 1

Training ramp up volume makes a BIG difference. Most training programs are too aggressive. What works for me (or coaches) won’t always work for our patients.

10 Evidence-Based Changes That Have Helped ….

1. Training Patterns
2. Nutrition
3. Cadence
4. Strength Training (Age-related sarcopenia)
5. Social Networking (Motivation)
6. Intensity Training
7. Pain Management
8. Electrolytes
9. Shoe Wear
10. Just Showing Up (Goals)

Nutrition

1999 – Eat all things, any time of night or day, anytime/anywhere

2024 – Eat all things, less processed foods, less sugar before bed (sleep). More proteinaceous diet and still plenty of carbs with training

Carbohydrates Reduce Muscle Injury

Subjects: Twenty-four male runners were randomly assigned to two groups

- Carbohydrate group: Maltodextrin solution
- Control group: Standard hydration

Training Program:

- Days 1-8: Overload training program
- Day 9: High-intensity intermittent running protocol (10 × 800 m)

Findings:

- **LDH levels remained constant** in the Carbohydrate Group and increased in the Control Group
- **Free plasma DNA (marker of cell damage) was lower** in the Carbohydrate Group
- **Leukocyte counts were lower** in the Carbohydrate Group
- Cortisol levels were correlated with free plasma DNA, leukocytes, and LDH
- **TAKEAWAY:** Use of a carbohydrate beverage during intense **training attenuated the acute post-exercise inflammation response** and enhanced recovery

de Sousa et al. *Eur J Appl Physiol*. 2012.

Adding Protein reduces Muscle Injury and improves Performance

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Subjects: Eighteen elite trail runners during a one-week training camp (13 sessions)

Fueling Intervention:

- **Protein + Carbs:** PRE: Protein drink (0.3 g/kg) + POST: Protein-Carb drink post- (0.3 g/kg; 1 g/kg)
- **Carb Only:** Time-matched carbohydrate drink only

Testing: 4-km run-test was performed before and on the last day of the intervention.

Results:

- **Pro + Carbs improved performance in the 4-km run-test**
- **Greater increase in creatine kinase in Carb only group**
- Lactate dehydrogenase and cortisol increased during the week = No difference between groups
- Reduction in perceived performance capacity was greater in Carb only group

Takeaway: Ingestion of whey protein before and after each exercise session **improves performance and reduces markers of muscle damage** during a strenuous training camp.

Hansen et al. *J Sport Nutr Exerc Metab*. 2015.

Protein Aids with Muscle Maintenance

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"Recent evidence suggests that protein intake closer to 1.2–1.5 g/kgbodyweight/day, in combination with adequate exercise, is more beneficial in preventing age-related declines in muscle mass and strength, improving health status"

doi: 10.3390/nu13030743

Lesson 2

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I’m all in for food! I’m all in for eating all things!

I’m not 25. I need more protein in my diet.

10 Evidence-Based Changes That Have Helped ….

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Cadence

Higher cadence = lessened GRF

Study:

15 Runners – 7 controls, 8 increased cadence.

Baseline session run was completed at participant's naturally preferred cadence and cadence session run was completed at a cadence targeted to be 10% greater than baseline

Cadence differences of 7.3% were observed between baseline and cadence sessions ($p<0.001$). A concurrent decrease in average peak force of 5.6% was demonstrated during the cadence run ($p<0.05$)

doi: 10.26603/001c.25166

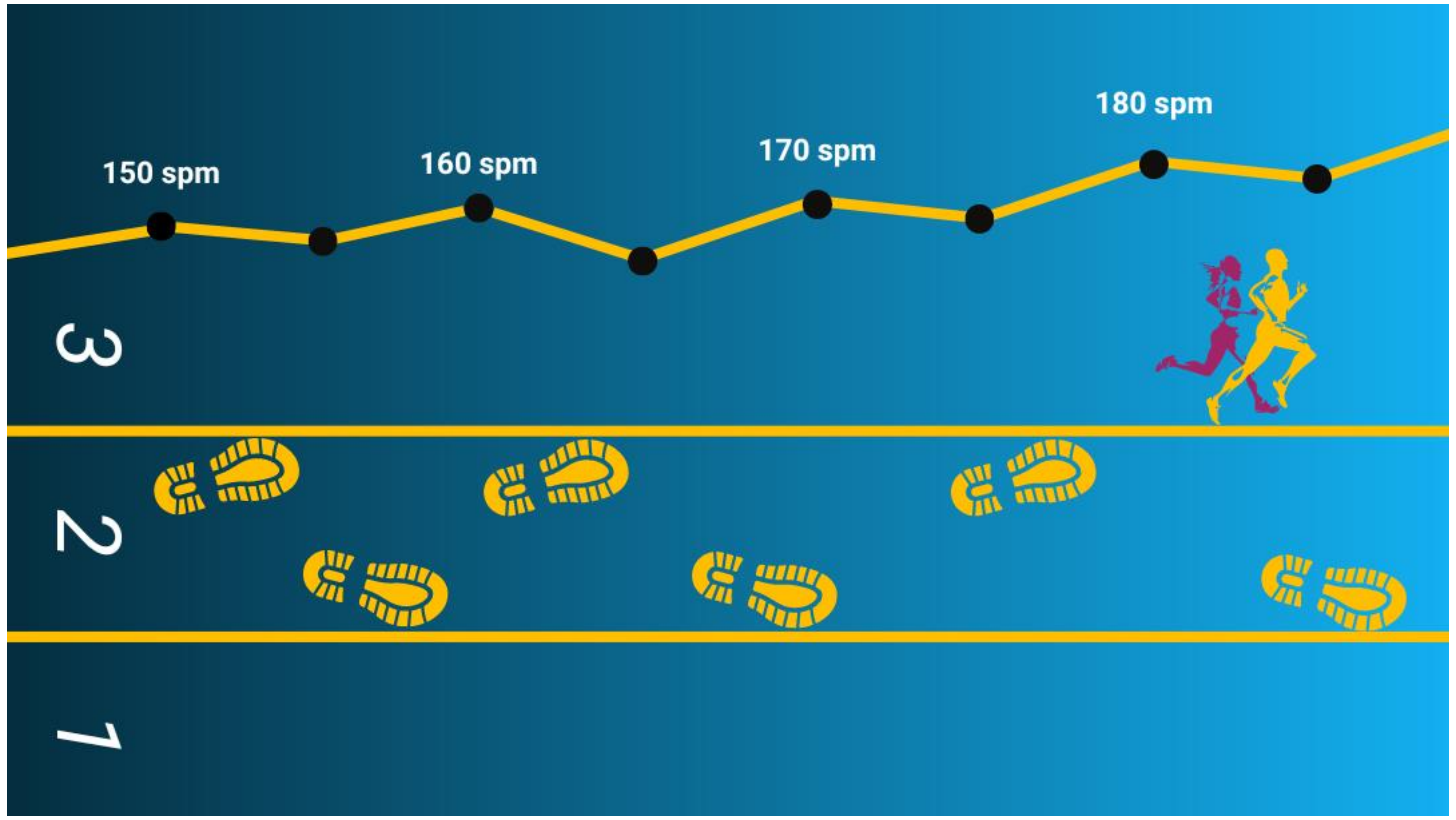
Cadence Tricks

Counting foot strikes (160-180 double, 80-90 each side)

Metronome app, Spotify with 180 bpm

Running uphill on treadmill

Trial and error



doi: 10.26603/001c.25166

Lesson 3

When I shorten my stride everything hurts less

10 Evidence-Based Changes That Have Helped ….

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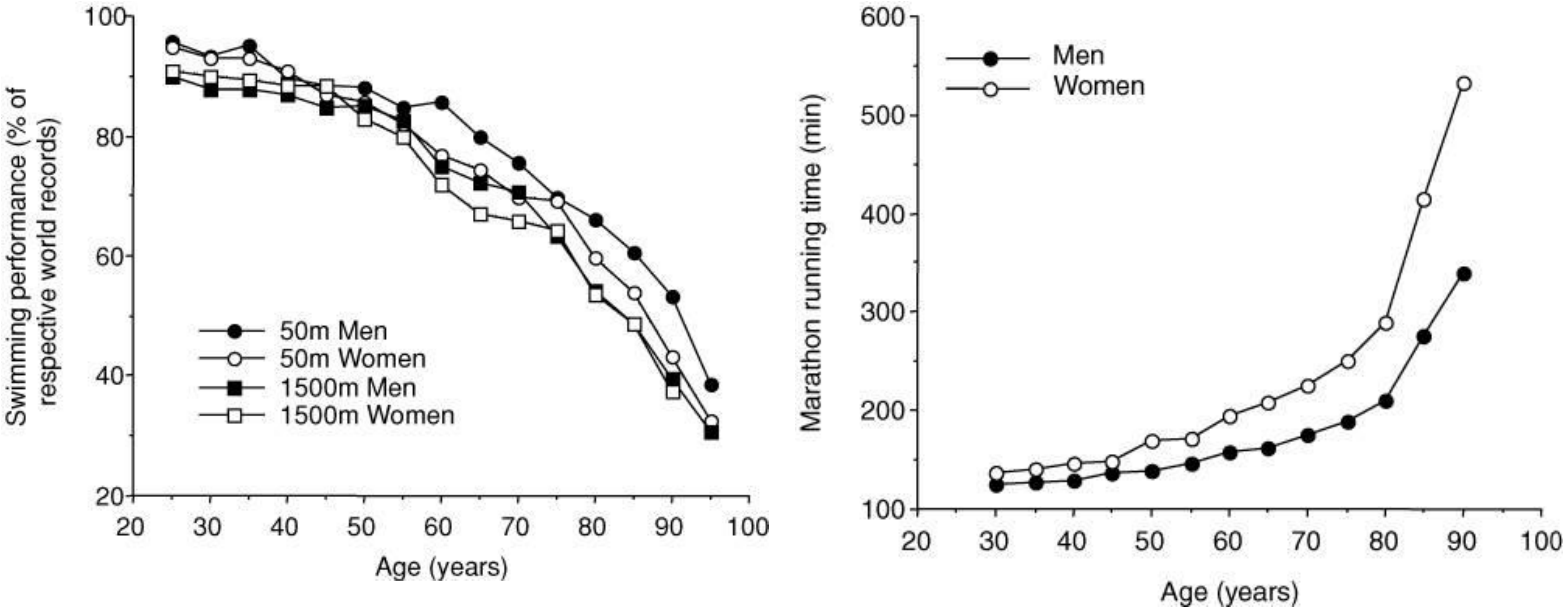
Aging and Elite-Level Sports Performance



doi: 10.1113/jphysiol.2007.141879

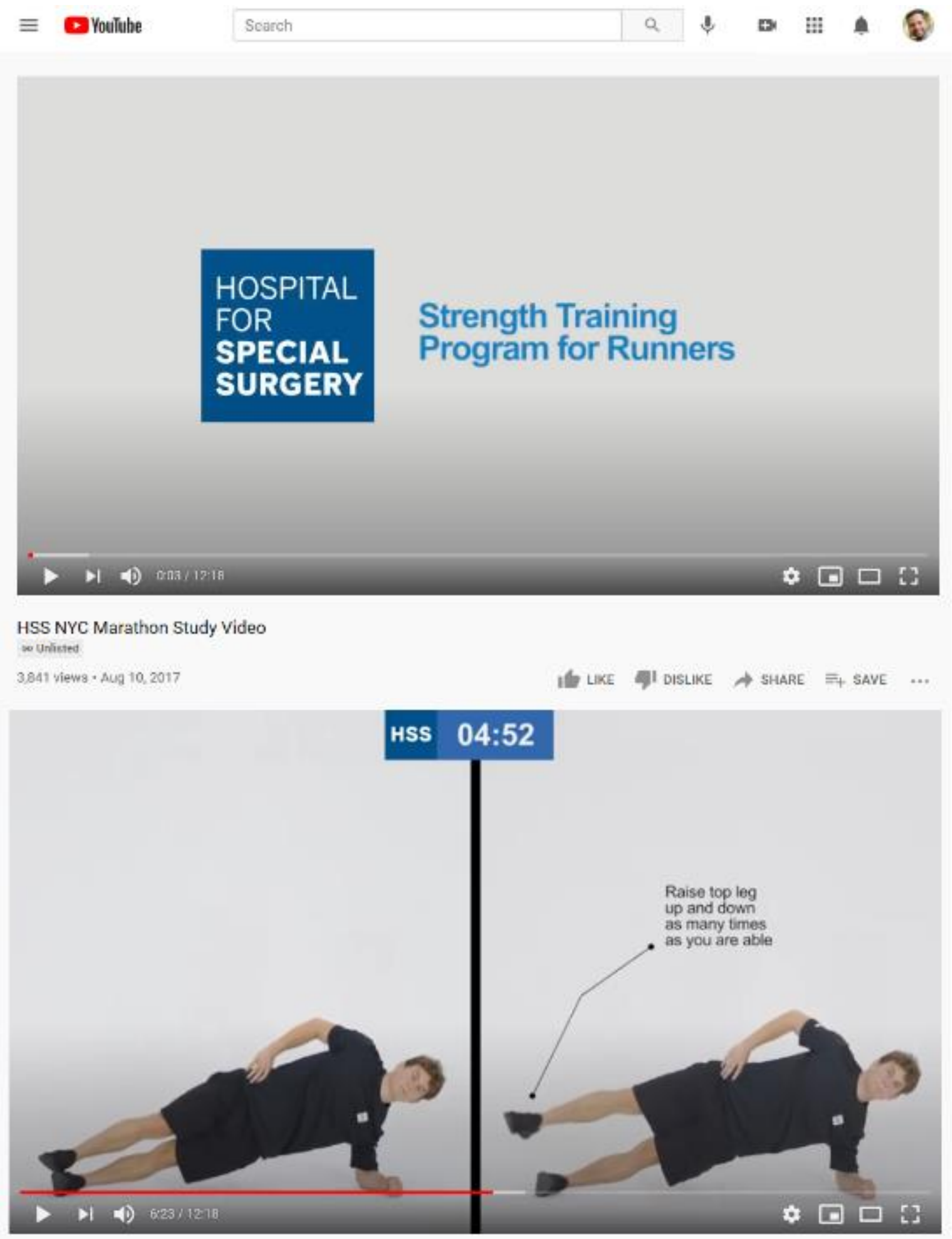
2017 Marathon Study

Purpose

1) Evaluate the effect of strength program on injury rates
2) Determine risk factors for injuries

Methods

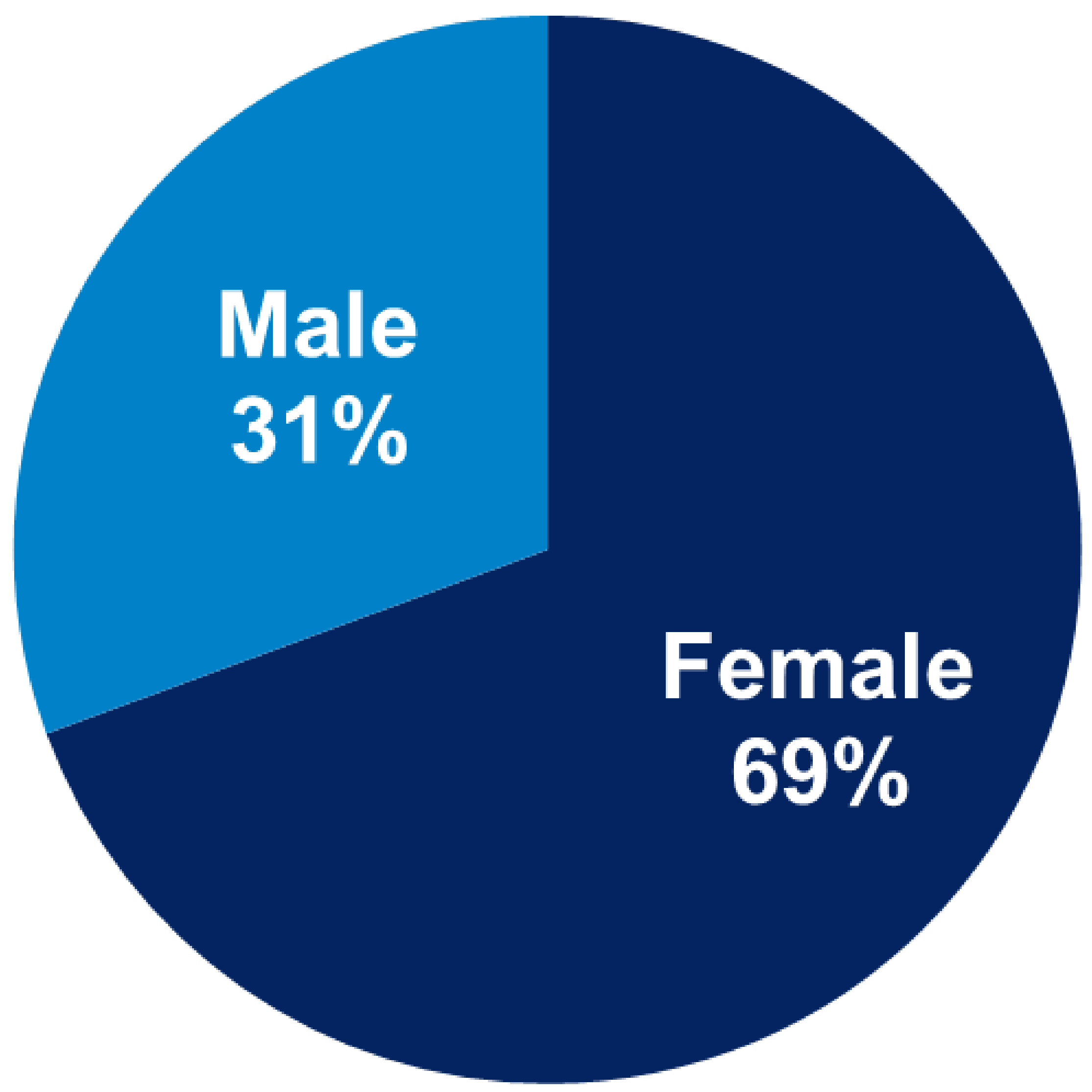
- Recruited first-time marathon runners
  - Age ≥18 years, no current injury
- Randomized 1:1 to strength training or control groups
- Pre-race biweekly surveys starting 12 weeks before
- Post-race survey

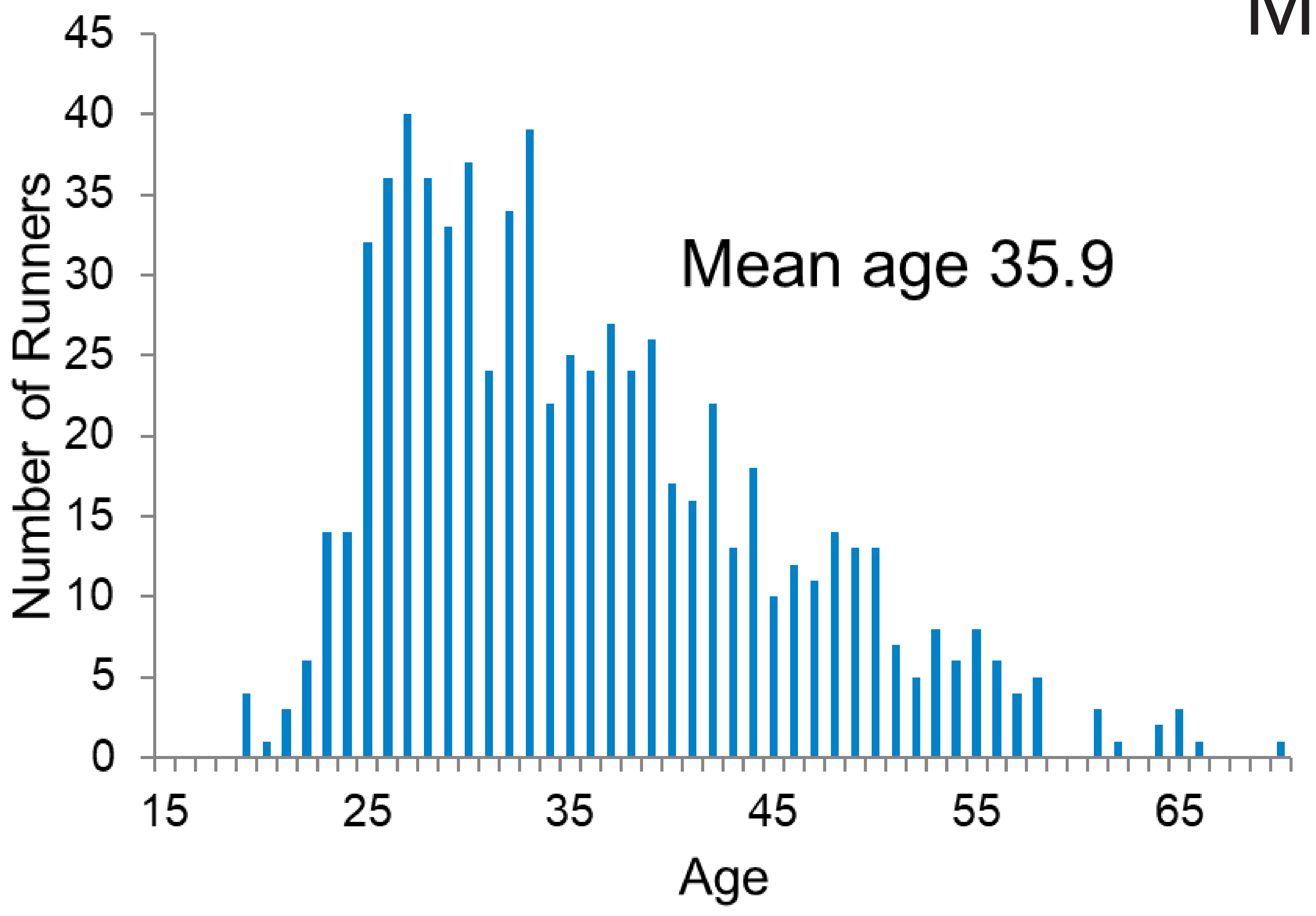


2017 Marathon Study

Results

720 participated / 675 (94%) completed the study





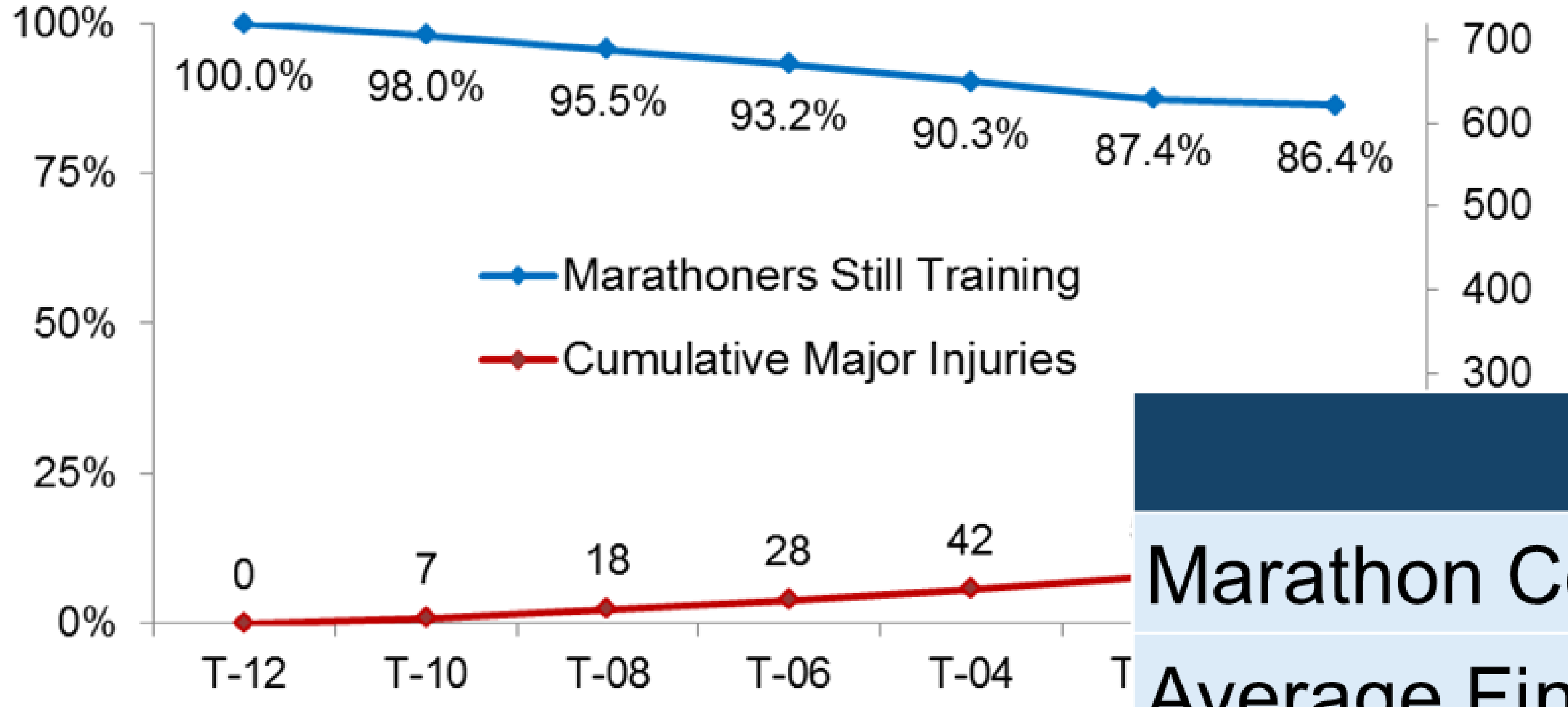
Marathon completion

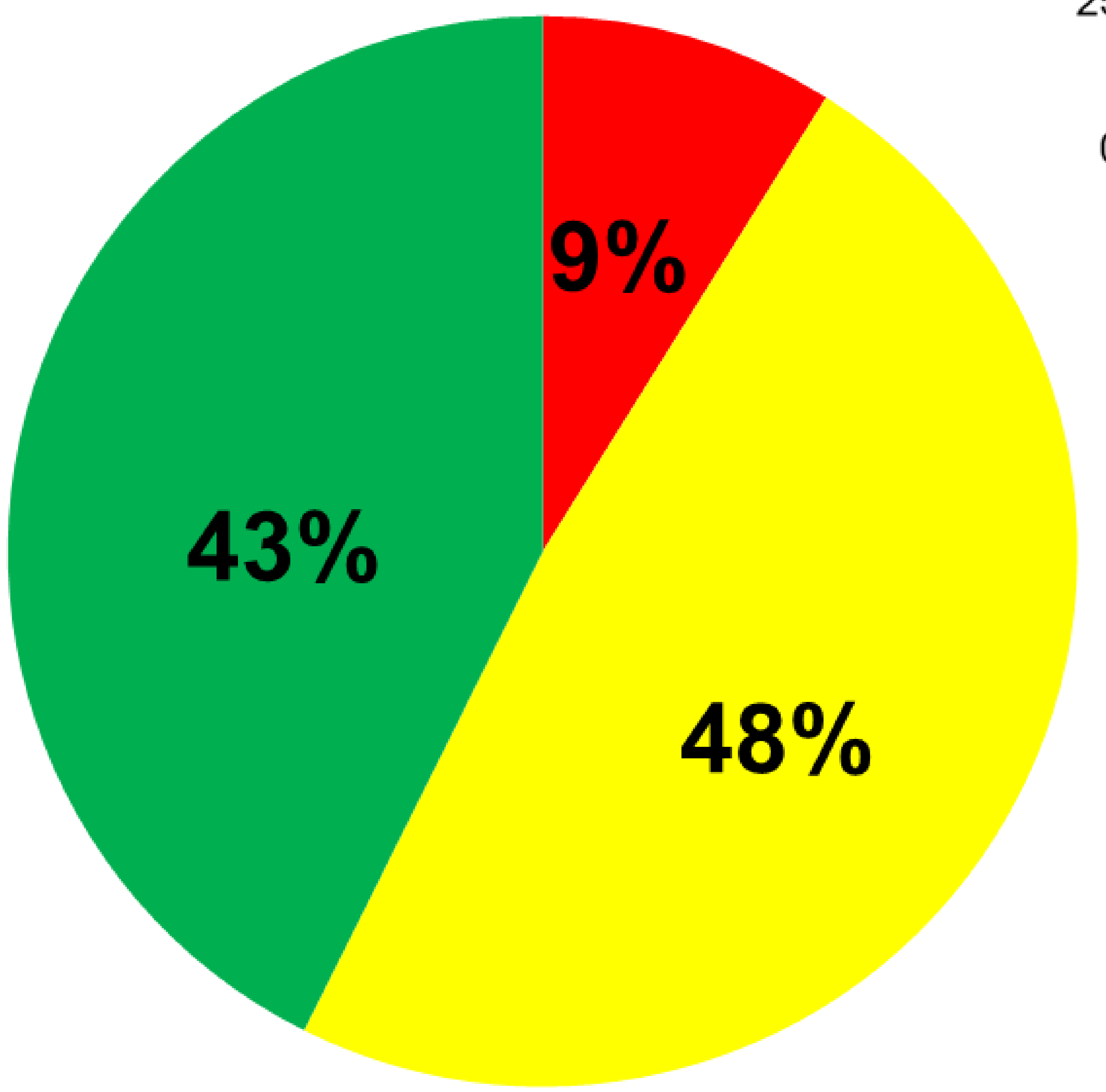
- 583 started
  - 579 (99%) completed
- Average finishing time
  - 4 hours 59 minutes
  - ± 57 minutes

2017 Marathon Study

HSS

Injury incidence





- Major Injury = unable to continue training/racing
- Minor Injury = limited training/racing
- No injury

	Strength	Control
Marathon Completion	87%	87%
Average Finishing Time	5h 2m	4h 59m
Major Injury	10%	9%
Minor Injury	47%	51%
Ave. Pain During Race	3.1	3.4
Use of Medical Tent	2.3%	3.9%

2017 Marathon Study

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Previously completed a half marathon → less likely to get injured

Multivariable OR 0.40, (0.22, 0.76), $p=0.005$

Averaging <4 training runs per week → less likely to get injure

Compared to those who averaged ≥4 per week

RR 1.36, (1.13-1.63), $p=0.001$

Distance of longest training run → inversely associated with race-day injury

OR 0.87 (0.81, 0.94), $p<0.001$

Strength Training and Injury Risk

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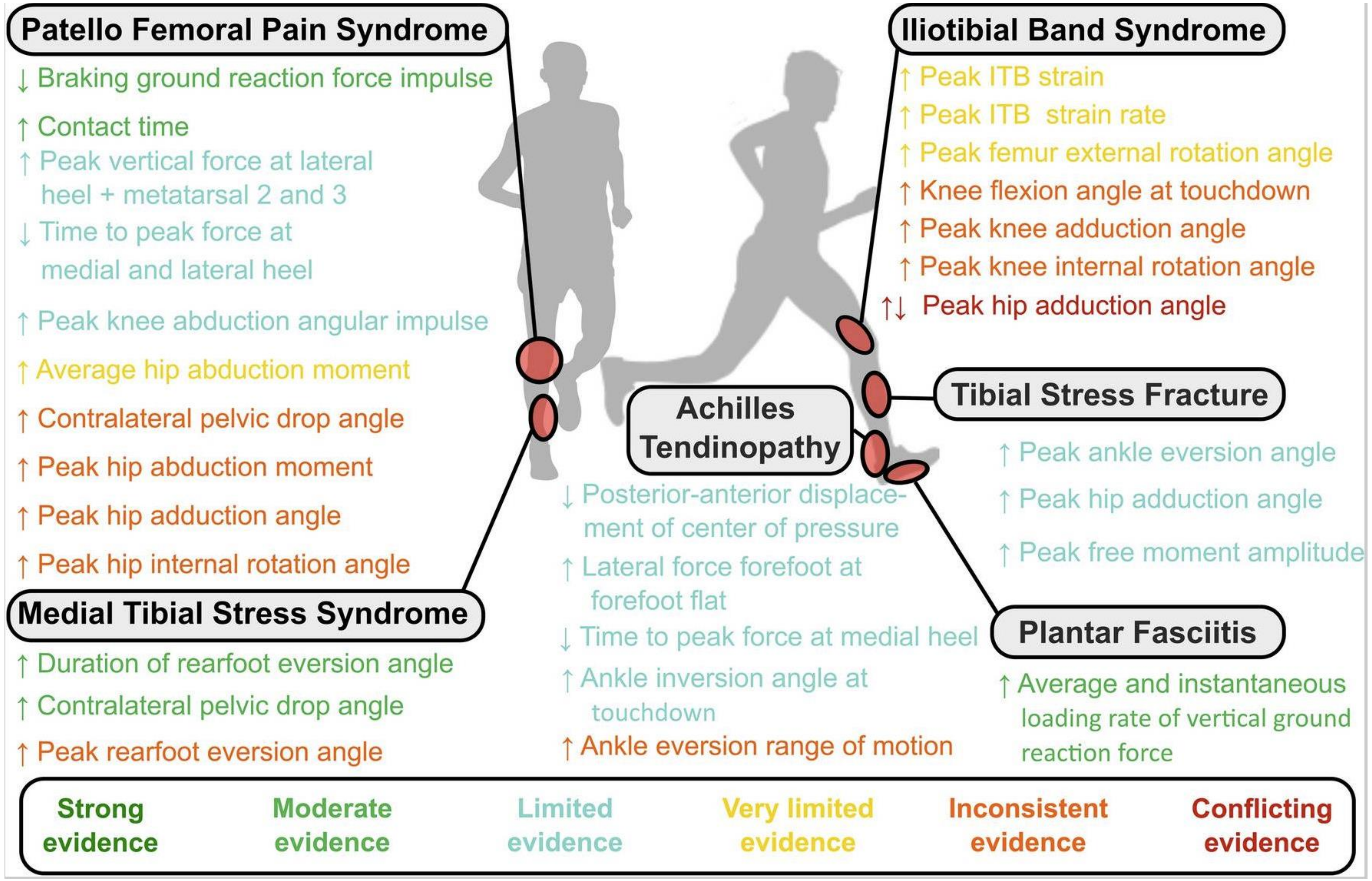

Willwacher et al. *Sports Med*. 2022.

Strength Training for Running

-Economy of movement

-Improved form with training, racing

-Reduction in joint loading force

-Plyometric based training = plyometric based activity

Fatouris et al, 2000, Vissing et al, 2008

Need Stronger Muscles!

Lesson 4

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Strong kinetic chain, plyometric focused, has been the biggest difference maker for keeping me on the road.

10 Evidence-Based Changes That Have Helped ….

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9. Shoe Wear
10. Just Showing Up (Goals)

Social Networking (Motivation)

Beat Your Brother!

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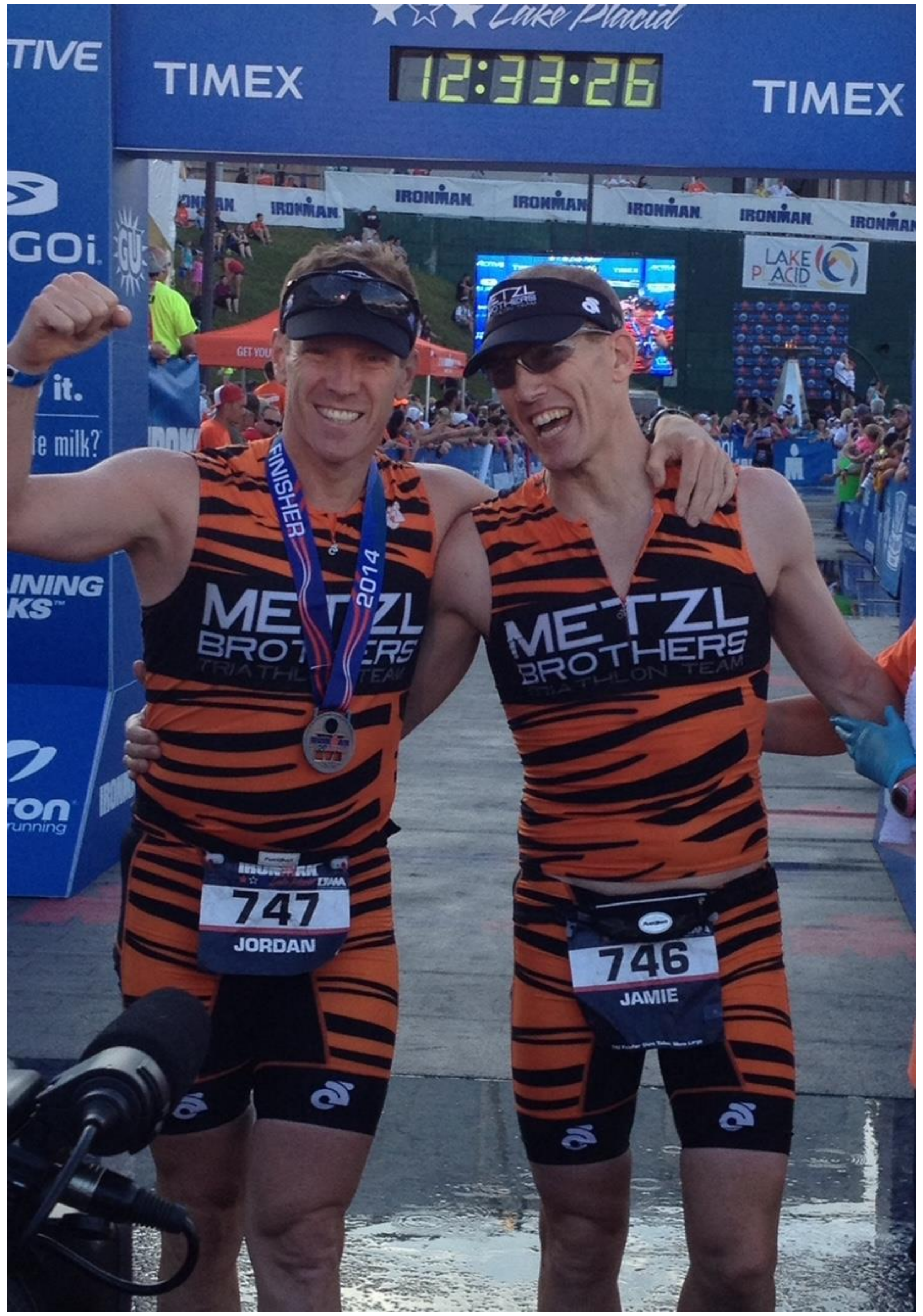

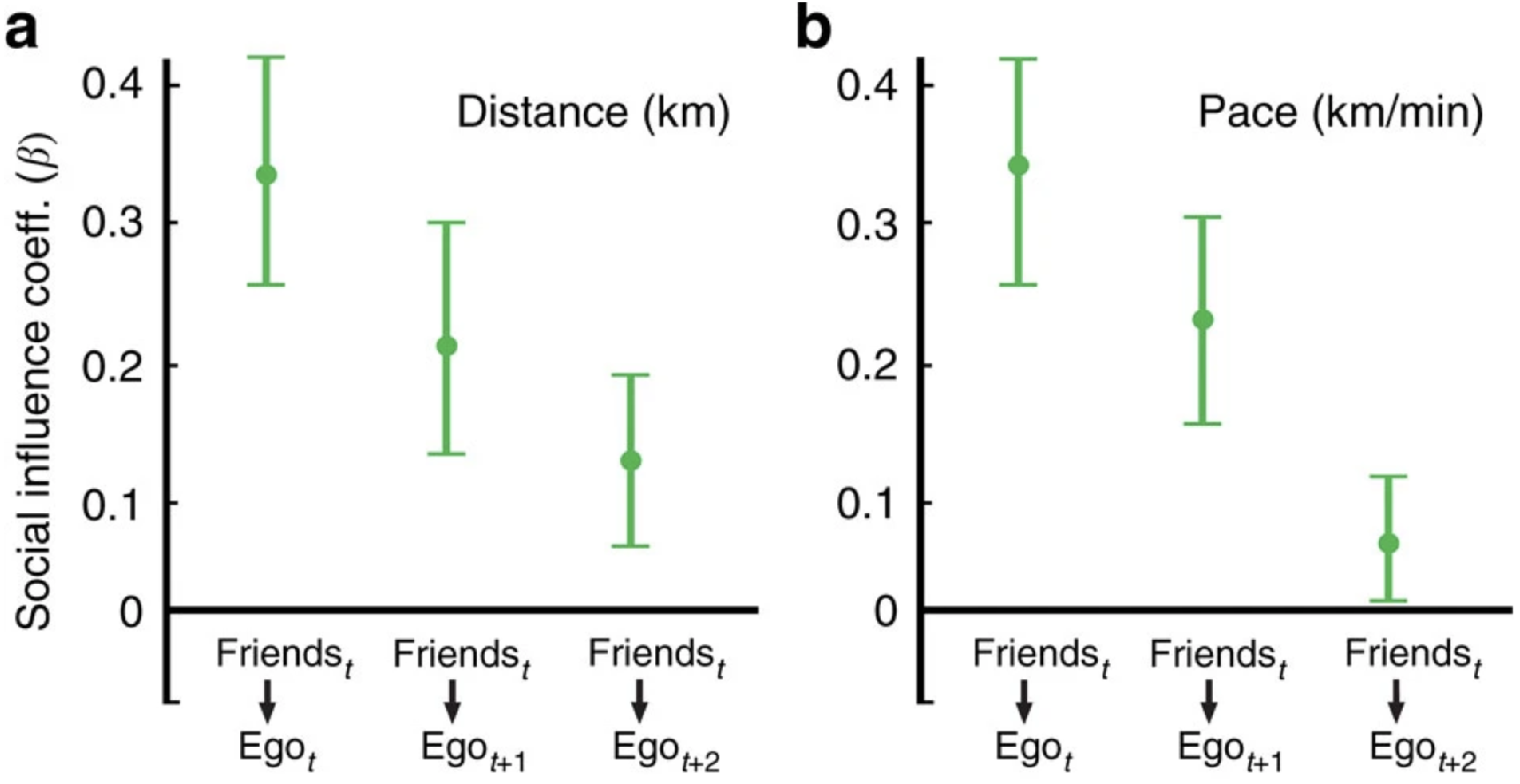

Aral. Nature, 2017

Lesson 5

Making and keeping a social network is a key to motivation.

10 Evidence-Based Changes That Have Helped ….

HSS

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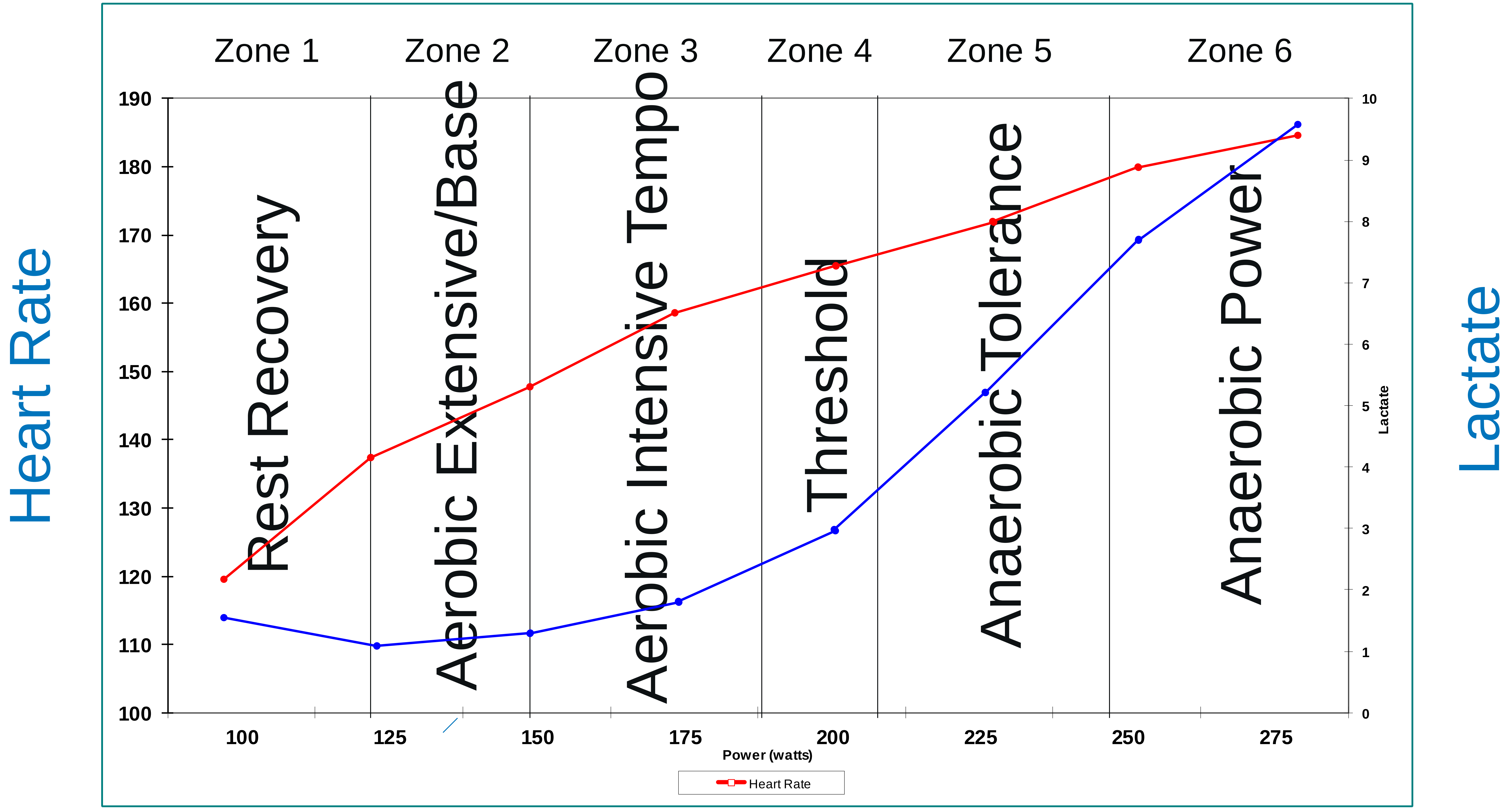
Heart Rate & Lactate vs. Power (Watts)



Courtesy of Polly DeMille, RN, CSCS

Physiologic Capacity and Aging

Oxygen consumption and its determinants at maximal exercise in endurance exercise-trained men

	Young men (28 years)	Older men (60 years)	Age-related change (%)
Oxygen consumption (ml kg^{-1} min^{-1})	68.2	49.4	28
Cardiac output (l min^{-1})	27.0	21.7	20
Stroke volume (ml $beat^{-1}$)	147	132	10
Heart rate (beats min^{-1})	184	165	10
a–v O_2 difference (ml $(100\ ml)^{-1}$)	16.7	15.2	8

The data were compiled from four studies in which values for all of the variables were reported in groups of young and older groups (Grimby *et al.* 1966; Hagberg *et al.* 1985; Rivera *et al.* 1989; Ogawa *et al.* 1992).

doi: 10.1113/jphysiol.2007.141879

Metabolic Performance Profile

Prepared for: SAMPLE
Date: SAMPLE

Aerobic Capacity (Maximum Oxygen Consumption)

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Aerobic capacity, otherwise known as Max VO_2, is a measure of your body's ability to take in, transport, and use oxygen to perform work. Your aerobic capacity is an indication of your ability to perform *vigorous* physical activity and depends on the capacity of your heart, lungs, and blood to deliver oxygen to your working muscles as well as the capacity of your muscles to take up and use oxygen in energy production. Increasing your max VO_2 can help improve the relative ease with which you perform your everyday activities as well as sport performance.

Your maximal oxygen consumption is primarily determined by your genetics; this includes the type of muscle fibers you have, your body size, and the structure and function of your cardiorespiratory system. Max VO_2 varies widely in humans because the *potential* maximal volume of oxygen consumption is genetically predetermined. In general, one may increase their aerobic capacity through training by roughly 10-30% above base measurements. Individual genetics have a tremendous influence on both max VO_2 and the response to a training program. One's individual genetic limit to oxygen consumption is not easily reached and requires consistent, intense, and well-structured cardiovascular training for a prolonged period. A high degree of aerobic fitness is also associated with decreased risk of chronic diseases such as the metabolic syndrome, cardiovascular disease, diabetes, and stroke to name a few.

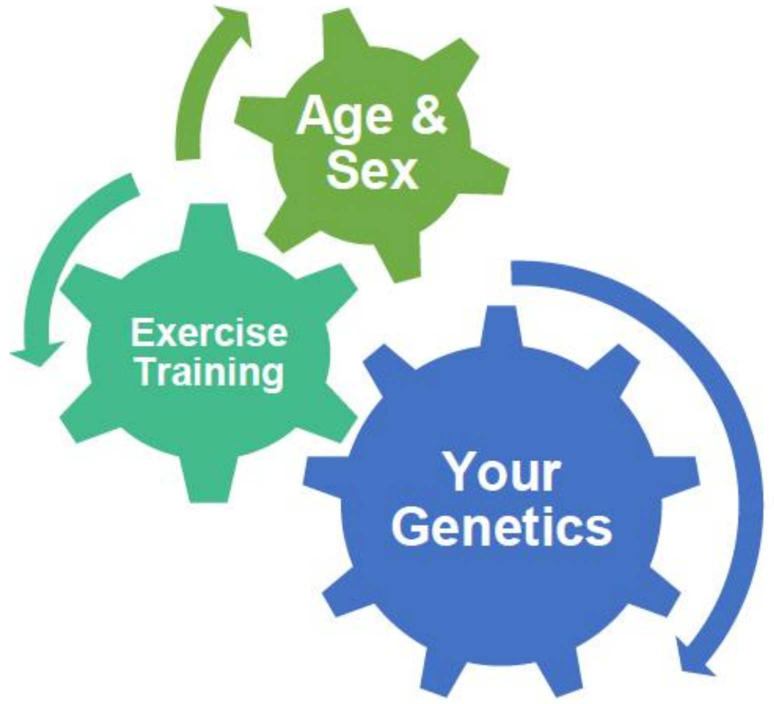
Max VO_2 is usually expressed in the units of milliliters of oxygen per kilogram of bodyweight per minute, or *ml/kg/min*. This gives an accurate picture of your body's total oxygen consumption relative to your body mass. This also allows for comparison between individuals of varying body masses. The average ranges for your age can be viewed in the chart below.

	Males	Females
Olympic Distance Runners	78	70
Olympic Distance Swimmers	72	68
Olympic Cyclists	73	68
Age 20-29, Average	43	36
Age 30-39, Average	42	34
Age 40-49, Average	40	32
Age 50-59, Average	34	29
Age 60-69, Average	28	26

Peak Performance

Peak Relative VO_2	38 ml/kg/min	49%
Peak Absolute VO_2	3.36 L/min	
Peak Breathing Rate	51 breaths per minute	
Peak Heart Rate	177 beats per minute	
Peak RER	0.99 (values above 1.10 typically indicates a maximal intensity effort)	
Peak Velocity (Pace)	6:44 min/mile or mph	

To put your peak VO_2 value into perspective, when you are sleeping or sitting quietly, your body consumes about 3.5ml of oxygen for every 2.2 lbs. of body weight per minute (1 MET). Walking on flat ground at 3 mph requires roughly 10mlO_2/kg/min (3.5 METS) and jogging a 10-minute mile requires about 35mlO_2/kg/min (10 METS). You may see "METS" (which stands for "metabolic equivalents") on many pieces of cardio equipment as an indication of the metabolic cost of the workout settings you choose.



Lactate Profile

HSS

Another important component of your capacity for sustained aerobic exercise and metabolic health is your **Lactate Profile**. Changes in blood lactate indicate transitions in the type of energy used by your body at various intensities. These changes, or inflection points on a curve, define the lower and upper limits of your exercise abilities and can be used to tailor your exercise program. Think about VO2max as the size of your engine, and lactate profile as your gears.

Exercise results in the breakdown of fats and glucose for energy. Glucose metabolism results in the production of lactate and hydrogen ions which enter the blood stream. Lactate is either recycled as an energy source (if the intensity is low enough) or accumulates in the blood. This dance between accumulation and clearance is what we track on the lactate curve.

Lactate at resting baseline is typically between 0.70-1.00mM. At the onset of continuous efforts, lactate may rise slightly but remain relatively low and constant. At this intensity any lactate that is produced is easily metabolized by the working muscles. This initial rise, with values up to about 2.0-2.5mM above baseline, typically marks the **aerobic threshold or first rise in blood lactate. Values under 2.0-2.5mM are characteristics of "base aerobic" zones.**

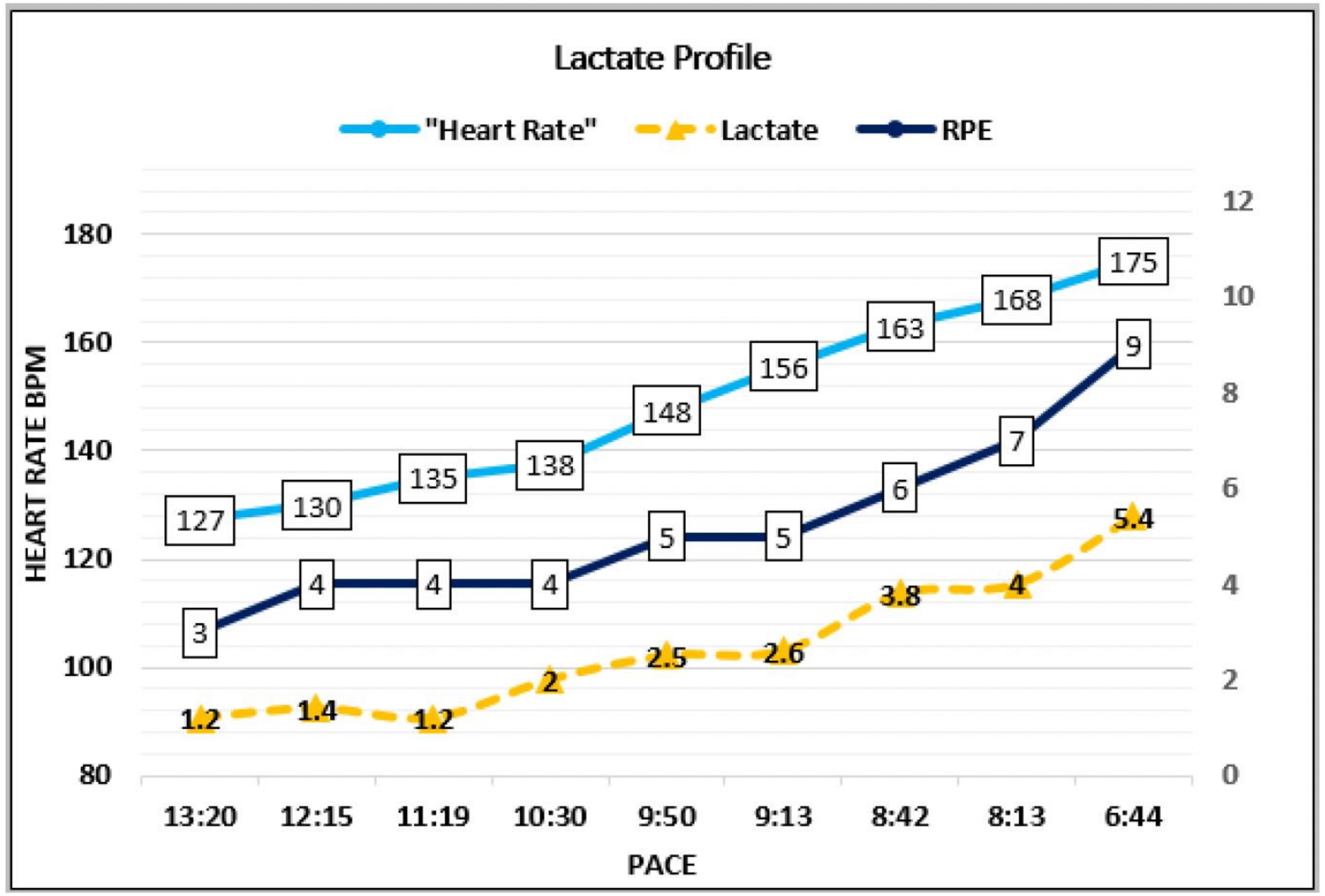
After this point, as intensity increases, lactate may begin to rise further. This occurs because the accumulation of lactate in the blood will begin to outpace the muscles' ability to metabolize it. This marks the **transition zone, or gray zone,** between the aerobic base and lactate turn-point.

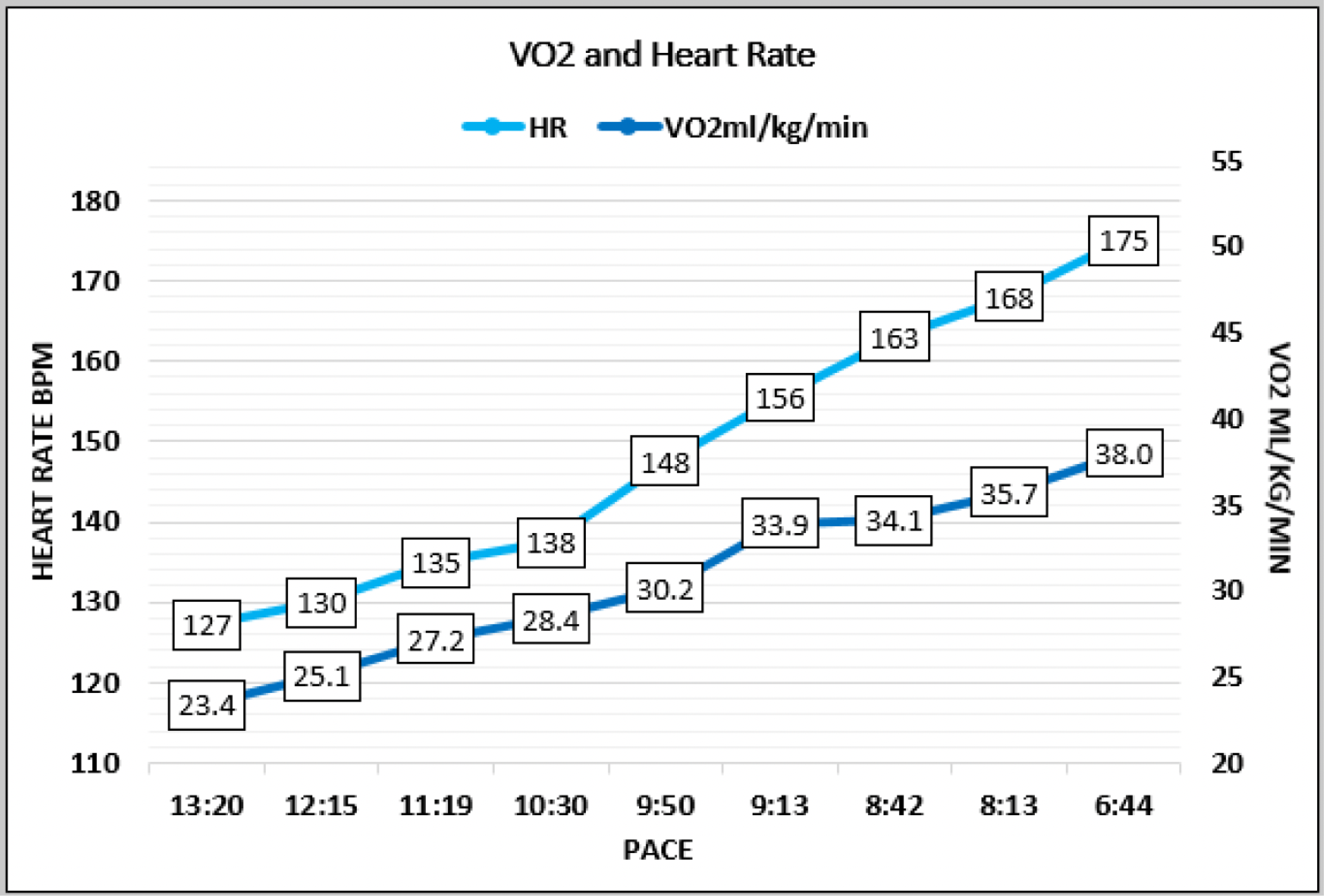
As intensity increases further, lactate production will inevitably reach a point that is greater than the body's capacity to metabolize it. It forms more rapidly than it can be removed and the curve begins to dramatically inflect upwards. This next rise in lactate refers to the **lactate turn-point or threshold** and gives way for the onset of blood lactate accumulation or OBLA.

Rising levels of lactate are associated with the accumulation of hydrogen ions in the blood and the lowering of muscle pH (increased acidity). This results in pronounced muscle fatigue and a reduced capacity to continue, otherwise felt as that intense desire to stop. The more work (faster pacing, higher power) you can perform below these thresholds, the greater your exercise and sport performance.

Your Lactate Profile

1st Rise above Baseline	10:30 min/mile or 5.7 mph
Heart Rate	138 beats per minute
Lactate	2.0 mM
Lactate Turn-Point or Threshold	8:42 min/mile or 6.9 mph
Heart Rate	163 beats per minute
Lactate	3.8 mM
Peak Lactate	5.4 mM

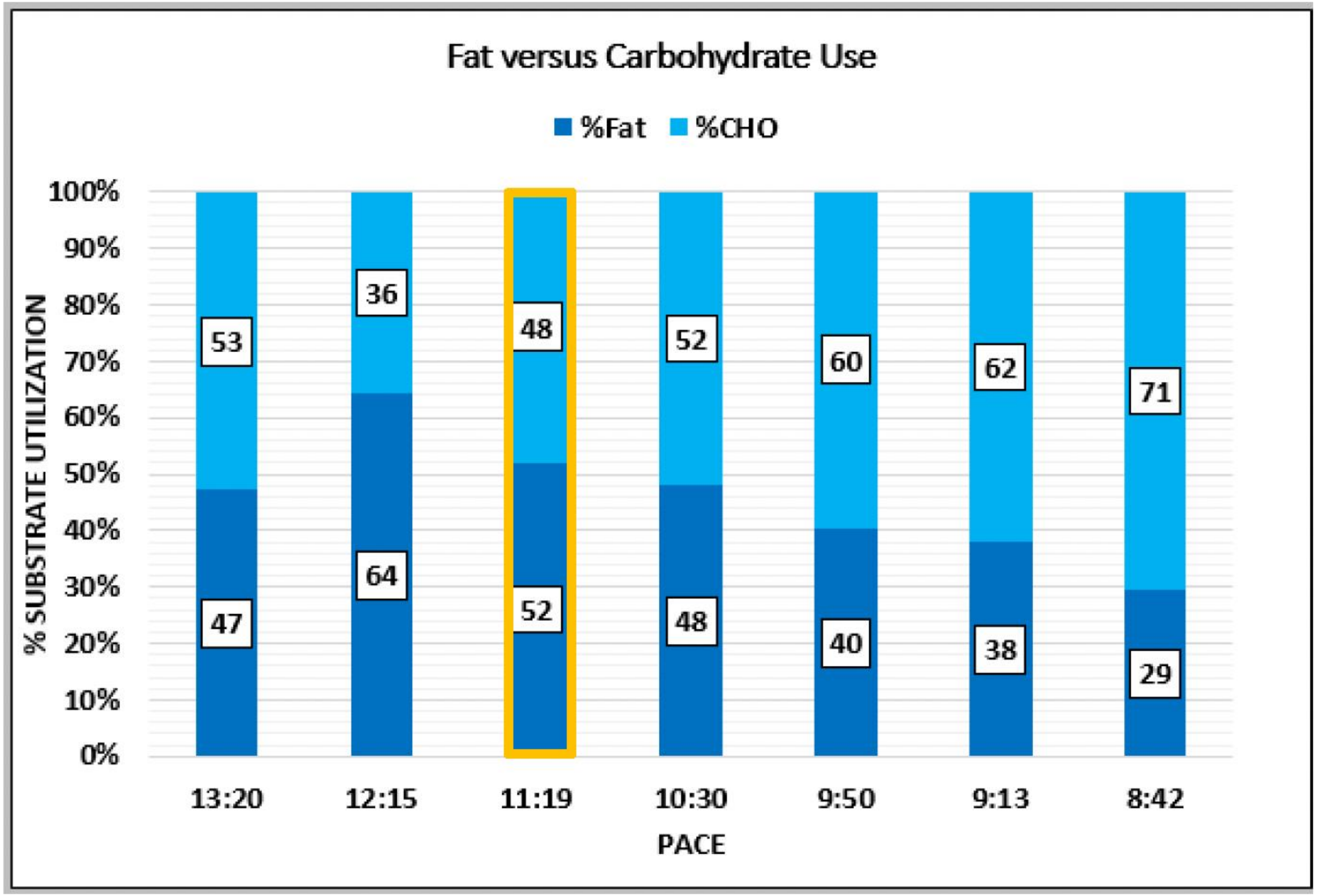



VO2 and Heart Rate
HR
VO2ml/kg/min
HEART RATE BPM
180
170
160
150
140
130
120
110
55
50
45
40
35
30
25
20
VO2 ML/KG/MIN
127
130
135
138
148
156
163
168
175
23.4
25.1
27.2
28.4
30.2
33.9
34.1
35.7
38.0
13:20
12:15
11:19
10:30
9:50
9:13
8:42
8:13
6:44
PACE

Metabolic Flexibility & Efficiency

We also measure the total calories and type of energy (fats or carbohydrates) that your body is utilizing at each workload. In normal metabolism, lower intensities can rely on the breakdown of fats to supply the energy for exercise. As the exercise intensity increases, all people will eventually hit a point in which carbohydrate is the primary fuel source. For an endurance athlete, the ability to continue to burn fat as exercise intensity increases is a big advantage. Even the leanest athlete has about 50,000 to 80,000 calories of stored fat and even the most highly trained athlete can only store about 1500 calories of carbohydrate. Consider that completing a marathon requires about 3,000 calories and an Ironman roughly 8,000 calories. Clearly, the ability to spare precious carbohydrate stores is extremely important. The flexibility to switch from our readily available and plentiful fat stores in the to our more limited carbohydrate stores also represents optimal metabolic function and health. Having to ingest loads of gels, bars, and energy drinks throughout the race often results in GI disturbances so the more calories that can be derived from fat stores, the fewer that will come from carbohydrate. Since the only calories that need to be replaced are those that come from carbohydrate stores, your need for exogenous carbohydrate will be reduced with greater use of fat stores.

We measure your calorie usage at each pace, the breakdown of fat vs. carbohydrate and look for the **Metabolic Efficiency Point (MEP)** which is the pace at which you burn 50% fat and 50% carbohydrate. It is thought that doing certain workouts (targeting the development of metabolic efficiency) at or below this pace will further enhance your fat-burning capabilities. **Your MEP occurred at a pace of 11:19min/mile.**

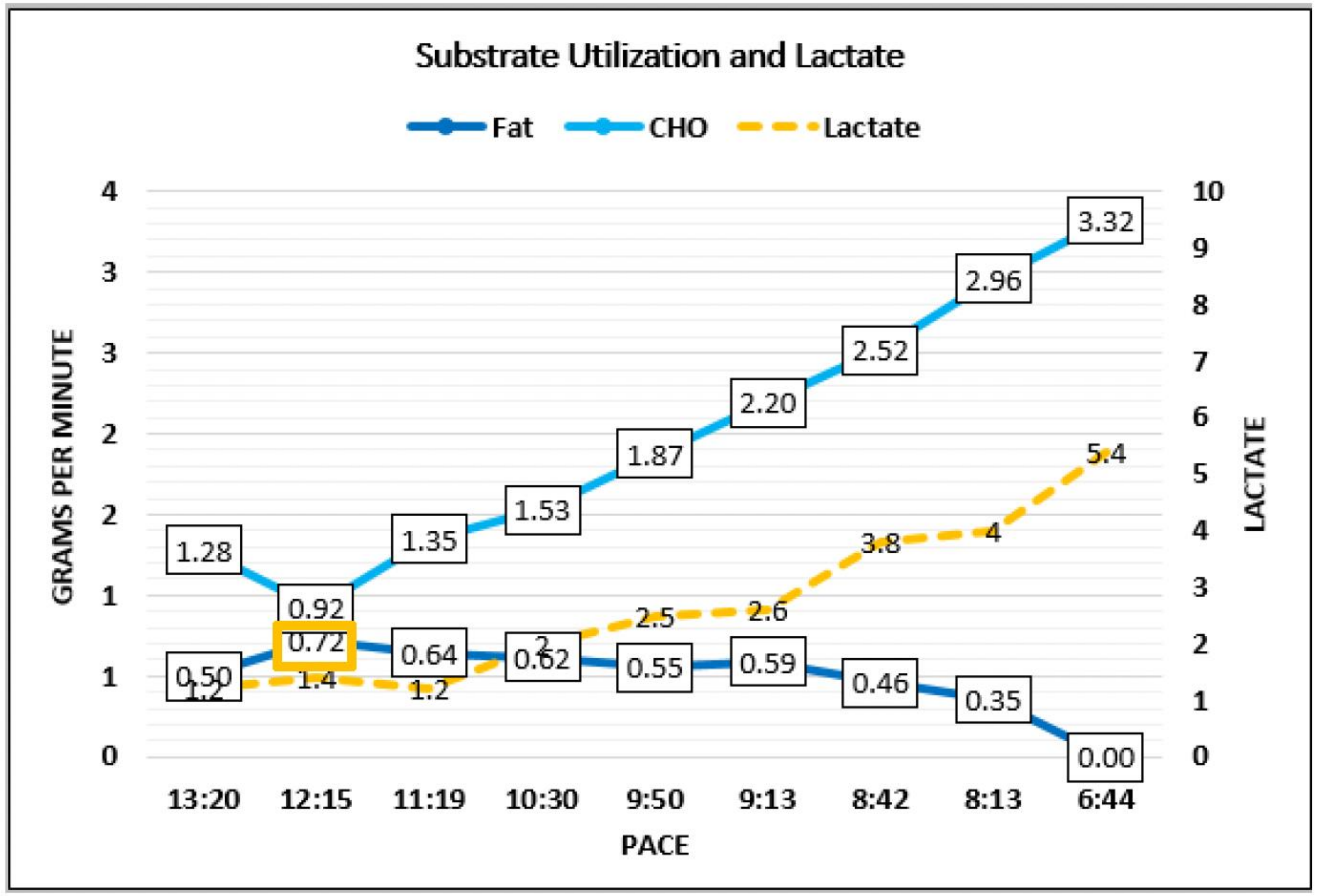


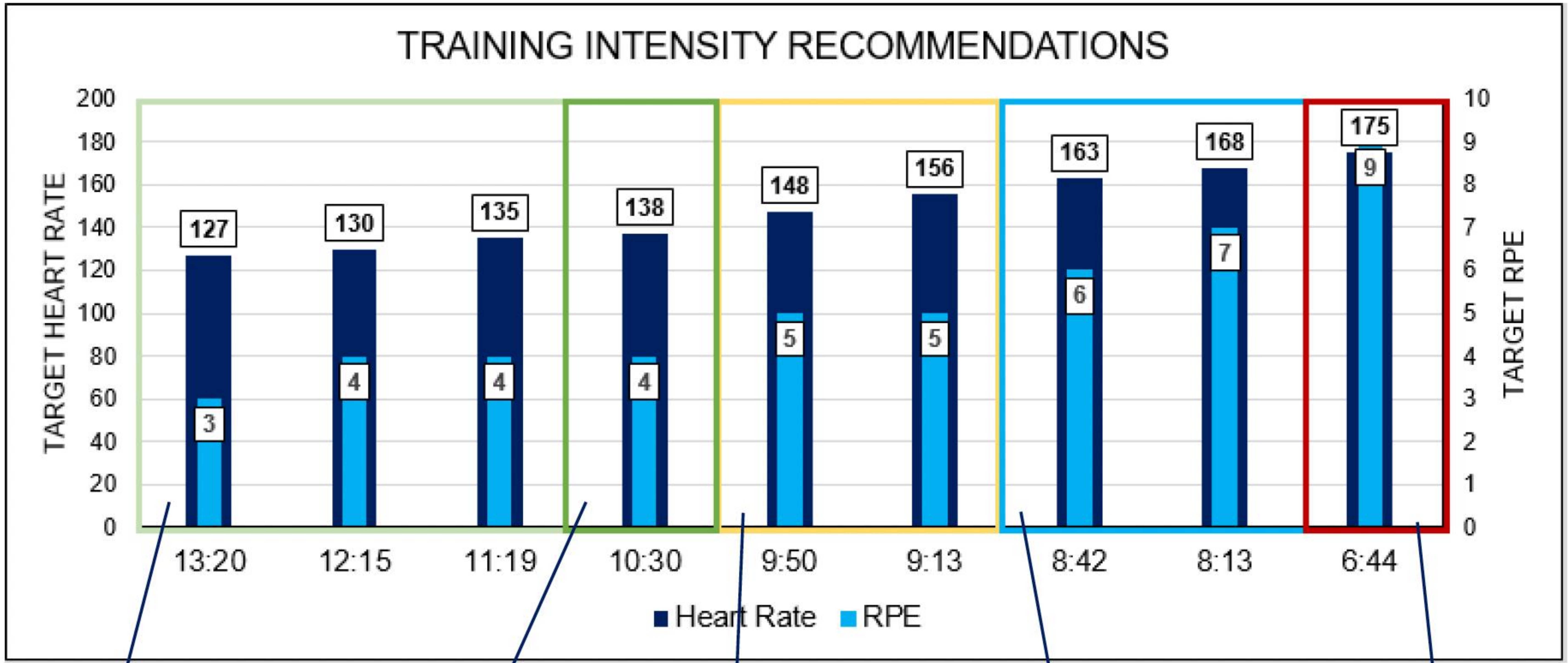
Fat versus Carbohydrate Use
%Fat
%CHO
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
% SUBSTRATE UTILIZATION
53
47
36
64
48
52
52
48
60
40
62
38
71
29
13:20
12:15
11:19
10:30
9:50
9:13
8:42
PACE

SS

HSS

Workload	Calories per minute	Calories per Hour	Fat g/min	% Calories from Fat	CHO g/min	% Calories from CHO	Calories from Fat	Calories from CHO
13:20	9.7	581	0.50	47	1.28	53	274	307
12:15	9.9	596	0.72	64	0.92	36	383	213
11:19	11.6	696	0.64	52	1.35	48	362	334
10:30	12.6	753	0.62	48	1.53	52	361	392
9:50	12.7	763	0.55	40	1.87	60	308	455
9:13	12.9	776	0.59	38	2.20	62	294	482
8:42	14.7	880	0.46	29	2.52	71	259	621
8:13	15.5	929	0.35	21	2.96	79	200	730
6:44	16.2	974	0.00	-	3.32	100	0	974





Training in this range helps with recovery & metabolic efficiency

Training in this range helps improve cardiac output

Training in this range helps improve mitochondrial respiration in type II fibers

Training in this range helps improve threshold & lactate tolerance/recovery

Training in this range helps improve muscle recruitment for high intensity efforts & sprints

Training Zone 1 | Light Continuous

This is your easiest effort training zone and can be done on very long duration workouts, as a warm up prior to starting a more intense workout, or to facilitate recovery the day after. Typical workouts in this zone are done as continuous and facilitate adaptations in cardiac output, mitochondrial function, capillarization in type I muscle fibers, increased blood flow to working muscles, and increased capacity for oxidative metabolism of substrates. This zone is primarily support by type 1 muscle fiber recruitment and the oxidation of fats in the skeletal muscle.

Training Zones 2 | Moderate Continuous Extensive

The common trend in health is to include a high volume of moderate intensity exercise, with the top end marked as the intensity at which blood lactate is rising slightly above baseline to about 1mM above baseline (or the first lactate inflection point during your test). Training at this intensity promote changes to bone, muscle, and connective tissue that will improve your overall tolerance, as well as helping to build your aerobic base. Typical workouts facilitate adaptations in mitochondrial function, cardiac output and stroke volume, left ventricular mass, and improvement of muscle-specific lactate clearance.

Training Zones 3 | Moderate Continuous Intensive

Zone 3 is the transition zone whereby the demand for energy exceeds that which can be sustained by the breakdown of fats alone, and so more type 2 muscle fibers begin to be recruited. This raises lactate further and, both as a necessity and mechanistically, suppresses the breakdown fat. This zone brings about orthopedic adaptations that condition your body to endure the demands of your sport and further challenges your abilities for higher work outputs. Typical workouts in these zones include both continuous training and interval modes and facilitate adaptations in mitochondrial proliferation, cardiac output and stroke volume, left ventricular mass, improvement of muscle-specific lactate clearance, increased muscle recruitment without enhanced fatigued, and reduce recovery time relative to intervals in zone 4.

Training Zone 4 | Intensive Intervals and Lactate Turn Point

This zone takes place at threshold and is associated with a noticeable increase in respiratory rate and rate of perceived exertion (RPE). It is in this zone that your muscles develop a greater tolerance for lactate and improve your ability to drive the glycolytic pathways for energy. Workouts in this zone are also effective for helping to improve aerobic capacity and to continue to improve overall metabolic fitness of the working muscles. Workouts in this zone typically include intervals with various rest times to facilitate specific goals.

Training Zone 5 & 6 | Aerobic Power and Sprinting

Training in zones 5 and 6 happen at an intensity above your lactate turn-point and includes VO2max intervals, lactate tolerance intervals, speed, and sprint training. This type of training is often included at a lower volume as it is much harder and requires more recovery time. This red zone training involves relatively short duration, high intensity bouts and helps improve mitochondrial respiration in type II muscle fibers, increased capillarization density in the skeletal muscle, recruitment of motor units associated with higher intensity work in your sport, sprinting ability, and similar effects on the heart as seen in previous zones.

Lesson 6

HSS

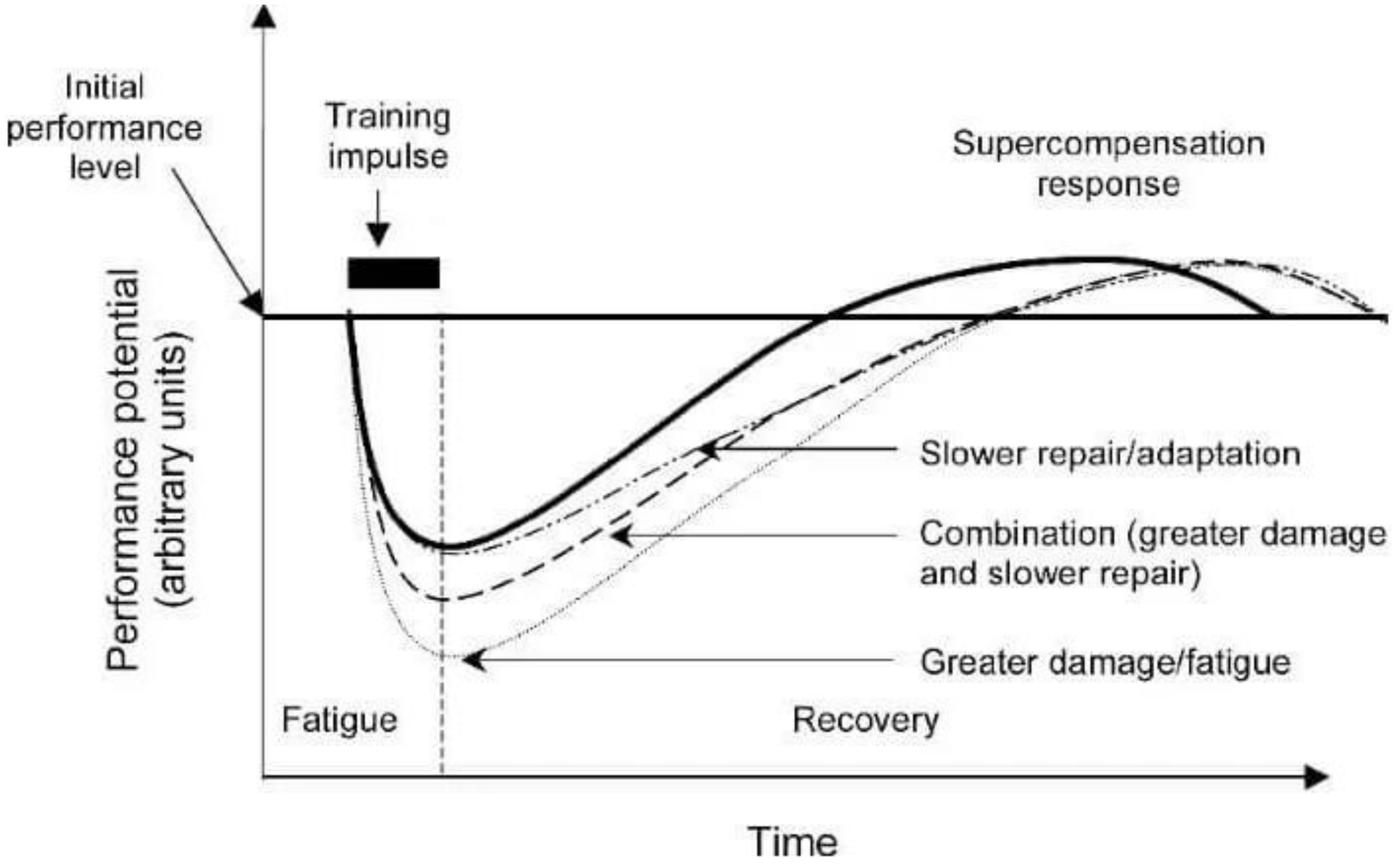
Intensity training is essential to maintain mitochondrial volume, exercise capacity, and to look at your performance and not feel like a donkey.

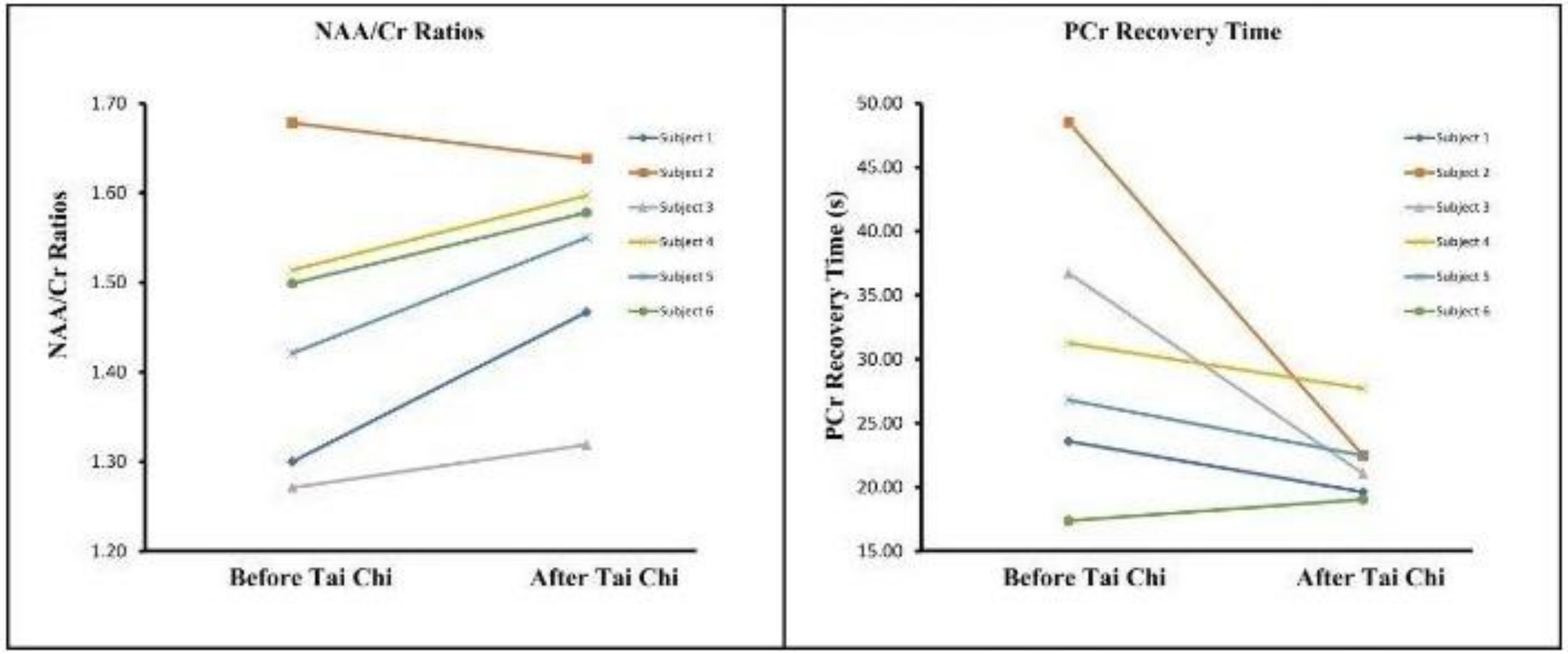
10 Evidence-Based Changes That Have Helped ….

HSS

1. Training Patterns
2. Nutrition
3. Cadence
4. Strength Training (Age-related sarcopenia)
5. Social Networking (Motivation)
6. Intensity Training
7. Recovery Matters
8. Electrolytes
9. Shoe Wear
10. Just Showing Up (Goals)

Recovery Matters





Recovery Slows with Aging

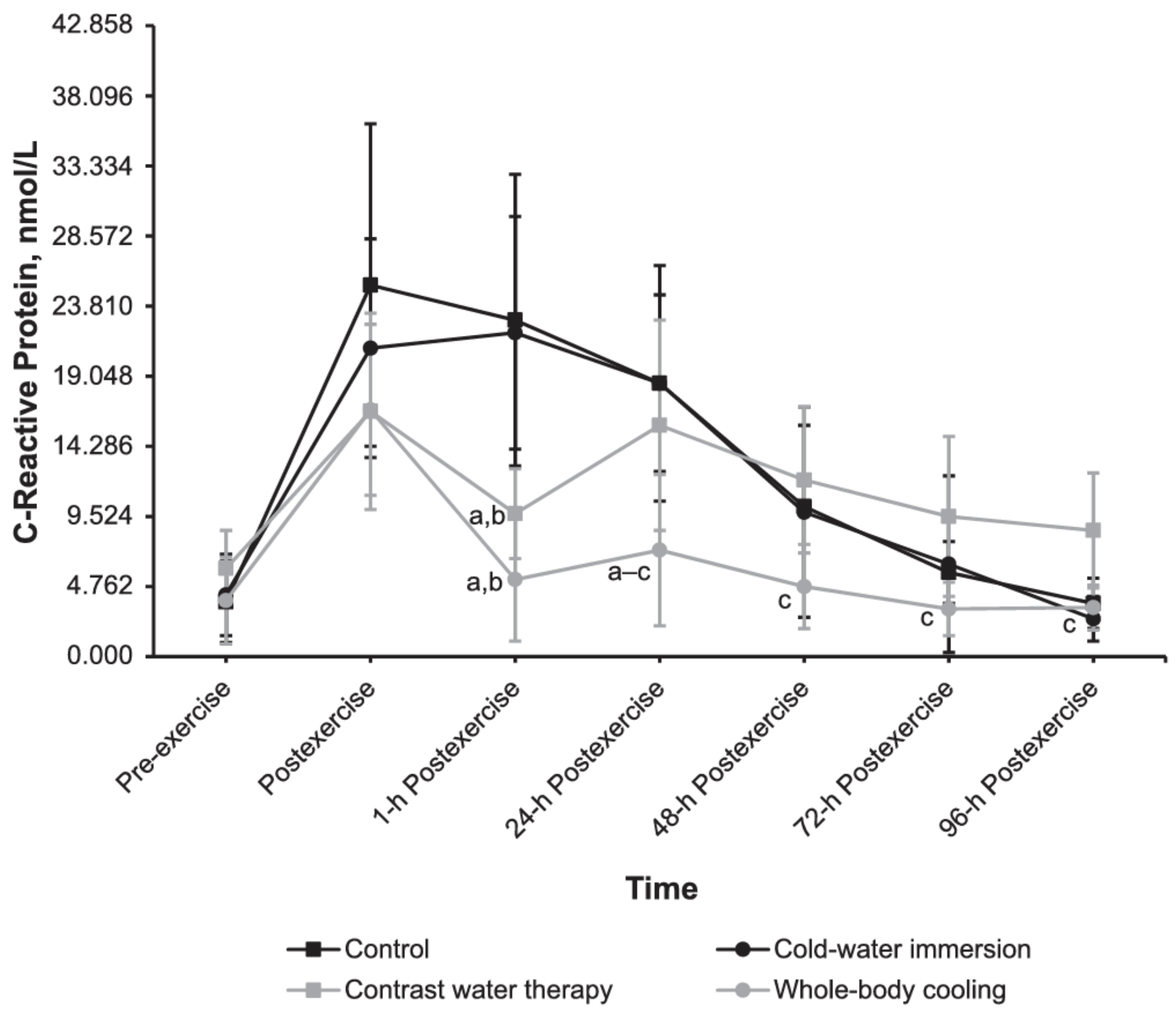
Active Recovery Improves Muscle Recovery Time (Tai Chi)

doi: 10.1123/japa.16.1.97

RECOVERY: Cryotherapy = Best Cold Therapy

Compared to Cold Water Immersion and CWT, Cryotherapy had:

- Greater improvement in pain
- Lower creatine kinase (muscle breakdown)
- Lower C-reactive protein (marker of inflammation)
- More rapid improvement in vertical jump height



Soft Tissue Massage Reduces Inflammation

Immediate post-exercise massage:

1) Decreases inflammatory markers
2) Up-regulates mitochondria production in the muscles.

Options include:

- Compression Boots → Mobilizes lower extremity edema and improves blood flow
- Percussion Gun (Hypervolt, Theragun)
- Foam Roller (no benefit of vibrating roller over standard foam roller)
- Sports massage which can specifically target focal sore or hot spots
  - No change in stiffness
  - No change in post-exercise soreness

Kong et al. *J Sports Sci Med*. 2018.

Lesson 7

Recovery becomes increasingly important with age.

10 Evidence-Based Changes That Have Helped ….

HSS

1. Training Patterns
2. Nutrition
3. Cadence
4. Strength Training (Age-related sarcopenia)
5. Social Networking (Motivation)
6. Intensity Training
7. Pain Management
8. Electrolytes
9. Shoe Wear
10. Just Showing Up (Goals)

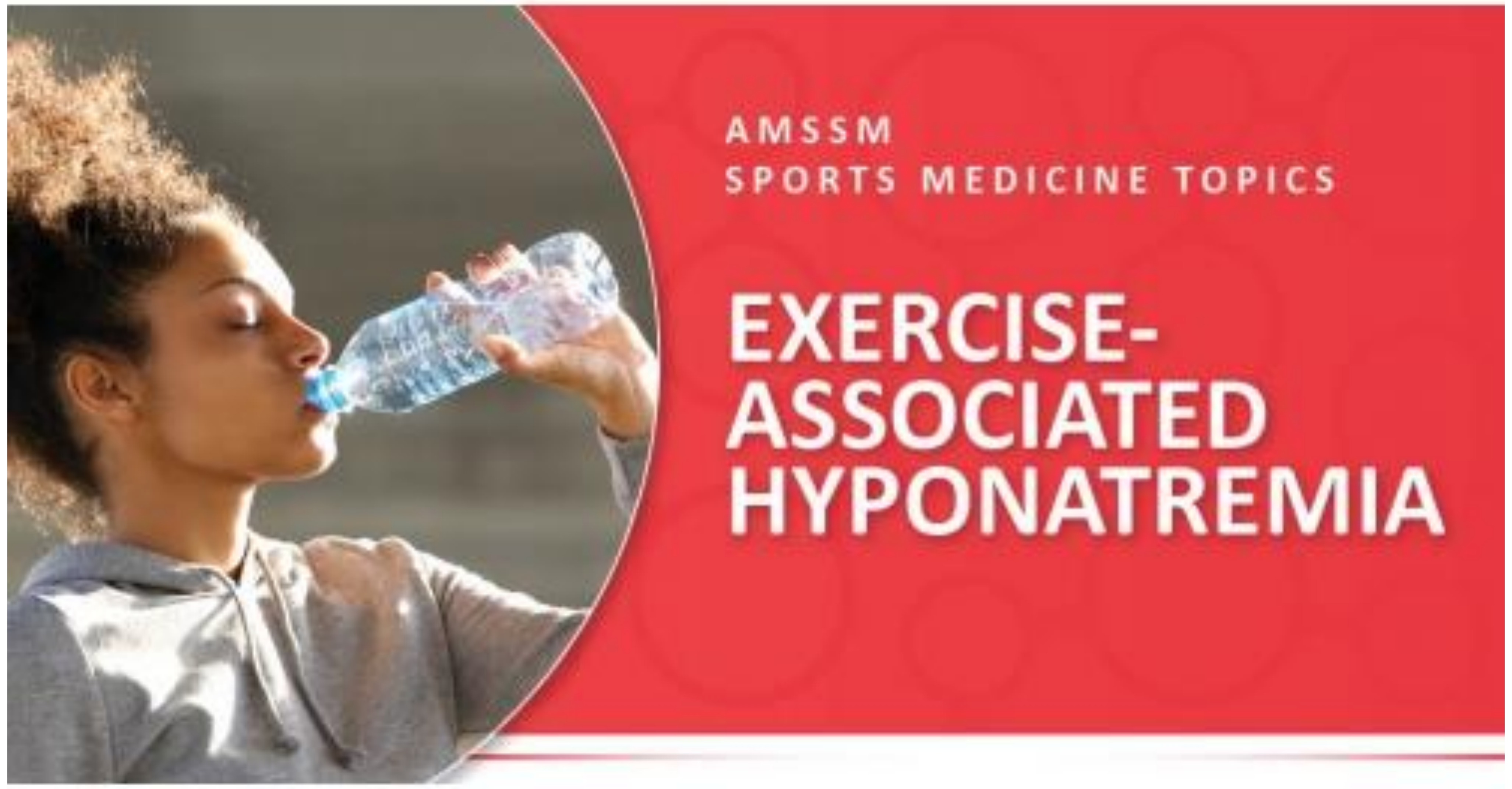
Electrolytes

Hyponatremia

EAH results from prolonged physical activity that results in a low level of sodium in the blood (< 135 mEq/L)

Symptoms/Risks

- Weakness
- Dizziness
- Headache
- Nausea
- Vomiting
- Muscle cramps
- Confusion
- Seizures resulting in a coma
- Impaired coordination



Lesson 8

HSS

Electrolytes don’t matter until they do. Be prepared.

10 Evidence-Based Changes That Have Helped ….

HSS

1. Training Patterns
2. Nutrition
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4. Strength Training (Age-related sarcopenia)
5. Social Networking (Motivation)
6. Intensity Training
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8. Electrolytes
9. Shoe Wear
10. Just Showing Up (Goals)

1949 – The First Marathon Shoe

The history of running shoe technology

The first shoe specifically designed for running was developed by Spalding Company in 1852

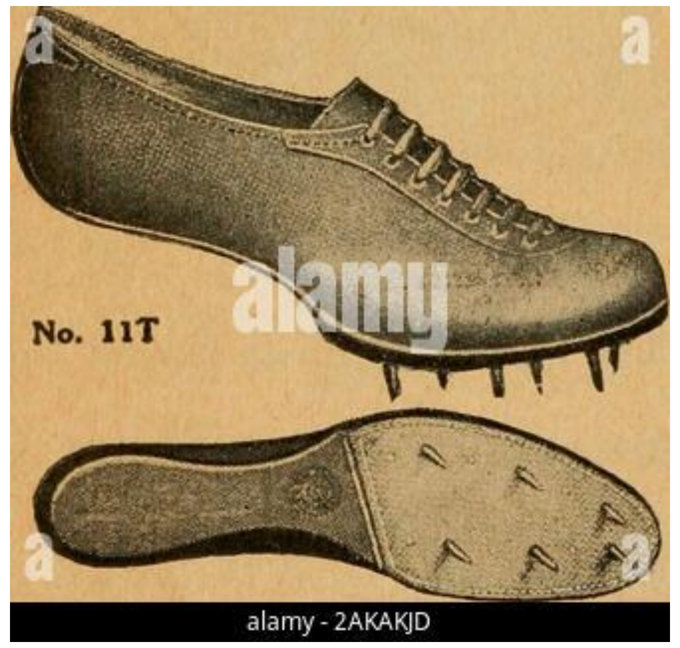
- Made of kangaroo leather and had 6 spikes

In 1917, Keds made shoe with rubber soles and cloth upper called Plimsoll

- They were much more comfortable
- They were quieter hence the name sneakers

In 1936, Adolf Dassler is credited with the modern running shoe

- His shoes were used by Olympians such a Jessie Owens
- He later founded Adidas in 1948



The modern Running shoes

In 1960s, the rubberized midsole was introduced by Bowerman and Knight

- Later formed Nike 1971

1970, removable spike were first introduced

1974, Nike introduced the Waffle shoe designed to have runner land of their heel

In 1975, Brooks incorporated Ethlyene vinyl acetate, an air-infused foam

1976 Brooks introduced Vantage to control pronation

1987 Nike created heel cushioning bubble technology

In 2005, Nike Free and Vibram FivFingers brought in the minimalist/barefoot running movement

Common Running Shoes Technology Terms

Upper – everything that sit on top of the sole

Outsole – layer of foam on the bottom of the shoe that makes contact with the surface

Midsole – layer of foam that connect the upper to the outsole

Heel to toe drop, the difference between the height of the heel box vs the toe box

- High toe drop >10mm
- Moderate 5-9mm
- Low <4mm

Where are we now

HSS

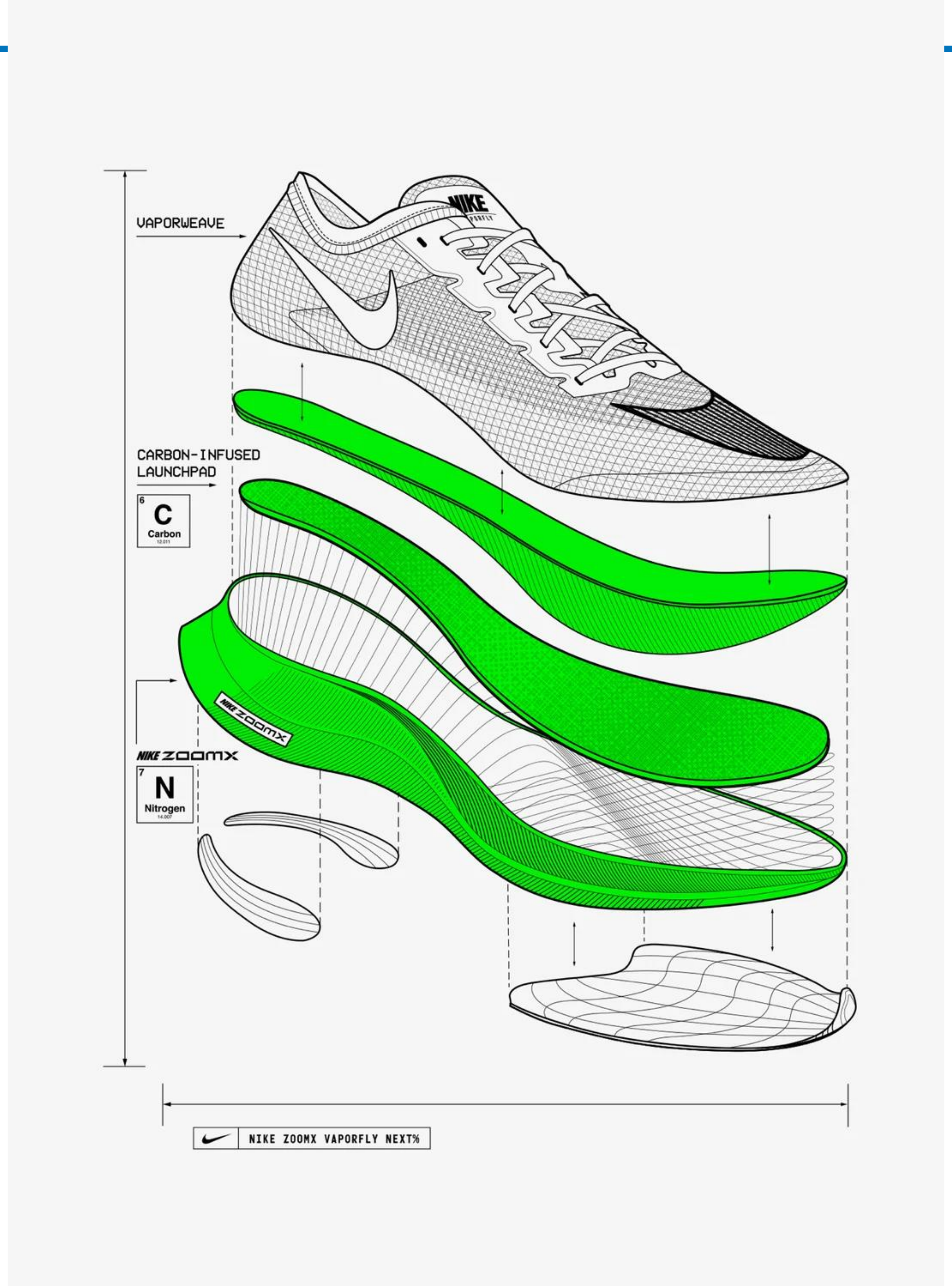
The main focus for the decade has been trying to create material that is more shock absorbing with more recoil that is lighter

In 2013, Adidas introduced their Boost technology which replaces EVA with a thermoplastic polyurethane midsole, made of thousands of energy returning capsules

- Most running shoe companies have developed shoes with a lighter, more responsive foam than EVA

Nike Vaporfly (2019) combines a carbon fiber plate with a new recoiling foam, PEBA with a thicker heel to create a spring loading effect “Supershoe”

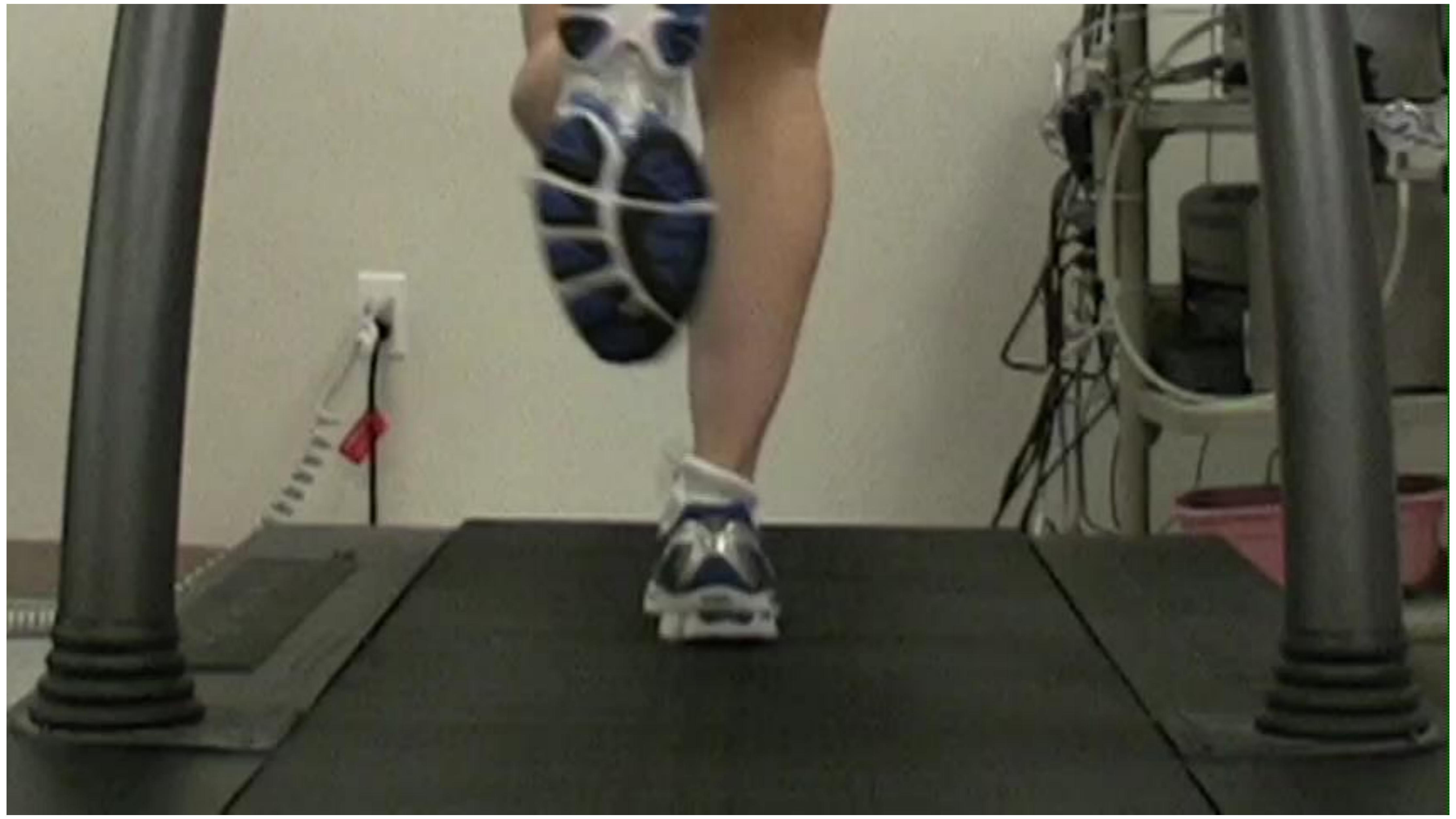
- 4% more efficient in competitive marathon runners
- 50 g lighter than traditional competitors
- All the latest record breaking runs in the marathon



Running/Walking With Right Shoes?

Bad Feet

Good Feet



Shoe Wear and Run Mechanics

To compare the vertical ground-reaction force and ankle kinematics between maximal and traditional shoes before and after a 6-week acclimation period to the maximal shoe.

There is increasing enthusiasm in the "cushioned shoe"

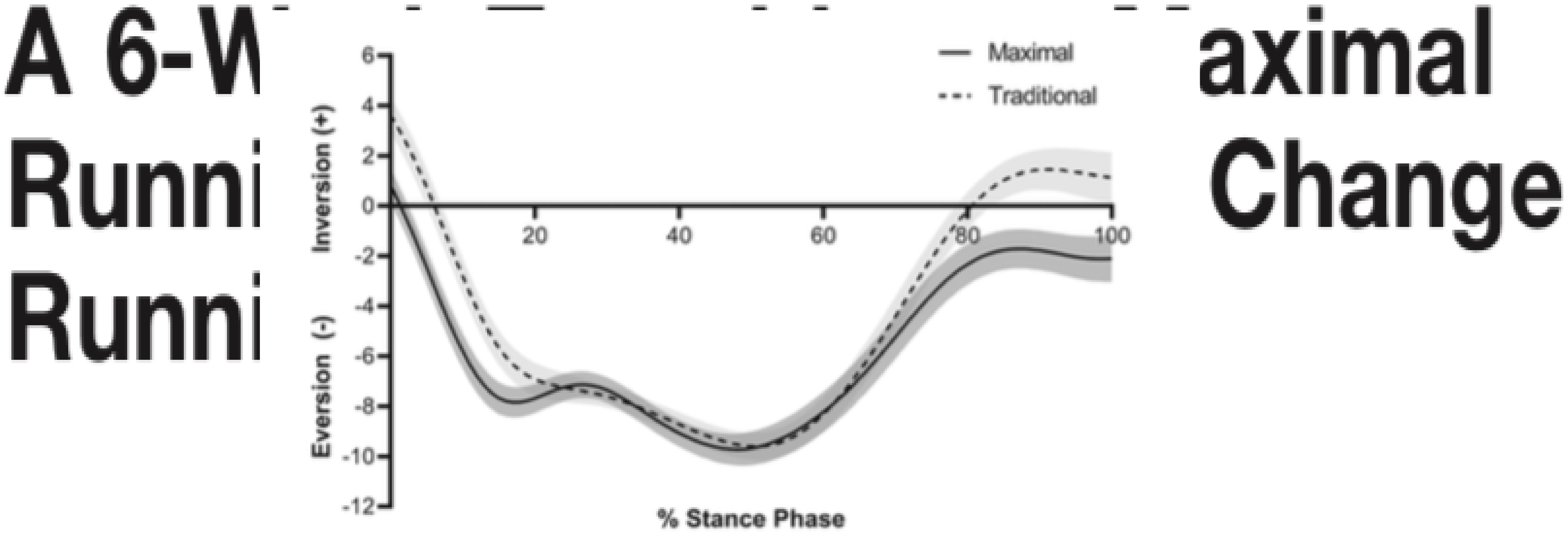


Figure 2. Ensemble curves for inversion (+) and eversion (–) in each shoe condition, in degrees. Error bars represent ±1 SE.

Hannigan J et al, AJSM, 2019

Lesson 9

HSS

I never believed all the hype about running shoes. I just use what feels ok.

10 Evidence-Based Changes That Have Helped ….

1. Training Patterns
2. Nutrition
3. Cadence
4. Strength Training (Age-related sarcopenia)
5. Social Networking (Motivation)
6. Intensity Training
7. Recovery Matters
8. Electrolytes
9. Shoe Wear
10. Just Showing Up (Goals)

Just Showing Up (Goals)

No matter who you are

No matter where you are

Give yourself a goal

Best Goals:

- You have to work for it
- Little bit scary
- Motivational
- 6 months-1 year ahead

Lesson 10

HSS

Nobody gives a crap how fast you are. Nobody cares what exercise you do. Just get your a## out there, set goals, do your best, and have fun because if you move every day you'll get more out of your life.